A MANUAL OF SURGERY

STEWART

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FOR STUDENTS AND PHYSICIANS

BY

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TO

DR. ROBERT G. LE CONTE

AS A TRIBUTE TO

HIS ABILITY AS A SURGEON

PREFACE TO FOURTH EDITION.

In the present edition of this manual those portions of the text dealing with investigation of the patient, particularly by instrumental means, e.g., bronchoscopy, esophagoscopy, proctoscopy, radiography, etc., have been expanded. Important changes have been made in the articles on transfusion, hemorrhage, spinal puncture, colectomy, hernia, tumors of the hypophysis, and the surgery of the lung, the liver, the stomach, the spleen, and the breast. Among the new sections that have been added may be mentioned those on exclusion of the pylorus, sporotrichosis, the surgical aspects of purpura, esophagectomy, esophagoplasty, foreign bodies in the palm, infections of the hand, and those on the transplantation of fat, fascia, bone, and veins. A number of the old illustrations have been discarded, a number of new ones inserted.

Dr. Willis F. Manges has kindly criticized the pages on the X-ray; Dr. W. Estell Lee, Dr. Edward J. Klopp, and Dr. Henry P. Brown, Jr., have looked over several chapters and made numerous valuable suggestions.

F. T. S.

PREFACE TO FIRST EDITION.

THE following pages have been prepared for the undergraduate, whose crowded hours demand a manual stripped of verbiage and unessentials, and for the medical practitioner who seeks a guide to present-day surgery. The chief desire, therefore, has been to set down concisely and completely those facts which the student must know, and to make such suggestions in diagnosis and treatment as will best aid the physician in his daily practice—in short the main aim has been to be brief and practical. For these reasons historical matter and bibliographical references have been omitted, and emphasis has been laid on those details which experience teaches to be of the greatest clinical importance.

Although information has been drawn from many sources, most aid has been derived from the text-books of Da Costa, Tillmanns, and Rose and Carless, from the operative surgeries of Binnie, Bryant, and Treves, and from the systems of Ashhurst, Delbet, and Le Dentu, and Von Bergmann, Von Bruns, and Von Mikulicz. Mention must be made, likewise, of the freedom with which the ideas of Gibbon, Harte, Hearn, Hutchinson, Keen, Le Conte, and Roberts have been appropriated.

Owing to the liberality of the publishers it has been possible to insert many original illustrations; most of those labeled Pennsylvania Hospital have been made from photographs secured while acting for Dr. Robert G. Le Conte in that institution. Thanks are due also to Dr. Charles F. Mitchell, Dr. James W. MacIntosh, and Dr. W. Estell Lee for valuable assistance in preparing portions of the manuscript, in reading proof, and in making the index.

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CONTENTS.

MANUAL OF SURGERY.

CHAPTER I.

DIAGNOSIS AND RÖNTGEN RAY.

Diagnosis is the process whereby the nature of a disease is determined; the term is applied also to the result of this process, i.e., the name of the disease. In many instances the condition, a crushed foot for instance, is self-evident and a *direct diagnosis* may be made; in others the symptoms suggest two or more affections, which must be distinguished by *differential diagnosis*; and occasionally a *diagnosis by exclusion* must be made; thus in a case of retroperitoneal sarcoma, it may be necessary to consider all the other forms of abdominal tumor, and to rule them out one by one, because of the absence of special symptoms, until finally the real cause of the growth is determined. In order to be *complete* a diagnosis should include the organ or part affected (*anatomical diagnosis*), the nature of the affection (*pathological diagnosis*), the constitutional change resulting from or causing the local lesion, the presence or absence of independent or associated maladies, and the individuality of the patient.

A diagnosis is made by interrogating the patient (*subjective symptoms*) and by physical examination (*objective symptoms or signs*). The chief factors in diagnosis are to obtain correct facts, to interpret them properly, to know what to look for, and above all to look. "More mistakes are made by want of looking than by want of knowing." In practice the *analytical method* is usually employed; the attention is first directed to the offending part, and by examination, coupled with questioning the patient, one considers the conditions most likely to be the cause of the symptoms, and then by further examination the diagnosis is finally reached. The *synthetical or historical method* is more scientific, more accurate, and better adapted for the keeping of written records. It consists of (a) the *history* (*anamnesis*), which, with the name of the patient and the date of examination, includes (1) the age, (2) address and nationality, (3) sex, (4) social condition, (5) family history, (6) previous history, and (7) the history of the present illness; and (b) the *physical examination* (*status presens*), which comprises (8) an examination of the affected part, (9) an examination of regions clinically related to the affected part, and (10) a general examination of the whole body.

1. The apparent as well as the real **age** should be noted. In childhood irritability of the nervous system is marked, and high fever and convulsions may be caused by trivial affections which would cause no such disturbances in the adult. A malignant neoplasm in a child would probably be a sarcoma, in later life a carcinoma. Ulcers in children may be due to tuberculosis or congenital syphilis; in adults syphilitic and traumatic ulcers are frequent; later in life the varicose ulcers and epitheliomata predominate. In the

child an injury to an extremity may result in a greenstick fracture or epiphyseal separation, the same in an adult might cause a complete fracture or a dislocation. In intestinal obstruction one would suspect imperforate anus in the new born, intussusception in infancy, and impacted feces or cancer in old age. In children difficulty in urination would probably be due to phimosis or calculus, in adults to stricture, in old age to enlarged prostate. In *childhood* infantile paralysis, congenital syphilis, rickets, adenoids, prolapse of the anus, rectal polypi, malformations, nevi, noma, foreign bodies in the air passages, tuberculous lymph glands, acute infectious osteomyelitis, postpharyngeal abscess, hemophilia, renal sarcoma, hydrocephalus, cretinism, and intussusception are common; in *adolescence* appendicitis, gastric ulcer, osteoma, chondroma, tuberculosis of bones and joints, and sexual disorders are frequent; in *middle age* aneurysm, carcinoma, floating kidney, mollities ossium, and gall-stones are most apt to occur; in *old age* hypertrophy of the prostate and degeneration of the circulatory apparatus, leading to gangrene and other disorders, are prone to develop. Hernia is most frequent at the extremes of life. Infancy and old age do not stand operations well, but infants who escape the immediate dangers of operation often convalesce more rapidly than adults.

2. Not only the present, but previous **addresses** should be ascertained, as well as the **place of birth.** Goiter is prevalent in Switzerland, Tyrol, Southeastern France, Northern Italy, parts of England, and in the Himalayas and Andes; leprosy in Norway and the tropics; bilharzia hematobia, tetanus, filariasis, and hepatic abscess in the tropics; rachitis in densely populated centers; vesical calculus in India and parts of England; hydatid disease in Iceland and Australia. The *Negro* is more susceptible to tuberculosis, aneurysm, elephantiasis, tetanus, and benign neoplasms, especially the fibromata; less liable to malignant disease, stone in the bladder, varicose veins, appendicitis, congenital deformity, enlarged prostate, and gall-stones; and less resistant to operative procedures. The *Hebrew* suffers frequently from intestinal and rectal disorders, and is more prone to develop diabetes with its surgical complications; his symptoms should be analyzed with due consideration to his highly sensitive nervous system.

3. The **sex** is occasionally of some importance in making a diagnosis. Excluding diseases of the reproductive organs, *females* are more liable to goiter, floating kidney, enteroptosis, gall-stones, mollities ossium, Raynaud's disease, myxedema, stricture of the rectum, tuberculous peritonitis, arthritis deformans, hysteria, and functional nervous troubles, but they stand operations better than men. *Males* are more apt to develop aneurysm, actinomycosis, appendicitis, cerebral abscess, cystic kidney, cirrhosis of the liver, Dupuytren's contraction, hematoma auris, hemophilia, intussusception, lymphadenoma, pancreatitis, stricture of the urethra, stone in the bladder, cancer of the lip, stomach and rectum, and conditions produced by exposure, hard work, and injurious habits.

4. Under the **social condition** note whether the patient is single or married, widow or widower. If a woman, elicit the menstrual history, the amount and character of leukorrhea, the number of children and miscarriages, the date of the last confinement, and the presence or absence of puerperal complications. Ascertain the nature of previous occupations as well as the present one. *Active occupations* predispose to hernia, aneurysm, and various forms of injury; *sedentary occupations* to gall-stones, hemorrhoids, ulcer of the stomach, and functional neuroses; *standing occupations* to varicose veins and

flat-foot. Certain occupations, by forcing the individual to assume a particular attitude or to use a certain set of muscles, produce alterations in the form of the body, thus the shoemaker, tailor, and rag-picker become round shouldered, and one who carries a load on the same shoulder day after day, or who uses one arm or leg constantly, may develop scoliosis. Constant pressure on a part, necessitated by many occupations, may produce deformity, callosities, bursæ, and even neoplasms. Skin handlers and wool-sorters are predisposed to anthrax; hostlers to glanders and tetanus; butchers, doctors, and veterinarians to anatomical tubercle and other infections; painters, potters, plumbers, lead-makers, tailors, and seamstresses to lead poisoning; match-makers to phosphorous necrosis of the lower jaw; morocco workers and those who use acids to ulcers of the hands and forearms; and those who handle grain to actinomycosis.

5. The **family history** includes an investigation into the diseases which have occurred, or the cause of death, in the parents, grandparents, uncles and aunts, brothers and sisters, husband or wife, and children. Especially to be inquired for are calculus, malformations, hemophilia, syphilis, tuberculosis, rheumatism, alcoholism, malignant tumors, and nervous affections.

6. In the **previous history** note the *habits* of the individual, especially regarding alcohol, which predisposes to aneurysm, delirium tremens, tuberculosis, neuritis, etc.; tobacco, which predisposes to carcinoma of the mouth and nervousness; tea and coffee, with reference to neuroses and gastric disorders; and the sexual life, particularly as to excesses and masturbation. Inquiry should be made also for previous injuries, diseases, and operations. *Injuries* may be followed by sarcoma, tuberculosis, epilepsy, abscesses, and many other disorders. Among the *diseases* which may have occurred the most important are syphilis and tuberculosis. Certain diseases predispose to subsequent attacks of the same malady; among such are appendicitis, salpingitis, gall-stones, kidney-stones, erysipelas, delirium tremens, neuralgia, rheumatism. Others render a patient more vulnerable to dissimilar affections; appendicitis, gall-stones, and osteomyelitis often follow typhoid fever; stricture of any of the canals of the body, ulceration involving those canals; vesical calculus, renal colic; arthritis, gonorrhea. *Operations* are responsible for a host of evils, e.g., laparotomy may be followed by hernia, adhesions, or intestinal obstruction, ovariectomy by amenorrhea, gastroenterostomy by ulcer of the jejunum, thoracotomy by scoliosis, trephining by epilepsy, thyroidectomy by tetany, myxedema, or aphonia. The history of removal of a tumor may explain obscure brain symptoms due to metastases. We recently saw a case in which a hernia cerebri was incised for an abscess, a mistake that could not have occurred had the physician known that a decompressive operation had been performed.

7. The **history of the present illness** includes not only the symptoms, but the supposed cause, the duration, the manner of onset, and the previous treatment. As to the *supposed* cause, there may be a history of exposure to one of the infective diseases, such as erysipelas or syphilis; in this connection it is important to ascertain the time elapsing between the exposure to infection and the beginning of the symptoms, i.e., the *period of incubation*. The *duration* sometimes has considerable bearing on the diagnosis, e.g., a tumor which has lasted a number of years is probably benign, one which has lasted but a few months and is growing rapidly is probably malignant. The *onset* is sudden in appendicitis, perforative peritonitis, various colics, and acute infections; aneurysm, tumors, ascites, and strictures of various kinds come on

slowly. The *previous treatment* may be of assistance in diagnosis; it may have failed, e.g., a tumor or ulcer unmodified by mercury and potassium iodid is probably not syphilitic, chills uninfluenced by quinin are not malarial; it may have succeeded, e.g., a scrotal tumor disappearing temporarily after withdrawal of a serous fluid is a hydrocele, after taxis a hernia; it may have intensified the symptoms, e.g., intestinal obstruction is made worse by purgatives, internal hemorrhage by stimulants; or it may have created additional mischief, e.g., drug eruptions, mercurial stomatitis, catheter cystitis, carbolic acid gangrene, iodoform delirium, splint sores, crutch palsy, ligature sinus, paraffin tumor, X-ray burn, cystoscopic ulcer. It may also obscure the diagnosis, e.g., chancre and epithelioma may be disfigured by caustics, the symptoms of peritonitis may be clouded by opium, and an unconscious man who has been given whiskey may be wrongly treated as an alcoholic.

8. The **local examination** needed will usually be indicated by the patient.

By **inspection** the size, shape, situation, and color of the lesion may be determined, as well as abnormal motion, and the lesion may be studied with reference to the influence of posture, active or passive motions, etc.

Whenever possible the *size* of a lesion should be expressed in exact terms, thus a tumor may be measured with calipers or tape measure, instead of being compared in size with an orange or other object. The length of a limb compared with that of its fellow is of the greatest value in the diagnosis of fractures and dislocations, as are also the length of the urethra in enlarged prostate, the width of the intercostal spaces in empyema, and the size of the head in hydrocephalus and microcephalus.

The *shape* may be accurately determined by a plaster cast, soft lead strips, photographs, or autoprints, e.g., in flat-foot. It is frequently of assistance in recognizing surgical conditions, especially fractures and dislocations. As other examples may be mentioned the notched teeth of hereditary syphilis, the pear-shaped swelling of a hydrocele, and the fusiform enlargement of a tuberculous joint.

The *situation* of a lesion may indicate not only the anatomical but also the pathological diagnosis (see diagnosis of ulcers and tumors).

The *color* should always be observed. Localized *yellowish discoloration* may be caused by xanthoma, an old bruise, or a nitric acid or iodin stain; *bronze patches* by syphilis, tuberculosis, scurvy, abdominal tumors, oil of cade, blistering agents, exposure to electric light or the X-ray, and the pressure of garters, belts, or collar buttons; *white patches* by ergotism, scars, frost bite, carbolic acid, leukoplakia, Raynaud's disease, neuritis, and leprosy; *redness* by acute inflammation or hyperemia (disappears on pressure but returns immediately on removal of the pressure), or by dyes, etc. (does not disappear on pressure and may be washed off); *blueness*, or lividity, by venous obstruction, nevus (returns quickly after pressure is removed), beginning gangrene (returns slowly after the relief of pressure), and ecchymosis (unaffected by pressure); *blackness* by moles, warts, gangrene, and melanotic sarcoma; *greenish* discoloration by chloroma; *change of color* by nevi; and *linear discoloration* by lymphangitis, rarely phlebitis and neuritis. The mingling of purple and red is often observed over malignant growths. *Petechia and ecchymosis* are unaffected by pressure; they occur in many diseases, but it will suffice here to mention only those which interest the surgeon, viz. scurvy, hemophilia, iodism, jaundice, pyemia, septicemia, snake poisoning, and lightning stroke. Occurring several days after an injury, ecchymosis indicates rupture of some deep structure, such as muscle or bone.

Absence of motion is noticed in most inflammatory troubles, e. g., the chest in pleurisy, the abdomen in peritonitis; it is caused by a tonic contraction of the muscles, which gives another important sign, rigidity. *Pulsation* may be *expansile* (the swelling enlarges in all its diameters with each cardiac systole), e.g., in aneurysm, tumors communicating with the cranial cavity, and very vascular growths, such as goiter, some sarcomata, and certain angiomata; or *transmitted* (the movement is in one direction only), e.g., in tumors situated over an artery and in the abdomen of nervous individuals. Transmitted pulsation ceases if the tumor can be lifted or, by posture, made to fall away from the artery. Increased *motion* is exemplified in the hurried respiration of intrathoracic disease, and the active peristalsis of intestinal obstruction.

In addition to the aids to the eye which have already been mentioned are the microscope, instruments for looking into cavities of the body (ophthalmoscope, laryngoscope, bronchoscope, etc.), aspiration to determine the contents of a cavity or swelling, and exploratory incision. *Diaphany*, or translucency, is employed to detect disease of the maxillary antrum, by placing a light in the mouth; to determine the size of the stomach, by passing a light into this organ; and to ascertain the nature of some swellings, such as hydrocele and meningocele, by placing the tumor between the light and the eye, in a dark room, and looking through the barrel of a stethoscope or a tube of paper.

Palpation is used to corroborate inspection, to ascertain the size, shape, position, etc., of a lesion which cannot be seen, e.g., by rectal or vaginal examination; and to determine the consistency, sensation, mobility, and local temperature. The *consistency* of normal tissues may be modified by the presence of solids, fluids, or gases. Solids, of which the most prominent example is tumor formation, may cause the tissues to become harder (osteoma, etc.) or softer (myxoma, etc.). Fluid infiltrates the tissues giving rise to edema, or accumulates in a cavity giving rise to fluctuation. *Edema* which is shown by the persistence of an indentation after digital pressure, occurs in contusions, inflammations, suppuration, obstruction to the venous or lymphatic circulation, extravasation of urine, and in diseases of the heart, lungs, liver, and blood. Hysterical edema and myxedema do not pit on pressure. *Fluctuation* is the wave felt by the hand on one side of a swelling when a sharp tap is given to the other side. In order to obviate the mistake due to a wave transmitted through the skin and subcutaneous tissues, the hand of an assistant may be placed on the swelling, between the hands of the examiner. This sign is often difficult to obtain when the fluid lies beneath firm fascia or thick muscle, is small in quantity, or under great tension, and it is often fallacious in semisolid tumors. Another sign, which is often called fluctuation, is the raising of the fingers of one hand when the fingers of the other hand push into the swelling; it may be obtained in normal tissues, in soft, elastic or movable tumors, and in tumors containing gas, as well as in swellings which contain fluid. Error may sometimes be avoided in eliciting this sign, e.g., in muscular tissue, by testing it longitudinally as well as transversely. Gas in the tissues (emphysema) causes a doughy swelling which crepitates on pressure. This *crepitus*, which is crackling in character, should not be confused with that of fracture or osteoarthritis, which is harsh and osseous; of epiphyseal separation, which is soft and cartilaginous; of synovial inflammation, which is creaking and leathery; or with that of blood clot or hydatid disease, which is moist and yielding. In certain bone diseases (cysts, sarcomata, craniotabes, disease of the frontal and maxillary sinuses) a crackling sensation may be obtained on pressure (parchment crepitus), owing to thinning of the osseous tissue; and in synovial inflammations with rice bodies a special form of crepitation may be obtained by forcing the bodies along the sac. Related to crepitus is *thrill*, which may be felt over an aneurysm or vascular tumor, and sometimes in the case of a foreign body in the air passages.

Aside from pain, disorders of *sensation* (hyperesthesia, hypesthesia, anesthesia, paresthesia, alteration of the heat sense or thermoesthesia, of the pressure sense, etc.) are mainly of value in diseases and injuries of the nervous system. **Pain** is the most frequent symptom; and **tenderness,** which is of more value to the surgeon than pain, is pain on pressure. Its *situation* does not always indicate the seat of disease. In a lesion near the origin of a nerve pain may be felt in the periphery; in a lesion at the periphery, at the end of another branch of the same nerve. Certain diseases of the brain and spinal cord produce pain at the nerve terminations. General pain or aching of the body may be present in acute infections or intoxications. If pain corresponds exactly to the distribution of a nerve, the cause will probably be found along the trunk or at the root of that nerve; the pain of a local lesion does not confine itself to the distribution of a single nerve. Absence of tenderness in a painful region generally but not invariably indicates that the pain is referred, but even in referred pain tenderness may be present. Pain in the top or the back of the head may be due to pelvic disease; in the supraorbital regions and the temples to disease of the eye; in the side of the head and the ear to disease of the teeth; in the forehead to disease of the nose or the nasopharynx; above the left clavicle to disease of the colon or the diaphragm; in the side of the chest to disease of the vertebra or the spinal cord; in the right shoulder to hepatic disease; in the nipple and the breast to uterine disease; between the shoulders to disease of the stomach and intestines; in the sacral region to intrapelvic disorders or disease of the testicle, rectum, or hip; in the epigastrium or any portion of the abdomen to diseases of the spine or the spinal cord; along the outer side of the thigh and in the heel to ovarian disease; at the inner side of the knee-joint to disease of the hip; in the sole of the foot to disease of the prostate, ovary, or rectum; in the head of the penis to vesical calculus.

The *character* of pain is sharp, knife-like, or lancinating in acute inflammations of serous membranes; dull or bruise-like in inflammations of mucous membrane, connective tissue, and parenchymatous viscera, and in chronic inflammation; paroxysmal in floating kidney, labor, neuralgia, colics, spinal tumor, and intestinal obstruction; shifting in hysteria, rheumatism, and flatulence; gnawing or boring in cancer, diseases of bone, and sometimes in lithemia; aching in muscles; burning and itching in the skin; smarting or scalding in the urethra; nauseating in the testicle; throbbing in suppurative inflammations; bearing down (*tenesmus*) in cystitis, proctitis, and labor. Pain which suddenly ceases may be due to the passage of a stone, the sudden overcoming of some obstruction, or to beginning gangrene. It is also studied with reference to the effect of pressure, change of weather, movements, etc. Most pains are worse at night, particularly those due to carcinoma, diseases of bone, rheumatism, locomotor ataxia, and neuritis. Much allowance must be made for the variation in individual tolerance to pain. The degree of tenderness may to some extent be gauged by the effect upon the facial expression and the pulse, and by the presence or absence of involuntary muscular rigidity.

Abnormal *mobility* is found in fractures, ruptures of ligaments, dissolution of joints, floating kidney, etc.; more or less immobility in ankylosis, inflammatory or neoplastic infiltrations, and in growths springing from a fixed portion of the body, e.g., osteoma.

The *local temperature* is elevated in inflammatory diseases and very vascular tumors, lowered in gangrene and trophic lesions. It may be accurately measured with a surface thermometer.

As aids to palpation may be mentioned probes and sounds, placing the patient in various postures, and measures for relaxing muscles, particularly general anesthesia.

Percussion is employed to outline organs, determine the composition of accumulations in cavities and the presence of gas in tumors, detect points of tenderness, and occasionally, as in hydrocephalus and certain fractures, to elicit the cracked-pot sound. **Auscultation** is used to detect disease in the chest, the presence or absence of intestinal peristalsis, the bruit of an aneurysm, the sound of a fetal heart, the succussion splash of a dilated stomach, the deglutition sound, and the garrulity of wounds communicating with the respiratory apparatus. Crepitus which cannot be felt may occasionally be heard, e.g., in fractures of the ribs. As aids to auscultation may be mentioned the stethoscope, the phonendoscope, and the telephonic probe.

The sense of **smell** may reveal necrosis of bone, gangrene of soft tissues, fecal fistulæ, stercoraceous vomitus, and ammoniacal urine. The odor of the breath is of value in diagnosticating uremia, acetonemia, diabetes, and some forms of poisoning. The odor in pyemia is that of hay, in hepatic abscess liverish, in actinomycosis earthy, in jaundice and peritonitis musty, in the critically ill cadaveric.

9. An **examination of the regions clinically related to the affected part** is of the greatest importance. A part should always be compared with that of the opposite side of the body, to detect deviations from the normal, e.g., in fractures and dislocations; and to ascertain whether the same lesion is present on both sides, e.g., hernia, tuberculous epididymitis, chronic mastitis, salpingitis, syphilitic eruptions, and many other conditions are often bilateral. In local infections and neoplasms the anatomically related lymph glands must be examined, and conversely in lymphadenitis the regions which the lymph glands drain must be scrutinized. One should make sure the pulse is present below fractures and dislocations, motion and sensation below wounds; examine the superficial veins for distention in tumors, the muscles for atrophy in joint disease, the spine for scoliosis in asymmetry of the lower limbs, the knee for effusion in fractures of the femur, the liver for cirrhosis in hemorrhoids.

10. A careful **general examination** is too often neglected. Attention need be called only to the fact that stomatitis may be caused by chronic nephritis; furunculosis and gangrene by diabetes; varicose veins of the leg by disease of the heart; amenorrhea by anemia; ulcer on the sole of the foot by disease of the spinal cord; and to the fact that abdominal disorders may be simulated by disease of the lungs, spine, spinal cord, and by hysteria. The height and weight should be noted. A progressive decrease in *height* is found in diseases like arthritis deformans. The patient's best *weight* and his present weight should be taken. *Cachexia* means marked emaciation, great weakness, and profound anemia; it is seen in carcinoma, diabetes, tuberculosis, chronic suppuration, large ovarian cysts, hereditary syphilis, organic disease of the stomach, stricture of the esophagus, and in obstructions of the thoracic duct.

The *facial expression* is of great value to the experienced eye. As examples may be mentioned the vacant expression of adenoids, the anxious expression of peritonitis, the pale frightened face of acute hemorrhage, the threatening and suspicious facies of delirium tremens, the staring expression of exophthalmic goiter, the mask-like expression of paralysis, the unmeaning grimaces of hysteria, the *risus sardonicus* of tetanus, and the weazened face of hereditary syphilis. The Hippocratic face—"The sharp nose, hollow eyes, collapsed temples; the ears cold, contracted, and their lobes turned out; the skin about the forehead being rough, distended and parched; the color of the whole face brown, black, livid or lead colored,"—is the face of impending death.

Posture.—Lying on the back and constantly slipping toward the foot of the bed is seen in acute infections or great weakness, the dorsal position with both legs drawn up in peritonitis, the ventral posture in intestinal colic, sometimes in abdominal aneurysm and spinal caries. The patient may lie upon the affected side in empyema, and be coiled up on one side in cerebral irritability and in various forms of colic. Great restlessness in bed indicates nervous irritability, acute hemorrhage, sometimes shock; it is a bad sign in the critically ill. The body may be bent forward so that it rests upon the forehead and feet (*emprosthotonos*), backward so that it rests upon the occiput and heels (*opisthotonos*), or laterally (*pleurosthotonos*) in meningitis, strychnin poisoning, tetanus, or hysteria. *Orthopnea*, in which the patient sits up and grasps some firm object in order to fix the accessory muscles of respiration, is often observed in diseases of the heart and lungs, large accumulations in the thorax or abdomen, and in foreign bodies in or stenosis of the air passages. A shuffling *gait* with a rigid body suggests caries of the spine, a waddling gait coxa vara or congenital dislocation of the hips. The head is thrown back and the feet apart in large abdominal tumors and accumulations.

The pulse, temperature, and respirations should be taken, and one should ascertain the condition of the organs of digestion, the spleen, the genitourinary apparatus, the heart and blood vessels, the lungs, the organs of special sense, and the nervous system. In special cases chemical and microscopical examinations of various secretions, excretions, and discharges may be required.

Blood Examinations.—The *red cells* may be increased in number (*polycythemia*) when the blood is concentrated, e.g., as the result of profuse sweating, vomiting, diarrhea, starvation, and exercise; when oxygenation is impaired, e.g., by high altitudes, cyanosis, and cardiac and pulmonary disease; in myxedema, purpura, diabetes, and direct blood transfusion; and as the result of active hemogenesis, thus after hemorrhages the blood-making organs may in time supply more than enough cells to replace those which have been lost. *Oligocythemia* (decrease in the number of red cells) takes place when the blood is diluted by the ingestion of large amounts of fluid, saline infusion, and when the genetic powers are overtaxed, e.g., by childbirth, lactation, and at puberty. *Anemia*, or a reduction in the number of red cells and the percentage of hemoglobin, may be primary, in which no cause can be found, e.g., pernicious anemia and chlorosis; or secondary, the most common causes of which are acute and chronic hemorrhage, bacterial infections, malignant growths, malnutrition, intestinal and blood parasites, and chemical poisons, such as lead, mercury, and the coal-tar derivatives.

Mikulicz believed that no general anesthetic should be given when the *hemoglobin* is below 30 per cent., but surgeons do not adhere to this rule, excepting, perhaps, in cases in which delay will cause not only no further deterioration in the quality of the blood, but also some improvement.

Leukocytosis, particularly of the polynuclear cells, indicates an inflammatory lesion, but only when other symptoms of the lesion are present, and only when other causes for an increase in the white cells have been excluded; hence, from the standpoint of surgical diagnosis, leukocytosis may be divided into the noninfectious and the infectious.

Noninfectious leukocytosis may be physiological, e.g., in infants, during pregnancy and digestion, and after exercise and bathing. It may occur in rickets, cirrhosis of the liver, chronic nephritis, gout, carcinoma, and sarcoma (the lymphocytes being in excess in lymphosarcoma). It may follow the administration of certain drugs, e.g., the salicylates, coal-tar derivatives, potassium chlorate, camphor, digitalis, some of the aromatic oils, tuberculin, thyroid extract, and quinin, acute and chronic hemorrhage, general anesthesia, and consequently the various surgical operations (a rising leukocytosis after the second or third day, however, would be highly presumptive of a septic complication). The leukocytosis of lymphatic and of splenomedullary leukemia are easily recognized by the increase in the lymphocytes in the former, and of the myelocytes in the latter. Agonal leukocytosis, which occurs just before death, is due to the gathering of the leukocytes along the walls of the capillaries as the result of the feeble circulation, or to a terminal infection.

Infectious leukocytosis may accompany any of the bacterial diseases, except uncomplicated influenza, measles, rubeola, typhoid, paratyphoid, malta fever, leprosy, and tuberculosis; malaria and trypanosomiasis, which are due to protozoa, also fail to show an increase in the white cells. The most important infections from the standpoint of surgical diagnosis are those of pyogenic origin.. The degree of inflammatory leukocytosis depends upon the virulence of the microörganism and the resisting powers of the patient, and some idea of the nature of these factors may be obtained by comparing the leukocyte count with the general condition of the patient. If leukocytosis is slight (12,000 to 15,000) or absent, it means, when the general condition is good, that the infection is trivial, well encapsulated or chronic, or, when the general condition is bad, that the infection is overwhelming. If leukocytosis is marked (20,000 or higher) it means, when the general condition is good, that the infection, although serious, is probably being localized or conquered, or, when the general condition is bad, that the infection, although actively combated, is too great for the patient's resistance. As with the temperature, pulse, and respirations, repeated observations are of more value than a single observation. A rising leukocytosis indicates a spreading infection or pus formation. According to Hewitt the total leukocyte count is an index of the patient's resistance to the infecting organism, and the relative polynuclear count an index of the severity of the infection. If the relative polynuclear count is between 75 and 80 per cent. infection is probably, if between 80 and 85 usually, and if above 85 almost certainly present. The normal polynuclear count is from 60 to 70 per cent. of the total number of leukocytes.

Iodophilia (iodin reaction in the leukocytes) also is found in septic processes, but as it occurs in many other conditions, e.g., malaria, late typhoid, etc., it is of little value to the clinician. *Eosinophilia* occurs in parasitic diseases, such as hydatid cysts, trichiniasis, anchylostomiasis, and filariasis, but it is found also in asthma and certain skin diseases, hence its value is not absolute

The presence of filaria is readily determined, however, by a microscopic examination of the blood during the night.

An estimation of the *coagulation time of the blood* is particularly indicated in cases like chronic jaundice and hemophilia, in which operation may be fatal from uncontrollable oozing of blood. Normally it is from three to six minutes.

Tests for *hemolysis* and *agglutination* should be made before direct blood transfusion. In this connection should be mentioned also *serodiagnosis* for syphilis, gonorrhea, pregnancy, and carcinoma.

Among the diseases which may simulate surgical conditions, and which may be excluded by a blood examination, are malaria (malaria parasites), typhoid fever (Widal reaction and leukopenia), lymphatic and splenomedullary leukemia (enormous leukocytosis, particularly of the lymphocytes in the former, and of the myelocytes in the latter), and lead poisoning (basophilic granulations in the red cells). It may be recalled that pneumonia, which may simulate intraabdominal inflammation, causes a leukocytosis and that Hodgkin's disease produces no distinctive blood changes. Examination of the blood for bacteria and acetone is sometimes desirable, both for diagnosis and prognosis. For Cryoscopy see Chap. xxix.

Recently some stress has been laid upon the importance of accurately determinating the *blood pressure* in surgical conditions. One may employ for this purpose the Riva-Rocci sphygmomanometer. A rubber cylinder is placed around the limb and then inflated until the pulse is cut off. The amount of pressure in the cylinder is recorded by a mercury manometer. According to this instrument, which is subject to error, the average blood pressure is 130 mm. of mercury.

THE RÖNTGEN RAY.

The Röntgen or X-ray penetrates substances opaque to the ordinary forms of light, casts shadows, causes fluorescence of certain salts, and has the same chemical action upon photographic films as sunlight. Recent investigations show that the X-ray can be polarized, reflected, and deflected, that it has the same velocity as ordinary light, and that its wave length is very short, the waves recurring about 10 times as fast as those of sunlight.

The apparatus necessary for the production of the X-ray consists of a sealed glass vacuum tube (Crookes tube), containing two or three electrodes, and a machine capable of generating electrical currents of high voltage. One of the electrodes, the cathode, is a concave metallic disk, which is connected with the negative terminal of the exciting apparatus. At the focus of this reflector is a metallic disk called the target. The electrode connected with the positive terminal is called the anode. Electrical discharges suitable for exciting a Crookes tube may be obtained from static machines, high frequency coils, the ordinary induction coil, or preferably from the more modern high-tension transformer. In a properly excited Crookes tube there is a current of electricity flowing toward the cathode, from the concave surface of which it is focused upon the target. As far as we know the Röntgen rays originate at this point. As the Röntgen rays are invisible, the green light seen in an excited tube is merely a fluorescence of the glass produced by the rays. Coolidge has invented a new type of tube, which is particularly valuable for therapeutic purposes. Its anode is a solid block of wrought tungsten, its cathode a spiral of tungsten wire, which is heated to a definite temperature by the current from a 12-volt storage battery. The high-tension current will pass through the tube only when this spiral is heated to a certain degree of incandescence, and this degree of heat determines the amount of current that can be passed through the tube. Further, the voltage of the high-tension current determines the hardness or softness of the X-rays emitted, so that by means of proper meters accurate doses of the X-rays may be given. The vacuum in the Coolidge tube is about 1,000 times as great as in the ordinary tube and needs no regulation.

The *Fluoroscope* consists of a piece of cardboard on one side of which is spread a thin layer of finely ground crystals of barium platinocyanid, potassium platinocyanid, or tungstate of calcium. This screen is mounted in an apparatus so constructed as not to expose the operator to the X-rays while studying the patient. When brought near an active Crookes tube, the crystals become luminous and give off a faint green light. The transparency of substances to the X-rays varies according to their atomic weights. If the hand be placed between an excited tube and the fluorescent screen, the softer tissues will appear as faint shadows, and the bones, which are more dense, as dark shadows. When these shadows fall upon a photographic plate, the silver bromid is changed as with light rays, and if the plate is then developed, a permanent record of the shadows is obtained (*Radiograph, or Skiagraph*). To make good pictures requires skill and much time, consequently most practitioners refer their cases to an X-ray specialist. The physician, however, should have some knowledge of the interpretation of plates, be familiar with the indications for the use of the X-ray (diagnostic and therapeutic), and know the dangers which may arise.

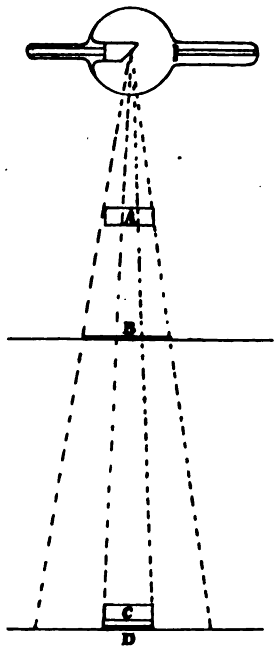

FIG. 1.—Note the size of the object (A) and its shadow (B) when the former is near the tube and some distance from the plate; and of the object (C) and its shadow (D) when the object is far from the tube and near the plate.

The **interpretation** of X-ray pictures is a study in shadows, which, like those cast by a candle light, are subject to distortion in size and in shape, the least distortion occurring when the object is very thin, is in close contact with the screen or plate, is as far from the tube as the rays are effective, and when the object and the target are in a plane perpendicular to the plate, hence one should know the distance between the tube, the object, and the plate, the angle at which the picture was made, and, if possible, the size of the object (Figs. 1 and 2). The kind of tube employed also influences the results. A high vacuum, or hard, tube gives a small quantity of deeply penetrating rays and little contrast between the tissues of different densities; a low vacuum, or soft, tube a large quantity of feeble rays and decided contrast between the various tissues. One must be familiar with the shadows of normal tissues at different ages. In the child the bones cast faint shadows and some of the epiphyses are not visible until puberty. Ununited epiphyses may be mistaken for fragments of bone, epiphyseal junctures for lines of fracture. Other sources of error are defective plates; congenital abnormalities, e.g., a bipartite scaphoid; superimposed shadows, which may be recognized by taking a second plate at a different angle; enlarged bronchial glands, siumlating aneurysm; and fecal masses, calcified lymph glands, phleboliths, and like conditions, which may be mistaken for calculi and foreign bodies.

As a **diagnostic agent** the fluoroscope permits quick and easy examinations, but the images lack detail, so that small foreign bodies, and fractures without deformity are frequently overlooked. Consequently the fluoroscope is employed chiefly to observe the movements of aneurysms, the heart, the lungs, the diaphragm, and of the stomach and intestines during peristalsis. The radiograph gives a permanent picture with delicate detail and sharp outlines not found in the fluoroscopic image.

These pictures are of great value in *localizing foreign bodies*, either extraneous, such as bullets, needles, etc., or those formed within the tissues, such as renal and vesical calculi. Minute fragments of coal, wood, and glass

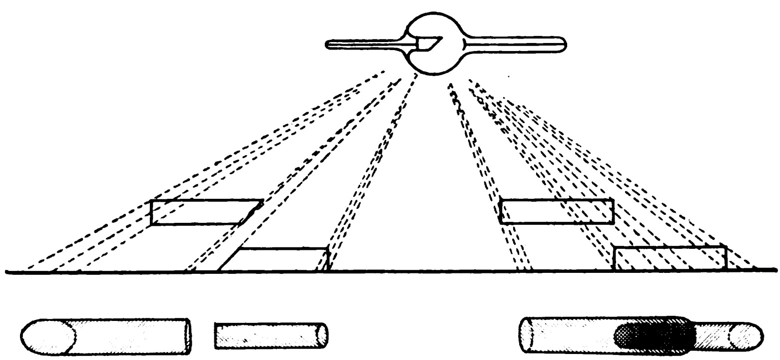

FIG. 2.—Diagram showing distortions produced by the X-ray. The horizontal line represents the X-ray plate, seen in profile; the objects above, broken bones; those below the shadows as seen on the plate. On the left is shown an oblique fracture with overlapping, the shadows of which indicate a transverse fracture with separation; on the right a transverse fracture with no overlapping, the shadows of which indicate an oblique fracture with overlapping As the shadows of the fragments nearer the tube are larger and less distinct than those close to the plate, an expert might detect these errors merely from the skiagraph, but a novice could easily be deceived. In all doubtful cases a second plate, at right angles to the first, should be taken or, better, stereoscopic plates made.

other than lead-glass, however, may evade detection, particularly if overshadowed by bone, or some distance from the plate. A preliminary fluoroscopic observation is made, and a mark placed on the skin directly over the foreign body. Stereoscopic plates are then taken to determine the relation of the foreign body to some surgical landmark. To obtain stereoscopic plates it is necessary to have a plate holder, by means of which plates can be inserted and removed without disturbing the part to be skiagraphed. Two plates are exposed, the tube being moved horizontally two and one-half inches, the average interpupillary distance. The plates are now developed and examined with a stereoscope, when the depth of the foreign body and the perspective of the various planes of tissue can be seen. Even the lines in the skin will appear if a thin coating of bismuth be applied before the plates are made. If a surgical landmark is not in close proximity to the foreign body a special localizing technic must be employed. Manges, Sweet, and others have devised exceedingly accurate but complicated forms of apparatus for this purpose, but the principle of all is that of angulation, as in the method here described. The target of the X-ray tube is fixed directly over the mark on the skin, the distance between the target, the skin, and the plate being measured. The tube, with the vertical distance from the plate remaining constant, is moved three inches to the left and an exposure made, then three inches to the right of the starting point and a second exposure made. The plate is now developed, the distance between the two images measured, and the depth calculated (Fig. 3). The X-ray is indicated in the diagnosis of so many conditions, other than those already mentioned, that, in order to avoid repetition, we must refer the student for additional information to subsequent pages, particularly those dealing with fractures, dislocations, bone diseases, sinus and fistula, the lungs and pleural cavity, subphrenic abscess, the esophagus, the stomach, the intestines, and the kidney. We shall there call attention to some of the methods employed to render transparent structures opaque and thus facilitate radiographic examinations, e.g., the introduction of bismuth into sinuses and the stomach, of collargol into the pelvis of the kidney, of styleted catheters into the ureters.

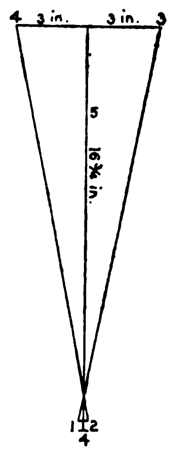

FIG. 3.—1 and 2 correspond to the shadow of the foreign body and are ¼ inch apart, the same distance as the shadows on the plate; 3 and 4 correspond to the two positions of the tube; 5 corresponds to the distance of the target from the plate. The point where the lines intersect represents the depth of the foreign body from the surface next to the plate. (American Practice of Surgery.)

The **therapeutic effects of the rays** may be classified as follows: (1) The production of atrophic changes in the appendages of the skin; (2) the destruction of organisms in the tissues; (3) the stimulation of the metabolic processes of the tissues; (4) the destruction of certain pathological tissues; and (5) their anodyne effects. In hypertrichosis, sycosis, favus, and tenia tonsurans it is desirable to remove the hair. Atrophy and decreased functional activity of the sebaceous glands are indicated in comedo and acne. Though the rays apparently have no effect on organisms growing upon culture media, they have a decided effect upon their growth when in the living tissues. Thus tuberculous ulcers and sinuses and those due to ordinary pyogenic organisms may dry up when exposed to the rays. A similar effect is produced upon diseases due to mycelial fungi, such as tenia barbæ, tenia tonsurans, favus, and blastomycosis. The destruction of these organisms is probably brought about by tissue cells stimulated to activity by the rays. Their effect upon the metabolic processes is still problematical, but their influence upon the blood in certain anemias, notably splenomedullary leukemia, is unquestionable. The only form of carcinoma which can be cured by the X-rays is chronic superficial epithelioma, and even in this excision is quicker and safer. In inoperable carcinoma and sarcoma the rays are often of decided value in lessening discharge, diminishing fetor, and ameliorating pain, and occasionally the growth shrinks for a time. Some surgeons advise exposures after all operations for carcinoma and sarcoma, to prevent recurrence. Good results have been claimed for this agent in exophthalmic goiter. In making therapeutic applications of the X-ray, the operator should always protect the healthy parts by a shield of lead, and when the rays are to be projected into deep structures filters of leather or aluminium should be placed between the tube and the skin. These filters absorb the softer rays, thus permitting larger doses of the penetrating rays without irritating the skin. As an anodyne the X-rays have been used not only in malignant disease, but also in neuralgia and other painful affections, sometimes with excellent results.

Untoward Effects.—The **X-ray burn** is characterized by delayed onset and remarkable sluggishness in healing. The acute burn, i.e., one resulting from a single prolonged exposure, usually appears on the second or third day, but may be delayed as late as the fourteenth day. It is essentially an inflammatory process, appearing at first much like the erythema of sunburn; if subsidence does not occur in this stage, vesicles and blebs develop which rupture and expose the inflamed corium; occasionally the deeper structures are invaded, and extensive sloughing may occur. The microscopic changes are those of degeneration and inflammation. Chronic burns occur in those constantly exposed to the rays. They appear slowly after an incubation period of from three to eleven years. The clinical features are at first much like those of acute burns, but the red color changes to a bronze or yellow, the nails show rugæ of malnutrition, telangiectatic spots develop, and the skin becomes glossy because of the loss of glands and hair. Cracks and hyperkeratoses appear and ulcers form, often exposing the tendons and even the bones, and occasionally undergoing epitheliomatous degeneration. Porter has collected 47 cases of X-ray carcinoma, with a mortality of 25 per cent. The skin seems to be easily protected by the ordinary clothing, for no case has been reported except upon the exposed surfaces. Several styles of gloves have been devised for the protection of the hands, but the most satisfactory suggestion appears to be the use of a large screen made of some substance impervious to the rays, as heavy plate glass, sheet iron, or lead, behind which the operator may stand. If healing does not occur after the usual applications for ulcer, an X-ray burn may be excised, and the resulting raw surface closed by a plastic operation or covered with skin grafts. Prolonged exposure to the X-rays may cause sterility in either sex, sometimes transient, sometimes permanent. Examination of the blood of Röntgenologists often shows a decrease in the total number of leukocytes and an increase in the number of lymphocytes.

Radium and certain other mineral substances (uranium, thorium, polonium) emit rays similar to, if not identical with, the X-rays. Radium bromid is the material usually employed for therapeutic purposes. It is kept in a hermetically sealed glass tube, which may be applied to a surface lesion, or buried in the tissues after making an incision. Exposures last from one to many hours. Radium therapy has been tried in the same diseases that are treated by the X-ray. The time is not yet ripe for passing judgement on the value of this agent. Its rays seem to have greater penetrating power than the X-rays, and some believe they have a specific action not possessed by the X-rays. The chief objections to the use of radium are its enormous expense and the difficulty in obtaining a pure sample.

CHAPTER II.

ANESTHESIA.

Anesthesia is a condition of insensibility induced by anesthetic agents.

GENERAL ANESTHESIA is associated with unconsciousness, and is *indicated* to abolish *pain* during surgical operations, renal colic, etc.; to control *convulsive seizures;* to secure *muscular relaxation* in order to make a diagnosis, or to carry out such treatment as reduction of a hernia or a dislocated joint; and to *abolish volition* in order to detect a malingerer. Except for the purpose of saving life, it is *contraindicated* in profound shock, great exhaustion, and in acute or advanced renal, circulatory, or pulmonary disease. The general anesthetics most frequently employed are, in the order of their safety, nitrous oxid (one death in 300,000), ether (one death in 15,000), ethyl chlorid (one death in 12,000), and chloroform (one death in 3,000).

The choice of a general anesthetic depends principally upon the condition of the patient and the character of the operation.

Ether is the best and least dangerous general anesthetic in the hands of one with little experience, likewise in the hands of the specialist in anesthesia when, as is the case in most of the major operations of surgery, the patient is to be completely relaxed, hence, under these circumstances, should always be employed unless there are distinct contraindications. The most important *contraindication* to ether is *inflammation of some portion of the respiratory apparatus*, owing to its irritating action upon mucous membranes. Of secondary importance, and by no means absolute, are marked *arteriosclerosis*, because of the danger of vascular rupture from the struggling incident to the etherization; *disease of the kidneys* (many authors believe chloroform to be more irritating to the kidneys than ether; in these cases nitrous oxid and oxygen or local anesthesia should be employed whenever possible); *operations about the nose or mouth*, in which the anesthetic can be applied intermittently only, and in which chloroform, being more powerful, will better maintain anesthesia (this contraindication ceases to exist if one of the insufflation methods is employed); operations in which the *actual cautery* may be needed in the region of the mouth, owing to the inflammability of ether, although it may be used in these cases, if the precaution is first taken to remove the anesthetic and fan away the fumes; and operations performed in the presence of an *exposed artificial light,* although, since ether vapor is heavier than air and descends, the danger in these cases is obviated by placing the light several feet above the level of the patient's head. Ether should not be administered in the presence of fire in an open grate or stove.

Chloroform secures complete muscular relaxation, and it does not distend the veins like ether, hence makes bleeding less annoying; it is also quicker in its action, more agreeable to the patient, and more convenient to the anesthetist and operator, especially in operations about the head, face, and neck; but these advantages are overbalanced by its increased danger. Chloroform is no safer in children or during pregnancy than at any other time. It is preferable in military surgery, because it economizes space and time, and is generally employed in the tropics, owing to the great volatility of ether. In diseases of the liver and in diabetes chloroform is absolutely contraindicated. In the latter nitrous oxid mixed with oxygen is the safest general anesthetic; ether, however, must be employed if muscular relaxation is mandatory.

Nitrous oxid is by far the safest anesthetic for brief operations (from two to five minutes) in which muscular relaxation is not desired, such as the extraction of a tooth or the incision of an abscess. For longer operations in which muscular relaxation is not important, nitrous oxid combined with oxygen or with atmospheric air is the safest anesthetic. It is particularly indicated in diabetes and nephritis. It is contraindicated when the heart or the arteries are seriously affected, when there is mechanical obstruction of of the air passages, when the patient is under five years of age (owing to the ease with which infants are asphyxiated), and when the anesthetizer is unskilled. Muscular adults addicted to the excessive use of alcohol and tobacco are bad subjects for nitrous oxid, indeed for any anesthetic. Among the disadvantages attending the administration of nitrous oxid must be mentioned its great expense, the necessity for cumbersome and complicated apparatus, and the marked increase in venous congestion, the last constituting a decided objection in many operations.

Ethyl chlorid is often used as a substitute for nitrous oxid in brief operations and as a preliminary to ether. As it is 25 times more dangerous than nitrous oxid, however, we believe it should never be employed.

The preparation for anesthesia, in cases requiring a major operation in which there is no emergency, should extend over two or three days, during which time, in addition to the special preparations for the operation itself, the patient should be carefully examined, particularly for the presence of disease of the heart, blood vessels, lungs, and kidneys. The condition of the nose, throat, and mouth should be known, and in many cases a careful examination of the blood will be required. The bowels should be moved by a laxative, and an enema administered the morning of the operation. The diet should be light and easily digestible. No solid food should be given on the day of operation, although a cup of tea, coffee, or consommé may be given not less than six hours before the time of anesthesia. In the feeble and exhausted purgation should be avoided, and stimulating or nutritive enemas may be continued until within a few hours of the operation. Just before operation the patient should pass urine, or, if necessary, be catheterized. If a woman, hair-pins should be removed and the hair braided and done up in a cap or towel. Artificial teeth or other foreign bodies should be removed from the mouth, the lips and nostrils greased, especially if chloroform is to be used, and, to prevent conjunctivitis from chloroform or ether vapor, the eyes covered with gauze moistened with boric acid solution. The patient should be protected from cold, and jewelry of various kinds should be put away in a safe place. In cases of intestinal obstruction the stomach should be washed out previous to the administration of the anesthetic, in order to prevent sudden death from inundation of the lungs with vomited fecal matter. In minor surgical procedures the period of preparation mentioned above will not be required. In all these cases, however, a complete examination should be made. A patient should never be anesthetized without removing the shoes and without making sure that all clothing about the neck, chest, and abdomen is loose; corsets always should be removed.

With the possible exception of nitrous oxid, a patient should never be anesthetized in the sitting posture.

The anesthetist should ascertain whether the patient has previously taken an anesthetic, and whether addicted to the use of alcohol or other drugs. He should know the results of the urinalysis, listen to the heart and lungs, study the pulse, note the color of the skin and mucous membranes, and assure himself that the mouth is free of foreign bodies. His hands should be clean, and in operations on the head and neck they should be sterilized and he should wear a sterile gown and cap. In addition to the anesthetic and inhaler one should provide himself with a mouth-gag, tongue forceps, a pair of hemostats with gauze sponges for swabbing out the pharynx, a hypodermic syringe with strychnin and atropin, and a tracheotomy tube. It is desirable to have also a solution of boric acid for the eyes in case they become irritated, and in some instances oxygen may be needed; an electric battery is very rarely demanded. A third person should always be present to assist, if necessary, in restraining the patient and to act as a witness, as unjust accusations are occasionally made against the anesthetizer, especially by females.

The administration of ether by inhalation is rendered less terrifying to the patient, and, it is said, actually less dangerous, if three or four drops of a 25 per cent. solution of oil of bitter orange peel in alcohol (75 per cent.) is placed on the mask a few minutes before commencing the administration of the ether. It is supposed that oil of orange, by dulling the sense of smell to the irritating fumes of ether, prevents harmful reflex stimulation of the pneumogastric nerve. One of three methods of etherization by inhalation may be employed. In the *open method*, which is very slow, the ether is inhaled from a folded towel, held over the patient's nose and mouth in such a way as not to exclude the air. The *closed method*, in which the air is decidedly restricted, and in which the expiratory products are retained and rebreathed, is quick, and warms, moistens, and economizes the ether, but is more dangerous than either of the other methods. Some anesthetists maintain, however, that rebreathing, with all forms of inhalation anesthetics, is physiologically advantageous. Those who use the closed method find the Clover inhaler satisfactory. It consists of a dome-shaped ether reservoir surrounded by a water chamber, which maintains the ether at the proper temperature for evaporation. A fenestrated metal tube runs through the reservoir from a large rubber bag to the face piece. By rotating the reservoir varying quantities of vapor escape into the rubber bag, from which it is breathed backward and forward with the expiratory products; fresh air may be admitted from time to time by raising the face piece. The *semi-open method*, in which the entrance of air is slightly limited, but in which the expiratory products are not retained, is the one commonly employed. An inhaler may be improvised by rolling a folded towel or a piece of gauze into the shape of a cone. The Allis inhaler (Fig. 4) consists of a cylindrical metal frame with slits in

FIG. 4.—Allis' Inhaler.

the sides, through which a bandage is threaded backwards and forwards; this is enclosed in a leather case or folded towel which projects beyond the frame and is fitted to the patient's face. The inhaler is placed over the patient's nose and mouth, and after several breaths have been taken to lessen fright, the ether is applied drop by drop until the patient is anesthetized, the intervals between the drops becoming shorter as the patient becomes accustomed to the vapor. The administration should be uninterrupted and as nearly uniform as possible. During the *first stage* of anesthesia, which ends with the loss of consciousness, the pulse is accelerated, the pupils large and mobile, and a rather pleasant feeling of drowsiness, and tingling in the extremities, is experienced. Many patients breathe deeply, others hold their breath; in the latter instance all that need be done is to remove the cone for a moment. Cough is rarely annoying if the drop method be employed. With the onset of unconsciousness there is a short period of analgesia (*primary anesthesia*), during which brief operations may be performed. The *second stage*, or the stage of excitement, extends from the loss of consciousness to the loss of reflexes. Memory, volition, and intelligence are abolished, while laughing, shouting, and struggling may occur. Slight movements of the extremities should not be restrained unless they interfere with the anesthetist, as such often evokes greater struggling. The pulse is rapid, the pupils are dilated and react to light, and the muscles may be rigid or thrown into clonic contractions. At this time the breathing may be irregular or temporarily suspended. The face is congested, sometimes cyanotic, and often covered with perspiration. More or less frothy mucus is present in the mouth and throat, and sometimes it becomes excessive. During the *third stage* the breathing is deep and audible, the pulse full and regular, the muscles relaxed, and the corneal reflex abolished. Touching the cornea with the finger, however, may produce irritation, and it is much better simply to separate the lids and notice the presence or absence of flaccidity. The pupils are of moderate size and react to light. Dilated pupils failing to react to light indicate a dangerous degree of anesthesia. During this stage a transient roseolous rash may be noticed.

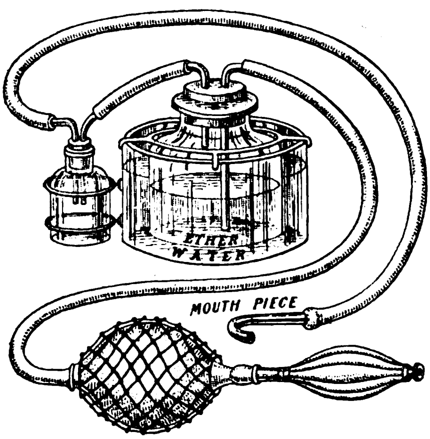

FIG. 5.—Vaporizing apparatus. Note that the ether reservoir is only half filled and that the long tube in it is attached to the pump; if the short tube were connected with the pump, liquid ether would be driven from the reservoir. Even when the tubes are properly arranged, a spray of ether may be forced from the reservoir, hence the small bottle on the left, which acts as a condenser.

Insufflation of ether into the mouth, nose, or pharynx is indicated particularly in operations about the head, face, mouth, and neck, since it removes the anesthetizer from the field of operation and permits an uninterrupted administration of the anesthetic. Anesthesia is induced by one of the foregoing methods and maintained by a vaporizing apparatus

(Fig. 5). By means of a hand bulb, a foot pump, or an electric blower, air is forced through a bottle of ether, which is placed in a can of water at a temperature of 98° F. The ether vapor, thus warmed, an important matter according to recent investigations, passes through an empty bottle, which acts as a condenser, to the outlet tube. The outlet tube is connected with a curved metal or rubber tube which is hooked in the nostril or angle of the mouth, or with a catheter which passes back through the nostril to the level of the soft palate. Intrapharyngeal insufflation economizes ether, facilitates breathing, and causes less cyanosis and post-anesthetic vomiting than the ordinary inhalation methods; free exit should be provided for the superfluous vapor by keeping the mouth open, or by inserting a tube in the opposite nostril.

Intratracheal insufflation of ether (Meltzer-Auer) promises to supplant the various forms of apparatus designed to prevent collapse of the lungs during intrathoracic operations, since it not only obviates the danger of pneumothorax but automatically ventilates the lungs. It is of great value also in operations about the mouth and pharynx, in that it keeps the anesthetizer out of the way, eliminates the possibility of obstruction of the air passages, and prevents the inhalation of blood, mucus, vomitus, and other deleterious substances. It should prove of service in operations for intestinal obstruction in which fluid is constantly regurgitated from the stomach, in operations for goiter and similar conditions in which the trachea is displaced or distorted, and in operations in which the patient must lie face downwards. According to Peck the relief of all strain upon the respiratory apparatus and consequently the relief of much strain upon the heart and central nervous system is one of the most valuable features of the method. "Overetherization is impossible." In cases of apnea from opium poisoning, etc., air, or air mixed with oxygen, can be blown into the trachea, thus maintaining aëration of the blood until spontaneous respiration returns. We have employed intratracheal insufflation of ether in many cases, and feel that its merits have not been overstated. The patient is first etherized in the usual way; then, with the aid of a Jackson laryngoscope, a silk elastic catheter is inserted into the trachea to a point just short of its bifurcation. In addition to the noise produced by the breath passing through the catheter, one may be sure it is in the trachea, unless there is a stricture or a diverticulum of the esophagus, by pushing the catheter onwards until it meets the resistance offered by the smaller bronchi. If more than 35 cm. of the catheter can be introduced it is in the esophagus, in which event the ether will enter and distend the stomach. The catheter should be about half the length of the glottis in diameter, i.e., about 24 F. for the average adult, and correspondingly smaller for children. It should have two marks on it, one 13 cm. and one 26 cm. from the tip. When the latter mark is opposite the teeth the first mark is opposite the glottis, and the tip 5 cm. above the bifurcation of the trachea. The tube is held in place with a special clip, or fastened to the cheek with adhesive plaster, and then connected with the insufflation apparatus. The apparatus devised by Elsberg or a simpler home-made contrivance may be employed. The air is driven by foot bellows (or an electric blower, in which case an oil filter is needed) through a wash bottle containing hot water, thus filtering, warming, and moistening the air, which is then delivered to a bifurcated tube, one branch of which passes directly to the tube connected with the catheter and the other to the ether reservoir, the ether reservoir having another tube on its opposite side joining the tube connected with the catheter. By manipulating clamps or stop-cocks on these branches the patient may receive pure air, pure ether vapor, or a mixture of air and ether. In the Elsberg apparatus the percentage of ether and air is regulated by a hand wheel which is connected with an indicator, so that the anesthetizer knows the exact quantity of ether the patient is receiving. The tube leading to the catheter is connected with a manometer, which records the pressure of the air current passing through it. The average pressure during anesthesia should be 20 mm., but, if indicated, it can be increased to 40 or even 50 mm. Every minute or two, however, the pressure should be reduced to zero for an instant, to allow the lungs to deflate. The percentage of ether needed varies with the patient, half ether and half air probably being the average. "If the patient is cyanosed, it means either that the tube is not far enough in the trachea or that too large a tube has been introduced" (Elsberg). At the end of the operation quick recovery from the anesthetic can be secured by insufflating pure air, thus blowing the ether from the lungs. Hoarseness and pulmonary complications are not produced by insufflation anesthesia, post-anesthetic vomiting is less common than after other methods, and shock from operation seems to be less marked (Peck and Elsberg).

Intratracheal insufflation of nitrous oxid and oxygen, after preliminary etherization, has been tried by Cotton, Boothby and others.

Intravenous administration of ether (Burckhardt) is not recommended. It may cause thrombosis and embolism, nephritis, hemoglobinuria, and, owing to the large amount of fluid injected, it increases the strain on the heart, and markedly augments the bleeding, even from the smallest vessels. It is especially dangerous in patients with vascular disease or a high blood pressure. Kümmel and others, however, advocate this method of etherization in cases in which intravenous infusion of salt solution is beneficial, e.g., in intraabdominal bleeding, gastrectomy for carcinoma, etc. Normal salt solution at a temperature of 85° F. (ether boils at 96°) containing 5 per cent. of ether is allowed to run slowly into a vein of the arm, the technic being identical with that for the infusion of salt solution (q.v.). Connected with the cannula, however, is a second tube which leads from a reservoir containing salt solution without ether, so that when the stream of ether is interrupted the salt solution can be turned on, thus lessening the danger of clotting in the vein. In from five to ten minutes after beginning the injection the patient is ready for operation. Kümmel's longest anesthesia extended over two hours, during which time 1,700 cc. of the mixture (corresponding to 85 grammes of ether) were injected.

Chloral, veronal, hedonal, isopral, and paraldehyd likewise have been administered intravenously for the production of general anesthesia, but are more dangerous than ether.

Rectal etherization has been employed in operations about the upper respiratory passages. A bottle of ether to which a rubber rectal tube is attached is placed in water at a temperature of 120° F., or the ether vapor may be forced into the rectum by means of the vaporizer shown in Fig. 5, a rectal tube being substituted for the mouth piece. The disadvantages of the method are the greater time necessary to induce anesthesia, and the unpleasant sequelæ, such as prolonged stupor, meteorism, and bloody diarrhea.

The administration of chloroform requires more skill and care than etherization. A preliminary hypodermic injection of atropin is advisable, as this drug prevents reflex inhibition of the heart, owing to its depressing effect on the pneumogastric nerves. The chloroform may be inhaled from a handkerchief or a piece of gauze, but a special mask, such as the Skinner or Esmarch (Fig 6), each of which consists of a wire frame covered with one layer of flannel, is more convenient. The inhaler is held just over the nose and mouth and the chloroform dropped on it. The average adult patient will require one drop of chloroform every four or six seconds to maintain anesthesia. The vapor should always be liberally mixed with air; liquid chloroform should never be allowed to touch the skin, as it may produce blistering. The phenomena of chloroform anesthesia are in the main similar to those of ether. The *first* and *second stages* are shorter, the vapor is more pleasant, and being less irritating than ether, not so much mucus is poured out. An excess of chloroform causes the patient to hold his breath, and if the inhaler is not withdrawn at this time, the patient may take a deep inspiration and get an overdose. This accident has resulted in death, and should be recalled when chloroforming crying children, and when a surgeon attempts to operate before the third stage is reached, thus causing the patient to breathe deeply. During the stage of muscular excitement, which is less marked than with ether, the respirations should be watched with great care. Chloroform vapor is not inflammable, but in the presence of a naked flame gives off irritating products (phosgene and hydrochloric acid), which, in a small room, may cause irritation of the eyes and respiratory passages. The *third stage* is characterized by quiet respirations which are often difficult to appreciate. The pulse is sluggish and feeble in contrast to the full and rapid pulse of ether. The pupil is moderately contracted unless the anesthesia is profound, when it dilates. As with ether, dilated pupils, failing to react to light, indicate a dangerous degree of anesthesia. Throughout the anesthesia the pulse and respirations should be carefully watched. The character of the respirations may be determined by listening to them, by observing the movements of the chest and abdomen, and by noting the patient's color. The pulse may be felt at the temple.

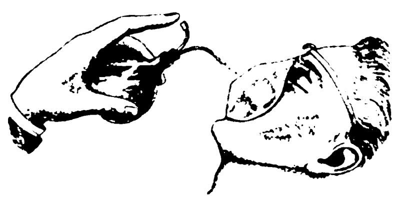

FIG. 6.—Esmarch Mask.

Oxygen combined with ether or chloroform tends to prevent spasm of the respiratory muscles and cyanosis. That it lessens irritation of the kidneys and post-anesthetic vomiting is doubtful. The oxygen, after bubbling through the anesthetic, is conveyed to the face piece through a rubber tube. It may be given also by placing the end of the oxygen tube in or beneath the inhaler.

Nitrous oxid comes in steel cylinders, in which it has been liquefied by pressure. It is allowed to escape into a rubber bag in which it is vaporized, and from which it passes through a tube to a mouth piece. A piece of cork or wood to which a string is attached, so that it cannot be swallowed, is placed between the molar teeth and the mouth piece adjusted. The gas is then turned on and the nostrils closed by the thumb and finger. The patient becomes cyanotic, the pupils dilate, and squint is often seen. With the onset of unconsciousness, which is usually complete in about one minute, the breathing becomes stertorous and muscular twitchings are observed. The duration of complete anesthesia is about one minute. The pulse and respirations should be carefully watched. Nitrous oxid is often used to induce anesthesia, which is then continued by ether, with the object of reducing the period of narcosis, the amount of ether used, and the unpleasantness of the early stages of ether anesthesia. Anesthesia may be induced with an ordinary nitrous-oxid apparatus and etherization begun with an ordinary inhaler. Much better is an apparatus which allows the gradual administration of ether before the nitrous oxid is discontinued. Hewitt uses a Clover's inhaler to which is attached a charged gas-bag holding about two gallons of gas. By means of a stop-cock the patient is allowed to breathe about one-half the nitrous oxid, the remaining half being breathed backwards and forwards during the gradual admission of the ether. Nitrous oxid anesthesia may be prolonged by mixing the gas with atmospheric air, or by combining it with oxygen; the latter method is the safer and may be employed in operations of any length, provided muscular relaxation is not necessary. For the administration of nitrous oxid and oxygen Hewitt employs an apparatus consisting of two steel cylinders containing the respective gases; these communicate with two bags which are connected with the mixing chamber, to which the mouth piece is attached. By means of a regulator the percentage of oxygen, which at the beginning of the administration should be 2 or 3 per cent., is increased progressively to 8 or 10 per cent. The longer the duration of the anesthesia, the greater the amount of oxygen which may be given. In anemia and toxemia the quantity of oxygen may, in some cases, be increased to 20 per cent., owing to the diminished oxygen-carrying capacity of the blood. Many anesthetizers have an ether chamber connected with the apparatus, in order to secure, when desired, at least partial relaxation. The addition of ether is demanded in from 10 to 25 per cent. of major operations. A preliminary hypodermic injection of morphin and atropin also tends to minimize muscular rigidity and is almost a routine practice with those who give nitrous oxid and oxygen.

Ethyl chlorid, like ether, is highly inflammable, and is easily administered without special apparatus. It may be given with a closed inhaler, or by spraying it upon gauze placed over the nose and mouth. Ten cc. are usually sufficient for this purpose. Anesthesia is induced in from one-half to two minutes; the patient rapidly recovers, usually without vomiting or other disagreeable phenomena. See also local anesthesia.

Ethyl bromid is somewhat similar in its effects to ethyl chlorid, and may be used for the same purposes, but is less safe. It may be given from a closed mask or from a towel. The entire dose of from 15 to 30 grams is poured into the cone at once and all air excluded. Narcosis is quickly induced and recovery rapidly follows. Ethyl bromid is a cardiac depressant, and is contraindicated in children, in the weak and anemic, and in those suffering from cardiac disease, alcoholism, and kidney affections.

Anesthetic mixtures containing chloroform, the best known of which is the A. C. E. mixture (alcohol 1, chloroform 2, ether 3), should rarely or never be employed. That they possess advantages over ether is doubtful, that they are more dangerous is positive. Many operators prefer to give gr. $\frac{1}{8}$ to $\frac{1}{4}$ of morphin hypodermatically a short time before beginning the anesthesia, to shorten the preliminary stages, make them more pleasant, and to obviate fear, limit the amount of anesthetic necessary, and prevent shock. The objections to administering morphin are that it makes the pupillary reaction, the most valuable guide in anesthesia, untrustworthy; interferes with the expulsion of mucus, blood, or other material from the air passages; depresses respiration, thus delaying the elimination of the anesthetic after operation; and that it not infrequently causes vomiting.

The practice should not be a routine one, but in certain cases, such as morphin or alcoholic habitues, it may be advantageous. Hyoscin or atropin is sometimes given just before ether in order to lessen the amount of mucus secreted. Recently *scopolamin-morphin* anesthesia has been tried. One milligramme of scopolamin (hyoscin), and 25 milligrammes of morphin are divided into three doses, which are injected hypodermically $2\frac{1}{2}$, $1\frac{1}{2}$ and $\frac{1}{2}$ hour before operation (Korff). The patient falls into a sound sleep which lasts for five or six hours after the last injection. Inhalations of chloroform or ether may be necessary. Several deaths have been reported and the method cannot be recommended.

Anociassociation is a term invented by Crile to designate a condition in which, according to his theory, all noxious influences attending anesthesia for operation are eliminated. Fear is abolished by a preliminary hypodermic injection of morphin and scopolamin; the patient is anesthetized with nitrous oxid and oxygen, combined, if necessary, with ether; and, "as all inhalation anesthesia puts asleep only a portion of the brain," novocain or other local anesthetic is injected into the field of operation, thus preventing the harmful afferent impulses arising in the traumatized area from reaching the brain.

Complications during anesthesia arise chiefly from interference with the respiratory or circulatory apparatus, the former more particularly with ether and nitrous oxid, the latter with chloroform. A second anesthesia, within a few hours, is always more dangerous than the first; and irregular administration, i.e., allowing the patient nearly to recover and then forcing the anesthetic, is attended by much more risk than a uniformly deep narcosis.

Respiratory difficulties may be due to many causes not directly connected with the anesthetic, such as faulty posture of the patient, assistants leaning on the chest, tight bandages about the neck or chest, swellings within or about the air passages, excessive distention of the abdomen, and diseases of the lungs. Any of these should, of course, be promptly removed if possible. It may be said at once that great rapidity or cessation of the respirations, associated with cyanosis and rapid pulse, calls for vigorous measures. If the cause is not obvious, the mouth should be opened, the tongue drawn forward, and the pharynx cleared. If this does not overcome the difficulty, oxygen and strychnin should be administered, artificial respiration employed and, if necessary, tracheotomy performed. Only those causes more or less directly connected with anesthesia will be considered at this time. *Forgetting to breathe*, or holding the breath, may be encountered in the early stages, and is met by withdrawing the anesthetic and perhaps dashing a little ether on the chest or abdomen. *Falling backwards of the tongue* over the epiglottis requires the turning of the patient's head to one side, and pressure behind the angles of the jaw, so as to lift it forward. Rarely will the mouth-gag and tongue forceps be necessary for this purpose. The best tongue forceps is a double tenaculum, which secures a firm hold without crushing or bruising. The tongue may be pressed forward also by passing a finger into the pharynx, a procedure which at the same time will reveal any other form of obstruction. *Falling together of the lips*, especially in toothless patients, with or without nasal obstruction, may interfere with respiration. All that need be done is to place the finger or the end of a towel between the lips. *Mucus, saliva, blood, pus, vomitus, or other liquids* may be removed from the pharynx by turning the head to one side, and swabbing with gauze sponges secured by a hemostat. *Spasm of the respiratory muscles* requires the same treatment as falling backwards of the tongue. If there is great rigidity of the muscles of the jaw, tracheotomy may be necessary. *Paralytic arrest of respiration* may be precipitated with great suddenness, especially with chloroform. With ether the approach is more gradual; the respirations become weaker and weaker, the pupils dilate and remain immobile, the color grows dusky and the pulse feeble. The treatment is artificial respiration, the administration of strychnin subcutaneously, and inhalations of oxygen. Henderson advises that the oxygen contain 10 per cent. of CO_2. He believes, since CO_2 is the predominant stimulant maintaining respiration, that apnea is not infrequently due to acapnia (deficiency of CO_2), the result of excessive breathing during the stage of excitement; hence unskilled timidity in the administration of an anesthetic, rather than overboldness, may be responsible for some cases of respiratory failure. *Edema of the lungs* is not often encountered. The patient may be inverted to favor drainage from the lungs, and oxygen and cardiac stimulants administered. Venesection is sometimes employed to relieve the right side of the heart, and artificial respiration should be performed if breathing ceases. *Cyanosis* is simply a symptom which has for its cause one of the conditions mentioned above. **Artificial respiration is**

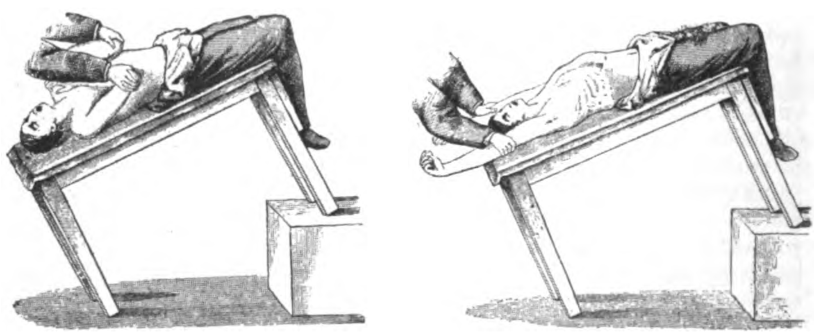

FIG. 7.—Expiration. FIG. 8.—Inspiration.
FIGS. 7 and 8.—Artificial Respiration. (Esmarch and Kowalzig.)

best done by the *Sylvester method*. One should first make sure that the air passages are clear, and draw out the tongue to establish free air way. The operator stands at the patient's head, grasps the arms at the elbows, presses them firmly against the sides of the chest to induce expiration (Fig. 7), then draws the arms upward until they almost meet above the head, in order to raise the ribs by means of the pectoral muscles and thus cause inspiration (Fig. 8). These movements should be repeated about fifteen times a minute. In *Marshall Hall's method* the operator grasps the lower thorax with his hands, presses upwards and inwards for two or three seconds, then relaxes the compression for two or three seconds. This compression can be made with more force if, as in the *Howard method*, the operator kneels astride the patient's hips, braces his elbows against his sides, and throws his weight upon the patient's chest. In *Schäfer's method* the patient lies on the abdomen, and pressure is made as in the Howard method. *Laborde's method* consists in alternately drawing upon and relaxing the tongue at intervals of four seconds. *Fell's method* consists in the introduction of a tube into the larynx, or through a tracheotomy wound, respiration being maintained by means of foot-bellows. When the bellows are connected with a laryngeal tube the apparatus is known by the name of Fell-O'Dwyer. When ether is given by *intratracheal insufflation* artificial respiration may be inaugurated at a moment's notice by insufflating pure air.

Circulatory Difficulties.—A mild degree of syncope sometimes results from nausea and vomiting. Cardiac failure may result from operative manipulations during light narcosis, overdose of the anesthetic, hemorrhage, shock, or from arrest of respiration. Among the measures which, after withdrawing the anesthetic, may be adopted in cardiac failure, are the subcutaneous administration of strychnin, atropin, digitalis, or nitroglycerin, inversion of the patient, artificial respiration, faradism of the phrenic nerve (one pole on the epigastrium, the other at the junction of the external border of the sternomastoid with the clavicle), rubbing the extremities toward the heart, compression of the abdominal aorta, stretching of the sphincter ani, rhythmic pressure over the precordium, and direct massage of the heart.

Coughing and swallowing during the induction of anesthesia indicate that the vapor is too strong. Coughing, swallowing, or vomiting during the third stage indicate returning consciousness and call for more anesthetic. *Vomiting* is often heralded by swallowing, shallow breathing, pallor, feeble pulse, and dilated pupils, a group of symptoms which may be confused with shock; in the latter the anesthetic should be withdrawn, in the former it should be increased in order to prevent the vomiting. If vomiting occurs, the head should be turned to one side and the stomach contents allowed to escape, swabbing out the pharynx if necessary. *Hiccough* is most apt to occur during abdominal operations and usually demands an increase of the anesthetic.

Recovery from anesthesia varies in duration according to the character and quantity of the anesthetic and the condition of the patient. After nitrous oxid and ethyl chlorid it occurs immediately on withdrawal of the anesthetic, usually without any special phenomena. After ether and chloroform the temperature is usually subnormal, the respirations are quiet, the eyeballs rotate, the lid reflex returns, swallowing begins, and vomiting often follows. Some patients remain quiet, many become noisy and turbulent. The anesthetist or a competent nurse should remain with the patient until recovery is complete. The head should be low and turned to one side, and the patient kept warm. Vomited matter should be received in a towel or basin without raising the head. Food is rarely given before six hours, and often not for many hours. Vomiting is more frequent after ether, but is apt to be more severe and protracted after chloroform. As a rule it ceases of itself and no treatment is required.

After effects more frequently follow ether than other anesthetic agents. In order to minimize the unpleasant sequelæ of inhalation anesthetics, one may inject, during or immediately after operation, saline solution into the subcutaneous tissues, or 1 or 2 quarts of water, containing 1 or 2 ounces of glucose, into the rectum. The fluid restores the blood pressure, and dilutes and assists in the elimination of the anesthetic. The glucose reestablishes the glycogenic function of the liver. Gastric lavage, at the completion of operation, assists in eliminating the anesthetic, and tends to prevent nausea and vomiting.

Conjunctivitis, and *burns* of the first degree about the face and neck may occur, particularly if ether or chloroform has been "poured on." *Persistent vomiting* may be due to acute gastrectasia, peritonitis, intestinal obstruction, opium, or other causes independent of the anesthetic, and these should be excluded before deciding that the anesthetic is wholly responsible. Acetonuria, which is described below, may be the cause or the effect of protracted vomiting. Continued vomiting due to the anesthetic alone is best treated by withholding all food by mouth, gastric lavage, nutritive enemata containing sodium bromid, and, to hasten elimination of the anesthetic, fresh air and hypodermoclysis. Later champagne and various liquid foods may be tried. *Bronchial and pulmonary affections* are often due to the irritation of ether, but may arise also from exposure of the patient, the inhalation of septic material, emboli, interference with respiration (e.g., from an epigastric incision), and sluggish circulation (e.g., from a weak heart or prolonged recumbency). Ether pneumonia is of the lobular variety and quickly follows anesthesia. Pneumonia from other causes may be of the lobar variety and may not arise for a number of days. Preventive measures consist in the use of a clean inhaler, the exclusion of foreign material from the air passages, and the careful protection of the patient. (See also pulmonary embolism.) Bronchial irritation, and possibly bronchitis, may be caused, as already pointed out, by the decomposition of chloroform in the presence of a naked flame. *Renal complications* may occur after ether, chloroform, or ethyl chlorid. Whether they are more frequent after ether than after chloroform does not seem to be satisfactorily settled. The urine is always decreased in quantity during the first twenty-four hours after anesthesia, and should be carefully watched. If signs of renal incompetency appear, heat should be applied over the kidneys, diuretics administered, and water given by mouth, rectum, subcutaneously, or intravenously. *Apoplexy* may occur in those with chronic arterial disease, but is rare if the patient is skillfully and thoroughly anesthetized; the struggling induced by pushing the anesthetic or by operating before anesthesia is complete is dangerous in these cases. Complete anesthesia is usually less to be feared than fright and pain. *Insanity* has followed anesthesia (see p. 120). *Post-anesthetic paralysis* may result from cerebral hemorrhage or embolism, but is usually the result of pressure, e.g., a wrist drop due to the hanging of an arm over the edge of a table. This subject, with the position to be assumed by the upper extremities, is referred to in Chap. IV. *Acetonuria* (acetonemia, acid intoxication) rarely follows the administration of any anesthetic except chloroform, in which event it is called *delayed chloroform poisoning.* That chloroform occasionally produces glycosuria has long been known, but only recently has attention been directed to the form of late poisoning described below. It is more apt to occur in children, and after quickly repeated anesthesias. Other predisposing causes are diabetes, disease of the liver or kidneys, exhaustion, and infection. The condition may appear in from a few hours to many days after the anesthesia, and it may last several days and end in recovery, but usually terminates in death. The symptoms are vomiting, rapid pulse, dyspnea, cyanosis, delirium or stupor, and finally coma. The breath has a sweetish, chloroform-like odor, and there may be fever. The urine contains acetone and diacetic acid, and sometimes leucin and tyrosin. Jaundice may occur and there may be a tendency to hemorrhage. Autopsy reveals fatty degeneration of the liver and sometimes of the kidneys and other organs, the changes being much like those found in phosphorus poisoning. The treatment, at least so far as the acetonemia is concerned, consists in the use of measures to promote elimination, stimulation if necessary, glucose or levulose by rectum, and the administration of bicarbonate of soda by mouth, or 1 per cent. in salt solution by rectum, subcutaneously, or intravenously.

Local Anesthesia is the production of insensibility in the parts to be operated upon, without destroying the general bodily sensibility or producing unconsciousness. It is *indicated* in minor operations, and in major surgery when general anesthesia is contraindicated. It is not satisfactory in children or in nervous patients. Local anesthesia may be induced by freezing, or by the application or injection of various drugs.

Freezing may be produced by spraying the parts with ether, rhigolene, chlorid of methyl, liquid air, or chlorid of ethyl. *Chlorid of ethyl* is the agent usually employed. It is put up in glass tubes, and is sprayed on the part from a distance of about one foot. When the part becomes hard and white it is ready for incision. The anesthesia lasts from one to two minutes. Both the freezing and the thawing are painful. In the absence of ethyl chlorid freezing may be induced by *ice and salt*, in the proportion of two parts of the former to one of the latter, placed in a gauze bag and applied to the skin; analgesia results in about fifteen minutes.

Cocain hydrochlorid is an efficient local anesthetic, but is not without danger. Death has resulted from one dram of a 20 per cent. solution instilled into the urethra, and from swabbing the larynx with a 2 per cent. solution. Not more than one-half a grain should be used for injection, not over two-thirds of a grain should be applied to a mucous membrane. *Cocain poisoning* is characterized by headache, nausea and vomiting, pallor, tremor, restlessness, dryness of the mouth, dilatation of the pupils, weak pulse, prolonged insomnia, and in severe cases by delirium, unconsciousness, and heart failure. The treatment consists in placing the patient recumbent, applying external heat, and administering cardiac stimulants. Cocain is contraindicated in glaucoma because it dilates the pupils; it is said also to have a deleterious effect upon diseased kidneys. As cocain is destroyed by prolonged boiling, the solution is best prepared (fresh each time) by adding to normal salt solution the crystals which have been sterilized in glass tubes at 300° F., dry heat, for fifteen or twenty minutes. The strength of the solution should be from 2 to 4 per cent. for the eye, 4 per cent. for the urethra, 2 per cent. for the bladder, 5 to 10 per cent. for the rectum, vagina, mouth, nostrils, and from ½ to 1 per cent. for injection into any portion of the body.

Eucain hydrochlorid is, for practical purposes, just as powerful as cocain, one-quarter as toxic, and is not destroyed by boiling. Solutions for injection should be from 1 to 4 per cent. It does not cause dilatation of the pupil, nor is it followed by as marked congestion as cocain. Sloughing has, however, been observed in a few instances after its use.

Stovain, novocain, and **tropacocain** are closely related to cocain, but the first is four times and the other two seven times less toxic than it and all are just as anesthetic. They come already sterilized in closed tubes. For injection a ¼ to 1 per cent. solution in sterile water or salt solution may be employed. For infiltration 125 cc. of a ¼ to ½ per cent. novocain solution can be used with safety.

Adrenalin chlorid, when added to any of the above drugs, causes exsanguination of the part by constricting the blood vessels, thus lessening the hemorrhage, limiting absorption, and intensifying and prolonging the anesthesia. Barker prepares a solution by adding to 100 cc. of boiled distilled water 1 cc. of adrenalin chlorid (1 to 1,000), 3 grains of eucain, and 12 grains of sodium chlorid. Not more than fifteen drops of adrenalin chlorid should be added to any solution for injection.

Quinin-urea hydrochlorid, injected in from ¼ to 1 per cent. in salt solution, induces prolonged anesthesia, hence lessens post-operative pain.

It is not toxic and diminishes bleeding. Induration and tardy healing sometimes follow its use.

Schleich's solution produces anesthesia by causing an artificial edema, the tension resulting in ischemia and in pressure on the nerve endings, hence the term *infiltration anesthesia* (Fig. 9). *Sterile water or normal salt solution* produces much the same effects, but is not quite as efficient. Schleich uses three solutions as follows: No. 1 (for the most painful operations—not more than 5 drams should be used) consists of cocain hydrochlorid gr. iii, morphin hydrochlorid gr. $\frac{1}{3}$, sodium chlorid gr. iii, distilled water f℥iiis, acid carbolic (5 per cent.) gtt. iii. Solution No. 2 (of which not more than 10 drams should be injected) is used in less painful operations, and is the same as No. 1 except that the cocain is reduced to gr. iss. Solution No. 3 (used in deeper and less sensitive tissues and in extensive operations—11 oz. may be injected) contains but gr. $\frac{1}{6}$ of cocain. Adrenalin chlorid also may be added to these solutions.

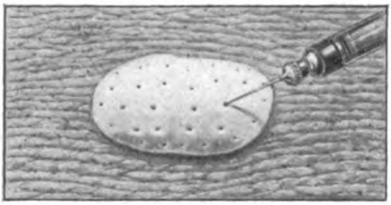

FIG. 9.—Method of injecting local anesthetics into the skin. The fluid is introduced into and not beneath the skin, which is elevated, tense, and white.

The injection of local anesthetics may be by the *direct method*, i. e., the drug is injected into the tissues to be operated upon, or by the *indirect method* (*regional anesthesia*), in which the drug is injected into (*intraneural*) or about (*paraneural*) the nerve or nerves supplying the part with sensation, into the blood vessels of the part (*Bier*, *Ransohoff*), or into the subarachnoid space of the spinal cord (*spinal anesthesia*). In the *direct method*, whenever possible, e.g., in the fingers, toes, and penis, a tight ligature should be placed above the area to be anesthetized, after it has been exsanguinated by elevation, or in some cases, by pressure; this in itself has a benumbing influence, as well as restricting the anesthetic solution to the injected area. After making sure that all air has been driven from the syringe (a hypodermic, antitoxin, or special syringe may be employed), the point of the needle is inserted obliquely into the skin until the eye is just beneath the epidermis; in other words, an effort is made to enter the true skin and not the subcutaneous tissues. Care should be taken not to enter a vein. A few drops of the solution are introduced, producing a white wheal; the needle is then pushed a little further, and the process repeated until the proposed line of incision is marked out by a white and elevated ridge (Fig. 9). From five to ten minutes should elapse before making the incision. If the deeper structures are to be severed, they also should be infiltrated, or one of the more powerful solutions may be dropped in the wound. *Intra- or paraneural* injections may be employed in amputation of the finger, by forcing the solution into the tissues about its base, when the entire finger will become anesthetic. In amputation of the leg the tissues over the sciatic and long saphenous nerves may be infiltrated with Schleich solution, and the nerves exposed and injected with a $\frac{1}{2}$ to 1 per cent. cocain solution. In amputations of the thigh it will be necessary to inject the anterior crural instead of the long saphenous nerve. Many other operations may be performed by this method.

In **Bier's intravenous anesthesia,** after rendering the limb bloodless with an Esmarch bandage, a tourniquet is placed above and another below the field of operation. Under infiltration anesthesia a cannula is inserted into a superficial vein immediately below the proximal tourniquet, and from 40 to 100 cc. of novocain (.5 per cent. in salt solution), at the temperature of the body, injected towards the periphery. Anesthesia is induced between the tourniquets in from 2 to 5 minutes; beyond the distal tourniquet in from 5 to 15 minutes, when the distal tourniquet may be removed. At the completion of the operation the proximal band is removed gradually, to prevent rapid diffusion of the novocain. *Ransohoff* applies an Esmarch band to the limb with sufficient firmness to obstruct the venous flow, and under infiltration anesthesia injects, with a fine needle, 4 to 8 cc. of a .5 per cent. cocain solution into the main artery. Anesthesia results in 2 minutes, after which the band may be tightened to check oozing. These methods are still in the experimental stage and must be used with caution. They are contraindicated in the presence of vascular disease.

Spinal anesthesia, or medullary narcosis, is produced by the injection of a local anesthetic into the subarachnoid space. Cocain and eucain are seldom used at the present time. Stovain has a strong affinity for the motor nerves and may, in high anesthesia, cause paralysis of the respiratory muscles. Tropacocain and novocain possess less of this affinity, hence are safer; the usual dose is from one-half to one grain. The solution is prepared by dissolving the drug selected (previously sterilized) in cerebrospinal fluid, which is drawn into the syringe containing the anesthetic, after the introduction of the needle into the subarachnoid space. In order to make the solution of a higher specific gravity than the spinal fluid and so remain in the lower part of the spinal theca, Barker uses distilled water 1 cc., glucose .05 grams, and stovain .1 gram. The syringe should be boiled in plain water, as the soda solution employed for other instruments may diminish the efficacy of the anesthetic. The patient lies on the side or assumes the sitting posture; in either case the back should be bent forward in order to increase the space between the vertebral arches. The operator places one finger upon the spine of the fourth lumbar vertebra, which is on a line drawn between the two iliac crests, and enters the needle, fitted with a stylet, just below and to the right of this point, in a slightly upward and inward direction, until the dura has been punctured, which in the adult is usually at a depth of two and one-half inches. The stylet is withdrawn and one dram of the cerebrospinal fluid allowed to escape. The anesthetic solution is then slowly injected, the needle withdrawn, and the puncture sealed with collodion. The patient is then placed in the proper position for operation, but never should the head and shoulders be on a lower level than the lumbar vertebræ, as the fluid may gravitate towards the medulla and cause respiratory paralysis. Anesthesia results in about five minutes and lasts from one to three hours or longer. No attempt should be made to induce anesthesia above the diaphragm. Headache, nausea, and vomiting are frequent sequelæ, and evidence of transient and permanent cord injuries has been noted. The chief dangers are infection, injury to the cord, and poisoning from the anesthetic employed. The mortality has been estimated at 1 in 200. From what has been said it may be gathered that the method is destined to pass into desuetude.

CHAPTER III.

BACTERIOLOGY.

Bacteria, schizomycetes, or fission fungi, are microscopic, non-nucleated, unicellular, vegetable organisms, devoid of chlorophyl and consisting of protoplasm inclosed in a cell wall. The terms germ, microbe, and micro-organism also are loosely applied to bacteria and allied organisms.

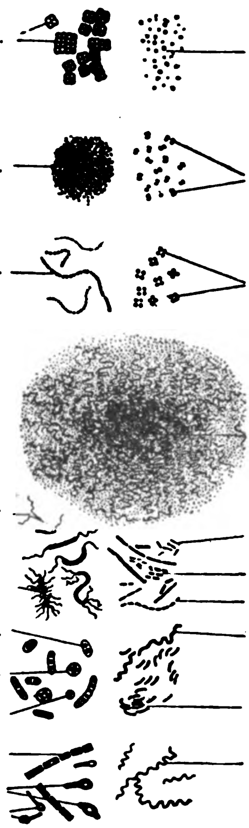

FIG. 10.—Diagram illustrating the nomenclature of schizomycetes based upon their morphology. (Coplin after Shenk.) × about 700 diameters.

According to **shape** (Fig. 10) bacteria are divided into *cocci* (spherical), *bacilli* (rod-like or cylindrical), and *spirilla* (spiral). Cocci are divided according to number into *monococci* (existing singly), *diplococci* (in pairs), *tetracocci* (groups of four), and *sarcinæ* (cubical groups of eight); according to arrangement into *streptococci* (chain-like) and *staphylococci* (irregular masses like bunches of grapes). Globular masses held together by gelatinous matter are called *zooglea;* a group of cocci in a capsule, *ascococci.* Bacilli in chain formation are called *streptobacilli.* A *leptothrix* is a long thread-like bacillus which many class with the molds.

The **distribution** of bacteria is almost universal. They exist in the air, water, food, soil, alimentary canal (being most numerous in the mouth, lower ileum, and cecum), nose, lower urethra, and vagina, and even in the hair follicles and sweat glands of the skin.

The **reproduction** of most bacteria takes place by *fission*, i.e., the cell simply divides into two or more fragments when it has reached the stage of maturation. A few bacilli (e.g., B. anthracis, tetani, and edematis maligni) and spirilla multiply by sporulation. A *spore* is analogous to the seed of a plant, and may appear in the end of the organism (*endspore*), or in the middle (*endospore*), thus making the organism club-shaped or fusiform. Although as a rule only one spore forms, a number may develop throughout the length of the organism, presenting a bead-like appearance (*arthrospores*). A spore has a dense capsule which renders it very resistant to all kinds of disinfectants.

For **development** bacteria require a temperature at or near that of the human body, moisture, and food. Their food consists of complex organic compounds, such as are found in the bodies of animals and in plants. *Aërobic* bacteria require oxygen for their development; *anaërobic*, e.g., the bacillus of tetanus, of malignant edema, and the bacillus aërogenes capsulatus, the absence of oxygen. Most pathogenic micro-organisms are *facultative anaërobes*, i.e., they thrive best with oxygen, but have the faculty of living without it. An *obligate anaërobe* cannot live with oxygen. The terms facultative and obligate are applied also to aërobes and to parasites and saprophytes. *Parasites* grow in living tissues, *saprophytes*, or putrefactive organisms, in dead tissues. Like the cells of the human body, bacteria attract elements essential for their growth (*positive chemotaxis*) and repel those which are harmful (*negative chemotaxis*). *Motile* bacteria possess the power of moving from place to place by means of thread-like processes, or *flagellæ* (e.g., B. typhosus and B. coli), or by means of a rotary or undulatory motion; *amotile* bacteria (all cocci and most bacilli) depend for transportation upon fomites or upon physical or chemical currents. In common with other minute particles suspended in fluid, bacteria oscillate (*Brownian movements*).

Bacterial death is caused by disinfection, and by the cells and fluids of the human body.

Freezing renders bacteria inert, but does not destroy them. Drying renders them dormant, but permits of their dissemination by means of the air. It is important to remember that bacteria are not blown or driven from moist surfaces, and that a table, for instance, which is wiped with a moist cloth is not as dangerous from a surgical standpoint as one which is dusted. Direct sunlight, the X-rays, electric currents, and electric light, are detrimental to the growth of microbes.

Bacterial products represent the excretions of bacteria, the substances generated by their decomposition, and the compounds resulting from the action of either of these on the tissues. Bacteria may produce alcohols; acids, such as lactic, acetic, and butyric; alkalies, e.g., ammonia; and pigments (*chromogenic* bacteria), e.g., bacillus pyocyaneous; some are capable of causing phosphorescence (*photogenic*). The *aërogenic* (gas producing) bacteria are the bacillus aërogenes capsulatus, the bacillus of malignant edema, and the saprophytes, the most prominent of which is the bacillus coli. *Zymogenic* bacteria cause fermentation.

The ferments are known as *enzymes*. These ferments, like the digestive juices, emulsify fats, change albumin into peptone and starch into sugar. The enzymes may be absorbed in the human body and produce disease. The poisonous substances elaborated by bacteria are the ptomains, the toxalbumins, and the toxins. A *ptomain* is a crystallizable alkaloid produced by the action of bacteria on dead animal matter. *Toxalbumins* are amorphous albumoses produced by the action of enzymes on albumin. *Toxins* are crystallizable alkaloids existing in the protoplasm of bacteria and excreted by them (*ectotoxin*), as in diphtheria and tetanus, or liberated by their death (*endotoxin*), as in tuberculosis. The term toxin as commonly employed means any or all of the poisonous substances elaborated by bacteria, and the condition resulting from the absorption of these toxins is called toxemia.

Infection is said to have taken place when *pathogenic* (disease producing) bacteria invade living tissues and cause symptoms. Bacteria which are incapable of producing disease are spoken of as *non-pathogenic*, and many of these are not only harmless, but even useful, producing alcoholic and acetous fermentation, and cleansing the earth of dead animal and vegetable matter by putrefaction. To demonstrate that a micro-organism is the specific cause of a given disease, it should fulfil *Koch's postulates*, which are, that it be found in every case of that disease, that it be absent in normal tissues under normal conditions, that it be cultivated in pure culture, that these cultures be capable of reproducing the disease, and that the germ be again cultivated in pure culture from the infected animal. To these has been added the isolation, from the cultures of the organism, of a toxin which will produce the disease or elaborate an antitoxin in susceptible animals.

The usual **methods of infection** are through wounds (inoculation), through the mucous membrane of the alimentary canal (ingestion), through the mucous membrane of the respiratory passages (inhalation). Bacteria rarely pass through intact healthy skin. It is known that micro-organisms may pass through the placenta. Germinal infection (infected ovum or spermatozoön) is very doubtful, although it is generally taught to be the cause of some cases of congenital syphilis. A wound may be infected with one variety of bacteria only, and a *secondary infection* with another variety may occur; this is known as *mixed infection*, and explains the care with which a surgeon sterilizes his hands and instruments, even when the tissues are known to be infected. In mixed infection one form of bacteria may antagonize another form (*antibiosis*, *enantiobiosis*), or the varieties may harmonize in their development (*symbiosis*).

Infection extends by continuity, as when it creeps along a surface or plane of tissue; or by contiguity, as when it spreads from one organ or tissue to another, e.g., from the ovary to the appendix. Transportation from one part of the body to another is effected by the blood or the lymph, the bacteria floating free in the stream, or being carried by cells or emboli; by secretions, excretions (e.g., from the kidney to the bladder by the urine), or pathologic discharges, e.g., from the lung to the intestine by swallowed sputum. Transmission outside of the body also may occur, e.g., when gonococci are conveyed from the urethra to the eyes by the fingers.

Disease production is not the direct result of the deposition of bacteria, that is, the process is not a mechanical one. They may injure the tissue cells by stealing their food, but as a rule the morbid phenomena are due to the absorption or local action of toxins. The production of disease depends on the dose of the micro-organisms and their virulence, and also upon the resistance of the tissues. Many of the organisms entering the tissues are swallowed by the leukocytes or dissolved by the bactericidal action of the blood serum, so that probably a large number are necessary for the production of morbid phenomena. The virulence of micro-organisms differs according to many conditions; those which at one time are benign may at a later period become extremely harmful. The susceptibility of the tissues also varies considerably under different conditions; thus their resistance is decreased by prolonged exposure to cold, mechanical injury, alcoholism, diabetes, kidney disease, underfeeding, overcrowding, etc.

Insusceptibility, or **immunity**, to an infection may be natural or acquired. *Natural immunity* is illustrated in the negro, who possesses an inherent resistance to yellow fever. *Acquired immunity* may be active or passive. *Active immunity*, so called because the tissue cells are activated to form antibodies, is produced by a previous attack of a disease, e.g., syphilis and the exanthemata; by direct inoculation, such as was once employed in small-pox, and is still used for certain diseases in animals; by the introduction of attenuated virus, e.g., vaccination for small-pox and the prophylactic treatment of hydrophobia; and by the injection of bacterins (p. 34). *Passive immunity* is produced by the injection of immune serum (p. 34), and involves no action on the part of the tissue cells.

Theories of Immunity.—The body defends itself against infection (1) by destroying bacteria and (2) by neutralizing their toxins.

(1) The *antibacterial* methods of defense are (a) phagocytosis and (b) bacteriolysis. (a) *Phagocytosis* is the process whereby microbes are devoured and digested by certain cells of the body, especially the leukocytes; these cells are called *phagocytes*. Leukocytosis, local or general, or both, is nature's effort to supply a sufficient number of phagocytes to overcome the invading bacteria, and the surgeon sometimes tries to assist nature in this effort, e.g., by applying heat, inducing passive hyperemia (Bier), or by injecting nucleinic acid (Mikulicz) or horse serum (Petie). The substances in the blood serum which prepare bacteria for phagocytosis are termed *opsonins* (see also bacterin treatment).

(b) *Bacteriolysis* is the dissolving of bacteria, in the blood serum and body fluids, by an albuminous substance (*bacteriolysin*) furnished chiefly by the leukocytes. Buchner believes there is but one bacteriolysin, which he calls *alexin*, for all bacteria and that it exists in normal serum; others, that there is a separate antibody manufactured for each bacterium. The serum of animals immunized to the bacilli of typhoid fever, cholera, and the bacillus coli, cause *aggultination*, or clumping, of the respective microbes. The Widal test for typhoid fever is based on this phenomenon. This clumping is probably a preliminary step to bacteriolysis, but some attribute it to specific bodies, called *agglutinins* or *precipitins*.

(2) The *antitoxic* method of defense consists in the formation of *antitoxins* by the blood and tissue cells as the result of the action of bacterial antigens. An *antigen* is any substance (bacterial toxins, alien blood serum and cells, certain animal poisons, etc.) which causes the generation of antibodies (lysins, agglutinins, antitoxins, opsonins). Antitoxins neutralize toxins but have no effect on bacteria.

Ehrlich explains the phenomena of immunity by the *side-chain theory*.

He believes that every living cell consists of a central body, and of a number of other chemical groups or side-chains (*receptors*) which are especially concerned with nutrition. A toxin consists of two chemical groups, the toxic carrying portion (*toxophore*) and a combining portion (*haptophore*). When a toxin enters the circulation, it must find receptors to fit its haptophore group, in order to exert a deleterious action on the cells. The toxophore group without its haptophore group, and a toxin whose haptophore group cannot find an affinity for receptors, are harmless. When a toxin combines with a cell, the receptors are destroyed, and the cell makes an effort to supply the loss, producing many more receptors than are necessary; these are thrown into the circulation and constitute antitoxin, because when they meet with the toxin, they immediately combine with its haptophore group and render it inert. Certain of these receptors, called also immune bodies and amboceptors, have two combining groups, one (cytophile) for bacteria or other cells, the other (complementophile) for the complement. The complement (bacteriolysin, alexin) dissolves bacteria after being fixed to them by the amboceptor.

In accordance with the theories outlined above, infections may be prevented or combated by means of (1) immune serums, (2) attenuated forms of virus, and (3) bacterins.

(1) **Immune serums,** when injected into the body, produce passive immunity. They are obtained from specially immunized animals, and are (a) antitoxic or (b) antibacterial. (a) *Antitoxic serums* are laden with antitoxin, produced by the injection of toxins into an animal; such are the antitoxins of pneumonia, plague, hydrophobia, diphtheria, tetanus, staphylococcic and streptococcic infections, and antivenine; the last is non-bacterial. (b). *Bactericidal serums* contain bacteriolysins and amboceptors, hence kill bacteria; such are the typhoid, dysentery, anthrax, tuberculosis, syphilis (?), and cholera serums. Those serums which are of interest to the surgeon receive notice under the diseases for which they are used.

Serum disease is the name given to certain symptoms which occasionally follow serotherapy, sometimes immediately, but more often after an interval of from eight to twelve days. The most frequent of these symptoms are pain and swelling at the site of injection, pain and swelling of the adjacent lymph glands, pains in the joints, fever, general urticaria or erythema, slight albuminuria, and leucopenia. Great weakness, dyspnea, cough, edema of the face, and swelling of the tongue may, however, occur, and a few cases of sudden death have been reported. Asthmatics are especially prone to suffer from disagreeable or dangerous sequelæ. The nature of serum disease is not thoroughly understood, but when it follows a second injection of serum, it is supposed to be due to supersensitiveness. *Supersensitiveness*, or *anaphylaxis*, in contradistinction to prophylaxis, is the increased susceptibility to serum (or to any proteid) arising in an animal as the result of a sub-toxic dose previously administered, the theory being that the tissue cells have been educated by the first injection to split up the proteid, hence when a second injection is given the process takes place so rapidly that the animal is overwhelmed by the toxic portion of the proteid.

(2) An **attenuated virus** is employed in the prophylactic treatment of hydrophobia (q.v.), and small-pox is prevented by vaccination with an attenuated form of small-pox (cow-pox).

(3) A **bacterin, or vaccin,** is a suspension of dead bacteria with their toxins in salt solution. Tuberculin, which must be put in this class, contains,

however, only toxins and is made up with glycerin or water (p. 148). Here should be mentioned also Coley's fluid, which on empirical grounds is used in the treatment of malignant growths (p. 163). Bacterins are injected into the body with the idea of inducing active immunity, especially by increasing the opsonic index and thus stimulating phagocytosis. The *opsonic index* is the amount of opsonin (p. 33) in the patient's serum compared with that in normal serum. It is determined by dividing the number of bacteria ingested by the leukocytes of the patient's blood, by the number ingested by those of healthy blood, 100 or more leukocytes being searched; thus if 400 are found in the leukocytes of normal blood and 300 in those of the patient's blood, the opsonic index is .75. The hope that the opsonic index might be of value in diagnosis and prognosis seems far from realization, and as a guide to the dose of bacterins it is seldom employed. Bacterins should, whenever possible, be *autogenous*, i.e., made by taking the organisms directly from the individual to be treated. When this is not done one may employ a stock bacterin, i.e., one already prepared from the organisms furnished by another individual suffering from the same infection. The stock bacterins supplied by manufacturing chemists have the number of bacteria in each cc., usually 40 to 600 millions, marked on the tubes. The initial dose varies according to the infection, 5 to 25 millions being the average. This is followed by a fall (negative phase), then, in a few days, by a rise in the opsonic index (positive phase). The injections are generally given at intervals of from 5 to 10 days, and never when the negative phase manifests itself clinically by aggravation of the symptoms. The status of this form of treatment is not yet fixed. It seems to be of distinct value in many chronic localized suppurative processes, and it is contraindicated in acute spreading infections accompanied by toxemia.

Other pathogenic micro-organisms besides bacteria are:

1. *Hypomycetes*, or mold fungi, which consist of filaments, or hyphæ, often forming an interlacing network, called the mycelium; these fungi multiply by sporulation. Some of the diseases produced by molds are thrush (*oidium albicans*), actinomycosis (actinomyces or ray fungus), mycetoma, or Madura foot (streptothrix Maduræ), favus (achorion Schönleinii), and certain other skin diseases.

2. The *yeasts, blastomycetes, or saccharomycetes*, which multiply by budding, or gemmation, cause bread to rise, and are responsible for many forms of fermentation. Blastomycetic dermatitis is due to yeast fungi, and some suppose that a yeast causes cancer.

3. *Protozoa*, which are microscopic unicellular organisms belonging to the lowest form of animal life. Malaria (plasmodium malariæ) trypanosomiasis (sleeping sickness), and certain forms of dysentery (ameba coli) are due to protozoa, and carcinoma, syphilis (spirocheta), variola, and molluscum contagiosum are supposed to be due to protozoa.

Special surgical micro-organisms are mentioned under the diseases for which they are responsible.

Disinfection, or sterilization, is the destruction of germs outside or on the surface of the body; germs within the tissues can be destroyed only by the tissues. The agent by which disinfection is effected is called a *disinfectant*, or *germicide*. An *antiseptic* restricts or prevents the development of micro-organisms; as commonly employed, however, the term is synonymous with germicide and disinfectant. A *deodorizer*, e.g., charcoal, may destroy an offensive odor, but is not necessarily an antiseptic. *Asepsis* means the absence of bacteria; *antisepsis* includes all the measures taken for the destruction of bacteria. Sterilization may be divided into (1) mechanical, (2) thermal, and (3) chemical.

1. *Mechanical sterilization* is the mordant for other forms of disinfection; it consists in shaving, scrubbing with soap and water, and irrigation. Without it many chemical disinfectants are useless, with it even the mildest are highly efficient.

2. *Thermal disinfection*, or heat, is the most effectual of all forms of sterilization, and should be used whenever possible. *Moist heat* (boiling water or other liquids, and steam) is more efficient than dry heat. Steam may be quiescent (simple steam), live steam, or steam under pressure. Live steam is better than simple steam, and steam under pressure is the best of all. An autoclave (Fig. 11) is a sterilizer into which steam is introduced under high pressure. A vacuum is first created, thus allowing greater penetration of the steam into the articles within the chamber. The steam is under a pressure of from 10 to 15 pounds to the square inch at 240° F. At the completion of the process of sterilization a vacuum is again created and the objects dried. By means of this apparatus complete sterilization (10 pounds pressure at 240° F.) of ordinary dressings, etc., takes place in three-fourths of an hour. Material for sterilization in the autoclave should be loosely packed, should not come in contact with the walls of the sterilizer, and should be heated before the steam is turned on. Simpler and cheaper sterilizers, without the advantage of pressure, also are on the market. *Dry heat* (flame, hot air, actual cautery, etc.) is rarely employed.

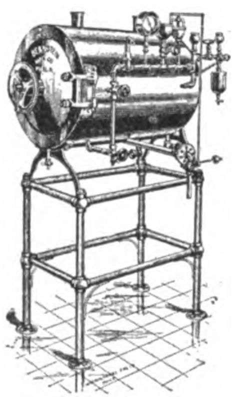

FIG. 11.—Autoclave.

3. *Chemical disinfection* is of less value than the mechanical and the thermal methods. A chemical sufficiently strong to be rapidly germicidal will kill not only bacteria, but also the tissue cells. Of the many chemical disinfectants the most important are given below.

Bichlorid of mercury (*corrosive sublimate*) is a white poisonous powder, used as a solution in water. As the solution is colorless and odorless a small quantity of eosin should be added, so that it may readily be distinguished from other fluids. Bichlorid of mercury is one of the best chemical disinfectants, but is very fastidious in its action; thus it decomposes when brought in contact with metallic apparatus, and is inert in the presence of alkalies and albumins, so that solutions must be made with distilled or filtered water. The union of bichlorid of mercury with albumin may be prevented by the addition of tartaric or citric acid, which, it should be remembered, will have the same effect also on albumins which may be administered to combat poisoning. Bichlorid solutions should be fresh, as standing for some time impairs their power, owing to the formation of an oxychlorid; this may be prevented by the addition of ammonium chlorid or sodium chlorid. For convenience bichlorid is put up in tablets containing 7.3 grains of corrosive sublimate and an equal amount of ammonium chlorid; one of these tablets added to a pint of water makes a 1 to 1000 solution. It is not a good rectal antiseptic, because in the presence of hydrogen sulphid it is changed into the insoluble sulphid of mercury; and it is a poor antiseptic in fatty tissues, because it will not reach bacteria which are coated with oil. It is never used in clean wounds, as it destroys some of the cells and causes exudation; and because of its irritating qualities, it is never applied to serous membranes, such as the peritoneum, meninges, pleura and synovial membranes. For the skin it is employed in the strength of 1 to 1000; for wounds, 1 to 2000; for the vagina 1 to 5000; for the urethra, 1 to 10,000; and for the conjunctivæ, 1 to 40,000. Unless one is accustomed to its use corrosive sublimate frequently causes a cracking and blackening of the hands. Occasionally bichlorid of mercury causes a severe dermatitis with the formation of pustules, and it is sometimes absorbed from wounds, producing constitutional symptoms of poisoning, viz., salivation (p. 140) stomatitis, metallic taste in the mouth, foul breath, vomiting, colicky pains in the abdomen, diarrhea, and in very severe cases collapse and death; the drug is withdrawn, of course, on the first indication of absorption.

Carbolic acid, or phenol, occurs as crystals which deliquesce on exposure to air, the resulting fluid being called pure carbolic acid. It is a less powerful germicide than bichlorid of mercury, and is rarely used in wounds because of its irritating effects, although it penetrates fatty tissues. It is a good deodorizer, however, and is often put into ointments because of its feeble anesthetic properties. It is not used on the hands, because it roughens and cracks them and impairs their sensibility. When powerful solutions are applied for a long time, gangrene may result. It finds its chief office in the disinfection of materials which do not stand boiling well. Pure carbolic acid is occasionally employed to sterilize badly infected wounds, alcohol, which is a powerful antidote, being used one or two minutes later for the purpose of neutralization. When the weaker solutions (1 to 5 per cent.) are continuously applied to a wound, absorption and poisoning may ensue; the pure acid produces a superficial area of coagulation which prevents its absorption. One of the first symptoms of absorption is smoky, greenish, or blackish urine (carboluria). Later there may be vomiting, headache, vertigo, sweating, feeble pulse, irregular and rapid breathing, great weakness, and subnormal temperature. The treatment consists in withdrawal of the drug, stimulation, and sodium sulphate or Epsom salts.

Lysol and *creolin* are coal-tar derivatives, which are feebler than carbolic acid, but less toxic and irritating. Creolin is a good rectal disinfectant in the strength of 3 per cent. Lysol, 2 per cent., is used in obstetrics, as it acts also as a lubricant for the hands.

Hydrogen peroxid is frequently employed to cleanse suppurating areas. It is a fluid which, when applied to a wound, sets free from ten to fifteen times its volume of oxygen, producing ebullition, and probably destroying the elements upon which bacteria live. It should be kept in a dark and cold place, should ordinarily be used in half strength, and should never be injected into deep sinuses unless a large external opening exists, as the liberated gas may do great harm by pressure. In order to render hydrogen peroxid less irritating, the acid which the manufacturers put into the fluid to preserve it may be neutralized by adding a small quantity of sodium bicarbonate, but only when the peroxid is to be used at once, since the alkali hastens its decomposition.

Permanganate of potassium is used as a deodorizer in foul wounds, sloughing tumors, etc., in the strength of from $\frac{1}{10}$ to 5 per cent. It is used also for disinfecting the hands (saturated solution in water) and as an antidote to snake poisoning. *Condy's fluid* is a 2 per cent. solution in water.

Alcohol is employed chiefly for the preservation of surgical materials, such as sutures, etc., for the disinfection of instruments with keen edges, and to remove fatty material from the skin previous to the application of bichlorid of mercury. *Gasoline, ether, benzin,* and *turpentine* also are occasionally useful for the last purpose.

Formaldehyd is a powerful antiseptic gas, which is sold as a 40 per cent. solution in water, under the name of formalin. It is very irritating, and should rarely be applied to living tissues; some operators employ a 2 per cent. solution for the disinfection of instruments. *Glutol,* or formalin gelatin, is a powder which gives off formalin when brought in contact with wound secretions.

Boric acid (saturated solution in water) is a mild antiseptic, which is indicated when more powerful but more irritating disinfectants cannot be employed. *Thiersch's fluid* is sterile water containing 1 gr. of salicylic acid and 6 gr. of boric acid to the ounce.

Tincture of iodin is now being widely employed for disinfection of the skin previous to operation, as described on p. 43. It is strongly recommended also for the sterilization of infected wounds. It may be applied, full strength, at long intervals, or the wound may be irrigated daily with a 1 per cent. solution. In irrigating large wounds with iodin solution, the possibility of poisoning should be kept in mind.

Iodoform is a yellow powder with a disagreeable smell. It liberates iodin when brought in contact with wound secretions, and so creates an unfavorable field for bacteria; but bacteria may grow upon dry iodoform, so that it must be sterilized for at least five minutes by washing in a 1 to 10,000 bichlorid of mercury solution. It is frequently used as iodoform gauze, or as an emulsion in ether, glycerin, vaselin, or sweet oil. Its chief value is in tuberculosis, owing to its ability to produce fibrous tissue as the result of the irritating action of the iodin. Iodoform sometimes causes a severe dermatitis, and occasionally constitutional symptoms of poisoning. In some cases there is marked gastrointestinal irritation, such as vomiting and diarrhea; in others cerebral symptoms, such as delirium or melancholia; in either case there is fever, yellowness of the conjunctivæ, suffusion of the eyes with contraction of the pupils, a metallic taste in the mouth, an odor of iodoform upon the breath, and iodin in the saliva and urine. A rash upon the skin, rapid emaciation, and nephritis are not infrequent. Many substitutes have been proposed for iodoform, but nothing as efficient for tuberculous cases has yet been created. The odor of iodoform may be made less disagreeable by the addition of one of the aromatic oils. Except in tuberculous cases, the author never uses iodoform and rarely any other antiseptic powder, unless it be *thymol iodid. Powders,* as ordinarily used from a box which is exposed to the air and dust, are laden with germs; hence they are contraindicated in aseptic wounds, and much better means of disinfection may be found for infected wounds. *Acetanilid* when freely used is positively dangerous; cyanosis and collapse may follow, especially in the old, the young, or the debilitated. Smaller doses, frequently applied, as in the dressing of ulcers, may lead to chronic poisoning (anemia, mental hebetude, and congestion of the liver, spleen, and kidneys).

The *salts of silver,* e.g., silver nitrate, lactate (actol), citrate (itrol), collargol, protargol, and argyrol have antiseptic properties. All but the first are proprietary preparations. The indications for these salts will be given in subsequent pages. Silver foil is occasionally applied to wounds.

CHAPTER IV.

SURGICAL TECHNIC.

An operation is performed with greater comfort to the surgeon, and greater safety to the patient, in a hospital than in a private house. A well-equipped hospital is supplied with an anesthetizing room, an operating room, a recovery room, and rooms for the surgeons and nurses to change their clothing. The most essential factor in an anesthetizing room is that it be well lighted, in an operating room that it may be easily and thoroughly cleansed, and in a recovery room that it has some means of immediately summoning aid in an emergency. There are also auxiliary rooms for the sterilization of the material used during an operation, for the storing of instruments, dressings, etc.

Instruments are usually kept in an air-tight glass case, in the bottom of which are small open compartments, containing calcium chlorid for the absorption of any moisture which may gain access to the closet and tarnish the instruments. Instruments should be all metal, with as few corrugations, indentations, and joints as possible, in order to facilitate proper cleaning. They are sterilized by boiling for fifteen minutes, in water to which has been added sodium carbonate, in the strength of 1 per cent. (1½ dr. to the pint), for the purpose of preventing rusting. As ebullition tends to dull sharp instruments, they should be protected by a wrapping of cotton and boiled for a shorter period, chisels and scissors for five minutes, knives and needles for three minutes; or placed in a solution of carbolic acid (5 per cent.), formalin (2 per cent.), or alcohol (95 per cent.), for 30 minutes. These solutions should be used also for instruments with wooden or ivory handles, which are cracked by boiling. Instruments containing lenses, e.g., the cystoscope, are ruined by boiling and by alcohol, hence must be disinfected in a solution of carbolic acid (5 per cent.) or formalin (2 per cent.), all traces of the chemical being removed subsequently by washing with sterile water, particularly if the instrument is to be used in the urethra, or any other situation in which an active germicide might do harm. The sterilizer consists of a copper tray, with a securely fitting lid, and a perforated false bottom with handles; the false bottom prevents injury to the instruments due to the exposure to the direct intense heat on the floor of the sterilizer, and facilitates their removal at the completion of boiling, the bottom being lifted from the sterilizer by means of hooks passed through the handles of the false bottom. After sterilization instruments may be placed in a tray containing sterile water or spread on a dry sterile sheet; in either case they should be covered with sterile towels until the operation is begun. At the completion of an operation the instruments should be scrubbed with soap and water, sterilized, and dried, before replacing them in the closet.

Sutures and Ligatures.—*Silkworm gut*, or fishing gut, is the thread drawn from the silkworm killed when ready to spin the cocoon. It is strong, smooth, readily tied in a secure knot, and is easily sterilized by boiling. In many hospitals it is placed in long glass tubes, which are securely corked, and boiled. It is then ready for instant use, the tube being submerged in bichlorid or carbolic acid solution before being uncorked. With the latter method, however, it is desirable to soak the silkworm gut in boiling water for a few minutes before using, in order to render it pliable. As silkworm gut is not absorbable, it is used only on surfaces from which it may be subsequently removed, and as it stiffens while drying, it is not used in such regions as the axilla, perineum, etc., without shotting, as the ends might occasion discomfort by pricking the tissues.

Silk is plaited, floss, or twisted. It is strong, very pliable, and may be tied in a firm knot. It may be sterilized by boiling in water for a half hour. This diminishes the strength of the silk, however, and a better method is to place the material, wound on glass spools, in a test tube plugged with cotton; the tube is then placed under 10 pounds' pressure in an autoclave for one-half hour, and the process is repeated the following day, and again on the third day (*fractional sterilization*), the theory being that any spores which may have escaped destruction during the first sterilization will have developed into adults by the second or third day, and will then be more easily killed. Silk is extensively used in abdominal surgery for the tying of pedicles and for suturing intestines. It is not absorbable.

Catgut comes from the submucous coat of the sheep's intestine. Being absorbable, it is generally used for ligatures and for buried sutures. After being put into the tissues it swells and tends to become untied, so that it should always be tied in three knots and the ends left at least ⅛ inch long. It may be sterilized by one of a number of different methods; boiling in alcohol, cumol, or xylol, and sterilization by dry heat are efficient, but require special apparatus. The following methods are simple and reliable:

Claudius uses *iodized catgut*. After the raw catgut has been wound on a glass spool it is soaked for eight days in a solution of one part of iodin and one part of potassium iodid in 100 parts of water. Before using it is placed in a 3 per cent. solution of carbolic acid or in sterile salt solution, to remove the surplus iodin. Unused catgut may be replaced in the iodin solution. Catgut thus prepared is absorbed in from 12 to 16 days, according to its size. To render the gut less absorbable, soak it in a 1 to 2000 aqueous solution of chromic acid for 24 hours before sterilization.

Congdon uses a modification of *Hoffmeister's* method; he winds raw catgut on a glass cylinder in a single layer, and places it in a 3 per cent. solution of formalin for from 1½ hours to 4 hours, according to the size of the gut. After it has been washed in running water for the same length of time that it has been in the formalin solution it is dried in the open air and stored away for future use. Catgut prepared by this method may be boiled like silk. When it is desired to have the catgut resist absorption for a longer period, a 5 per cent. solution of formalin is used instead of the 3 per cent. solution, and the gut is left in this solution twice as long as that stated for the 3 per cent. solution; it is then washed in running water for the same length of time that it has been submerged in the formalin solution. By the latter method No. 4 gut will resist absorption for from four to six weeks.

Bartlett's Method.—The catgut is rolled into little coils, which are strung on a thread and suspended in a beaker glass, without touching the sides or bottom, by bringing the ends of the thread through a small opening in a pasteboard cover, which is placed on the receptacle. The same opening admits a thermometer, the bulb of which is on a level with the topmost coils. The catgut is covered with liquid petrolatum, the temperature of which is gradually raised to 212° F. by placing the beaker in a sand bath. After 12 hours the temperature is increased to 300° F. in the course of an hour, and then the oil is allowed to cool. After allowing the superfluous oil to drop from the catgut, the coils are placed until needed in a 1 per cent. solution of iodin in Columbian spirits. This method, as modified by *Lee*, is employed in the Pennsylvania, Jefferson, and Germantown Hospitals. Lee drys the gut in a dry air sterilizer, at 100° C., for 15 minutes, then covers it with liquid petrolatum and raises the temperature to 140° C., where it is maintained for 15 minutes. At the end of 12 hours the temperature is again raised to 140° C. and there kept for 15 minutes. The gut is preserved in a $\frac{1}{16}$ per cent. solution of iodin in alcohol (95 per cent.).

Kangaroo tendon is obtained from the tail of the kangaroo, and may be prepared in the same manner as catgut. When chromicized it may not be absorbed by the tissues for two months. It is used for suturing bone, or when an absorbable suture which will last a long time is desired.

Some surgeons employ living *strips of fascia* from the margins of the wound which they desire to close.

Silver wire may be used for suturing bone; care should be taken in twisting the ends of the wire, lest it break. Although silver wire is said to have antiseptic properties, it frequently causes suppuration and sinus formation when allowed to remain in the tissues for a long time, and should very rarely be used except for the indication just mentioned. *Iron wire* has been recommended as a substitute for silver wire in bone work, as it is not so easily broken; *aluminum bronze wire*, which, unlike silver or iron, is ultimately absorbed, has been utilized for the same purpose; these wires may be sterilized by boiling.

Horsehair may be used for the nice approximation of skin where there is no tension; it may be boiled in water.

Pagenstecher's celluloid thread is linen thread impregnated with celluloid; it has the advantages of silkworm gut, as well as great flexibility. When placed in the tissues it absorbs a large quantity of fluid but does not soften.

Dressings are commonly made of cheesecloth, or gauze. Cotton or any material, however, which will absorb fluids and which may be sterilized, may be used for this purpose. The sizing should be removed from cheesecloth by boiling in a solution of carbonate of soda, but in the material coming from a surgical house this process has already been effected. The material is cut into suitable lengths for various operations, folded, and wrapped in covers of drilling or heavy muslin, which are secured by a pin. These packages are sterilized under 10 pounds' pressure for forty-five minutes, and are kept in covered, sterilized glass jars until required. Antiseptic dressings are prepared by soaking gauze in solutions of various antiseptics.

"Sponges," in surgical parlance, are small pads of gauze. They are put up in packages, each of which contains a definite and an invariable number of pads, usually 10 or 12, so as to facilitate counting at the time of operation. For intraabdominal work large gauze pads, six or more inches square, consisting of six layers of gauze, are employed to isolate the field of operation. To one corner of each pad is sewed a piece of tape, which emerges from the wound and is secured by a hemostat, in order that it shall not be forgotten. A better plan is to prepare a pad four yards long, six inches broad, and four layers in thickness; as much of this as may be necessary is packed into the abdomen. The gauze is then cut and the end allowed to protrude from the wound, and it is definitely known that but one piece of gauze is within the abdomen. All of these pads, as well as gauze drains, should, in order to prevent the detaching of loose threads, be folded, or folded and sewed, in such a way that the raveled edges of the gauze do not come in contact with the wound; and all are sterilized and preserved like dressings.

Iodoform gauze is prepared by mixing 4 ounces each of iodoform, glycerin, and alcohol, and 5 gr. of bichlorid of mercury; sterile gauze is soaked in this mixture, allowed to drip till almost dry, and then stored in covered, disinfected glass jars.

Caps, gowns, sheets, and towels, are sterilized with the gauze. Basins, pitchers, instrument trays, scrubbing brushes, and glass drainage tubes may be boiled, or soaked in 1 to 500 bichlorid of mercury solution. Articles made of hard rubber, such as pessaries, syringe nozzles, etc., should be washed with soap and water, and disinfected in a 1 to 500 bichlorid of mercury solution. Soft rubber, e.g., drainage tubes, catheters, etc., should be boiled in plain water for five minutes, and stored in bichlorid of mercury solution. Varnished catheters may be sterilized in formalin vapor. Instruments containing leather, such as the hypodermatic syringe, are sterilized by soaking in a solution of carbolic acid. Hypodermatic syringes with glass or asbestos pistons may be boiled and are much safer, from a bacteriologic standpoint, than the older variety. Lister's oiled silk, rubber tissue (thin sheets of gutta-percha), rubber dam, and wax or paraffin paper are sterilized, after washing, by soaking in bichlorid of mercury solution. As heat shrivels rubber tissue, care should be taken to have the solution cool. Silver foil is sterilized by dry heat. Cargile membrane is made from the peritoneum of the ox, is used as a protective, and comes already sterilized.

Physiologic or normal salt solution ($\frac{6}{10}$ per cent., or 1 dr. of salt to the pint of water), called physiologic or normal because it is isotonic with the blood serum, is filtered into clean glass flasks, which are plugged with cotton and then boiled. Perhaps, in view of the recent observations concerning the harmfulness of the proteid products of dead organisms in old water, it would be well to insist that salt solution, at least when it is to be used hypodermically or intravenously, be made from freshly distilled water.

Water, too, must be filtered as well as boiled. In hospitals the water-sterilizer outfit consists of two reservoirs, one for hot and one for cold water. Each has a filtering attachment. The water is boiled for 20 minutes, under a pressure of 15 pounds (240° F.). The faucets, when not in use, must be covered with sterile gauze.

The **surgeon,** the **assistants,** and the **nurses** should bathe daily, keep the teeth in good order, and not come in contact with contagious diseases. No one with acute tonsillitis, or an infected wound or furuncle on the hands or forearms, should take part in an operation. The surgeon should guard his hands from the grosser forms of contamination at all times; he should never open an abscess or dress suppurating wounds without wearing rubber gloves, and he should put on a rubber glove before making a rectal or a vaginal examination. He should avoid carrying heavy bags, restraining a patient who is being anesthetized, and lifting a patient from the litter to the operating table, lest his hands tremble during the operation. At the time of operation the surgeon, the assistants, and the nurses should wear sterile suits of duck or linen, and have the hair covered with sterile caps or gauze. Most surgeons use a gauze mask to prevent soiling of the wound by the shower of saliva which accompanies talking.

There are three methods frequently employed for the *disinfection of the hands,* the first step of each consisting in thorough scrubbing of the hands and forearms, up to and above the elbows, with soap and hot water, which is frequently changed. The brush should have been sterilized by boiling just before use, and special attention should be given to folds and creases, and to the spaces beneath and around the nails. The nails should be trimmed, the subungual spaces cleansed with a nail cleaner, and the scrubbing continued, according to different surgeons, for from five to fifteen minutes. The longer period is preferable, and should invariably be timed by the clock. Rings and bracelets must, of course, be removed before the hands are disinfected.

In the *Furbringer method*, after step one, the hands are scrubbed in absolute alcohol for one minute, then soaked and scrubbed in bichlorid of mercury solution 1 to 1000 for at least one minute, special attention being given to the nails. Many surgeons now dispense with the bichlorid wash and scrub the hands in 70 per cent. alcohol for five minutes. Absolute alcohol is less bactericidal, as it coagulates albumin, thus interfering with its penetration.

In the *Kelly method*, after step one, the hands are soaked in a saturated solution of potassium permanganate until the skin is stained a dark brown color; the skin is then decolorized by washing in a saturated solution of oxalic acid; next the acid is removed by sterilized lime water; and finally the hands are scrubbed for one minute in bichlorid of mercury 1 to 1000.

In the *Weir* or *Stimson* method, after step one, a heaping teaspoonful of chlorid of lime and the same quantity of sodium carbonate are placed in the palm of the hand, and made into a thick cream by the addition of water; this is rubbed over the hands and forearms, and around and under the nails, for from three to five minutes. The hands are now washed in sterile water or in dilute ammonia solution, to remove the odor of chlorin. After disinfecting the hands a sterile gown with sleeves reaching the wrists should be put on.

As absolute sterility of the hands cannot be secured, most surgeons, after employing one of the methods given above, use *rubber gloves*. Rubber gloves are sterilized by washing with soap and water, and boiling in a 1 per cent. solution of sodium carbonate for fifteen minutes. They are drawn on the hands while filled with sterile water, or by using glycerin as a lubricant, or they may be dried, and slipped on with ease after the interior has been dusted with sterile talcum. Oil should not be used for lubrication, as it injures the rubber. The cuffs of the gloves should be turned down before sterilization, and in putting the gloves on the surgeon should seize the cuff of the left glove at its point of reflection, pull the glove on the left hand, and then insert the fingers of the left hand beneath the reflected cuff of the right glove and so adjust it; the cuffs are then turned back over the sleeves of the gown; thus the bare fingers never come in contact with the outside of the gloves. Gloves, however, are not ideal; they impair sensation, necessitate very firm pressure in holding a slippery structure like the intestine, and tend to make an operator slovenly in the disinfection of his hands; they also cause perspiration, thus washing from the deeper layers of the skin bacteria, which gain entrance to the wound through punctures and tears in the gloves, an accident which demands a fresh glove, after washing the hand in bichlorid solution.

The Patient.—For preparation for anesthesia see section on anesthesia. The dangers common to all operations are those of anesthesia, hemorrhage, shock, and infection. Special dangers of individual operations receive mention with the description of the various operations. Whenever possible the patient should be under observation for at least two days before operation, in order that the patient himself, as well as the disease, may be carefully studied.

The history is taken, and a thorough examination, especially of the heart, lungs, urine, and blood, is made. The diet should be free of vegetables and consist principally of albumins, in order to leave little residue in the intestines, which are cleared by laxatives, usually calomel, gr. $\frac{1}{8}$ every hour for eight doses, followed by magnesium sulphate, oz. $\frac{1}{2}$. This prevents autointoxication, and in abdominal work renders the intestines docile, so that they may be kept from the operative field by gauze packing. Before operations on the mouth, esophagus, and gastrointestinal tract the number of bacteria in the alimentary canal may, aside from purgation, be diminished by removing carious teeth and tartar, frequently rinsing the mouth with an antiseptic wash, and sterilizing all food. Hexamethylenamin, because of its antiseptic effect upon the bile, the urine, and the cerebrospinal fluid, may be administered previous to, as well as after, operations involving the biliary tract, the urinary apparatus, and the central nervous system. The patient is given a daily soap and water bath, and should, in order to prevent "colds," wear an undershirt in bed, if so accustomed.

The day before operation the part to be operated upon is shaved, and then, after disinfection of the hands, it is surrounded with sterile towels, and thoroughly scrubbed with soap and water, using a sterile brush with soft bristles, or a piece of gauze if the skin is tender. Special attention is given to folds and creases in the skin, and to such places as the umbilicus. It is important to scrub not only the immediate region of the proposed wound, but also neighboring regions, e.g., for a brain operation, not only the head, but also the neck and ears, and for a breast amputation, not only the breast, but also the neck, axilla, arm, opposite breast, and the upper part of the abdomen. For an abdominal operation the disinfection should extend around to the spine, up to the breasts, and down to the pubes, including the upper part of the thighs; for a gynecological operation it is necessary to disinfect also the vagina. After scrubbing with soap and water, the skin is rubbed with alcohol (70 per cent.), in order to dissolve the sebaceous matter and fat in the mouths of the glands, and thus clear the way for the bichlorid of mercury solution, 1 to 1000, with which the part is next scrubbed. In children, in adults with sensitive skins, as well as on the scalp, a 1 to 2000 solution should be employed. With hard and filthy skin, such as is often found on the feet, a soap poultice, made by soaking a thick pad of gauze in soap suds, should be applied for many hours before the disinfection. Gauze soaked in bichlorid of mercury (1 to 2000) and covered with waxed paper, or, better, a dry sterile dressing, is applied to the disinfected region until the time of operation, when the whole procedure is repeated. Some surgeons omit the preliminary scrubbing, others claim that the scrubbing at the time of operation is objectionable, in that it uncovers bacteria in the skin by loosening fresh layers of epidermis; an increasing number are painting the skin with tincture of iodin (3 per cent.) the day before and again at the time of operation. Grossich, the originator of the iodin method, removes the hair immediately before operation by dry shaving, claiming that water swells the superficial layers of the epidermis and interferes with penetration of the iodin; he then applies, without preliminary scrubbing, the official tincture of iodin, which is allowed to dry spontaneously. Iodin is an admirable antiseptic which penetrates the epidermis and fixes the bacteria in the skin. Its disadvantages are that it may produce irritation of the skin of the patient and the eyes of the operator, and that it may cause intraperitoneal adhesions after laparotomies in which the viscera are brought out on the abdominal wall.

The last objection loses its force if the skin is completely covered with towels during the operation. The *ear* may be sterilized by prolonged syringing with a carbolic solution, 1 to 100, or with a bichlorid of mercury solution, 1 to 2000; the *nose* by spraying with Dobell's solution, followed by carbolic acid, 1 to 100; the *mouth* by having the teeth put in order and tartar removed by a dentist, and by the use of a good tooth powder and brush several times a day, followed by a thorough rinsing with a carbolic acid solution, 1 to 100; and the *bladder* by irrigation with potassium permanganate, 1 to 5000, argyrol, 1 to 1000, or by a saturated solution of boric acid. The *vagina* is scrubbed with a piece of gauze, with soap and water, then copiously douched with bichlorid of mercury solution, 1 to 4000. The *rectum* may be cleansed of fecal matter by an enema of soap and water, then irrigated with creolin, 1 to 3 per cent.

A nervous sedative may be administered the night preceding operation, if the patient is unable to sleep. No food should be given for at least six hours before operation, in order that the stomach may be empty and that vomiting may not occur. Several hours before operation the rectum should again be cleansed by a soap and water enema, 1 pint, so that any stimulating or nutritious fluids may be absorbed in case their injection becomes necessary. Immediately before operation the patient should pass urine or be catheterized, so that voiding will not occur on the table, so that there will be no danger of injury to the bladder in an abdominal operation, and so that the surgeon will know the exact quantity of urine secreted subsequent to operation. Before going to the operating room, those parts of the chest, abdomen, and limbs which are not to be operated upon, should be covered with a sterilized shirt, leggings, etc., to protect the patient from draughts.

In an emergency in which the patient is admitted immediately before the operation, the same precautions regarding the bladder and rectum should, as a rule, be observed. The disinfection is usually made by the process given above, after the patient has been anesthetized. In cases of intestinal obstruction it is of the greatest importance to wash out the stomach previous to anesthetization, to prevent suffocation by the large quantities of fetid fluid which are regurgitated while the patient is unconscious. In accident cases in which machine grease and dirt cover the part, cleansing is greatly facilitated by the previous application of sweet oil.

The Operation.—In all "clean cases," and even in septic cases in the cranium, chest, abdomen, and joints, the surgeon performs an *aseptic operation*, i.e., the preparations mentioned above are carried out, but after the incision has been made no antiseptics are used, sterile water or salt solution being employed for irrigating the wound, and sterile, not antiseptic, gauze being used to dress the wound. In septic and emergency operations not involving the cavities just mentioned, the surgeon may perform an *antiseptic operation*, i.e., antiseptics are used, not only in the preparation of the patient, but also to flush the wound, and antiseptic gauze is used for dressings.

The operating table is covered with a blanket wrapped in a sterile sheet; in special cases an electric mattress or a number of hot water bags are used to maintain the heat of the body. When the patient is placed on the table, care should be taken that the arms are properly disposed. If the arm is allowed to hang over the edge of the table, if the patient is allowed to lie on the arm twisted under the back, or if the arms are stretched far above the head for a prolonged period, an annoying paralysis may result. If the arms rest alongside of the patient, there is, with some operating tables, danger that they may be injured when the patient is lowered from the Trendelenburg posture, or when the stage for arching the spine forwards in biliary operations is elevated or lowered. In cases not involving the chest or upper abdomen the arms may be folded across the chest and secured by turning back the shirt. In operations on the upper abdomen the arms should be elevated not higher than a right angle with the body and the hands secured above the head. Never should the arms be so tied that they may not be readily freed for the purpose of artificial respiration should it suddenly become necessary. After the part to be operated upon has been exposed by a nurse whose hands are not disinfected, the surgeon's assistant places sterile towels over the adjacent clothing, and redisinfects the part by the process already given. All the clothing of the patient is now covered by fresh sterile sheets or towels. It is our custom, as soon as the incision is made, to fasten sterile towels to the fascia or, in an abdominal operation, to the peritoneum with catgut sutures, thus excluding the skin completely from the operative field. In order to avoid fatigue of the eyes and, especially in class work, bring the operative field into greater relief, we employ, following the advice of Sherman, black, instead of white, sheets and towels. In operations about the face or neck the hair should be covered by a sterile rubber cap or a sterile towel. In operations approaching the nose and mouth it is important also that the anesthetizer disinfect his hands, wear a sterile gown, and use a sterile piece of gauze, a cone wrapped in a sterile towel, or a vaporizing apparatus, for the anesthetic. As a rule one assistant is sufficient for almost any operation; the fewer hands that come in contact with the wound the less the danger of infection. At least three nurses are commonly on duty during an operat'on; one nurse attends to the sutures and ligatures, a second takes care of the sponges and dressings, and a third, "dirty nurse," exposes the field of operation, assists the etherizer, gets additonal instruments that may be called for, and does whatever else may be necessary that one with disinfected hands cannot do. Before and after operations involving the abdomen or other large cavity, not only sponges and pads, but also instruments and needles, should be carefully counted, to make sure that none has been left behind.

Incisions should be clean-cut and of equal depth throughout. The way the knife is held to make incisions is illustrated in Figs. 12 to 17. Tearing the tissues by blind and blunt dissection should be avoided as much as possible, as bruising is more likely to be followed by suppuration. Large blood vessels should be caught with hemostats, or ligated, before division; vessels too small to be recognized quickly should be caught as soon as divided, the forceps grasping not a large amount of tissue, but the bleeding point alone. Under no circumstances should the skin be crushed with hemostatic forceps. The assistant keeps the wound free of blood, not by scrubbing, but by quickly mopping with a gauze sponge. As soon as an instrument has been used, it should be washed in sterile water and replaced in the instrument tray. At frequent intervals during the operation the hands should be washed in sterile water. When the towels surrounding the field of operation become soiled, they should be replaced or covered by fresh ones. Sometimes during the operation, and often at its completion, it is desirable to flush the wound with hot sterile water or normal salt solution, to free it from blood clots and mechanically disinfect it. At this time it will be found that the smaller vessels which have been clamped do not bleed after removal of the forceps. Larger vessels should be ligated with catgut; torsion is not, as a rule, a satisfactory method for dealing with these vessels. If the bleeding has not been stopped, clots will accumulate and infection be favored. The deeper layers of the wound are brought together with catgut sutures, the skin with silkworm gut (see wounds).

Drainage is not required in an aseptic wound treated by the aseptic method,

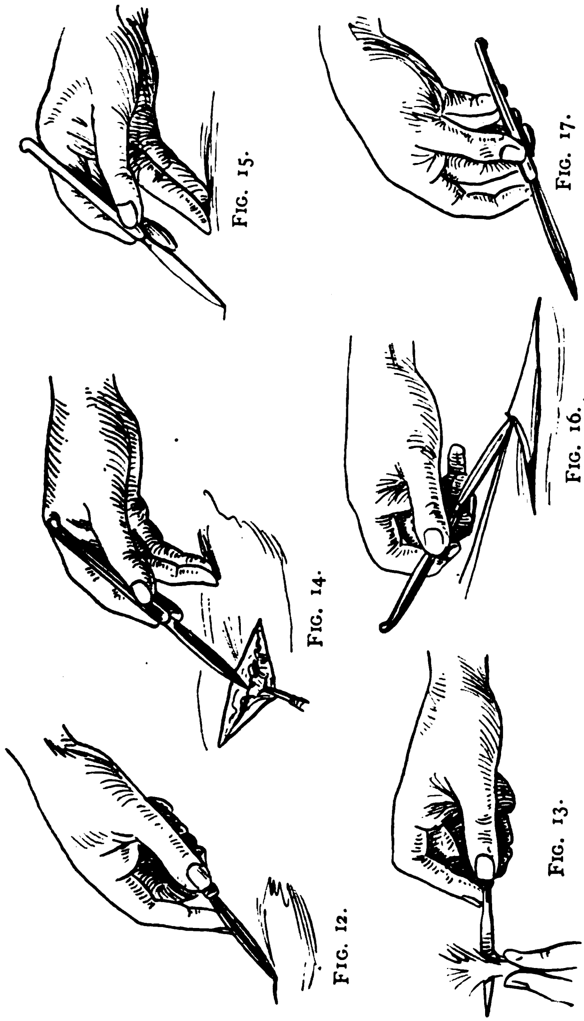

FIG. 12. FIG. 13. FIG. 14. FIG. 15. FIG. 16. FIG. 17.

In Figs. 12 and 13 the scalpel or bistoury is held like a table knife, thus giving great force and solidity to the movements; in Figs. 14 and 15, like a writing pen, in order to make light and precise incisions, and in Figs. 16 and 17, like a violin bow, for delicate and careful dissections. (Bernard and Huette.) In some amputations the knife is held like a sword.

if hemorrhage has been carefully controlled. If there is infection, if strong antiseptics have been used, if there is still some bleeding, if many large lymph vessels have been severed (e.g., as in the modern operation for carcinoma of the breast), or if it is feared that sutures put in a hollow viscus may not hold, drainage must be instituted. Drainage may be effected by rubber, silver, or glass tubes; by strands of catgut, horsehair, or silkworm gut; or by strips of gauze or rubber tissue. In order to prevent its adhering to the tissues, gauze may be surrounded with rubber tissue (cigarette drain), or impregnated with glycerin, vaselin, or an antiseptic ointment. Rubber tissue and ointments, however, are at first contraindicated if the gauze is to drain a septic lesion within the abdomen, in which the principal function of the gauze is, at least for a few days, to promote adhesions and so isolate the infected area. The writer, particularly in abdominal cases, frequently employs the Mikulicz drain. This consists of a thin gauze bag, filled with a separate strip of gauze, which may be removed and the cavity irrigated without disturbing the bag. The bag remains in place until it is loose. Vaselinized gauze is then employed to keep the tract open. A drain should, whenever possible, be placed in the most dependent part of a wound or cavity. In women the peritoneal cavity may often be drained through the vagina, thus permitting closure of the abdominal wound as well as facilitating the discharge. The *objections to drainage* are that it delays union, produces a wider scar, invites infection, encourages adhesions, and in abdominal cases predisposes to hernia and, because of adhesions, to intestinal obstruction; drain tubes may ulcerate into large blood vessels and cause secondary hemorrhage, or induce pressure necrosis of the intestine and fecal fistula, hence should rarely be used in the vicinity of the major arteries or veins, or in the free abdominal cavity. A copious dressing of sterile gauze is now applied, and maintained in place by suitable bandages. Occasionally in septic cases it is desirable to use antiseptic, instead of sterile, gauze.

After Treatment.—The patient is put into a warm bed with no pillow, and the head turned to one side, so that in case vomiting occurs, there will be less danger of the vomited material falling into the trachea. In all cases a physician or a nurse should remain with the patient until he has fully recovered from the effects of the anesthetic. *Shock*, if present, should be combated at once. If there is non-obstructive *retention of urine* and it is deemed inadvisable to allow the patient to get out of bed to make an effort to micturate, heat may be applied to the hypogastrium or warm water poured over the external genitals. Spontaneous urination, according to Franck, often follows, within 20 or 30 minutes, the injection of from 15 to 20 cc. of glycerin into the bladder through the urethra, without the aid of a catheter. If this "bladder laxative," which should not be used if there is acute cystitis or urethritis, fails, a catheter may be passed every eight hours. The treatment of retention due to obstructive lesions is given in Chap. XXIX. As a rule, even in abdominal cases, small quantities of water may be given as soon as the post-anesthetic nausea has disappeared. *Continued vomiting*, especially after abdominal operations, is an ominous sign (see "after effects" of anesthesia). For *thirst*, when water cannot be taken by the mouth, an enema of 8 oz. of salt solution may be given every four or six hours. In the few cases in which rectal injections actually cause nausea, they should of course be discontinued, and the salt solution given beneath the skin. The practice of leaving a large quantity of salt solution in the abdomen after celiotomy prevents thirst and favors elimination. *Pain* should be treated, whenever possible, by removing the cause, e.g., by loosening tight bandages, relieving tympanites, opening an infected wound. Analgesics should not be administered without investigation to determine the reason for the pain. If the cause cannot be found or removed and the suffering is great, the only remedy of value is morphin, which, however, must be used with great caution. Nurses should be warned never to rub a leg which becomes painful after an operation without the advice of a physician, as the pain may be due to phlebitis, in which event massage might liberate emboli. *Nervousness* may be allayed by the bromides, given per rectum if oral administration is contraindicated. *Insomnia* not due to pain is treated by hypnotics like trional and sulphonal. *Fever* after operation is considered in Chap. XII. The character of the *pulse* furnishes a surer index of the patient's condition than the temperature. Especially during the first twenty-four hours one should watch for the symptoms of *hemorrhage* (q.v.). *Backache* may be due to renal congestion, muscle strain, or distension of the colon, hence may be relieved by hot applications, increasing the urinary output, support to the back, or by securing a movement of the bowels. As soon as the stomach has become quiet, and usually at the beginning of the second day, the patient is given 1 gr. of calomel in divided doses, followed in one hour by magnesium sulphate, oz. ½. If the *bowels* do not move three or four hours later, an enema of soap and water, 1 pint, is given. If this is ineffectual, an enema consisting of magnesium sulphate 1 oz., glycerin 1 oz., turpentine ½ oz., and soap and water 1 pint, may be tried. An enema consisting of alum 1 oz., in a pint of water, is also highly efficient. The passage of a rectal tube up into the sigmoid flexure, or the administration of asafetida suppositories, grains v, every three hours, will often be followed by the expulsion of gas. These measures are of special importance after an abdominal operation, particularly when the constipation is associated with tympany and vomiting, which often indicate a beginning peritonitis or intestinal obstruction (Chap. XXVII). Symptoms of *sepsis* usually come on in from two to five days after operation; for the symptoms and treatment the reader is referred to the chapters on suppuration and fevers, and to the sections on regional surgery. After the bowels have moved the patient begins to take liquid *food* in small quantities, and as convalescence progresses the quantity is increased; semi-solid food follows, and finally the regular diet is reached. The *dressings* are changed when they become soiled with wound fluid, or with discharges from the mouth, rectum, or urethra; when it is desirable to remove drainage or stitches; and when there are signs of suppuration. They should not be disturbed unless there is some definite indication, as exposure of the wound always involves some risk of infection. If a *drain* has been used because of hemorrhage, it may be removed at the end of twenty-four or forty-eight hours, and not replaced. Drainage for infection usually demands frequent dressings. The *stitches* may be removed in a week or ten days, according to the amount of support needed. A *stitch abscess* usually makes its appearance in from five to ten days; it requires the removal of the stitch and drainage of the abscess cavity. The sequelæ of special operations are considered with the various operations.

Operation in a Private House.—Excepting an emergency, the proposed operating room should be carefully prepared. It should be well lighted, and heated by steam, hot water, or hot air; there should be no exposed fire to provide dust, or to ignite the ether if such be used. A bath room with hot and cold water should be convenient, but there should be no plumbing in the room itself. Everything which is not necessary for the operation should be removed from the room, including curtains, shades, and carpets. Wood work and painted walls should be scrubbed with soap and water; papered walls may be rubbed down with bread. At the time of operation the temperature of the room should be at least 70° F. The windows may be smeared with soap to discourage inquisitive neighbors. If the room is heated by hot air, the register should be covered by a moist towel in order to catch the dust.

In an emergency carpets and furniture should be covered with clean sheets or linen, and under no circumstances should dust be stirred up. It is convenient to have in the room the following articles: Kitchen-table, dining-table, bureau or table, wash-stand or table, another small table, four wooden chairs, several clean blankets and sheets, at least a dozen clean towels, two basins, a large pitcher of warm water, and a bucket or slop jar. The kitchen-table serves for the operating table. Very often this will prove to be too short, and a smaller table will have to be placed at either end for the patient's head or feet. Beneath the table should be spread a sheet of mackintosh or oilcloth, or a number of papers, for the protection of the floor, and alongside of the table should be placed the bucket or slop jar. The dining-table may be used for instruments, sutures, and sponges; the bureau for extra supplies, splints, etc.; the wash-stand with the two basins for scrubbing the hands. The etherizer sits on one chair and uses a second for his hypodermatic syringe and other necessities; on the third chair is placed a basin containing sterile water for the assistant; the fourth chair is used by the operator to sit upon in perineal cases, or when inverted, to put under the patient, if the Trendelenburg position is found necessary. Previous to operation, two wash-boilers, half or three-quarters full of water, should be provided; in one is placed a pitcher, three basins, and a sheet. The water in each is boiled for a half hour, and that in the boiler containing the pitcher, etc., allowed to cool without removing the lid. The water in the second wash-boiler is kept hot. The water from a kitchen boiler is sterile, and may be used, providing the pipes are first thoroughly flushed. The instruments may be taken to the house in a copper sterilizer, and, after boiling, both the sterilizer and its lid may be used as trays for the instruments and sutures. The operating table is covered with a blanket and a sheet, and over this is put a Kelly pad or a piece of rubber sheeting, which drains into the bucket or slop jar. While the surgeon is sterilizing his hands, the patient is anesthetized in an adjoining room. After the hands have been sterilized, a sterile gown is put on, and the sheet is removed from the boiler, wrung out, and spread over the dining-table; on this is placed the sterilizer and the two basins from the boiler, in one of which is put sterile water, and in the other bichlorid of mercury solution. The instruments, sutures, sponges, and dressings are arranged on the dining-table in the order in which they will be needed. The patient is carried into the room by the etherizer and a member of the family, so that neither the surgeon nor his assistant will soil the hands. The assistant sterilizes his hands with the surgeon, puts on a sterile gown, scrubs the patient, and redisinfects his hands while the surgeon applies the alcohol and bichlorid of mercury. A towel should be soaking in the bichlorid of mercury solution, so that if, in an emergency, it is necessary to handle some unsterilized object, the towel may be used and the hand saved. It is better to have caps, gowns, sheets, towels, and dressings sterilized at the surgeon's office or hospital and sent to the patient's house, as boiling them at the house previous to operation necessitates the use of wet materials. One of the great inconveniences in operating in a private house is the forgetting of some instrument that is needed, or the wanting of some instrument or appliance to meet an unexpected condition which has arisen. For this reason it is a good plan to have a list of the different instruments, etc., which may be needed in various operations, to check these off as they are packed into the hand-bag, and to be prepared for any possible emergency. The following articles may be needed in any operation: Anesthetic, mouth-gag, tongue-forceps, hypodermatic syringe, strychnin, atropin, adrenalin, tracheotomy tube, razor, soap, nail-brush, lubrichondrin or other sterile lubricant, alcohol, catheter, carbolic acid, bichlorid of mercury tablets, glass syringe, caps (towels or gauze may be used for this purpose), gowns (sterile sheets will do in an emergency), gloves if they are used, dressings, sponges, bandages, sterilized towels and sheets, adhesive plaster, two scalpels, tissue forceps, hemostatic forceps, probe, two pairs of scissors, needles, needle holder, aneurysm needle, retractors, curette, drainage tubes, silk, catgut, silkworm gut, safety pins, Kelly pad, instrument sterilizer, and an infusion apparatus. Special instruments that may be needed in various operations are mentioned in connection with the operation in subsequent pages. The after care of a patient in a private house differs in no way from that in a hospital. It is essential that, in an emergency, the nurse or caretaker have some means of immediately communicating with the surgeon; there should be a telephone in the house, or the nurse should know where the nearest one is situated. The bed room should have been thoroughly cleansed previous to operation, and the following articles should be handy: Pillows, blankets, sheets, mackintosh spread, hot water bottles or bags, towels, dressings, bandages, bed-pan, urinal, feeding-cup, medicine measure, temperature chart and note book, carbolic acid or bichlorid of mercury, ice, enema syringe, catheter, hypodermatic syringe, strychnin, atropin, and morphin.

CHAPTER V.

BANDAGES.

Bandages are employed to hold dressings or splints in place, to exert pressure, and to maintain parts in position after the correction of deformity.

Various kinds of **material** may be employed. *Muslin* is strong and cheap. *Flannel* is soft and elastic and adapts itself uniformly to uneven surfaces; it is used principally for eye and abdominal bandages, and as a primary roller beneath plaster-of-Paris. *Gauze* is light, and readily adaptable to the various parts; it is applied without making reverses, and is less liable to displacement than muslin. *Rubber* is used when firm pressure is desired. *Plaster-of-Paris, silicate of soda, starch*, etc., are used when absolute immobility is demanded.

The roller bandage has a body, an initial and a terminal extremity, an inner and outer surface, and an upper and lower edge. In preparing a muslin roller bandage the material is torn into strips, the selvage removed, and one end folded repeatedly until a small cylinder is formed. This is held between the thumb and index finger of one hand, with the body underneath, while the free extremity passes between the thumb and index finger of the other hand, with the thumb above. By pronating and supinating both hands and making tension, the free portion of the bandage is wound tightly and evenly; a loosely rolled bandage is not easily applied. By the use of a machine, bandages can be rolled better and more quickly. After winding, the remaining selvage is removed and the end folded under and pinned.

A part is bandaged in the position in which it is to be retained; a bandage applied to a limb in extension will be too tight when the limb is flexed. one applied in flexion will become loose during extension. It should be applied neatly and with uniform firmness; if too tight, it will cause pain, perhaps inflammation, or even gangrene; if too loose, the dressing will soon become displaced. Bony prominences and tender points should be padded, and apposed skin surfaces separated by lint or cotton. To begin a bandage, apply the outer surface of the initial extremity to the part at its smallest diameter, and hold it with the left hand until fixed by a few turns of the roller. The terminal end is secured by pinning it in such a way that the point will be concealed, and will not enter the tissues when the part is moved, by splitting the bandage and tying the two ends around the part, or by encircling the part with a strip of adhesive plaster. A bandage is removed by cutting with blunt pointed scissors, or by gathering the folds in a loose mass as it is unwound.

Varieties of Bandages.—The *circular* bandage (Fig. 18) is applied transversely to cylindric parts. The *oblique*, or *rapid spiral*, is applied in ascending turns, between which there are uncovered spaces. The *spiral* bandage may be *ascending or descending*, each successive turn overlapping a portion of the preceding one. The *spiral reversed* bandage (Fig. 19) is used on parts which are conical in shape. After fixing the initial extremity, the body is carried off obliquely for four or five inches, the applied turn held by the thumb of the left hand, the portion of bandage between the hands slackened, the right hand holding the body of the bandage changed from extreme supination to pronation, and the bandage passed around the limb and drawn firm. The reverses should be in line, and should not be made over bony prominences, lest they cause discomfort. The *figure of* 8 *bandage* (Fig. 20) consists of two loops of bandage forming a figure of 8, and is used to cover projecting parts, such as the elbow and knee in flexion. When a number of turns are made, each one higher than the preceding one, they form what is called a *spica bandage* (Fig. 48). The *recurrent* bandage (Fig. 23) is used for amputation stumps, the top of the head, or the end of a finger. It is applied by fixing the initial extremity by circular turns, making reverses over the end of the part until it is covered, and then terminating by a few spiral or spiral reversed turns.

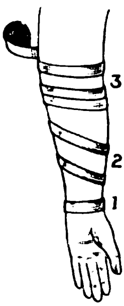

FIG. 18.—1. Circular turns. 2. Oblique turns. 3. Spiral turns.

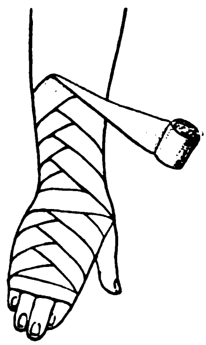

FIG. 19.—Spiral reversed of the forearm.

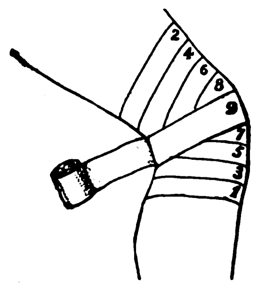

FIG. 20.—Figure of 8 of knee.

Tailed bandages are made from strips of muslin, which vary in length and width according to the part to be covered. Each end is torn into two or more pieces up to within a few inches of the center.

Handkerchief bandages are made of handkerchiefs or other pliable material, and are especially useful in emergency cases. A hankerchief folded squarely across the middle forms a *rectangle*, diagonally a *triangle*, and when rolled loosely it forms a *cravat*.

BANDAGES OF THE HEAD.

Barton's Bandage (Fig. 21).—6 yards x 2 inches. Place the initial extremity of the bandage just beneath the occipital protuberance, carry the roller obliquely upward under the right parietal eminence, across the vertex, downward over the left zygomatic arch, under the chin, upward over the right zygomatic arch, over the top of the head, crossing the first turn in the median line, downward and backward under the left parietal eminence to the starting point, forward under the right ear, around the front of the chin, and back again to the starting point. Three complete turns, each exactly covering the other, are thus made, and a pin inserted at each crossing point. The bandage is employed in fractures and dislocations to fix the lower jaw. Great care must be exercised in the application of any bandage to the jaw or neck, especially in unconscious patients, as it may interfere with respiration or the escape of vomited material.

Gibson's Bandage (Fig. 22).—6 yards x 2 inches. Place the initial extremity upon the vertex, pass downward in front of the left ear, under the chin, and up in front of the right ear to the point of starting. Repeat this turn twice. On arriving at the right temple for the third time, reverse the bandage and carry it horizontally around the head from forehead to occiput.

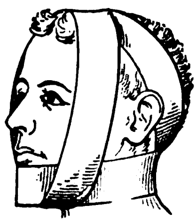

FIG. 21.—Barton's bandage.

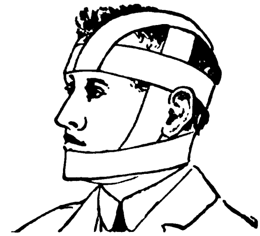

FIG. 22.—Gibson's bandage.

On arriving above the left ear for the third time, drop the bandage downward and carry it around the nape of the neck, under the right ear, around the front of the chin, and back beneath the left ear to the nape of the neck. Repeat this turn twice, and then, after pinning the bandage, make a reverse over the top of the head in the median line. Insert a pin at each crossing point. This bandage is used for the same purposes as, but is less secure than, the Barton bandage

Oblique of the Jaw.—6 yards x 2 inches. If the left jaw is to be bandaged, place the initial extremity above and in front of the right ear, and pass around the forehead from your left to right, applying two horizontal turns from forehead to occiput; on arriving above the left ear, pass down obliquely across the back of the neck, forward under the right ear, under the chin, up over the left side of the face at the edge of the orbit, obliquely over the vertex, down behind the right ear, under the chin, and up over the affected side, where each turn overlaps the preceding one from the orbit to the ear. Behind the right ear the turns overlie each other. On arriving above the right ear with the last turn, the bandage is reversed and terminated as it was begun by encircling the head from forehead to occiput. If the right jaw is to be bandaged, substitute right for left, and left for right, in the above description. This bandage is used for the retention of dressings to the parotid region and angle of the jaw.

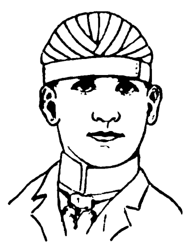

FIG. 23. Recurrent of head.

Recurrent of the Head (Fig. 23).—6 yards x 2 inches. Beginning at the right temple two horizontal turns are applied; from the center of the forehead, where the bandage is pinned or held by an assistant, it is reversed over the head in the median line to the occiput, where it is held, and brought back to the forehead covering one-half of the median turn. It is then carried back and forth from the center of the forehead to that of the occiput, alternately on each side of the median line, each turn covering two-thirds of the preceding turn. The bandage is completed by two horizontal turns. It may be made more secure by a turn passing under the chin, or by a cap with bands fastened under the chin. Instead of longitudinally, the recurrent turns may be applied transversely.

Crossed Bandages of One Eye.—5 yards x 2 inches. To bandage the left eye begin at the left temple, and fix by two horizontal turns from forehead to occiput, from the patient's left to right. On arriving for the second time above the right ear, pass down under the occiput, under the left ear, up obliquely over the left cheek, over the left eye, and up over the side of the head. A second or perhaps a third turn is applied, covering the preceding one one-half from below upwards on the cheek and from above downwards on the head. These oblique turns may be alternated with horizontal occipito-frontal turns, by which the bandage is terminated. It is more comfortable to the patient to have the ear on the affected side covered with cotton and included in the bandage. To bandage the right eye begin at the same point, and carry the bandage from the operator's left to right.

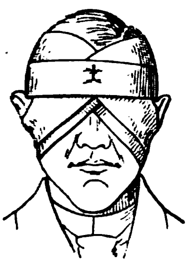

FIG. 24.
Crossed bandage of both eyes. (Gould.)

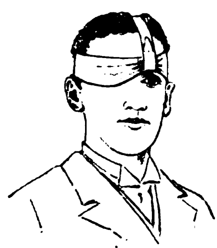

FIG. 25.
Borsch's eye bandage.

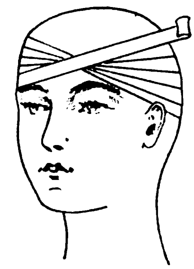

FIG. 26.
Oblique bandage of head, to be completed by a circular turn.

The crossed bandage of both eyes (Fig. 24) is practically a figure of 8 bandage with circular turns around the head.

Borsch's eye bandage is shown in Fig. 25.

The occipital frontal bandage consists of figure of 8 turns applied to the head longitudinally.

The oblique bandage of the head (Fig. 26) consists of figure of 8 turns applied transversely.

The head and neck bandage also is a figure of 8 bandage. The bandage is fixed by turns around the head above the ears, then carried across the back of the neck, around the throat, and back to the starting point.

The knotted bandage of the temple, used for hemorrhage, is shown in Fig. 27, a double roller being employed.

The four tailed bandage is shown in Fig. 28. It may be applied to the forehead by tying the ends under the chin and behind the head; to the occiput by tying the ends around the forehead and under the chin; or to the chin by tying the ends over the vertex and behind the neck.

The occipito-frontal triangle is a handkerchief bandage which is applied by placing the base of the triangle on the nape of the neck and bringing the apex forward over the forehead. The ends of the base are knotted over the apex, which is turned up over the knot and pinned.

In the vertico-mental triangle the base of the triangle is placed on the top of the head with the apex backward; the two ends of the base are knotted under the chin and the apex pinned at one side of the head.

The **cravat** may be used for various parts of the head when applied in the form of a figure of 8.


FIG. 27.—Knotted bandage of temple.


FIG. 28.—Four tailed bandage of head.

The square cap of the head is illustrated in Figs. 29 and 30. The handkerchief is folded in the form of a rectangle, with one of the free edges projecting an inch or more beyond the other. The outer corners are tied under the chin; the inner corners are drawn out, carried backwards, and knotted behind the head.

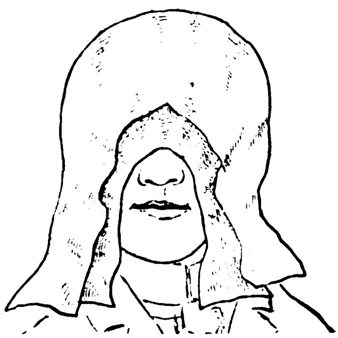
FIG. 29.—Square cap of head.


FIG. 30.—Square cap of head.

BANDAGES OF THE UPPER EXTREMITY.

The spiral of the finger (Fig. 31)—1½ yards x 1 inch—is applied by placing the initial extremity lengthwise on the finger, making one or two reverse turns over the end of the finger, then reversing and covering the finger by ascending spiral turns.

The Spica of the Thumb.—3 yards x 1 inch. Fix the initial extremity by two cicurlar turns around the wrist, and carry the bandage to the tip of the thumb, which is encircled once. Figure of 8 turns around the thumb and wrist, each one overlapping the previous one and alternating with a circular turn around the wrist, are now applied until the thumb is covered. The bandage is terminated by a circular turn around the wrist.

Gauntlet Bandage (Fig. 32).—3 yards x 1 inch. Fix the initial extremity around the wrist, and pass across the palm to the base of the thumb if bandaging the left hand; pass by an oblique turn to the tip of the thumb, which is encircled leaving the tip uncovered; cover the thumb by ascending spiral or spiral reversed turns, then pass across the dorsum of the hand to the ulnar side of the wrist and encircle once. The index finger is bandaged next, and so the other fingers, the bandage being terminated by a turn around the wrist.

Demigauntlet Bandage (Fig. 33).—Fix the initial extremity around the wrist. If bandaging the dorsum of the left hand, pass to the base of the little finger, encircle it, then pass to the radial side of the wrist and encircle it.

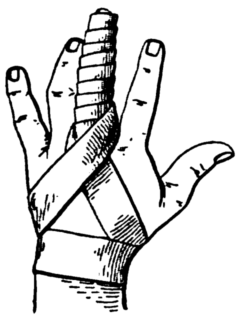

FIG. 31.
Spiral of finger. (Gould.)

FIG. 32.
Gauntlet. (Gould.)

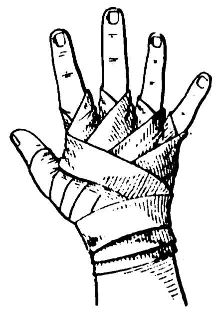

FIG. 33.
Demigauntlet. (Gould.)

The bandage is then carried to the base of the ring finger, and in turn to all the others, alternating a turn around the finger with one around the wrist.

Spiral Reversed of the Upper Extremity (Fig. 19).—7 yards x 2½ inches. Fix the initial extremity by circular turns around the wrist. Pass obliquely across the dorsum of the hand to the tips of the fingers and make a circular turn. The fingers are covered by spiral reversed turns, the back of the hand and wrist by figure of 8 turns, the forearm and humerus by spiral reversed

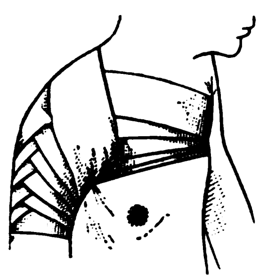

FIG. 34.—Spica of shoulder. (Gould.)

FIG. 35.—Brachio-cervical triangle. (Esmarch and Kowalzig.)

turns, and the bandage terminated as a spica of the shoulder. If the elbow is to be dressed in flexion, figure of 8 turns are used in this region. A bandage may be applied also to the upper extremity in a series of figure of 8 turns. This is more secure than the spiral reversed.

Spica of the Shoulder (Fig. 34).—8 yards x 2½ inches. Fix the initial extremity by circular turns around the humerus on a level with the axillary fold. If bandaging the right shoulder, carry the bandage across the front of the chest, through the left axilla, and across the back to the arm. Encircle the arm and chest alternately, making each successive turn ascend higher than the previous one, by exposing one-half or two-thirds its width, until the shoulder is completely covered. *A descending spica* is applied by fixing the bandage as described, and placing the first turn high up over the shoulder and overlapping from above downwards.

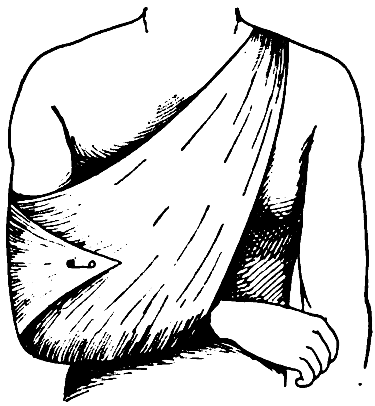

FIG. 36.—Oblique triangle of arm and chest. (Davis.)

The figure of 8 of the neck and axilla is applied by encircling the neck, then passing under the axilla, and ascending to the starting point, the turns intersecting over the shoulder.

FIG. 37.—Oblique triangle of arm and chest, second method. (Esmarch and Kowalzig.)

FIG. 38.—Triangle for suspending arm from injured side. (Esmarch and Kowalzig.)

A few of the handkerchief bandages and slings for the upper extremity are shown in Figs. 35 to 38.

BANDAGES OF THE TRUNK.

The spiral bandage of the chest consists of overlapping spiral turns, ascending from the waist to the level of the axillæ. The final spiral turn is pinned at the spine and the bandage carried over one shoulder to the middle of the sternum where it is again pinned. It is then brought back across the opposite shoulder to the spine, thus acting like suspenders.

The figure of 8 of the shoulders—6 yards x 2½ inches—may be applied anteriorly (Fig. 39) or posteriorly.

Suspensory Bandage of the Breast (Fig. 40).—7 yards x 2½ inches. Place the initial extremity on the scapula of the affected side, and pass over the opposite shoulder, down obliquely under the affected breast, and beneath the axilla to the starting point. Continue around the chest under the sound breast, and across the lower portion of the affected one. These turns are alternately continued, each one overlapping from below upwards, until the breast is covered. To dress both breasts apply an oblique turn to one side, then a circular turn, then an oblique turn to the opposite side.

Velpeau's Bandage for Fractured Clavicle (Fig. 41).—7 yards x 2½ inches. First place the arm in the Velpeau position, the hand of the injured side on the opposite shoulder. From the axilla of the sound side pass across the back, over the outer part of the injured shoulder, down across the middle of the arm, behind the elbow, across the chest, and through the axilla of the sound side to the point of starting. Next apply a horizontal turn on a level

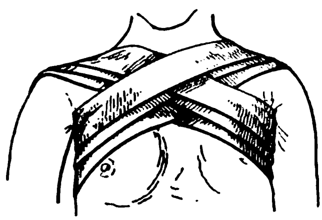

FIG. 39.—Anterior figure of 8 of shoulders. (Gould.)

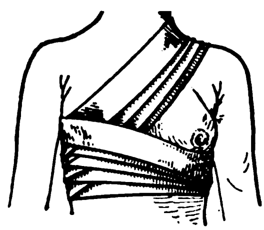

FIG. 40.—Suspensory of breast. (Gould.)

with the affected elbow. Repeat these turns until the elbow is covered with the vertical, and the wrist with the horizontal turns. The vertical turns should overlap two-thirds of each preceding turn, and the horizontal ones, one-third. Secure the bandage by strips of adhesive plaster.

Desault's Bandage for Fractured Clavicle (Fig. 42).—Three bandages, 7 yards x 2½ inches, and a wedge-shaped pad. The pad is placed in the axilla of the injured side, base up. The arm is allowed to hang by the side, and the forearm is flexed at a right angle. The first bandage is used to hold the pad in place. Beginning at the base of the pad, descending spiral turns, encircling the chest, are applied down to its apex near the elbow, and then ascending spiral turns back to its base. To hold the pad up in the axilla, the first bandage may be terminated with a figure of 8 turn of the opposite shoulder. The second bandage binds the arm to the side. Beginning at the axilla of the sound side, on a level with the base of the pad, descending spiral turns are applied, with increasing firmness, down to the elbow so as to carry the shoulder outwards. The third bandage is applied in the form of an anterior and a posterior triangle, the apex of each being formed by the axilla of the sound side, and the base by the humerus of the injured side. Begin the bandage at the axilla of the sound side posteriorly, pass over the affected shoulder, down in front of and parallel with the humerus, under the elbow, and across the back to the starting point. The anterior triangle is applied in the same way, by continuing the bandage through the axilla, across the chest, over the shoulder of the injured side, down behind the humerus, under the elbow, and back across the front of the chest to the starting point. The formula of both triangles is, from axilla, to shoulder, to elbow, and back to axilla. These turns are repeated two or three times, each succeeding turn covering in two-thirds of the preceding one. The third bandage carries the injured shoulder upwards and backwards.

The double T bandage of the chest consists of a broad band which encircles the chest, and to which are attached two narrow bands, one passing over each shoulder.

The double T bandage of the abdomen is similar to the above. The vertical strips are attached to the lower edge, and are passed from behind forward between the thighs and pinned in front, to prevent the binder from slipping up on the abdomen.

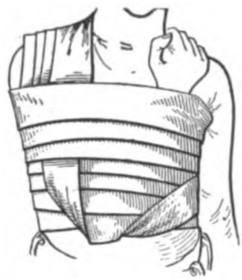

FIG. 41.—Velpeau bandage. (Gould.)

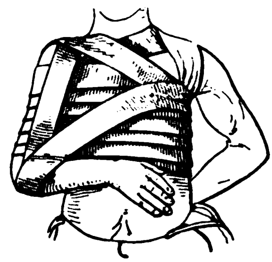

FIG. 42.—Desault bandage. (Gould.)

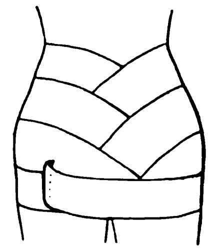

FIG. 43.—Many tailed bandage of abdomen.

The many tailed or Scultetus bandage of the abdomen (Fig. 43) consists of a piece of flannel long enough to reach one and a half times around the body and wide enough to reach from the costal border to the pubic bone. Each end is torn, for one-third the length of the bandage, into several tails. The untorn portion is placed behind, and the tails are overlapped alternately in front, from above downwards, and secured by safety pins.

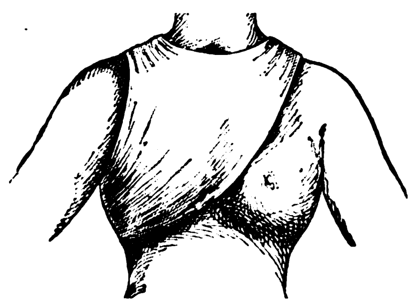

FIG. 44.—Triangle for suspending breast. (Davis.)

The T bandage of the perineum consists of a strip of muslin about 2½ inches wide, and long enough to fasten around the abdomen. To the center of this is attached a strip about five inches wide and about two feet long, which passes between the thighs and is fastened in front, either by pinning it to the horizontal band, or by tearing it into two bands (in the male) and knotting each to the horizontal band.

The **handkerchief bandage for suspending the breast** is illustrated in Fig. 44.

BANDAGES OF THE LOWER EXTREMITY.

Foot Bandage Covering the Heel (American).—6 yards x 2 inches. Fix the initial extremity at the ankle by two circular turns, pass obliquely across the dorsum of the foot to the base of the toes, and apply a complete circular turn. Ascend over the dorsum by several spiral reversed turns until

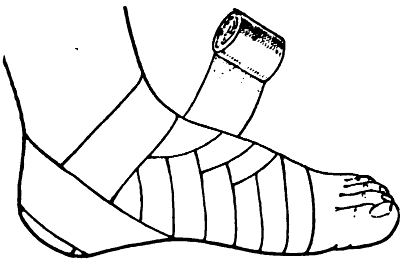

FIG. 45.—American bandage of heel; circular turns about ankle have been omitted.

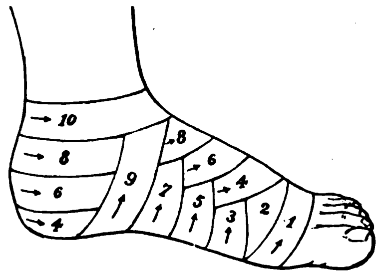

FIG. 46.—Spica of foot.

opposite the heel, around which the bandage is carried by a circular turn; next pass above the heel, beneath the arch of the foot, then up over the instep (Fig. 45). Similar turns are applied to cover the other side of the heel, and the bandage terminated by encircling the ankle.

The foot bandage not covering the heel (French) is the same as the above, except that the ankle is covered by figure of 8 turns and the heel remains exposed.

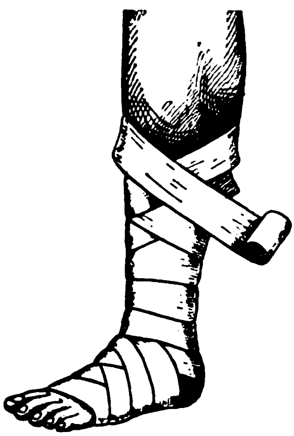

FIG. 47.—Figure of 8 of leg. (Davis.)

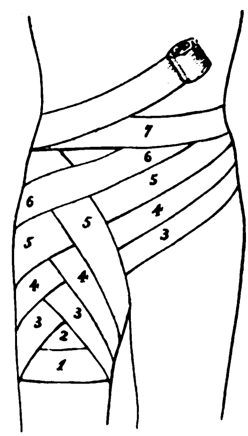

FIG. 48.—Spica of groin.

The spica bandage of the foot is explained by Fig. 46.

The spiral reversed of the lower extremity is similar to that of the upper extremity.

The figure of 8 of the leg is shown in Fig. 47.

Spica Bandage of One Groin (Fig. 48).—7 yards x 2½ inches. Fix the initial extremity at the upper portion of the right thigh near the perineum, by two circular turns; pass obliquely across the front of the pelvis, just above the pubes, to the top of the left thigh, across the back, obliquely down across the first turn at the junction of the thigh with the scrotum, and then around the thigh. These turns are repeated, overlapping from below upwards (*ascending spica*). The bandage may be applied also by encircling the pelvis higher up and overlapping from above downwards (*descending spica*).

Spica of Both Groins.—12 yards x 2½ inches. Fix the initial extremity as in the single spica, and pass obliquely across the front of the pelvis to the opposite side of the abdomen, across the back, and obliquely downward to the outer side of the left thigh. Apply a circular turn to the left thigh, and from the inner side of the thigh pass obliquely upward and outward over the same hip; then apply a circular turn around the waist, pass across the back again, and down in front of the right thigh; carry the bandage around the thigh, and from the outer side of the thigh repeat the turns, overlapping from below upwards, and terminating by a circular turn around the abdomen or thigh. A spica bandage may be applied to the outer aspect of the thigh or to the buttock in the same way.

FIG. 49.—Sacro-pubic triangle. (Esmarch and Kowalzig.)

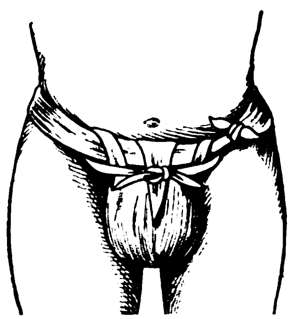

FIG. 50.—Scrotal triangle. (Davis.)

Figs. 49 to 53 demonstrate the use of the **handkerchief bandages of the lower extremity.**

Fixed dressings are largely used to immobilize parts after fractures, osteotomy, and tenotomy, and in the treatment of inflammatory affections of joints and deformities. Among the materials which have been used for this purpose are glue, gum arabic, paraffin, and tripolith, but those most commonly employed are plaster-of-Paris, silicate of soda, and starch.

Plaster-of-Paris is the best material for a fixed dressing. Coarse cotton or crinolin bandages are rolled by hand or machine, the meshes being filled with dry plaster. Owing to the hydroscopic powers of the plaster-of-Paris, the bandages should be kept in air tight receptacles, or baked before use in order to drive off the moisture. Bony prominences are first padded and a flannel bandage applied. The plaster-of-Paris bandages are submerged in water until the bubbles of air cease to escape, and, after squeezing out the excess of water, applied evenly to the limb until the desired thickness is obtained, making as few reverses as possible. The appearance of the cast is improved by coating it with plaster-of-Paris cream, which is prepared by mixing equal quantities of plaster-of-Paris and water. The cast may be strengthened by incorporating in it strips of wood, metal, cardboard, etc., and it may be coated with a layer of silicate of soda or varnish, to render it impervious to water. The finest grade of plaster hardens in fifteen minutes, the coarser grades in a longer time. The hardening process may be hastened by using hot water, or by adding salt (one ounce to the quart of water),

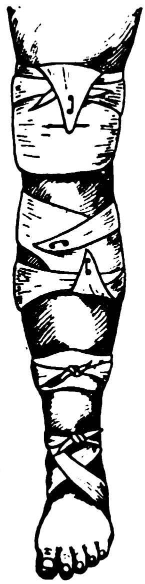

FIG. 51.—Handkerchief bandages of lower extremity. (Davis.)

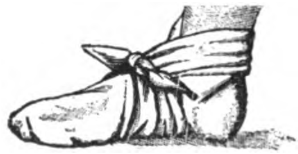

FIG. 52.—Malleolo-phalangeal triangle. (Esmarch and Kowalzig.)

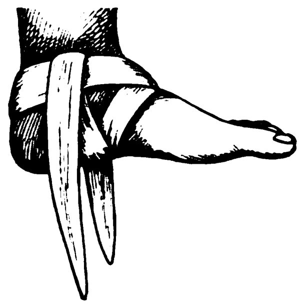

FIG. 53.—Gerdy's extension cravat. (Davis.)

alum, or cement; it may be delayed by using cold water, or by adding starch, glue, dextrine, or milk. When nearly dry the cast should be cut with a sharp knife; in order to protect the patient, a narrow strip of sheet lead or similar material may be placed over the flannel bandage before the plaster

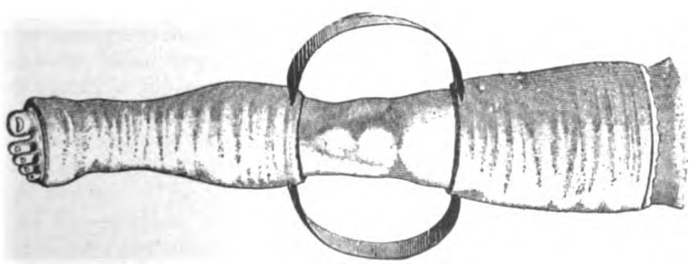

FIG. 54.—Stirrup plaster-of-Paris dressing for knee. (Esmarch and Kowalzig.)

is applied. The hardened plaster may be cut with a knife, saw, or shears, after the line of division has been moistened with hydrochloric acid, vinegar, or salt water. When there is a wound which will require dressing, it should be surrounded by a strip of lead or other material which will form a projection through the plaster dressing and indicate the portion to be cut away, or the area may be left uncovered when the plaster is applied. Another method, particularly useful after resection of joints, is to apply the cast in two sections which are connected by metal or wooden arches (Fig. 54), the ends of the arches being horizontal to be incorporated in the plaster-of-Paris. *Plaster-of-Paris splints* may be made by spreading plaster-of-Paris cream between layers of linen, which are molded to the parts and allowed to harden.

Silicate of soda can be bought as a solution, which is sometimes called liquid glass. It may be applied in the same way as plaster, or a few layers of gauze bandage may be applied and painted with the solution, this process being continued until the desired thickness is obtained. The silicate cast is light and strong, but has the disadvantage of drying very slowly (twenty-four hours); the process may be hastened by adding pulverized chalk or cement.

The starch bandage is used when a very firm splint is not required. The bandage is soaked in a solution of starch, made with boiling water, and applied like the plaster bandage. It also requires twenty-four hours or more to harden.

CHAPTER VI.

INFLAMMATION.

Inflammation consists of (1) changes in the blood vessels, (2) the passage of fluids and solids from the blood vessels, and (3) changes in the perivascular tissues.

The predisposing **causes** of inflammation comprise those conditions which lower the general vitality, such as old age, cardiac and vascular derangement, alcoholism, plethora, gout, syphilis, rheumatism, tuberculosis, diabetes, Bright's disease, anemia, and diseases and injuries of the nerves. The exciting causes are injury and infection. Injury may be mechanical, such as blows and wounds; chemical, such as strong acids or alkalies, stings of insects, and bites of animals; or thermal, either heat or cold; all of which kill the tissue cells, the resulting products of the dead cells acting as irritants. Infection is by far the most common cause, and the most important factor even in traumatic inflammation. Bacteria induce inflammation by their toxins, which act directly, and also indirectly, like trauma, by killing the cells, which set free irritating products.

1. The **changes in the blood vessels** consist of a momentary *contraction*, followed by *active hyperemia*, i.e., a dilatation of the blood vessels with a marked *acceleration* in the velocity of the blood stream. After a time *retardation* of the blood current occurs, and the stream becomes slower and slower (*passive hyperemia*), until in some cases it no longer progresses, but sways backward and forward (*oscillation*); finally all motion may cease (*stasis*), and the blood may coagulate (*thrombosis*) or rupture the vessel wall (*rhexis*). While these changes are taking place, the leukocytes separate from the axial stream and mass themselves along the walls of the blood vessels (*margination*), while the red corpuscles run together, forming rows, or *rouleaux*. The blood plaques are increased in number and tend to associate with the leukocytes along the sides of the stream.

2. The passage of fluids and solids from the vessels, or **exudation**, begins as soon as the blood vessels have dilated. The exuded material includes liquor sanguinis or plasma, red cells, leukocytes, and blood plaques. Normally the liquor sanguinis leaves the interior of the blood vessels to nourish the tissue cells, and the excess is absorbed by the lymphatics, but in inflammation the amount is much greater than that which can be removed by the lymph vessels. The process is probably not a simple filtration, but may be likened to secretion, in that the endothelial cells play an active part. This fluid dilutes the toxins, contains bactericidal and antitoxic sera, and in chronic inflammation increases the nourishment of the tissues. The leukocytes, particularly the polymorphonuclears, *migrate* from the vessels by insinuating a little process between the endothelial cells, which have been weakened, stretched, and probably separated as the result of the dilatation of the vessel; this process, or pseudopodium, gradually works its way through the vessel wall until it reaches the exterior, when the body of the leukocyte flows into the pseudopod and is then in the perivascular tissues. Although

the leukocytes migrate to some extent from the capillaries and arterioles, the process is most active in the venules; migration begins with the onset of hyperemia, and continues as long as the blood is in motion. There is a vast increase in the number of leukocytes, not only in the inflammatory area, but also in the general blood stream (leukocytosis). The red cells and blood plaques, being incapable of ameboid movements, are passively carried through the vessel walls with the plasma (*diapedesis*).

3. **Changes in the Perivascular Tissues.**—As the result of the breaking up of some of the leukocytes, which sets free fibrin ferment, the plasma coagulates, forming *inflammatory lymph;* the serum which forms infiltrates the tissues, giving rise to edema. The leukocytes destroy bacteria, devour particles of dead tissue, and pass back into the circulation through the lymphatics; if suppuration ensues they form pus cells. The red blood cells and the blood plaques are disintegrated, and reabsorbed by the lymphatics, or are devoured by the leukocytes and fibroblasts. The connective tissue cells proliferate, and the resulting cells are known as *fibroblasts.* It is believed that the leukocytes neither multiply, nor enter into the formation of new tissue. The mass formed by the fibroblasts is called *embryonic or indifferent tissue,* because it repairs any of the various tissues in which it may be found.

In **inflammation of non-vascular tissue,** e.g., the cornea and cartilage, the surrounding blood vessels dilate, and exude their contents into the lymph or intercellular spaces of the tissues, where the exudation undergoes the changes already described.

The **pathology of chronic inflammation** is practically the same as that of the acute form, except that the phenomena are less active and much longer in duration. The chief difference is seen in the behavior of the perivascular tissues, which in chronic inflammation become thickened and hardened as the result of the proliferation of the fixed connective tissue cells; later, particularly in syphilitic and tuberculous subjects, marked degenerative changes may take place in this tissue.

Inflammation extends in the same manner as other infections (p. 32).

Inflammation terminates in recovery or in death of the tissues. Recovery takes place suddenly (*delitescence*); gradually, the exudate being absorbed by the lymphatics (*resolution*); or with *new growth,* the embryonic tissue becoming vascularized, or organized, and the fibroblasts forming fibrous tissue. Death occurs as *suppuration, ulceration,* or *gangrene.*

The **varieties of inflammation** are: *Acute,* which is sudden in onset and runs a severe course; *subacute,* which is more tardy and less severe than the acute; *chronic,* which is of a low grade and lasts for a long time; *sthenic,* a robust inflammation in a robust individual; *asthenic, or adynamic,* a low grade inflammation in an old or a debilitated individual; *parenchymatous,* in which the parenchyma or secreting cells of an organ are affected; *interstitial,* involving the connective tissue of an organ; *traumatic,* due to an injury; *idiopathic,* in which the cause cannot be found; *simple, or common,* due to non-bacterial irritation; *infective, or specific,* due to bacteria; *serous,* characterized by a profuse exudation of serum; *plastic, adhesive, or fibrinous,* in which the exudate causes adjacent organs to adhere; *purulent, phlegmonous, or suppurative,* characterized by the formation of pus; *hemorrhagic,* in which the exudate contains considerable blood; *catarrhal,* affecting mucous membranes and causing an increased flow of mucus; *croupous, or pseudo-membranous,* characterized by the formation of a false membrane consisting of fibrin and cells; *diphtheritic,* in which the false membrane is formed from the tissues rather than from the exudate; *gangrenous*, resulting in gangrene; and *sympathetic, reflex, or metastatic*, when the process appears in a distant tissue, as inflammation of the breast, ovary, or testicle following mumps.

The **symptoms** of acute inflammation are local and constitutional. When the symptoms are slight or absent, e.g., in some instances of inflammation of Peyer's patches in enteric fever, the condition is called latent.

The **local symptoms** are pain, heat, redness, swelling, and disordered function (*dolor, calor, rubor, tumor, functio læsa*).

Pain is due to pressure upon the nerve terminals by the dilated vessels and the exudate, or to irritation the result of bacterial toxins or chemical changes in the part. It is increased by pressure with the hand (*tenderness*), and by raising the blood pressure, e.g., by placing the inflamed part in a dependent position; in organs, such as the eye, testicle, and bone, which are covered by dense fascia or fibrous tissue, and in which swelling cannot easily occur, the pain is much more severe. In viscera covered by serous membrane the pain is dull until the serous membrane is reached, when it becomes severe and lancinating. Inflammatory pain is slow in onset, remains in one situation, persists, and is accompanied by other signs of inflammation.

Heat is due to the large amount of blood brought to the inflamed area, and in inflammations on the surface is easily appreciated by the hand. The temperature as shown by a surface thermometer, however, is never greater than that of the blood in the internal organs, hence as a symptom local heat is of value in superficial inflammation only.

Redness is due to the increased amount of blood. In the early stages it is bright, and returns with great rapidity after the relief of pressure, showing an active circulation; as the velocity of the blood stream decreases, it becomes more dusky, and returns more slowly after the removal of pressure. During the stage of stagnation it may be impossible to remove the color by pressure. In avascular tissue the redness is seen at the edges of the part. In inflammation of the iris it is absent owing to the amount of pigment in that structure. In non-vascular tissues and in serous membranes the inflamed part may be white; when a number of red corpuscles have been forced into the tissues, there may be yellowish discoloration.

Swelling is due partly to the dilatation of the vessels, but principally to exudation and cell proliferation. It varies with the severity of the inflammation and the structure of the part, and as a rule is in inverse proportion to the severity of the pain; in regions covered by dense fascia it is more marked in adjacent parts, as is illustrated by the puffiness of the back of the hand in palmar abscess. The swelling pits on pressure (*edema*) and is at first soft, becoming harder with coagulation of the exudate and cellular proliferation; late softening indicates suppuration.

Disordered function is due to pain, swelling, or to chemical changes in the cells. It may be expressed as increased action (frequent micturition in cystitis), decreased action (small amount of urine in nephritis), absence of action (intestinal paresis in peritonitis) or perverted action (delirium in encephalitis). Sometimes, notably in nervous structures, the action is at first increased owing to irritation, and then, owing to the pressure of the exudate, decreased or abolished.

The **constitutional symptoms** vary with the cause, severity, and extent of the inflammation, and the part involved. In the milder forms they are slight or absent. In simple inflammations they are due to the absorption of fibrin ferment liberated by the degenerating leukocytes, hence identical with those of aseptic fever (q.v.); in bacterial inflammations to the absorption of toxins, or toxins and bacteria, hence identical with those of sepsis (q.v.).

The **treatment** of inflammation is local and constitutional.

Local treatment consists in (1) removal of the cause, (2) rest of the part, (3) reduction of the hyperemia, (4) promotion of absorption.

1. Any **causative irritation** should be removed, e.g., a foreign body in the conjunctiva producing conjunctivitis, a stone in the bladder causing cystitis. Micro-organisms are removed by proper incisions and disinfection.

2. **Rest** should, as far as possible, be both physical and physiological. It diminishes the amount of blood taken to the part and prevents the irritation or motion. Physical rest is obtained in arthritis by means of splints, in pleuritis by strapping the chest; physiological rest, in inflammations of the eye by dark glasses, in nephritis by purgatives and diaphoretics, in inflammation of the brain by sedatives. In severe inflammations rest in bed is of value, in that it lessens the number of heart beats, and thus decreases the quantity of blood pumped into the inflammatory area. Rest may be secured also by relaxation, e.g., extension in coxalgia, semi-flexion of the knee in inflammation of that joint.

3. **Reduction of Hyperemia.**—*Elevation* reduces hyperemia, lessens pain, and limits exudation. It is particularly applicable in inflammations of the extremities, but may be used also in other regions, e.g., raising the head on a pillow, supporting the breast by a bandage, elevating the testicle with a suspensory bandage.

Local blood letting may be carried out by punctures, scarification, incision, leeching, and cupping. Aseptic *punctures* relieve tension by allowing blood and exudate to escape, and are useful in parts which are greatly swollen and in which incisions are not indicated. *Scarification*, or the making of small superficial incisions, is used for the same purpose. *Free incisions*, entering deeply into the inflammatory mass, are indicated when suppuration is threatened, when pus is actually present, and when the tension is so great that gangrene is feared. *Leeches* should never be used, because there are cleaner and better ways for removing blood and exudate. *Cupping* is used to draw blood up under the skin (dry cupping), or actually to remove it from the tissues (wet cupping). *Dry cupping* may be accomplished by greasing the edge of a glass, and igniting a small piece of blotting paper, soaked with alcohol, which has been placed in the bottom of the glass. As soon as the flame disappears, the edge of the glass is pushed into the skin; the tissues are sucked up as the air in the glass cools and contracts. There are special instruments made for this purpose, in which a vacuum is created by means of a rubber bulb. The bulb is emptied of air and the glass applied to the skin; when the hand is removed from the bulb, the tissues are pulled up into the glass. *Wet cupping* is performed in the same manner as dry cupping, except that the skin is previously scarified or punctured, so that a certain amount of blood is drawn from the tissues. The "*artificial leech*" is a syringe-like instrument which draws blood from a part after previous scarification. Because of its hygroscopic powers, *glycerin* may be used for depletion. Cataplasma kaolini, which is composed of kaolin, glycerin, boric acid, thymol, methyl salicylate, and oil of peppermint, is used as a local application for its depletive effect.

Cold contracts the vessels, acts as an anesthetic, and is indicated in the early stages of inflammation. After the occurrence of exudation it hinders the evolution of the process and prevents absorption. It should be applied continuously, not intermittently. Intense cold applied for a long time may result in sloughing, hence should be used with great caution at the extremes of life and in the debilitated. *Wet cold* is not as easily managed as dry cold and is more depressing to the tissues, but is very useful at the onset of sthenic inflammations. Over the part may be suspended a reservoir filled with cold water, from which a strip of gauze acting as a wick descends to the inflamed part. If there is a breach in the skin, the solution should be sterile or antiseptic. A Kelly pad or a piece of mackintosh should be placed beneath the part, to direct the fluid into a receptacle beside the bed. Cold compresses are frequently employed in inflammations of the eye. Two or three small pads of gauze are put on a cake of ice; as soon as the pad which has been placed on the eye becomes warm, it is replaced by a fresh one, and the old one is placed on the ice. Cold may be generated also by evaporating lotions, such as lead-water and laudanum (1 oz. each of liquor plumbi subacetatis dilutus and tinctura opii to 1 pint of water), equal parts of alcohol and water, and a solution of ammonium chlorid in water (1 to 2 drams to a pint); these solutions may be applied by means of cloths laid on the part, or by means of a reservoir and wick as described above. Dressings containing an evaporating lotion should never be covered with wax paper, as is the custom with some physicians, because evaporation is thus prevented. *Dry cold* may be applied by means of tin cans, bottles, bladders, etc., filled with ice water, or by the rubber ice cap, all of which should be protected by a covering of flannel. An inflamed part may be covered or enveloped with a coil of rubber tubing through which ice water is constantly moving by syphonage. The same principle is utilized in Leiter's tubes, which consist of a coil of narrow leaden pipes made to fit various regions of the body.

Bier's treatment directly antagonizes the principles set forth above. Bier believes the increased number of leukocytes and the increased amount of bacteriolytic blood serum to be helpful rather than harmful, and therefore seeks to produce a "passive hyperemia" by constriction above the inflamed area, or by a suction apparatus (which acts like a cup) in regions in which constriction is inapplicable. The vacuum apparatus also draws pus and sloughs from an inflamed wound. It is applied for 3 minutes, then removed for 5 minutes, this procedure being repeated for three-fourths of an hour each day. In the extremities a rubber bandage is placed above the affected part and drawn tight enough to retard the venous return, without interfering with the arterial circulation. If white edema, coldness, or anesthesia result, the constriction is too tight. The bandage remains in a place a number of hours each day, sometimes as long as twenty-two, and should markedly lessen pain. In the presence of suppuration a small incision is made and the wound is not packed with gauze. The pus is at first increased in amount and then rapidly disappears. The method appears to be of some value in mild and well localized infections, but distinctly harmful in virulent and spreading inflammations, diabetes, and atheroma. It is suited only for cases which are under constant surveillance, and it requires some skill and judgment for its proper application.

4. **Absorption** is promoted by (a) compression, (b) massage, (c) astringents and sorbefacients, (d) heat, (e) douches, and (f) counterirritation.

(a) *Compression*, judiciously applied and carefully watched, may be used in the first stage of inflammation to limit the swelling and give the paralyzed vessels a chance to recover themselves. Firm compression before swelling has fully developed increases pain and may result in gangrene. At a later period it hastens absorption and is a measure of great value. In acute cases compression should be elastic, the part being thickly covered with loose gauze or, better, cotton, and bandaged from the end of the extremity to above the point of inflammation. In the terminal stage of acute inflammation and in subacute and chronic inflammation, firm compression with a thin rubber bandage, adhesive plaster strapping, tampons, or a shot bag is frequently employed.

(b) *Massage* finds its chief value in the treatment of subacute or chronic inflammation about joints. *Effleurage* consists in rubbing the limb with the hand, emphasis being placed upon the upstroke so as to encourage the flow of blood and lymph from the part. *Pétrissage*, or kneading, and *tapotement*, or tapping, also quicken the circulation and hasten absorption. Care should be exercised in advising compression and massage in the treatment of phlebitis or other inflammations in which there is danger of dislodging a clot, and also in individuals with atheromatous arteries or tuberculous foci.

(c) *Astringents* are largely used in inflammations of mucous membranes. The efficiency of lead-water and laudanum depends partly upon the astringent effect of the lead-water. Silver nitrate is a bland astringent, frequently used on mucous membranes; it coagulates the superficial albumen, and forms a protective shield for the parts beneath. Tincture of iodin should never be placed on acutely inflamed tissues, because of its irritating qualities, but it is often employed as a counterirritant in deep-seated inflammations. Its absorptive powers when applied locally are probably slight, although it is often used as a sorbefacient in the form of an ointment. Ichthyol may be used in the form of an ointment as strong as 50 per cent., remembering, however, that it occasionally produces irritation of the skin; or it may be sprayed or painted upon a part, in the strength of 1 dram to the ounce of water. Mercurial ointment is often employed in chronic inflammation. If used for a long time, it should be diluted one-half or one-fourth, as the pure ointment may vesicate the skin or salivate the patient. Belladonna ointment is another valuable sorbefacient, especially when combined with equal parts of ichthyol, mercurial ointment, and vaselin or lanolin.

(d) *Heat* is rarely used in the first stage of inflammation, because the amount necessary to contract the vessels is too great for comfort; that which is comfortable to the patient relaxes the tissues, lessens tension, relieves pain, assists absorption, and in the presence of bacteria hastens suppuration. In inflammations below the surface it acts as a counterirritant by diverting blood from the affected part. It is applied as fomentations, poultices, baths, or as dry heat. The *fomentation, or stupe*, is a piece of flannel, spongiopiline, or similar material, soaked in a hot liquid, which may be water, lead-water and laudanum, turpentine and water, etc., or an antiseptic solution (*antiseptic fomentation*). The flannel is wrung out until almost dry, then applied to the part and covered with some material, such as wax paper or oiled silk, which will retain the heat; over this may be placed a hot water bag, which is refilled as often as may be necessary. In a turpentine stupe from 1 to 20 drops of turpentine are sprinkled upon the flannel. A *poultice, or cataplasm*, may be made of arrow root, bread, bran, potatoes, hops, starch, slippery elm, turnips, and many other such materials, but flaxseed is the substance usually employed. Charcoal poultices are sometimes used for deodorizing foul ulcers. The selected material is made into a thick paste with hot water (yeast, lead-water and laudanum, or an antiseptic solution), spread upon muslin, lint, or linen, to the thickness of a fourth or half inch, and covered with gauze, or coated with olive oil, so that it will not stick to the skin; oiled silk or wax paper is placed over the poultice to prevent evaporation and loss of heat. The poultice should be changed about every two hours. Poultices should never be employed where there is an open wound; if heat and moisture are desired in such cases, as for the separation of a slough, the antiseptic fomentation should be used. *A general warm bath* is sometimes used in extensive burns, *partial baths* in badly infected wounds. The *sitz bath*, or hip-bath, is of value in pelvic and abdominal inflammations. *Dry heat* may be obtained by heating sand bags, salt bags, cloths, or bricks; by bottles, cans, bladders, or rubber bags filled with hot water; and by means of rubber or leaden tubing, as described under cold. The hot air apparatus is chiefly employed in chronic inflammatory affections of joints. The limb is wrapped in lint and placed in the apparatus, the temperature of which may be raised as high as 300° F. The part may be baked for one hour several times a week. Radiant heat, generated by a number of electric bulb-lights, and diathermy also are employed for the same purposes as the baking machine.

(e) The *douche* is a stream of water used for flushing, for conveying heat, cold, or medicaments, or for the mechanical effect produced by the stream directed against the tissues. Hot vaginal douches are of great value in pelvic inflammations, and douches are useful also in other cavities of the body. The "*Scotch douche*" is of service in low-grade chronic inflammation; it consists in alternately pouring hot and cold water upon a part. The heat relaxes and the cold contracts the vessels, which are strengthened by this form of exercise.

(f) *Counterirritation* is the process whereby a structure is affected reflexly by means of an irritant at a distant point. It relieves pain, promotes absorption, and is used principally in chronic inflammation. *Irritants*, such as silver nitrate, tincture of iodin, and copper sulphate, are sometimes applied to stimulate a sluggish area of inflammation into activity. *Blisters* (*epispastics*) are produced by confining chloroform beneath oiled silk or a watch glass, by croton oil, by ammonia mixed with an equal part of some ointment base, and by cantharidal collodion or cantharidal plaster (fly blister). A blistering plaster is moistened with sweet oil, and applied after the skin has been shaved and washed with soap and water. A blister usually forms in from five to six hours, in tender skins in a much shorter period; it should be punctured with an aseptic needle and dressed with a bland ointment. *Frictions with stimulating liniments* do good by their counterirritation and massage. *Rubefacients*, e.g., mustard, spice, or capsicum plaster, and turpentine stupes, produce redness of the skin. Mustard plasters come already prepared, it being necessary simply to dip them in warm water before application. A mustard plaster may be made by mixing equal parts of mustard and flour, with a little vinegar or water, the paste being spread upon a cloth and covered with gauze. The addition of the white of an egg prevents vesication. When a more severe form of counterirritation is required, the hot-iron (*actual cautery*), or escharotics (*potential cautery*), such as antimonial ointment, caustic potash, or arsenical paste, may be applied. The cautery-iron is heated in a fire, and in an emergency may be improvised from a telegraph wire, a curling-iron, or a poker. Much more convenient is the *Paquelin thermocautery* (Fig. 55). After heating the platinum point (a) over an alcohol lamp, benzine vapor is blown from the bottle into the point by the rubber bulb (b), care being taken to keep the heated point higher than the bottle lest an explosion occur. The more rapidly the bulb is squeezed, the hotter will be the tip. For counterirritation the cautery should be red hot and allowed to touch the skin lightly; it should not be used over a bony prominence, a large nerve, or a blood vessel.

Constitutional treatment may not be needed in trivial inflammations; in the severer forms of acute inflammation the treatment is that of sepsis (q.v.). The internal remedies for hastening *absorption* are mercury and the iodids, especially in chronic inflammation. The same rule holds good in the general, as in the local, treatment of inflammation, to find the *cause* and try to remedy it. Many cases of chronic inflammation are tuberculous, syphilitic, gouty, or rheumatic, and poor results in the local treatment of acute inflammation may be due to some general disorder, such as Bright's disease or diabetes. These constitutional affections should, of course, receive appropriate treatment. *Tonics*, such as iron, quinin, and strychnin, will be found of value in most forms of inflammation, both acute and chronic. In certain inflammations of bacterial origin *vaccins* or *serotherapy* may be

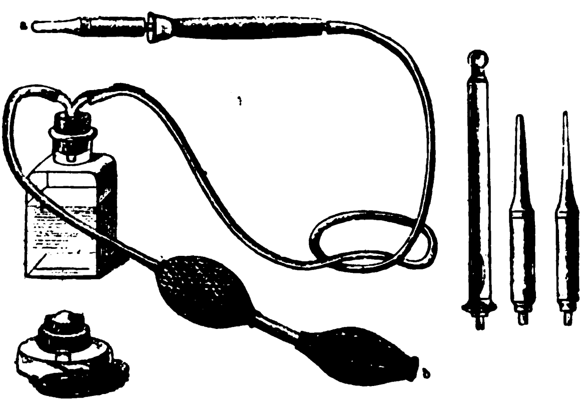

FIG. 55.—Paquelin thermocautery.

tried. The serum treatment of specific diseases is referred to in subsequent pages, it being necessary in this place merely to call attention to the great value of antitoxin in diphtheritic inflammations.

REPAIR.

Destroyed tissue is usually replaced by fibrous tissue (*repair*), and not by the highly specialized cells characteristic of the tissue (*regeneration*). Repair takes place most rapidly in healthy vascular tissues which have been carefully brought together, kept aseptic, and put at rest. Repair is hindered by infection, strong antiseptics, motion, lack of blood supply, separation of the tissues, e.g., as the result of gaping, inversion of epithelial surfaces, or the interposition of foreign bodies, and by many constitutional diseases, prominent among which are syphilis, tuberculosis, nephritis, diabetes, and carcinomatous cachexia.

The first of the **phenomena of repair** are identical with those of inflammation, except in intensity, hence the absence of clinical signs. Inflammation is a pathological process that may or may not end in repair, which is a physiological process. There is a slight dilatation of the vessels, exudation of liquor sanguinis, and the escape of many leukocytes and a few red cells and blood plaques. The leukocytes devour and remove devitalized cells and blood clot. The fixed connective-tissue cells and the endothelial cells proliferate by the indirect method (*mitosis or karyokinesis*), in which, instead of simple segmentation, cell division is preceded by picturesque changes in the nucleus. These new cells are called *fibroblasts*, or indifferent cells, and form a mass called indifferent or *embryonic tissue*. The leukocytes wander back into the circulation or are devoured by the fibroblasts. From the walls of the capillaries little buds of protoplasm shoot out, which unite with similar processes from other vessels and become canalized, i.e., form new capillaries; thus vascularization, or *organization*, of the mass is brought about, and the new tissue is spoken of as *granulation tissue*. In regeneration the parenchyma cells, or specialized cells, of a tissue or organ also proliferate. The fibroblasts elongate and develop fibrillæ, which interlace and form *fibrous tissue* (cicatricial or scar tissue). Fibrous tissue is at first red, but later contracts, compresses the newly-formed capillaries, and thus in the course of time becomes dense, hard, and white. In wounds of the skin or mucous membrane the gap at the surface is covered with epidermis, which grows, not from the granulation tissue, but from the epithelium at the margins of the wound.

When an incised wound heals without suppuration, the process is called *healing by first intention*, or *primary union*. The bleeding is checked by small clots in the mouths of the vessels, and the wound margins are glued together by the fibrin of the extravasated blood. The small amount of devitalized tissue and blood clot is soon absorbed, and healing progresses as described above. Healing by *second intention*, or by *granulation*, occurs when the lips of a wound are separated as the result of infection or the loss of a large amount of tissue. In the former instance the dead tissue is gotten rid of by sloughing or suppuration. Many of the fibroblasts are separated from their fellows by the peptogenic action of the toxins on the intercellular substance, and discharged from the wound as pus cells. The mass of cells which remains becomes vascularized, forming granulation tissue. Each granulation is made of a series of capillary loops surrounded by and nourishing fibroblasts. Healthy granulations are bright red, smooth, and firm. The fibroblasts multiply, new capillaries are formed, and finally the cavity is filled. As the granulations grow upward the fibroblasts at the bottom of the cavity become fibrous tissue, which contracts and lessens the size of the healing area. In the meantime the epithelium at the edges of the wound has been creeping inward by a proliferation of its cells (*epidermization*). If granulations grow above the level of the skin (*exuberant granulations, or proud flesh*), epithelial proliferation is checked until the granulations are removed. These granulations are usually large, pale, flabby, and edematous. When two clean granulating surfaces unite after being brought together, healing by *third intention* is said to occur. Healing by organization of a blood clot is seen where a cavity is filled with an aseptic blood clot. The process differs in no respects from that which has already been described. The clot acts as a scaffolding for the granulations and is gradually absorbed.

In the repair of *non-vascular tissue* leukocytes and serum come from adjacent tissues. In the cornea the wound is at first glued together by fibrin, which is later replaced by proliferated corneal cells. In a very trivial injury the resulting tissue may be transparent; in a severe injury fibrous tissue forms and an opaque scar results. After an incised wound of cartilage much the same process takes place, but the chondral cells make little effort at regeneration, and the resulting cicatrix is always fibrous tissue. After fracture of cartilage, however, a sort of callus is thrown out, which may become cartilaginous or even bony.

Skin and *mucous membrane* are repaired by fibrous tissue covered by epithelium; the deeper layers of the skin, the hair follicles, and the sebaceous and sweat glands are not regenerated. Wounds involving the cuticle alone are not followed by permanent scars; those which pass into or through the deep skin leave a permanent scar.

Blood vessels, after division or ligation, are closed by clot, which is finally replaced by fibrous tissue. After aseptic ligation it is claimed that healing may occur without the formation of a thrombus (Chap. xv). Repair of tendon and muscle takes place by fibrous tissue, but striped muscular fiber may regenerate after trivial wounds. Bone is repaired by bone (Chap. xix). Nerves may regenerate (Chap. xvii). Regeneration of the brain and spinal cord is possible but very rare (Chap. xxi, xxii). Lymphatic tissue and glandular organs may regenerate, but in the latter destroyed parenchyma is usually replaced by scar tissue. In general it may be stated that nature usually replaces all losses with one material, viz., fibrous tissue, hence the nearer a structure is histologically to connective tissue the more apt it is to regenerate, since with connective tissue repair and regeneration are synonymous. Thus skin, fat, fascia, tendons, blood vessels, peritoneum, cartilage, and bone are often reproduced, while highly developed cells like those of the parenchymatous organs and the central nervous system are seldom regenerated.

A normal **scar**, or **cicatrix**, is at first smooth, hard, and, owing to its vascularity, red in color. Later, in obedience to the contraction of the fibrous tissue, it becomes white (avascular), more dense, and often wrinkled. It is insensitive, because of the absence of nerves, and contains no lymphatics. The itching or burning sensation sometimes referred to a scar is due to irritation of the nerve filaments in the adjoining skin or subjacent tissues. The principal deviations from the normal are listed below.

Discoloration may be due to foreign substances, e.g., gunpowder, particles of coal, or to partial retention of normal pigment, e.g., in the negro. Excision, followed by careful apposition of the wound with a subcuticular suture, is indicated in some of these cases, as well as in some cases in which *disfigurement* is due solely to the shape and site of the scar, e.g., a wide, irregular cicatrix on the face or neck.

Excessive contraction is most frequent after extensive superficial wounds, notably burns, the granulation tissue reaching the surface and undergoing conversion into fibrous tissue long before the completion of epidermization, hence, when possible, the necessity for early skin grafting in wounds of this character. On the surface of the body the evils of contraction are most marked about the face, the neck (Figs. 56, 57) and the joints. In these cases liberation of the parts by proper incisions, and filling the resulting gap by a plastic operation, is to be considered. In the various canals of the body contraction results in stricture.

Stretching may occur when a recent scar is subjected to an almost continuous strain, thus are produced the post-operative hernias of the abdomen. Stretching is sometimes utilized as a therapeutic measure, especially in the treatment of strictures.

Depression may be due to adhesion of the scar to deeper structures. A depressed scar, circular, serpiginous, or semilunar in shape is suggestive of syphilis.

"Hypertrophied" scars are most frequent after infected wounds and in the negro. When the hyperplasia continues the growth is called a *false keloid* (see Chap. on the skin).

Painful scars are due to the pressure of the contracting tissue on a nerve filament. Relief is obtained by excising the painful area, or by finding and excising the involved nerve.

FIG. 56.—Cicatricial contraction following a burn; side view.

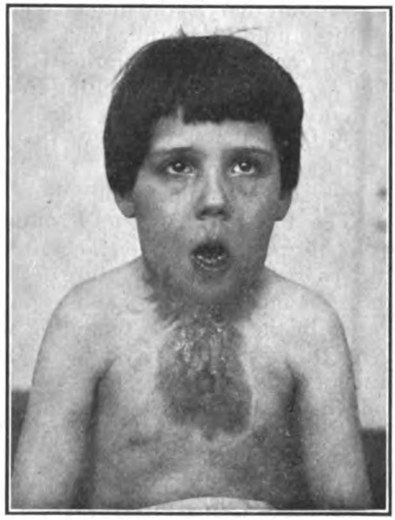

FIG. 57.—Cicatricial contraction following a burn; front view.

Ulceration is prone to occur in scars, because of their lack of nourishment, and for the same reason such ulcers are difficult to heal, unless the scar tissue is removed.

Epithelioma may develop in any scar, but is most frequent in those exposed to constant irritation, and in those following X-ray burns. Pain and lymphatic metastases are absent, so long as the growth is confined to the scar.

CHAPTER VII.

SUPPURATION.

Suppuration is the liquefaction of the products of inflammation, the resulting fluid being called pus.

The **cause** of suppuration is almost invariably infection with bacteria. The *puruloid* material resulting from the injection of sterile irritants, such as mercury and croton oil, is theoretically not pus. Constitutional diseases which lower the resistance of the tissues, especially diabetes and nephritis, predispose to suppuration. Locally, injuries in which the tissues are bruised or lacerated are prone to suppurate.

The **Pyogenic or Pus Producing Bacteria.**—The *staphylococcus pyogenes aureus* is an amotile, facultative anaërobe, grows in clusters like grapes, thrives best at the temperature of the body, is normally present on the skin, in the nose, mouth, rectum, and vagina, and represents about 10 per cent. of the germs in the air of an operating room; hence the most common organism generating pus. It may remain latent in ice and dry pus for days; in the human body, especially in osteomyelitic foci, for many years. It produces golden-yellow colonies on culture media, and is instantly killed by boiling water. It is strongly leukotactic, i.e., attracts leukocytes from the blood; hence usually causes a limited infection which is walled in by cell barriers; it may, however, be found in spreading suppurations and produce fatal results. Staphylotoxin causes degeneration of tissue cells and constitutional symptoms. The *staphylococcus pyogenes albus* and the *staphylococcus pyogenes citreus* are varieties of the staphylococcus pyogenes aureus. The former, which is probably identical with the *staphylococcus epidermidis albus*, shows a white color in its growth, and is commonly found in stitch abscesses, the normal habitat of the organism being upon and in the crypts of the skin; the latter organism produces a lemon-yellow color. The *streptococcus pyogenes* (chain coccus) is identical with the streptococcus erysipelatis. It is an amotile, facultative anaërobe, grows best at the temperature of the body, and is found on the skin and mucous membranes and in dust and sewage. It is readily killed by the usual antiseptics, but may remain latent in ice and in a dry form for months. It sometimes has a favorable influence on sarcoma, but as a secondary invader in tuberculosis and other infections it increases tissue destruction and the violence of the general symptoms. It is feebly leukotactic, consequently produces a thin watery pus, readily invades the lymph channels, and causes spreading inflammations and widespread suppuration. Its toxin is hemolytic and causes serious constitutonal symptoms. The *bacillus coli communis* is morphologically identical with the typhoid bacillus. It is a plump straight rod, possesses flagellæ, is actively motile, is a facultative anaërobe, and generates gas with a fecal odor. It normally inhabits the intestine as a harmless saprophyte, but becomes pathogenic when it invades damaged tissue, e.g., strangulated bowel, or lodges in foreign soil, e.g., in the gall bladder or genito-urinary apparatus. The *bacillus pyocyaneus* is frequently present in wounds and ulcers which are not dressed regularly; it produces green or blue pus and is of little significance, although a few cases of general infection have been reported. It is aërobic, motile, having a polar flagellum, and is found in water and in the mouth and alimentary canal. Other pathogenic organisms occasionally found in suppurative processes are the *staphylococcus cereus albus*, *staphylococcus cereus flavus*, *staphylococcus flavescens*, *micrococcus tetragenus*, *micrococcus pyogenes tenuis*, *gonococcus*, *pneumococcus*, and the *bacillus of typhoid fever*, *influenza*, and *diphtheria*. Non-pathogenic saprophytes cause putrefactive changes in foul wounds. The *bacillus of tuberculosis* and the *ameba coli* (the cause of tropical dysentery and hepatic abscess) originate not true pus, but a puruloid material.

Pyogenic bacteria usually enter the tissues through wounds; they may, however, make their way through the hair follicles, sebaceous glands, or sweat ducts. When suppuration occurs in a subcutaneous lesion, such as a hematoma, micro-organisms reach the area by way of the blood, probably having entered the circulation through the tonsils, the lungs, or the intestinal canal.

The **pathology** of suppuration is that of inflammation, plus the peptonizing influence of pyogenic bacteria, i.e., by means of enzymes they digest or liquefy the intercellular portion of the inflammatory exudate. Staphylococci and other organisms of low virulence give the inflammatory exudate about the area of infection a chance to organize and form a barrier to further dissemination, thus an abscess is formed. Organisms of high virulence, such as the streptococcus, prevent coagulation of the exudate, and the infection quickly spreads far and wide. The same result may ensue with less virulent bacteria when the tissues have little resistance.

Pus consists of liquor puris (liquefied intercellular exudate and microbic products) and pus cells (dead and dying leukocytes and connective-tissue cells).

Varieties of Pus.—*Normal, healthy, or laudable* pus is generally due to the staphylococcus; it tends to remain localized, and the tissues from which it comes quickly recover after thorough drainage has been established. It is a greenish-white, creamy fluid, alkaline in reaction, and of a specific gravity of 1030. It may be odorless or smell like paste. *Sanious* pus is mixed with blood, and is sometimes seen in caries and carcinoma. *Malignant or ichorous* pus is watery, acid, and very irritating to the tissues. *Blue* pus is due to the bacillus pyocyaneus, *orange* pus to hematoidin crystals the result of degeneration of red blood corpuscles, and *stinking* pus to the bacteria of putrefaction or the bacillus coli communis. *Concrete or fibrinous* pus contains flakes of lymph; *serous* pus, a large quantity of serum; and *muco-pus*, mucus. *Gas producing* pus is due to the bacteria of putrefaction, bacillus of malignant edema, bacillus aërogenes capsulatus, bacillus coli communis, or to communication with one of the air-containing viscera. *Tuberculous, scrofulous, caseous, or curdy* pus, found in tuberculous processes, and *gummy* pus, the result of a degenerating gumma, are not, strictly speaking, pus.

Suppuration occurs on epithelial or endothelial surfaces, or in the tissues. Pyogenic inflammation of a mucous membrane (e.g., urethritis, bronchitis) may subside and leave the structure normal, or eventuate in suppurative destruction (ulceration) of a portion of the membrane. When pus accumulates in a cavity lined with endothelium, or, owing to obstruction to its drainage, in a duct or a cavity lined with epithelium the condition is called, according to its location, pyosalpinx, empyema of the pleural cavity, of the gall bladder, of the antrum of Highmore, etc., although from a clinical standpoint it is an abscess. Suppuration in the tissues may be diffuse (suppurative cellulitis, which is described on a later page) or circumscribed (abscess).

An **abscess** is a "circumscribed cavity of new formation containing pus."

Suppuration begins in the center of the inflammatory area, and steadily extends by melting down the surrounding embryonic tissue. An abscess at this stage exhibits five zones: (1) The pus, (2) a zone of melting down embryonic tissue, (3) a zone of inflammatory tissue filled with leukocytes, fibroblasts, and thrombosed vessels, hence the absence of hemorrhage as the abscess spreads, (4) inflammatory tissue containing many leukocytes, with the blood stream in the stage of retardation, and (5) a zone of active hyperemia with beginning exudation (Fig. 58). These zones increase in size as the abscess enlarges, not in mathematical circles, but in the direction of least resistance, until finally the abscess reaches the surface or a cavity and empties itself. The tissues at the surface pass through the various stages of inflammation and liquefy, until ultimately nothing remains but a very thin layer which is pushed up by the pus below (*pointing*), giving the abscess a characteristic acuminate appearance. When this thin layer liquefies, the abscess "bursts" and spontaneous evacuation occurs. After an abscess has emptied itself or ceased to spread, the inflammatory phenomena subside, and the embryonic tissue forming its walls is organized into granulation tissue; at this stage the zones of an abscess are (1) the pus, (2) zone of granulation tissue, (3) fibrous tissue, (4) slightly hyperemic normal tissue (Fig. 58).

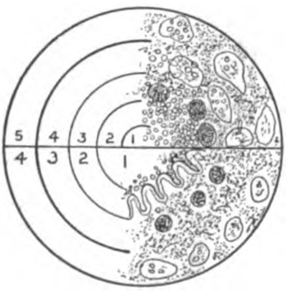

FIG. 58.—Diagram illustrating zones in spreading (upper half) and healing abscess (lower half).

The **varieties of abscesses** may be designated according to the structure involved, as *lacunar*, involving a lacuna of the urethra; *follicular*, involving a follicle; *psoas*, traveling in the psoas sheath; *thecal*, involving a tendon sheath; *bursal*, involving a bursa; *brain; pulmonary*, etc. According to duration an abscess may be *acute or phlegmonous*, or *chronic* (*congestive, cold, strumous, lymphatic, caseous, cheesy, or tuberculous*). Other terms used to describe abscesses are, *circumscribed* (isolated by granulation tissue); *diffuse* (infiltrating the tissues); *gravitating, wandering, or hypostatic* (traveling from one point to another, *e.g.*, psoas abscess); *diathetic or constitutional* (due to some constitutional disorder); *symptomatic* (constituting a sign of another disease); *critical, or consecutive* (occurring during an acute disease); *atheromatous* (occurring beneath the intima in endarteritis); *canalicular* (communicating with a duct); *gangrenous* (the surrounding parts become gangrenous); *tympanitic, or emphysematous* (containing gas); *encysted* (limited by adhesions in a serous cavity); *fecal, or stercoraceous* (communicating with the bowel); *hematic* (containing broken down blood); *tropical* (in the liver following amebic dysentery); *marginal* (near the margin of the anus); *pyemic, metastatic, embolic, multiple, or miliary* (due to septic emboli); *milk* (in the breast of a nursing woman); *shirt-stud* (the cavity of a deep abscess communicates with a superficial abscess by a narrow sinus); *perforating* (breaking into some cavity); *ossifluent* (due to diseased bone); *secondary, or sympathetic* (occurring some distance from the infecting lesion, e.g., abscess of axilla after infected finger); *urinary* (due to extravasated urine); *residual, or Paget's* abscess (recurring months or years later); *syphilitic, or gummatous* (due to syphilis); *Brodie's* (tuberculous abscess near the epiphyseal line of a long bone); *superficial* (above the deep fascia); and *deep* (below the deep fascia).

The **symptoms of an acute abscess** are, (1) the local symptoms of inflammation, plus fluctuation and pointing; (2) pressure symptoms; and (3) constitutional symptoms.

1. The *local symptoms* of inflammation all become intensified; the swelling is greater, edema more marked, heat more apparent, redness more, dusky, pain more severe and often throbbing in character, and the function of the part is lost or greatly impaired. As the abscess matures, signs of fluctuation manifest themselves; the abscess becomes acuminate, pointing occurs, and spontaneous evacuation follows.

2. The *pressure symptoms* depend upon the size and seat of the abscess; in the cranium an abscess produces symptoms of compression of the brain; in the tonsil, dysphagia; in the neck, dyspnea. Large blood vessels, especially veins, are occasionally compressed, but very rarely opened by an abscess.

3. The *constitutional symptoms* vary from a slight rise in temperature to the severer grades of septicemia or even pyemia (q.v.). Leukocytosis occurs when there is free absorption of the toxin and active resistance of the tissues. It may be absent in trivial suppurations, in very severe forms in which all resistance is overcome, and in those abscesses of a subacute nature which are thoroughly walled in by fibrous tissue.

The **diagnosis** of a superficial abscess is, as a rule, easily made. A suspected abscess near a large blood vessel should always be carefully investigated, in order to avoid the calamity of opening an aneurysm. The differential diagnosis is given under aneurysm. Lipomata and small-celled sarcomata not infrequently present pseudofluctuation, and a cyst actually fluctuates; in these conditions, however, the absence of inflammatory phenomena, and the aspirating needle if necessary, will dispel all doubt.

The prophylactic **treatment** consists in the thorough disinfection of all abrasions and wounds. In severe inflammations early incision will occasionally prevent, or at least limit, the formation of pus. Suppuration is often encouraged when it is known to be inevitable, by the application of antiseptic fomentations. When pus is once formed, the abscess must be opened.

The *antiseptic preparations* before incision should be as thorough as before any operation, because of the danger of secondary infection.

Anesthesia may not be necessary, in which case the knife should be sharp and the hand quick, the incision being so made that if the patient draws the part away he will assist rather than hinder the surgeon. Infiltration anesthesia is too painful in inflamed tissues and may spread infection. Freezing likewise, is attended by pain, and acts only on the skin. Regional anesthesia (q.v.), when applicable, is the best form of local anesthesia. If a general anesthetic is desired the best, if only an incision is to be made, is nitrous oxid.

The *incision* should, in order to facilitate drainage, be made, whenever possible, at the most dependent part of the abscess. Important structures (e.g., vessels and nerves) must be avoided and, especially on the face and the neck the incision should, in order to render the subsequent scar inconspicuous, be made in, rather than across, the natural creases of the skin. When an abscess is situated in a dangerous region, such as the neck, one may employ *Hilton's method*, i.e., the skin and deep fascia are incised, and after a director has been pushed into the cavity, a pair of closed hemostatic forceps is passed along the groove, then opened, and withdrawn while open so as to dilate or tear the structures. In some cases a *counter-opening* is desirable for better drainage, or for through and through irrigation. This is made by pushing a pair of forceps against the opposite wall of the abscess, and cutting down upon the end with a knife.

Exploration of the abscess cavity with the finger may lead to the discovery and the removal of the cause, e.g., an inflamed appendix, a foreign body. Squeezing the abscess increases the inflammation, curetting exposes new areas to infection.

Disinfection of the abscess cavity with a strong antiseptic is occasionally indicated, irrigation with salt solution is often desirable, but antiseptics and irrigation are both contraindicated in many cases, particularly when the abscess is in the cranium, the thorax, or the abdomen.

Drainage may be effected by tubing, gauze, or strips of rubber tissue.

Dressings should be changed frequently and the part kept at rest. Heat is often grateful to the patient, and perhaps there is some virtue in hot fomentations of Wright's solution (sod. chlor. 4 per cent., sod. cit. 1 per cent., in water). Sodium chlorid in hypertonic solution increases the exudation of lymph, the calcium salts of which are precipitated by sodium citrate, thus removing one of the elements necessary to coagulation and ensuring a free discharge. The skin must be protected from the irritating action of the sodium citrate by vaselin, and the solution should not be used if there is a tendency to oozing of blood or if adhesions are desired. Further, as pointed out by Crandon, the solution should be discontinued after 36 or 72 hours, since prolonged applications lead to maceration and to indolence in healing. No matter what dressing is employed, if there is pain severe enough to interfere with sleep, or if the fever persists, it will usually be found that drainage is insufficient and that a larger incision is indicated. (For Bier's treatment see inflammation).

The *constitutional treatment* is that of sepsis (q.v.)

Chronic abscess may follow the acute form, owing to encapsulation in firm fibrous tissue. In the brain, the breast, and the tongue a chronic abscess due to pyogenic organisms sometimes forms without preceding acute symptoms. Chronic abscess may be due also to syphilis, and it occurs in the liver from infection with the ameba coli. The term chronic, however, when applied to abscess, usually means tuberculous, and it is with such that we shall deal under this heading. The abscess is formed by the liquefaction of tuberculous tissue (see tuberculosis), and although it may occur in any portion of the body, it is most frequently found in connection with bones, joints, and lymphatic glands. The contents is not true pus, but a yellowish-white, odorless fluid containing cheesy masses of broken down tissue, coagulated fibrin, a few cells undergoing fatty degeneration, and frequently cholesterin crystals; there are no pyogenic organisms, and few or no tubercle bacilli, although injection of the fluid into guinea-pigs produces miliary tuberculosis. The abscess wall is composed of two layers, the inner (*Volkmann's layer*) consists of large flabby granulations, grayish-yellow or purplish in color, containing miliary tubercles, and is easily detached from the outer layer, which is composed of dense fibrous tissue (*pyogenic* or *prophylactic membrane*). There is no zone of inflammation.

The abscess forms without inflammatory **symptoms**, hence the term *cold abscess*. Pain, when present, is due more to pressure upon surrounding parts than to the disease process itself, and tenderness is often absent in the abscess itself, although usually demonstrable in the tissue primarily diseased. The skin, instead of being red, may be paler than normal (*white swelling*); while softening and fluctuation are usually quite evident, owing to the absence of inflammatory infiltration. As the cause of trouble is often deep, the pus is prone to make its way beneath dense fasciæ, and to appear on the surface at a point far distant from the original focus. In tuberculosis of the dorsolumbar spine pus may appear in the lumbar region, iliac region, perineum, or in the thigh. When a tuberculous abscess suddenly makes its appearance on the surface, it has usually come from a distance and broken its way through some resistant structure, as its formation generally occupies weeks or months. An untreated tuberculous abscess may reach the surface and evacuate itself, or be walled in by fibrous tissue. In the latter event the contents become putty-like in consistency, calcified, or absorbed and replaced by fibrous tissue. When such an area again becomes active, it is called a residual abscess.

Constitutional symptoms may be absent. Progressive loss of weight with pallor is often absent in uncomplicated tuberculous abscesses, and there is no leukocytosis. After the abscess bursts and other organisms gain entrance, the discharge is thick, purulent, and increased in amount, and constitutional symptoms of mixed infection are present, viz., those of hectic fever and, if the suppuration is long continued, amyloid disease. Secondary infection by way of the blood is possible but rare.

Hectic fever (chronic septic intoxication) occurs only when there is mixed infection; it may be found not only in the tuberculous, but in any case in which there is protracted suppuration. It is due to the persistent absorption of toxins, and is characterized by a daily afternoon rise in temperature, at which time the cheeks become flushed (*hectic flush*), the eyes bright, and the pulse quickened; during the night the temperature falls rapidly with profuse sweating (*night sweat*); and the patient soon becomes weak and emaciated.

Amyloid disease (albuminoid, lardaceous, waxy, or colloid degeneration) finally supervenes. The cause of this condition is not known; it may be due to the chronic toxemia, or to the discharge draining from the blood alkaline salts. The walls of the capillaries and arterioles and eventually the viscera, especially the spleen, liver, and kidneys, become infiltrated with an albuminoid or waxy material. The mucous membranes, particularly those of the intestines, likewise are frequently involved. The affected organ is large, pale, heavy, and smooth. Owing to the changes in the intestinal mucosa, disorders of digestion and diarrhea are present. The cachexia is due partly to the prolonged suppuration and partly to the visceral changes. The diagnosis is easily made, when in the course of a prolonged suppuration, the spleen and liver enlarge, and there is diarrhea and polyuria, with albumin, and amyloid casts giving the iodin reaction. The time necessary for the production of amyloid disease varies within wide limits; the shortest period probably being three months. Amyloid disease should be prevented by the active treatment of chronic suppuration. Its onset, although serious, is an indication for, rather than a contraindication to, operation, as the process may be checked in its early stages.

The **diagnosis** of a cold abscess is made by its chronic course, the absence of inflammatory symptoms and leukocytosis, and frequently by the detection of changes in the bones or joints from which it has arisen. In doubtful cases aspiration may be used. The diagnosis of tuberculosis is given in more detail under tuberculosis.

The **treatment** is *incision* under scrupulous antiseptic precautions and removal of the cause (necrotic bone, tuberculous lymph glands, etc.). After removal of the granulations with a curette, the cavity should be thoroughly irrigated, and packed with iodoform gauze. If the limits of the

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abscess cannot be reached, or if the cause cannot be removed, the incision may be *sutured*, in order to avoid secondary infection during the subsequent dressings. In cases in which the abscess is small, particularly when connected with a lymphatic gland, *excision* of the whole abscess cavity and suture of the wound is indicated. Simple *aspiration* and *aspiration followed by irrigation* with a weak antiseptic solution are occasionally successful. *Iodoform emulsion* (10 per cent. in glycerin or olive oil) may be injected, after tapping and irrigation, once a week until healing occurs. Not more than 4 or 5 drams should be used in an adult, and not more than 2 or 3 drams in a child, because of the danger of poisoning. Ethereal emulsions become gaseous after injection, and in certain regions may produce harmful pressure. *Bier* makes a small incision and applies a vacuum pump (p. 69). Beck evacuates the pus through a small opening, fills the cavity with *bismuth paste* (p. 88), and applies a sterile dressing. If the opening heals and the fluid reaccumulates, the wound is reopened and the fluid allowed to escape; the injection is not repeated. It may be necessary to adjust apparatus if the abscess proceed from bones or joints. The *constitutional treatment* is that of tuberculosis (q. v).

Abscesses in various parts of the body which require special mention will be found in those sections devoted to regional surgery.

CHAPTER VIII.

ULCERATION.

Ulceration is the progressive molecular destruction of superficial tissues. Ulceration of bone is called caries.

The cause of ulceration is infection, or lowered resistance of the tissues with infection. From an etiologic standpoint ulcers may be grouped under the following headings:

1. *Simple ulcers* include those in which the molecular destruction is due, wholly or principally to pyogenic organisms, the lower resistance of the tissues being the result of inflammation; traumatism (mechanical, chemical, thermal); deficient circulation, such as is caused by scars, atheroma, the lodging of an embolus, pressure (splint sores and bed sores), and passive congestion (varicose ulcer); nervous lesions (corneal ulcer following removal of the Gasserian ganglion, perforating ulcer of the sole in locomotor ataxia); or constitutional diseases, such as gout, scurvy, diabetes, and mercurialism.

2. *Ulcers due to specific bacteria* occur in chancroid, tuberculosis, syphilis, leprosy, glanders, and anthrax.

3. *Malignant ulcers* are caused by the breaking down of malignant growths. In groups two and three infection with pyogenic bacteria is inevitable, and augments the destructive process.

Pathologically an ulcer presents the changes which are found in the wall of an abscess, the suppuration being in excess of the reparative process. As ulceration extends, adjacent structures may be involved, e.g., a leg ulcer may produce caries or necrosis of the tibia; occasionally large vessels are opened, and ulcers in the gastrointestinal canal may perforate and cause generalized peritonitis. When an ulcer ceases to extend and the reparative processes are in excess of those of destruction, strictly speaking, the lesion ceases to be an ulcer and becomes a healing wound.

The **diagnosis** of ulcers is made by considering the (1) mode of onset, (2) duration, (3) number, (4) amount of pain, (5) size, (6) shape, (7) situation, (8) floor, (9) edges, (10) discharge, (11) surrounding tissue, (12) condition of the adjacent lymph glands, and (13) the age and (14) general condition of the patient.

1. *Mode of Onset.*—An injury may inaugurate many forms of ulceration besides the traumatic, e.g., tuberculous, syphilitic, varicose, etc. An ulcer due to an embolus is preceded by a small area of gangrene. Pressure ulcers are found after the removal of splints and apparatus. An ulcer which has been preceded by a swelling may be the result of inflammation, tuberculous abscess, gumma, or a breaking down neoplasm.

2. *Duration.*—Traumatic ulcers are acute; malignant ulcers may last months, varicose ulcers, years.

3. *A number* of ulcers scattered over the body commonly indicates some general disease, although chancroids (local infection) are multiple and chancre (constitutional disease) is single.

4. *Pain.*—The perforating ulcer of the sole of the foot and other trophic ulcers may be painless; acute ulcers in healthy tissues are accompanied by a

burning or stinging pain. Intense pain without inflammation is experienced in the erethistic, irritable, or neuralgic ulcer.

5. *Size.*—Bed sores, varicose, phagedenic, and malignant ulcers may attain a large size. The ordinary traumatic, trophic, and syphilitic ulcers are smaller.

6. *Shape.*—Syphilitic ulcers are circular, semi-lunar, irregular, or serpiginous, and often punched out in appearance. Tuberculous ulcers are ovoid or ragged.

7. *Situation.*—Traumatic ulcers occur in regions exposed to injury, such as the shin and elbow. Ulcers on the tips of the fingers and toes may be due to defective circulation. Tuberculous ulcers are frequent about the mouth and in the vicinity of lymph glands (neck, axilla, groin) and joints; syphilitic ulcers about the genitals and in the neighborhood of joints; lupoid ulcers on the face; carcinoma about the face, mouth, breast, rectum, and genitals; scorbutic ulcers on the gums; and varicose ulcers in the lower third of the leg.

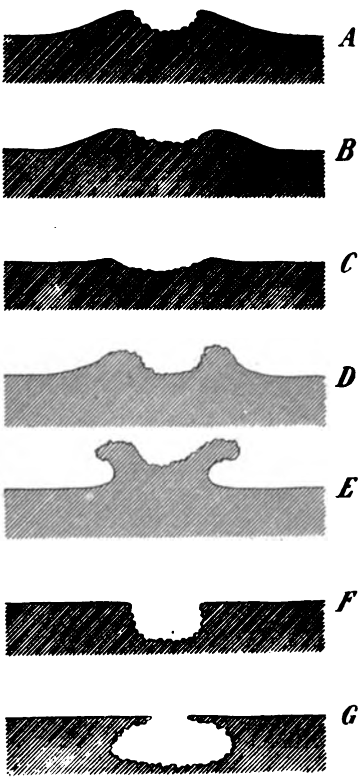

FIG. 59.—Diagrammatic profiles of ulcers. *A*, Acute; *B*, indolent; *C*, healing: *D.E.*, carcinomatous: *F*, syphilitic: *G*, syphilitic or tuberculous.

8. The *Floor.*—A healing ulcer is covered with firm, bright red granulations; an extending ulcer with disintegrating, grayish-yellow tissue and no granulations; a stationary ulcer with a few, feeble, yellowish granulations on a smooth and glistening surface; and a scorbutic ulcer with a thick, soft crust of clotted blood. Large, pale, edematous granulations suggest tuberculosis or some other debilitating malady; in many of these cases will be found a sinus leading down to necrotic bone or caseating glands. The floor may be covered with diphtheritic false membrane. A syphilitic ulcer (Fig. 80) may show the characteristic, dirty-yellow, tough slough of gummy degeneration. In some cases a section should be removed for microscopic examination.

9. In a spreading ulcer the *edges* are inflamed, thickened, eroded; in the indolent or callous ulcer hard, well defined, and raised above the surface; and in a healing ulcer sloping, with three zones, (1) a red zone of granulation tissue, (2) a blue or purplish zone of beginning epidermization, (3) a white zone of skin. Undermined edges are seen especially in syphilis and tuberculosis, and thick, non-granulating, everted edges in carcinoma (Fig. 59).

10. The *discharge* may be fetid in any ulcer, from contamination with saprophytes; it is profuse, watery, ichorous, and often mixed with blood in a spreading ulcer; fetid and sanious in a scorbutic ulcer; seropurulent in a healing ulcer; purulent and irritating in an indolent ulcer. In a gouty ulcer urate of

soda may be detected; in other ulcers examination of the discharge may be made for various forms of organisms.

11. The *surrounding tissues* may show evidence of syphilis or defective circulation, or they may be healthy. In malignant ulcers the surrounding tissues are the seat of a neoplastic infiltration; loss of sensation and hair, and a shiny appearance indicate trophic changes.

12. *The adjacent lymph glands* may be enlarged in any form of ulceration, from the absorption of bacterial products. In ordinary pyogenic ulcers they show the signs of acute inflammation. In early syphilis the enlargement is general, and the glands are discrete and do not mat together; in carcinoma they enlarge, infiltrate the surrounding tissues, and are often of stony hardness; in tuberculosis they mat together, become adherent to the skin, form sinuses which discharge caseous pus, and are often painless.

13. *Age.*—Ulcers in children are often tuberculous or due to congenital syphilis; in old age varicose and malignant ulcers are more common.

14. *General Condition of the Patient.*—Examine for tuberculosis, syphilis, gout, scurvy, diabetes, nephritis, cardiac disease, and for any cause that impairs the general health.

The **treatment of ulceration** may be considered under the following headings, (1) removal of the cause, (2) disinfection, (3) rest, (4) elevation, (5) other measures to promote healing.

1. *Removal of the cause,* when possible, converts the ulcer into a healing wound. Varicose veins may be removed or supported, an ingrowing toe nail excised, tuberculous glands extirpated, and jagged teeth extracted. One should look for and combat the conditions mentioned above among the constitutional causes of ulceration.

2. *Disinfection* is often synonymous with removal of the cause. Microbic invasion, if not the primary cause, is at least a secondary factor in all forms of ulceration. Disinfection is usually carried out by spraying with peroxid of hydrogen and, according to the condition of the ulcer, washing with bichlorid of mercury or salt solution.

3. *Rest* is as important here as in inflammation. In an ulcer of the cornea rest is secured by bandages or dark glasses, in an ulcer of the stomach by rectal feeding or gastroenterostomy, in an ulcer of the anus by dilatation or division of the sphincter, and in some other regions by placing the patient in bed or by the use of splints.

4. *Elevation* is indicated in all forms of ulceration in which it may be secured; even in those due to deficient arterial circulation the tissues are apt to be filled with fluid.

5. *Other measures to promote healing* may be studied according to whether the ulcer is (a) spreading, (b) stationary, or (c) healing.

(a) In an acute *inflamed ulcer,* which is not infrequent in alcoholics and in the debilitated, the part should be elevated, disinfected, and dressed with hot antiseptic fomentations, held in place by a bandage applied from the extremity of the limb to above the ulcer. If sloughing is present, heat will hasten separation, and the sloughs may be removed with forceps and scissors. Powders are usually contaminated with micro-organisms, and form a crust which interferes with the proper toilet of the part. Ointments are difficult to sterilize, interfere with drainage, and are hard to remove; if they are used, lanolin or vaselin makes the best base. Lard should never be employed as it quickly putrefies. The adjacent lymph glands, if swollen, may be covered with a 20 per cent. ichthyol ointment; if suppurating, they should be excised. Attention should always be given to the general health by the administration of laxatives, or by other measures to promote elimination; tonics, such as iron, quinin, strychnin, are usually indicated, and sedatives may be necessary. *Phagedenic ulceration* is occasionally seen in syphilis, in fact in any ulcer, but it most frequently attacks chancroid, and was at one time common as hospital gangrene. Depraved vitality probably has as much to do with the process as the virulency of the infection. The ulcer spreads with great rapidity, and requires powerful disinfectants, such as the actual cautery, pure carbolic acid, or nitric acid, while the general condition of the patient is improved by tonics and stimulants.

(b) *The indolent, chronic, or callous ulcer* is most frequently seen on the lower third of the leg, in the latter half of life (*varicose ulcer*), but is encountered also in syphilis and tuberculosis and after large burns. Varicose ulcer is oval in shape, usually painless, and may last for years. It has humped-up, hard and congested edges, and a smooth, glistening, dirty-yellow floor with a few feeble granulations. The discharge is often irritating and causes eczema of the neighboring skin (*eczematous ulcer*). The ulcer is firmly attached to the surrounding parts, so that contraction is prevented; adjacent vessels may be compressed, causing a persistent edema, sometimes with an overgrowth of the subcutaneous tissues resembling elephantiasis. In some cases there is marked pigmentation of the surrounding skin, owing to the escape and disintegration of red blood cells. The *irritable, erethistic, neuralgic, or painful* ulcer is often seen in these cases, and is due to the exposure of nerve filaments. It is treated by cauterizing or excising the painful spot, by passing a tenotome above it to divide the affected nerve filament, or by curetting the whole ulcer. The treatment of chronic indolent ulcers is frequently tedious and disappointing, as they often occur in patients who cannot afford the time to care for them properly. Any existing constitutional disease should receive attention, especially diseases of the heart and blood vessels. Strychnin, digitalis, and nitroglycerin are often of service. Varicose veins should be treated (p. 199). If possible, rest and elevation should be secured. The ulcer may be cleansed, if sloughs exist, with hot antiseptic fomentations (boracic acid, carbolic acid, salt solution). Massage of the surrounding parts is often beneficial. *Compression* is usually indicated; it may be made by a muslin bandage, by a flannel bandage, by *Martin's rubber bandage*, or better by the *Randolph bandage*, which consists of elastic webbing that does not tend to macerate the skin like the rubber bandage; another useful form of compression is secured by overlapping strips of adhesive plaster which encircle the limb two-thirds only. A piece of lint the exact size of the ulcer, soaked in copper sulphate, grains 10 to the ounce, is first placed over the sore. Unna's dressing consists of gelatin 5 parts, oxid of zinc 5 parts, boric acid 1 part, glycerin 8 parts, and water 6 parts; these are mixed and liquefied in a water bath. After cleansing the part, a gauze bandage is applied from the extremity of the limb to above the ulcer and painted with the fluid; several layers of gauze may thus be applied and painted. The liquid solidifies on cooling and resembles adhesive plaster, so that most of its virtue lies in the compression exerted; this dressing may be left in place until it loosens (one to three weeks). If there is much discharge, the dressing may be applied every few days, or, better, the ulcer itself may be left uncovered for drainage and cleansing. Schulze purifies the ulcer with soap and water, and dresses it with a solution of acetate of aluminium (2 per cent. in water) until the discharge decreases and loses its odor; a piece of lint the size of the ulcer is then soaked in spirits of camphor, and applied beneath absorbent cotton, rubber dam, and a compression bandage. The camphor is reapplied every other day, after washing with a 2 per cent. solution of carbolic acid. In cases in which there is marked congestion, scarification or blistering of the ulcer and surrounding parts has been advised. When healing is prevented by adhesions to the underlying structures, the edges may be liberated by curved incisions on each side of the ulcer, or by radiating incisions through its margins, or the whole ulcer may be excised. In very large ulcers which have involved bone, which resist treatment, and which occur in patients who cannot afford to be ill for a long time, amputation must be considered. *Weak, fungous, or exuberant* ulcers are covered with *exuberant* (proud flesh) *or edematous granulations*, often occur in debilitated patients, and are best treated by removal of the granulations with scissors or curette and touching the base with pure nitrate of silver. *Deficient granulations* require applications of silver nitrate (10 gr. to the ounce), copper sulphate (gr. 10 to the oz.), balsam of Peru, red wash (zinc sulphate gr. 2, compound tincture of lavender m. 10, water 1 ounce), argyrol (10 per cent.), or tincture of iodin (half strength). Scarlet red ointment (8 per cent. in vaselin) stimulates epithelial proliferation, but not the granulations; it should be applied to the epithelial margin only, for 24 hours at intervals of several days, and not continuously. *Hemorrhagic ulcers* are seen in anemia and scurvy; the principal indications are to treat the constitutional condition and apply pressure. Eczema requires cleansing with sweet oil, and the application of ichthyol (5–10 per cent.), lead-water and laudanum, Unna's dressing, liq. carbonis detergens (1 ounce to liq. plumbi subacetat. dil. 1 pint), oxid of zinc ointment, or boracic acid ointment. In some cases healing is prevented by turning in of the skin edges, a condition which is met by freeing the edges with incisions.

(c) In a simple ulcer, after removal of the cause, all that need be done is to maintain cleanliness and the tissues will effect repair. In large ulcers situated near a joint, the limb should be placed in the best position to prevent contraction during the healing process. In many of these cases skin grafting should be employed.

Trophic ulcers, bed sores, and those ulcers occurring in groups 2 and 3 are considered under their respective headings in later chapters.

SINUS AND FISTULA.

A **sinus** is an abnormal canal leading from the surface of the body down into the tissues; it is lined with granulations and usually ends in the cavity of an unhealed abscess. Sinuses are caused by (1) *foreign bodies*, either exogenous (e.g., a bullet, needle, or non-absorbable ligature), or endogenous, e.g., a caseating gland, necrotic bone, or carious tooth; (2) *deficient drainage*, that is, the orifice heals, pus accumulates, another abscess forms, spontaneous evacuation occurs, and the process is repeated over and over; (3) *want of rest;* (4) *infection of the walls*, especially by the tubercle bacillus; (5) *ingrowth of epithelium;* (6) *fibrous rigidity of the walls* which prevents their coming together; and (7) *general debility*.

The **treatment** is removal of the cause. The sinus should be widely opened, thoroughly explored, carefully disinfected, and loosely packed with gauze, so that it may heal from the bottom. In ligature sinuses the ligature may often be removed by fishing with a crochet needle. In some cases, e.g., those caused by rigid walls or ingrowth of epithelium, excision should be performed. In tuberculous sinuses not suited for radical operation Bier's suction pump (p. 69) or the injection of *Beck's bismuth paste* may be tried. Two preparations of bismuth paste are used. The first consists of bismuth subnitrate 33 per cent., and vaselin 67 per cent.; the second of bismuth subnitrate 30 per cent., white wax 5 per cent., paraffin 5 per cent. (120° melting point), and vaselin 60 per cent. The vaselin, wax, and paraffin are sterilized by boiling, and the bismuth stirred in after the mixture has been removed from the fire. As the bismuth gravitates to the bottom the mixture should be heated and stirred before using. Care should be taken to exclude water, as it destroys the homogeneous quality of the mixture and interferes with its retention in the sinus. The syringe should have a blunt nozzle like that of a urethral syringe. The mouth of the sinus is sterilized with alcohol, the nozzle of the charged syringe pressed against it, and the injection made until the patient complains of pressure. A piece of gauze is then pressed against the opening until the paste has set; an ice bag will hasten this process. The first preparation is used for diagnosis (by taking a radiograph after the injection) and during the early part of the treatment, the second preparation when it is desired to retain the paste in the sinus and when there is no danger of damming up pus. Healing may follow a single injection, or it may be necessary to repeat the injection once a week. The bismuth, which is bactericidal and astringent, is absorbed and replaced by fibrous tissue. If septic symptoms supervene the bismuth may be dissolved with hot olive oil and withdrawn with a Bier suction pump. More than 100 grams of the 33 per cent. paste should never be injected, because of the danger of bismuth poisoning (stomatitis, black line on the gums, diarrhea, cyanosis, desquamative nephritis, emaciation), and in the vicinity of large veins the possibility of embolism should be kept in mind. No matter what local treatment is adopted constitutional diatheses should receive proper attention.

A **fistula** is an abnormal canal between two anatomical cavities, or between an anatomical cavity or a gland and the surface of the body. Fistulæ are the result of (1) developmental defects, e.g., branchial and umbilical fistulæ; (2) injuries, e.g., aërial, salivary, and vesico-vaginal fistulæ; (3) disease, e.g., urinary and anal fistulæ; and (4) purposive operations, e.g., gastric and biliary fistulæ. Each of these will be considered in its appropriate place.

CHAPTER IX.

GANGRENE.

Mortification, or gangrene, is death of all the tissues composing a portion of the body, e.g., the leg. Death of the soft parts alone is called sloughing, or sphacelation, and the dead tissue a slough, or sphacelus. The terms gangrene and sloughing, however, are often used interchangeably, and the term necrosis, which means any form of local death, is usually restricted by the surgeon to indicate the death of a visible portion of bone, the dead mass being called a sequestrum.

The **signs** of gangrene are (1) loss of arterial pulsation; (2) loss of heat, the temperature of the part becoming that of its surroundings; (3) loss of sensation, a dead limb may, however, have pain or sensation referred to it, just as a patient whose arm has been amputated may feel pain in his fingers; (4) loss of function; (5) loss of natural color, the part becoming pale, then purplish or greenish in moist gangrene, and black in dry gangrene.

According to the changes which ensue, gangrene is divided into two forms, the dry and the moist.

Dry gangrene (*mummification*) results when the tissues have very little fluid in them at the time of death. It is usually but not invariably due to gradual cutting off of the arterial supply. The fluid in the tissues evaporates, the part becoming dry, hard, wrinkled, shriveled, and finally deep black in color (Fig. 60). The tissues above the area of gangrene are usually inflamed. The odor is slight unless putrefactive organisms are present.

Moist gangrene occurs when the tissues are full of fluid at the time of death. It usually follows sudden blocking of the arterial supply or obstruction to the venous return. There is great swelling, the formation of blebs, and loosening of the whole epidermis. The color changes from white to purple, and finally becomes greenish or blackish; there is a very offensive odor, due to putrefaction, and the tissues become soft and rotten (Fig. 61), and frequently contain gas. Aseptic moist gangrene, in which putrefaction is absent, is rarely seen by the surgeon, but should be striven for by strict antisepsis, when it is known that a part, e.g., a limb after ligation of the main artery, is about to fall into moist gangrene.

Gangrene terminates in (1) death of the individual, or (2) in separation of the dead part from the living. In the internal organs a small aseptic area of gangrene may be absorbed or encysted. On the surface, or in the internal organs if the process be septic, separation takes place by ulceration, the line between the living and dead tissues being called the *line of demarcation.*

According to **etiology** gangrene may be classified into three groups: (1) *Indirect gangrene,* which is caused by interference with the blood supply, and in which the general condition of the patient is usually an important factor, includes (a) senile. (b) pre-senile, (c) diabetic, (d) post-febrile, (e) Raynaud's, (f) and ergot gangrene, (g) ainhum, and (h) gangrene from embolus, (i) ligature of the principal artery of a limb, (j) thrombosis of an artery the result of injury, and (k) obstruction of the principal artery and vein; (2) *direct gangrene,* the result of direct trauma to the tissues, includes gangrene from

(a) severe crushes, (b) prolonged pressure, (c) chemical injuries, (d) the X-ray, (e) frost bites, and (f) burns and scalds; (3) *Mixed or microbic gangrene,* in which the tissue cells are directly killed by bacterial toxins and the blood vessels occluded by thrombosis, includes (a) traumatic spreading gangrene, (b) hospital gangrene, and (c) noma.

(1) INDIRECT GANGRENE.

(a) **Senile, chronic, or Pott's gangrene** is the result of obliterating endarteritis, and occurs in the old, in whom the heart is generally feeble and the kidneys diseased, thus contributing to the impairment of nutrition. It is most frequent in the lower extremity, but occasionally attacks the upper extremity or even the nose and ears. The arteries become calcareous, much reduced in calibre, and inelastic. The actual onset of gangrene is often determined by a slight injury or inflammation, which induces thrombosis in the smaller vessels; or a thrombus may form in the artery supplying the part.

The prodromal **symptoms** are coldness, numbness, tingling or cramp-like pains, and sometimes intermittent claudication. The leg (for such is the part usually affected) is congested, the color returns slowly after pressing the finger on the skin, and the pulse at the ankle is very faint. The gangrene starts as a little area of inflammation, which usually ulcerates and then dries, forming a black slough, which gradually spreads into the adjacent tissues and assumes the characteristics mentioned under dry gangrene. The surrounding tissues are inflamed, the redness becoming purple, and finally black as the process advances. When tissues are reached in which the blood supply is sufficiently active to prevent thrombosis, a line of demarcation forms. Occasionally a spurious line of demarcation will begin to form, but the gangrene advances beyond it. Severe pain and marked exhaustion are often present, and if infection occurs, a fetid odor arises and symptoms of sepsis supervene. Death occurs from exhaustion, septic absorption, or from complicating cardiac, pulmonary, or renal disease.

The prophylactic **treatment** in those who exhibit prodromal symptoms consists in avoidance of injury, careful attention to the slightest bruise or cut, cardiac stimulants, nitroglycerin, massage, and keeping the feet warm with woolen stockings in the day time and a warm water bag at night. The treatment of the gangrene itself depends upon its extent and the general condition of the patient. If but one or two toes are affected and the general health good, one should wait for a line of demarcation, in the meantime keeping the foot dry, warm, elevated and antiseptic. In order to prevent the spread of the gangrene, an anastomosis between the femoral artery and vein, to permit the veins to carry blood to the undernourished tissues, has been tried in a few cases, without, however, encouraging results. When the line of demarcation forms, the casting off process may be assisted by scissors, and the remaining ulcer treated antiseptically, or a formal amputation may be performed. If the gangrene spreads to the foot or higher, if symptoms of sepsis arise, or if the general condition of the patient is such that he will not withstand the tedious efforts of nature to rid him of the gangrenous part, immediate amputation should be performed well above the limits of the disease. Most surgeons advise amputation through the lower third of the thigh, as at any lower point recurrence of the gangrene is almost certain to follow. The tissues should be bruised as little as possible, the flaps made of the same length, so that they will be well supplied with blood, and the Esmarch band omitted, as it favors the formation of a thrombus in the femoral artery. This disadvantage of elastic constriction contraindicates also the Moszkowitz test for determining in advance the probable line of demarcation (see amputations, Chap. XXXI). The deep femoral artery, which helps to nourish the flaps when amputation is performed at this point, rarely becomes atheromatous.

(b) **Presenile, or spontaneous gangrene,** is the same as senile gangrene, except that it attacks the young. It is more frequent in Hebrews and is often improperly called Raynaud's gangrene. The *treatment* is that of senile gangrene. The cause of the arteritis, if ascertainable, also should be combated.

(c) **Diabetic gangrene** likewise is, in most instances, due to an obliterating endarteritis. Sugar in the blood lessens the resistance of the tissues and acts as a contributing factor. Some believe the cause to be a peripheral neuritis. The gangrene is apt to be inaugurated by a slight wound, which becomes infected and necrotic, the process extending and involving the whole limb; it may occur in any portion of the body, but is most frequent in the lower extremity, in the latter half of life. It may be dry if the arterial disease is far advanced, but is much more likely to be of the moist variety, and is then often very rapid in its progress. The *treatment* is that of senile gangrene. Even after high amputation the flaps are apt to become gangrenous, and many cases die in diabetic coma after operation. Albuminuria, the presence of acetone, diacetic, or oxybutyric acid in the urine, or an increase in the amount of ammonia excreted, makes the prognosis particularly unfavorable. The symptoms and treatment of acidosis or acetonuria, are given under delayed chloroform poisoning (see anesthesia). In order to prevent acidosis the patient should not be restricted to a diabetic diet at once, but only gradually, and if acetone or diacetic acid appear in the urine, the amount of sugar in the diet should be increased and sodium bicarbonate administered. A local anesthetic may be employed to lessen the danger; if a general anesthetic is used, nitrous oxid and oxygen is the safest; chloroform is absolutely contraindicated.

(d) **Post-febrile gangrene** may occur during the convalescence from any fever, especially those of long duration like typhoid. It may be dry or moist, and is due to arteriothrombosis the result of endarteritis, or to the lodging of an embolus. The occurrence of gangrene from phlebitis alone is doubtful. The *treatment* is that of senile gangrene.

(e) **Raynaud's, or symmetrical gangrene,** is a form of dry gangrene occurring in Raynaud's disease, which is a vaso-motor neurosis most frequently found in young, anemic, hysterical females. The cause probably lies in the vaso-motor centers. It usually attacks the fingers or toes, occasionally other parts of the body, and sometimes follows exposure to cold, sometimes emotional disturbances. Hemoglobinuria and scleroderma occur in some cases. There are three stages: (1) The parts become white, stiff, and painful (local syncope), owing to spasm of the arterioles; then (2) cold, blue, and congested (local asphyxia); or if the attack terminates in this stage, red, hot, and swollen; and finally in unfavorable cases (3) dry, black, and anesthetic (gangrene), as the result of thromboarteritis. The process usually remains superficial, although a phalanx may become necrotic. The *treatment* is that of senile gangrene, and attention to the associated neurosis. Thyroid extract is occasionally beneficial. In the first stage an Esmarch band may be applied above the affected part for several minutes; when it is removed blood rushes into the paretic vessels.

(f) **Ergot gangrene** is very rare at the present time. It is due to a spasmodic contraction of the arterioles, from eating bread made with diseased rye. The gangrene is dry and superficial, but may spread rapidly and involve an entire limb, especially if there is associated arteriosclerosis and infection. The fingers and toes are the parts most often affected. The *treatment* is that of senile gangrene, with measures for promoting the elimination of the ergot.

(g) **Ainhum** is a peculiar trophic lesion affecting the little toe, rarely the other toes or the fingers. It almost always attacks negroes and is confined to tropical and subtropical countries. A furrow of callous tissue forms around the base of the toe and slowly deepens until the toe falls off. Division or excision of this furrow may be of service, but amputation is the usual result.

(h) **Gangrene from Embolus.**—In the lower extremity an embolus usually lodges at the bifurcation of the femoral or the popliteal, in the upper extremity at the point where the superior profunda is given off or at the bifurcation of the brachial. As ligature of the main artery of a limb is usually insufficient of itself to cause gangrene, so with the lodgment of an embolus;

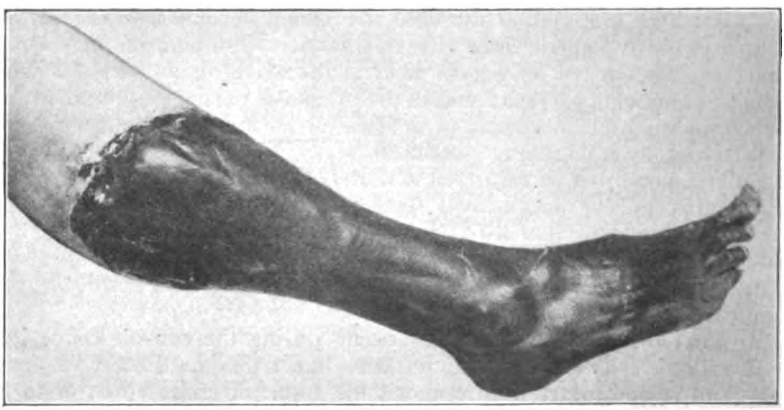

FIG. 60.—Dry gangrene from embolus. (Jefferson Hospital.)

the collateral circulation is likely to be established unless there be a previous diminution in the vitality of the part, e.g., from cardiac disease, endarteritis, or an associated general disease. The symptoms and general facts of embolism are given in Chap. xv. Owing to the sudden cutting off of blood pressure, venous blood surges back into the limb, which becomes bluish, swollen, edematous, and finally the seat of moist gangrene. Dry gangrene, however, occasionally follows, particularly if there has been previous chronic malnutrition of the limb the result of endarteritis. The *treatment* is that of senile gangrene. In order to prevent or to limit embolic gangrene we have in two cases incised the artery (femoral, abdominal aorta) and removed the embolus, subsequently suturing the wound in the vessel.

(i) **Gangrene from ligature of the principal artery of a limb** seldom occurs if the general health is unimpaired and the limb sound. The same general facts apply here as in gangrene from embolus. Except in emergency cases it is a good plan to compress the artery at intervals for several days before ligation, in order to encourage the formation of an efficient collateral circulation. In many instances there is a loss of one or two toes, the result of dry gangrene. The *treatment* is that of senile gangrene.

(j) **Gangrene from thrombosis of an artery** the result of injury occasionally occurs, the symptoms and treatment being practically identical with those of embolic gangrene. Lejars and the author have each opened the femoral artery, removed a thrombus, and then sutured the vessel. In each case the thrombosis recurred and the limb was amputated for gangrene.

(k) **Obstruction of the principal artery and vein,** the result of ligature or injury, is almost sure to be followed by gangrene. This is the form of gangrene which occurs in strangulated hernia and in a limb which is tightly constricted by bandages. When a large artery has been wounded, the venæ comites may be obstructed by the extravasated blood. The gangrene is of the moist variety. The *treatment* in cases complicated by serious crushing of the surrounding parts is immediate amputation; in other cases one should wait for a line of demarcation, unless the occurrence of sepsis prevents such a course.

(2) DIRECT GANGRENE.

(a) **Severe crushes** (Fig. 61), such as are produced by machinery and railroad accidents, may directly destroy the tissues, which if allowed to remain, putrefy, the gangrene being of the moist variety. The *treatment* is immediate amputation (see amputations).

(b) **Gangrene from prolonged pressure** is seen principally in bed sores and after the use of improperly applied splints. The so-called *trophic gangrene* usually occurs in parts which have been deprived of sensation, as the result of pressure or irritation which continues simply because the patient does not know of its existence; vaso-motor paresis is a secondary factor. Gangrene the result of pressure from splints, bandages, or apparatus, is generally the result of carelessness, but occasionally occurs when such accusation cannot be made with justice, for instance, in an old person with badly diseased arteries, or in a limb in which the vessels have been occluded by an injury. The gangrene is generally superficial (slough), but may extend deeply and widely if the parts become septic. The sloughs are allowed to separate under antiseptic dressings, and the ulcer is skin grafted to hasten healing and prevent contractures.

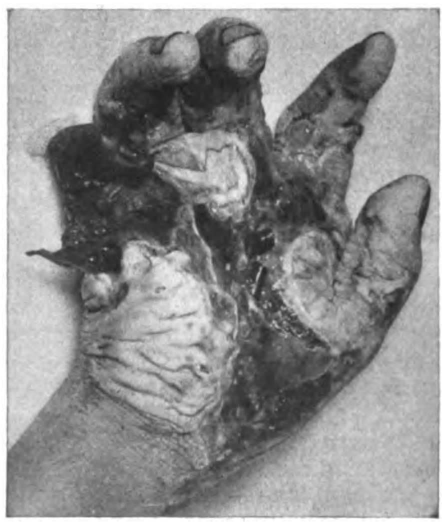

FIG. 61.—Moist gangrene from injury. (Pennsylvania Hospital.)

Bed sores (decubitus, decubital gangrene) are the result of prolonged pressure on tissues whose resistance is lowered by long illnesses. They are most apt to occur over bony prominences, such as the occiput, scapulæ, elbows, sacrum, trochanters (Fig. 229), and heels. At first the part becomes red, and in the center of the red area appears an excoriation or small blister, which is soon rubbed off; the resulting ulcer spreads into the surrounding tissues, or a large slough forms. In neglected cases or in cases in which there is impairment of sensation, the sore rapidly increases in extent and depth, and may involve even the bone, in which event exhaustion and death may follow from severe pain and septic absorption, or, if recovery ensues, healing may not occur for months or even years. In disease or injury of the nervous system, especially fractures of the spine, bed sores may appear within a day or two (*acute bed sores*). The *prophylactic treatment* consists in changing the position of the patient, so as to give as much rest as possible to the parts exposed to pressure, and the use of circular air cushions, or of a water or air bed; these should be neither too full, which makes them too hard, nor too empty, which allows the body to rest on the bed supports. Parts exposed to pressure should be inspected frequently, and the circulation maintained by rubbing with salt and whisky (a tablespoonful to the pint), or with alum and alcohol (15 grains to the pint), followed by powdering with talcum, boric acid, or stearate of zinc. The sheet should be kept clean and smooth, rough handling avoided, hot water bags if used applied with great caution, and special care taken that no particles of food find their way beneath the patient. If the sheet becomes soiled with urine or feces, or wet with perspiration, it should be changed at once. If there is incontinence of urine a permanent urinal may be used. When redness or congestion is first noticed, the skin may be protected by collodion, soap plaster, or a thick layer of some bland ointment. Irritants of all sorts should be avoided. After the sore has formed it should be cleansed with peroxid of hydrogen, half strength, and bichlorid of mercury, 1 to 2000. Sloughs should be removed and sinuses opened. In very large bed sores the patient may be placed in a continuous bath, as advised for burns. Healing may be stimulated as already indicated in the section on ulcers.

(c) **Corrosive chemicals** directly destroy the tissues. *Carbolic acid gangrene* (Fig. 62) requires special notice, because it may follow the continuous application of even a weak solution (1–20), especially if the drug is confined by an impervious covering under a tight bandage. As carbolic acid induces anesthesia, the mischief may not be suspected if the dressing remain undisturbed. The condition is most frequently seen in a finger or toe, and is of the dry variety. If an entire finger or toe be gangrenous, wait for a line of demarcation and amputate. If the superficial parts only are affected, assist separation of the slough with hot fomentations and remove it with scissors.

(d) **X-ray gangrene** is considered in Chap. i., (e) **frost bites** and (f) **burns and scalds** in Chap. xi.

(3) MICROBIC GANGRENE.

Infective gangrene occurs in various parts of the body, and may be localized or diffuse. The localized form (e.g., carbuncle, necrosis of bone) is described in subsequent chapters. The diffuse form has, according to the character of the infection and the resistance of the tissues, numerous gradations (see cellulitis), but only three varieties will be considered at this time.

FIG 62.—Carbolic acid gangrene. A splinter wound of the finger was treated by the application of a solution of carbolic acid of unknown strength for five hours, at the end of which time the finger was cold, white, and numb. Amputation. (Jefferson Hospital.)

(a) **Traumatic spreading gangrene (malignant edema, emphysematous gangrene, gangrene foudroyante)** is a gangrenous cellulitis which spreads with frightful rapidity, as the term foudroyante (lightning-like) indicates. It may follow the most trivial scratch, as well as an extensive injury, particularly when the resistance of the tissues has been lowered by debilitating maladies of a general nature. The infection is usually a mixed one, the suppuration depending upon the ordinary pyogenic bacteria, especially the *streptococcus pyogenes*, and the emphysema upon the *bacillus aërogenes capsulatus* (an amotile, aërogenic, spore producing anaërobe, sometimes found in the soil, the feces, and on the skin), the *bacillus of malignant edema* (a motile, flagellated, spore-producing, aërogenic anaërobe, found in soil, manure, and dirty water), the *bacillus coli communis*, or nonpathogenic saprophytes. Clinically the picture is the same, and the form of infection can be determined only by bacteriological examination.

The **symptoms** are those of a rapidly spreading cellulitis (Chap. xii), accompanied by severe pain, great swelling, and livid discoloration. The gangrene begins in the margins of the wound and rapidly follows the extending cellulitis. Blisters containing a thin, dark, irritating fluid appear, and the tissues become greenish and finally black, and crackle owing to the presence of gas. A line of demarcation does not form. The general symptoms are

FIG. 63.—Noma following measles.

those of profound septicemia. The mortality is 55 per cent., death usually occurring in from three to seven days.

The **treatment** is immediate amputation high above the extending gangrene. At the beginning, when the process is still localized, free incisions, with constant irrigation or immersion in a warm antiseptic fluid, may possibly check the infection. The patient should receive vigorous treatment to eliminate the toxins and sustain the strength. Anti-streptococcic serum, although rarely beneficial, may be administered.

(b) **Hospital gangrene (wound phagedena)** was an active form of ulceration or gangrene attacking wounds in the preantiseptic days. It was treated by removing the sloughs with scissors, then applying bromin, nitric acid, or the actual cautery, or by amputating, and by stimulating and sustaining general treatment.

(c) **Noma** is a gangrenous process occurring most often between the second and twelfth years. *Cancrum oris* (*gangrenous stomatitis*) is noma of the mouth, (Fig. 63); *noma pudendi* is the same process in the genitals; the condition occasionally occurs in other parts. About half of the cases follow measles, but it may be seen after other infectious diseases, and occasionally in diabetes and nephritis. The causative organism has not been isolated, but is probably the ordinary pyogenic bacteria acting on tissues whose resistance has been reduced by the preceding disease.

The **symptoms** are inaugurated by an abrasion, which becomes inflamed and finally sloughs. The part swells and becomes extremely fetid, but pain is not a prominent feature. The gangrene rapidly makes its way through the whole cheek, and may involve even the adjacent bone. The general symptoms are those of sepsis (q.v.); occasionally pyemia arises from involvement of the facial vein. Inhalation pneumonia is very apt to develop. Often the temperature falls to normal or subnormal before death, which occurs in from 70 to 90 per cent. of the cases.

The **treatment** is removal of the slough with scissors, and cauterization with the actual cautery, or, after protecting the throat with gauze, with nitric acid or carbolic acid, neutralizing the excess of the former with sodium bicarbonate, of the latter with alcohol. A general anesthetic should be used for this purpose, remembering that chloroform, and not ether, must be given if the actual cautery is to be employed. The mouth is frequently washed with boric acid solution or liquor antisepticus. Hot antiseptic fomentations of boric acid are applied to the exterior, and the patient is given nourishing liquid food, with alcohol, iron, and strychnin. If recovery ensues, the loss of tissue may be supplied by a plastic operation. In noma pudendi, in addition to the measures already mentioned, the patient may be placed in an antiseptic bath.

CHAPTER X.

CONTUSIONS AND WOUNDS.

Mechanical injuries of the tissues are of two kinds, contusions and wounds.

A **contusion** is an injury, generally the result of blunt violence, in which some of the tissues of a part are irregularly torn or ruptured, but the part as a whole remains intact and its surface continuity unbroken. It may occur in any region, but here we refer only to contusions of the skin and subjacent cellular tissue. Contusions of special structures are discussed on subsequent pages.

The **symptoms** are pain, tenderness, swelling, discoloration, impaired function, and in severe forms shock. The swelling is due partly to exudation, but principally to subcutaneous bleeding (*extravasation*), the blood either infiltrating the tissues (*ecchymosis*, or *sugillation*) or accumulating as a localized fluctuating swelling (*hematoma*). An ecchymosis when minute is called a *petechia*, when very large a *suffusion*. The amount of blood extravasated varies with the size of the vessels injured and the construction of the part, thus in lax tissues, e.g., the scrotum and eyelids, it is generally extensive, while in the scalp it is usually slight. It is apt to be excessive in the delicate, in females, in hemophilia and allied conditions, and trifling in the robust. The blood in an ecchymosis soon coagulates and is disintegrated and absorbed; the red corpuscles liberate pigment, which, as seen through the skin, is at first black, then blue, changing, as absorption progresses, to brown, green, yellow, and finally disappearing. A hematoma is surrounded by a deposit of fibrin, so that the edges feel hard and the center soft; it may be absorbed, converted into a fibroid mass, become inspissated and calcified, result in a cyst, or suppurate. A hematoma differs from an abscess in that it appears immediately after an injury without signs of inflammation, and is at first soft and later hard, while an abscess is first hard and later soft. A contusion may terminate in resolution, inflammation, suppuration, sloughing, fibroid thickening, or tumor formation, particularly sarcoma, and it sometimes, by establishing a point of lessened resistance, determines the site of chronic inflammatory lesions, notably tuberculosis. The possibility of a complicating injury to important vessels or nerves, to muscles, tendons, bones, joints, and viscera should always be kept in mind.

The **treatment of contusions** is first to combat shock, if it be present, and locally, to check bleeding and limit swelling, by means of ice, evaporating lotions, compression, elevation, and rest. In the asthenic, and in severe contusions in which there is danger of sloughing, heat with very moderate compression should be employed. In the presence of an abrasion hot or cold antiseptic dressings should be applied. During the subsiding stage ichthyol, compression, and massage will hasten absorption. Incision is not indicated unless a large vessel has been injured, or unless the tension is so great as to threaten sloughing. If a hematoma persists, it may be aspirated and firm compression applied. The slight fever which results from the absorption of the fibrin ferment of the extravasated blood needs no special treatment.

A wound is a mechanical injury with a breach in the surface continuity. Wounds may be incised, contused, lacerated, punctured, or gunshot; aseptic, septic (infected), or poisoned; complicated or uncomplicated; penetrating (which enter but do not go through a part) or perforating (which go entirely through a part); open or subcutaneous or submucous. The last includes ruptures of muscles, viscera, etc., and fractures of bones. An *abrasion,* or *excoriation,* is a rubbing off of the epidermis without breaking of the corium, a *brush burn* a superficial contused, lacerated, burned wound caused by friction and the resulting heat, as when an individual rapidly slides down a steep incline.

The **symptoms** of uncomplicated wounds are pain, hemorrhage, gaping of the edges, loss of function, and in severe wounds shock.

The local **treatment** is (1) to arrest hemorrhage; (2) disinfect, remove foreign bodies and devitalized tissues; (3) coaptate divided structures, drain, and dress; (4) secure rest. (See Chaps. on hemorrhage and technic.) The constitutional treatment is (1) that of shock (Chap. XII), the presence of which forbids, as a rule, anything more than hemostasis and the application of a temporary dressing; (2) general hygienic measures, including regulation of the diet, the bowels, and the secretions; (3) attention to sepsis (Chap. XII), should it arise, and to any general dyscrasia which may be present.

Incised wounds are those in which the edges are cleanly cut and sharply defined; they are usually produced by keen instruments, but occasionally by blunt force, e.g., the clean-cut wound of the scalp which may result from the blow of a club. Pain is severe at the time of injury, but usually subsides quickly; bleeding is profuse because the vessel walls have not been squeezed together but cleanly severed. The gaping depends upon the length and situation of the wound, being wide when the wound crosses and slight when it parallels muscle fibres or a line of "cleavage" in the skin, which line is often marked by a wrinkle. The amount of bruising present is only microscopic, so that with reasonable precautions an incised wound heals by first intention.

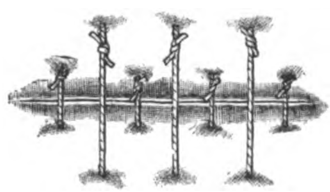

FIG. 64.—Superficial and deep interrupted sutures.

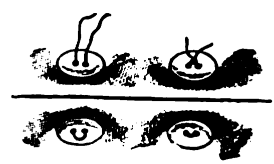

FIG. 65.—Button suture.

Treatment.—Bleeding ceases spontaneously if no large vessel has been injured. If a large vessel has been injured, it may be caught at once with hemostatic forceps, compressed with a sterile sponge, or controlled by a tourniquet above the wound. In the meantime measures should be taken to combat shock if it be present. After careful disinfection a thorough examination is made to determine the amount of injury done. Divided nerves, tendons, or muscles may be seen in the wound, sensation and motion may be investigated in the parts beyond the wound. If any of these structures have been severed, they are to be sutured with chromicized catgut.

The margins of the wounds may be coaptated by bandaging, by sterilized adhesive plaster, by gauze plastered down with collodion, or by small metal clips with serrated edges (*Michel clamps*) which are applied and removed with special forceps, but these measures are not nearly so satisfactory as **sutures**. Deep parts should be approximated with *buried sutures* of catgut. When there is much tendency towards retraction of the edges, or when a

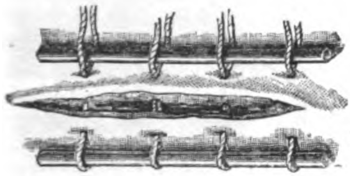

FIG. 66.—Quilled suture.

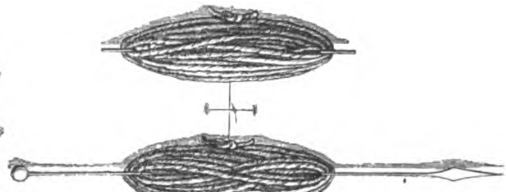

FIG. 67.—Twisted suture. (Esmarch and Kowalzig.)

wound is deep, two varieties of sutures will be required, viz., *deep sutures* (*retention sutures, or sutures of relaxation*) and *superficial sutures*, or *sutures of coaptation* (Fig. 64). Retention sutures are usually of silkworm gut, but may be of silk or silver wire; they are inserted an inch or more from the margins of the wound, traverse the entire thickness of the divided parts, and are then tied, or are fastened to lead buttons (Fig. 65), which distribute the

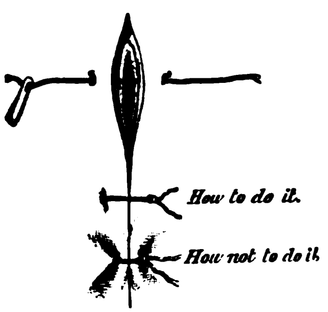

FIG. 68.—Tension in suturing.

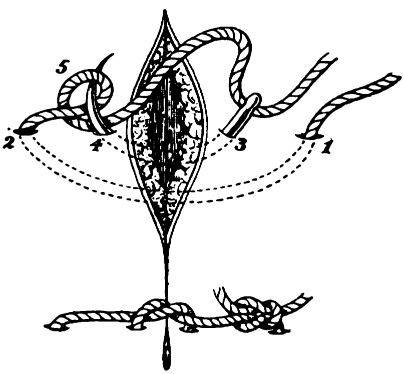

FIG. 69.—Combined retention and coaptation suture. The needle is inserted at 1, brought out at 2, reinserted at 3, and emerges at 4, passing through the loop at 5. When drawn tight it holds the wound edges firmly together and prevents inversion of the skin, as shown in the lower part of the illustration.

pressure. The *quill suture* (Fig. 66) and the *twisted suture* (Fig. 67) are varieties of the retention suture. Superficial sutures are inserted near the margins of the wound for coaptation only; they should not be tight enough to produce wrinkling or to invert the edges of the skin (Fig. 68). In the former instance stitch abscess is fostered, in the latter healing is prevented. We frequently employ a *combined retention and coaptation suture* as shown in Fig. 69. The *interrupted suture* consists of separate stitches, tied so that the knot rests over one of the suture holes, and not on the wound. The *continuous or Glover's stitch* (Fig. 70) traverses the entire length of the wound without interruption. The *button-hole stitch* (Fig. 71) makes tension at right angles to the wound. When desirable a continuous suture may be tied after each insertion (Fig. 72). The Halsted *subcuticular suture* (Fig. 73) is a continuous suture inserted into the deeper layers of the skin, but not penetrating the epidermis. Catgut is the best material for this suture, although silkworm

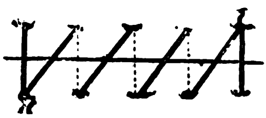

FIG. 70.—Continuous or Glover's suture. (Esmarch and Kowalzig.)

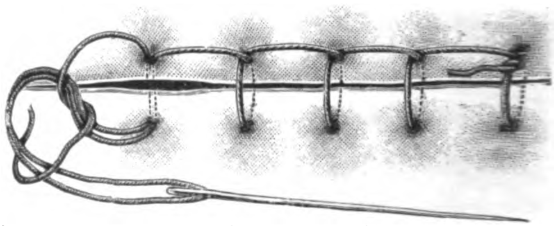

FIG. 71.—Continuous button-hole suture. (Walsham).

gut or silver wire is often used, the ends being left long and protruding from each angle of the wound, so that it may be removed when healing is complete. The suture gives a fine cicatrix without the presence of suture scars. Theoretically the staphylococcus epidermidis albus lies undisturbed in the superficial layers of the skin and does not cause stitch abscesses. Care should be taken to approximate the deeper structures with catgut or to apply firm pressure, so that the dead space beneath will be obliterated and the formation of a hematoma prevented. Other varieties of sutures are described in con-

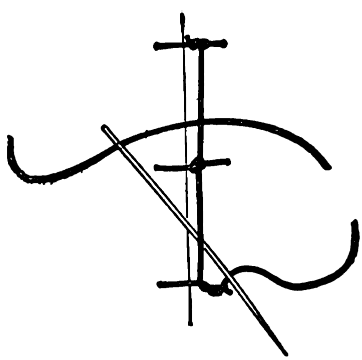

FIG. 72.—Ford's suture: showing two square knots, a single knot, and the method of completing a square knot. (DaCosta.)

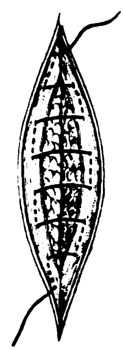

FIG. 73.—Halsted's subcuticular suture.

nection with the operations for which they are used. Sutures should be tied, not in a granny knot (Fig. 74), but in a reef knot (Fig. 75), or, if there is much tension, in a surgeon's knot (Fig. 76). Sutures are removed in from seven to ten days, or at any time if they cut or the wound becomes infected. In removing a suture the exposed portion should not be dragged through the tissues, because of the possibility of infection (Fig. 77). *Drainage* is discussed in the chapter on technic. In wounds which have been completely closed, dry sterile gauze should be applied, and retained in place by a bandage or binder. In infected wounds a dressing wet with bichlorid of mercury, 1–5000, should be employed. Rest is secured by confining the patient to bed in serious cases, or by splints, slings, sedatives, etc. Reference has already been made to some of the complications of wounds, viz., inflammation, suppuration, and gangrene, others are discussed in Chap. xii.

A **contused wound** is one whose edges are bruised as the result of a crushing or tearing force. A **lacerated wound** is one whose edges are irregular or torn, and is produced in the same way as a contused wound. Since contusion and laceration are commonly associated, these wounds will be

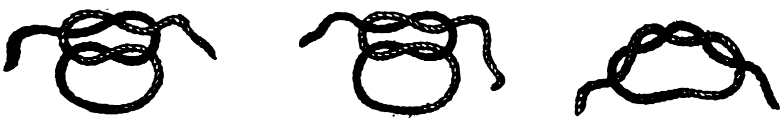

FIG. 74.—Granny knot. FIG. 75.—Reef knot. FIG. 76.—Surgeon's knot.

discussed together. The bleeding is often trivial, owing to the fact that the vessels are torn; the inner and middle coats give way first, curl up, and plug the vessel. In other cases the vessels are crushed, and the walls adhere to each other with sufficient firmness to stop hemorrhage. The edges separate less widely than in an incised wound of the same size, but the amount of devitalized tissue is much greater, and before repair occurs this must be removed by the surgeon or by nature. As nature's method is usually suppuration, wounds of this character are very apt to heal by second intention. Wound complications and shock are much more frequent than in incised wounds. Among contused and lacerated wounds are some of the most

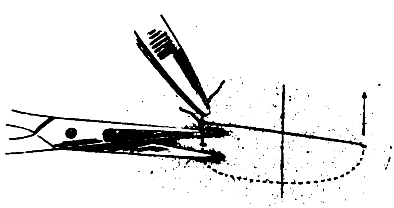

FIG. 77.—One side of the suture is drawn out of the tissues a short distance and cut close to the skin. Steady traction perpendicular to the skin, in the direction of the arrow, is then made on the other side, holding back the skin, if need be, with the separated blades of the scissors.

dreadful which a surgeon is called upon to treat, such as those resulting from the tearing off of a scalp or the avulsion of a limb. An aseptic contused and lacerated wound, such as is sometimes made by the surgeon, may heal by first intention, especially if drainage be employed for a few days. When infection occurs, and such is the result in practically all accidental wounds of this character, inflammation and suppuration are sure to occur, often with serious constitutional symptoms of sepsis.

The **treatment** in a severe contused-lacerated wound, in the absence of urgent hemorrhage, is directed to the shock. After this has subsided, the patient should be anesthetized in order thoroughly to disinfect the wound.

Tissue whose vitality is questioned should be removed if it is unimportant, in other cases it should be retained unless known to be badly infected. All visible vessels, whether bleeding or not, are ligated, and provision made for abundant drainage. It is important to introduce as few sutures as possible, and to be sure that they do not unduly constrict the tissues, otherwise the subsequent swelling will cause necrosis. The wound is dressed with hot antiseptic fomentations. The later treatment depends upon the complications. If there are symptoms of sepsis, the whole wound should be opened, redisinfected, and packed with antiseptic gauze. Sloughing demands hot antiseptic fomentations, and removal of the slough at the earliest possible moment. Secondary hemorrhage may occur at this period from the separation of a slough involving the wall of an artery. The general health should of course receive proper attention. The indications for amputation are given in the section on amputations.

Punctured wounds and stabs are deep, narrow wounds caused by any long, narrow instrument, from a needle to a sword. The outer opening is trivial in size, the danger depending upon the injury to the deeper structures and the nature of the infection which may have occurred. These wounds are especially favorable for the development of anaërobic organisms, the most important of which is the tetanus bacillus.

The **treatment** depends upon the character of the vulnerating instrument and the damage which has been inflicted. If possible, the instrument should be inspected to ascertain if any portion of it has been broken off and left in the tissues. The X-ray also may be used for this purpose. If a portion of the instrument has been left in the wound, the wound should be enlarged, the foreign body extracted, disinfection made, and drainage instituted. Practically all punctured wounds, especially those known to be infected, such as those produced by dirty nails or the teeth of animals, should be incised, disinfected, and drained. Instruments like fish-hooks, and needles with barbed ends, which become entangled in the tissues, require incision for their extraction, or removal of the barb after it has been pushed through adjacent skin. After all punctured wounds the advisability of a prophylactic injection of tetanus antitoxin should be considered (see tetanus). Punctured wounds or stabs may injure large vessels, nerves, tendons, or any of the viscera. Injuries of these structures are dealt with in later chapters.

Gunshot wounds are a special variety of contused-lacerated wounds, produced by missiles thrown by explosives.

In **civil life** gunshot wounds are usually produced by small shot, revolver and hunting rifle bullets, and blank cartridges. The *bullet of civil life* is made of lead, moves at a low velocity (700 ft. per second), is readily deformed, frequently lodges in the tissues, often carries with it particles of clothing and skin, and practically always causes an infected wound. The entrance wound is slightly smaller than the bullet, and may be punched out, ragged, or inverted. The tract of the bullet is surrounded by contused and devitalized tissue, which is very likely to become necrotic and suppurate. The wound of exit is larger than the bullet, everted, and more ragged than the wound of entrance. The bullet is apt to be deflected by bone or dense fascia, and often pushes nerves, tendons, and blood vessels out of the way instead of cutting them, so that serious primary hemorrhage is usually absent, although secondary hemorrhage from sloughing of contused vessels may occur. Injured bones are generally splintered or comminuted. *Small shot,* if at close range, produces extensive laceration and burning of the tissues, into which are driven the shot, powder-grains, and portions of the clothing. At a longer range the shot may simply contuse the tissues without entering, or may enter and be scattered in the soft parts, usually producing little damage unless a delicate structure like the eye has been struck. Wounds by *blank cartridges* are contused, lacerated, burned wounds, in the depths of which a wad is lodged, and are especially dangerous because of the frequency with which tetanus follows.

The **treatment** of wounds due to the *leaden bullet* is that of any other infected wound in which a foreign body is lodged. Hemorrhage, if present, should be checked at once, and if necessary the patient treated for shock. For determining the position of the bullet, the X-ray is by far the best means. In the absence of the X-ray one should ascertain the direction from which the bullet was fired and the position of the body at the time, examine the clothing for the position of perforations in relation to the skin wound as well as to determine whether portions are absent, and see whether or not there is a wound of exit. After disinfection the wound may be explored for the bullet and any foreign body which has been carried in with it. This is best done with the sterilized finger, enlarging the wound if necessary. When deeply lodged out of reach of the finger, a probe may be employed. Nélaton's probe is one whose end is capped with porcelain, on which a black stain is found after it has rubbed against lead. The same result may be had with the stem of a clay pipe or a probe of pine wood. Fluhrer's aluminum probe is occasionally employed in brain wounds because of its lightness. It is allowed to find its way along the tract of the bullet by gravity. Various electrical devices have been invented for the detection of bullets, such as Bell's induction balance, Girdner's telephonic probe, and Lilienthal's electric probe. Girdner's telephonic probe is made by fastening a metal plate, which is moistened and placed in contact with the patient's body, to one of the wires of a telephone receiver, and using the other one as a probe; a click is heard when the probe strikes the bullet. Lilienthal's probe may be improvised as follows: A piece of copper wire is wrapped around a silver coin, and another piece around a copper coin, the connection in each instance being covered with sealing wax. One of the wires is insulated by rubber tubing or adhesive plaster, to within an eighth of an inch of the end. These two wires are now twisted together to form a probe, the bright ends being about one-sixteenth of an inch apart and nowhere touching each other. A drop of melted sealing wax may be used to fix them in position and at the same time act as a head for the probe, the ends of the wire, of course, being exposed. The coins are placed in the surgeon's mouth, one on each side of the tongue and not touching each other. When the tips of the wires come in contact with the bullet, a peculiar metallic taste is appreciated by the operator. Probes, however, will not detect pieces of cloth. The bullet may be removed with the finger, or with strong forceps, such as the sequestrum forceps or special forceps (Fig. 78). The wound is then disinfected with bichlorid of mercury solution and drained with gauze. When a large number of shot are scattered in the tissues, or when the exact location of a bullet is not known, less risk will often be taken in leaving the bullet than in a long or mutilating operation to remove it. The treatment of bullet wounds of the head, chest, and abdomen is considered in the sections on regional surgery.

Blank cartridge wounds should invariably be treated by anesthetizing the patient, removing the wad and devitalized tissues, carefully disinfecting the wound, and draining it with gauze. The administration of a prophylactic dose of antitetanic serum also is strongly recommended (see tetanus).

Gunpowder stains are best removed by picking out each grain with a sharp pointed tenotome. Irritating ointments followed by poulticing may be used with the hope that the grains will be discharged by suppuration. The application of equal parts of ammonium iodid and distilled water has been recommended; the spots gradually turn red, and the red marks are faded by the application of dilute hydrochloric acid. Electrolysis and caustics cause permanent scarring. When the stains are quite superficial, the upper layer of the skin may be shaved off, and the raw surface covered with a Thiersch graft.

In **military surgery** about nine-tenths of the wounds are due to bullets, and one-tenth to artillery missiles. The modern rifle bullet (Springfield, Lebel, Lee-Metford, Mauser, etc.) consists of a lead core, hardened by the addition of from 2 to 5 per cent. of tin or antimony, and enclosed in a dense jacket, usually of cupronickel, 80 parts of the former to 20 of the latter. It is long, conical, and of reduced calibre, usually between 6½ and 8 mm. The muzzle velocity is very great, 2000 ft. and upward per second, the bullet revolving on its own axis as the result of the rifling some 2000 times the first second; it is capable of producing a mortal wound at 4000 meters distance.

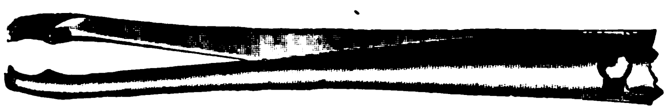

FIG. 78.—Bullet forceps.

The trajectory is comparatively flat, hence the accuracy of aim much increased. Owing to its high speed, small calibre, and dense jacket the bullet rarely (10 per cent.) lodges in the body or carries particles of skin or clothing with it, and it is seldom deflected or deformed by the dense tissues, unless, as the result of great range (over 1200 meters) or ricochet, the velocity is diminished, when the modern bullet may behave much like the leaden one. A hard-jacketed bullet moving at the rate of 2000 ft. per second perforates any portion of the body and still maintains its form, "but as the velocity drops there comes a point when the resistance is too great for the momentum of the bullet to overcome quickly, and then the bullet piles up on itself, just as it does when it strikes a very hard object, and the lead crowds to the front of the bullet till the nose of the jacket bursts" (Wadsworth). Ricochet not only slows but may deform the bullet, and is more frequent than with the leaden projectile, which, instead of skipping when it strikes an object, is apt to flatten and stop. The character of the wound varies with the tissue injured and the range or velocity of the bullet. In the soft parts (muscle, fascia, skin, vessels, nerves, tendon) direct shots, up to about 2000 meters, produce a clean perforation. The wound of entrance is slightly smaller than the bullet, with cleanly cut depressed margins; the wound of exit is slightly larger than the bullet and often stellate or slit-like. A large, lacerated wound of exit may be produced by a fracture of bone, the splinters being driven onward by the bullet. The walls of the tract are apt to be smooth, with very little tearing or laceration. The bullet is not deflected by bone or fascia, and it severs instead of pushing aside nerves, tendons, and blood vessels, thus increasing the frequency of violent primary hemorrhage. Violent bleeding, however, is rarely seen by the surgeon, because the patient dies quickly, or as the result of the small size of the wound of entrance and exit and a small opening in the vessel, an aneurysm forms; in recent wars in which this bullet has been used, arteriovenous aneurysm has been comparatively frequent. These wounds are usually sterile, and, if subsequent infection is prevented, heal by primary union. The percentage of infections in those reaching the hospital has varied from 15 (Balkan wars) to 50 (Manchurian campaign). Great destruction of tissue occurs under certain conditions. At close range (under 500 meters) there is an explosive effect, due to waves of force transmitted from the bullet to the surrounding parts. This effect is still seen in the brain, parenchymatous organs, hollow viscera containing fluid, and in the diaphyses of long bones up to 1000 meters, "while clean perforations in the liver, spleen, and kidneys can hardly be said to occur at any range." Lacerated wounds are produced also by ricochet shots. Pain is usually slight at the time of injury, but later may become very severe. In cancellous bone a clean perforation is produced, but in hard bone there is comminution, gradually diminishing with increased range; "typical perforations in the diaphyses are not to be expected at any range." At close range soft bone may be splintered. At short range wounds of the head are extensive and practically always fatal; over 1600 meters, clean perforations may occur; and beyond 2000 meters the bullet may lodge, comparatively little harm being done unless an active portion of the brain is injured. Abdominal wounds are less serious than with the old bullet, but still give a very large mortality. Chest wounds are decidedly less dangerous than formerly, excepting those cases which die at once from hemorrhage. Of those wounded by the "humane" bullet about 10 per cent. die on the field or in the ambulance, thus the immediate mortality is greater than with the leaden projectile, but in virtue of the morphologic and ballistic properties of the modern bullet, and of the antiseptic and conservative treatment of the modern surgeon, the ultimate mortality of those who do not succumb on the battle field is comparatively small.

The *Dum-Dum bullet* has a soft nose, that is, the tip of the lead core is left uncovered. It has been used in battles with the uncivilized, because when it strikes, the lead core spreads out, or mushrooms, inflicting extensive damage and stopping the charge of an individual no matter where it strikes.

Wounds by artillery missiles have no essential differences from other large contused-lacerated wounds. They contain splinters of shell, and are practically always infected.

The **treatment** of gunshot wounds on the battle-field is limited to the arrest of bleeding by tourniquet or other form of compression, and the protection of wounds from infection by the application of an antiseptic dressing, a small package of which is carried by each soldier. At the field hospital the wounds are reviewed, bleeding points ligatured, foreign bodies and easily accessible bullets removed, and disinfection carried out. Probing and usually drainage are dangerous. Operative abstention is the rule, unless complications necessitate intervention. Wounded nerves should be left alone; they are often only partly destroyed and recover of themselves. One should be still more reserved with vascular injuries, because of the grave consequences which may follow precipitate action, which, naturally, is mandatory in the presence of severe bleeding. Diffuse aneurysm and arteriovenous aneurysm should at first be treated conservatively; they regress and sometimes even heal spontaneously (Billet). Amputations and resections are very much less frequent than formerly, owing to the character of the wounds and to the protective antiseptic dressings. In comminuted fractures wholly detached portions of bone are removed and proper splints applied. Gunshot fractures of the skull, even with clean perforations, demand trephining for the removal of depressed portions of the inner table. Chest wounds are treated by an external occlusive dressing. In marked contrast to the custom in civil life (Chap. xxvii), abdominal wounds are dealt with expectantly, unless there is some distinct indication for operation beyond the fact of penetration of the peritoneal cavity; this is due to the lack of facilities for abdominal section, and to the now clearly established fact that patients may recover without operation, after even the viscera have been perforated. In addition to the character of the wound recovery is favored owing to the fact that the intestinal canal is generally empty at the time of injury, and that, when struck, the intestine violently contracts and remains in such a condition for a sufficiently long period for adhesions to form.

Poisoned wounds are contaminated with some animal or nonbacterial vegetable poison. Among the former are the poisons of snakes and insects, among the latter curare and other plant extracts, some of which are used by savages to poison weapons of warfare.

It is customary to consider under this heading **dissection** and **post-mortem wounds,** because the infection to which they give rise was at one time thought to be due to a specific virus generated in the dead body. It is true that an abrasion may become inflamed from the irritation of injection fluids or saprophytic organisms, but the virulent infections are produced only by pathogenic organisms, which are especially numerous in septic operations on the living, and in the body a few hours after death; hence the predisposition of students, surgeons, butchers, and pathologists. Wounds acquired in the operating room rarely become infected, because of the frequent use of antiseptics; in the dissecting room wounds are apt to be less serious than those acquired in an autopsy on a body into which no antiseptic preservative fluid has been injected. The infection varies in virulency with the nature and number of the bacteria and the resistance of the individual, being most frequent in those who are "run down." In the graver forms there are widespread cellulitis, lymphangitis, and profound toxemia, which may result fatally. As a prophylactic measure some anoint the hands with sterile vaselin, but much more efficient is the wearing of rubber gloves. If a wound is received, the base of the finger should be compressed with a bandage or with the opposite hand, in order to encourage bleeding, and the part washed with soap and water, sucked with the mouth, and disinfected with bichlorid of mercury solution, 1 to 500. A deep and narrow wound should be incised in order to facilitate disinfection. The part is dressed with gauze wet in bichlorid solution, and at the first indication of infection incision and redisinfection should be practised.

Insect stings, produced by *hymenoptera,* such as *bees, wasps, hornets,* and *yellow jackets,* cause pain and swelling, but are not dangerous unless there be a great number, unless infection occurs, or unless the injuries are in the mouth or throat, in which event edema of the glottis may arise. As the poison is acid it may be neutralized with dilute ammonia water, or a solution of bicarbonate of soda; if there be much swelling, ice, or lead-water and laudanum may be applied. The wasp has a pointed sting and may inflict several injuries; but that of a bee is barbed and remains in the tissues, from which it should be extracted with small forceps, after being made prominent by the pressure of a watch key. The bites of *flies, fleas, gnats, bedbugs,* and *mosquitoes* are never serious, unless the insect is soiled with some form of infection at the time of the bite, or unless the wound is subsequently infected by scratching. Special mention, however, should be made of the rôle played by the fly in transmitting typhoid fever and other diseases, and by the mosquito in transmitting malaria, yellow fever, and filariasis. *Gad-flies* deposit eggs in the hides of animals, but rarely in the human skin. *Ticks* (*ixodes*) bury themselves in the skin, producing great annoyance, sometimes localized suppuration, rarely a spreading cellulitis. Large *spiders*, including the *tarantula* and the *scorpion*, may cause great swelling and serious constitutional disturbances, but seldom death. Bites by the more poisonous insects are treated by placing a ligature above the bitten point, incising the bite and sucking it, washing with a strong solution of permanganate of potassium or cauterizing with silver nitrate, and then dressing antiseptically. The ligature is gradually loosened, and symptoms of prostration watched for and treated, if they appear, by alcohol and other stimulants.

Snake bites are harmless unless produced by venomous snakes, the varieties of which, in the United States, are the rattlesnake, moccasin, copperhead, and viper; with these is usually classed a poisonous lizard, the Gila monster. The venom is injected from the poison sac on each side of the jaw, through the hollow fangs of the teeth, into the wound; it is a sterile, viscid, yellowish, acid fluid, with a peculiar odor, and contains several proteids, a peptone, and a globulin, all of which are toxic.

The character of the **symptoms** is the same with all varieties of venomous snakes, but differs in degree with the amount and virulence of the venom and the resistance of the individual. The bitten part is the seat of great pain and begins to swell immediately. As the swelling extends ecchymotic spots, due to extravasated blood, are noticed, and symptoms of severe prostration appear, sometimes with vertigo, convulsions, delirium, or other nervous symptoms. Snake venom has a hemolytic action on blood cells, and dissolves also the endothelial cells of the capillaries, thus accounting for the ecchymotic spots. Death may occur very rapidly if the poison enters a vein, or it may be postponed a number of hours or even days, the parts being the seat of a spreading cellulitis. The mortality is about 25 per cent.

The **treatment** is to constrict the limb tightly by a ligature above the bite, which should be excised, and as much as possible of the poison removed by cupping, or sucking and squeezing. The wound should then be cauterized, preferably with the actual cautery, and dressed with a saturated solution of permanganate of potassium. Constitutional symptoms are met by stimulation with ammonia, alcohol, strychnin, and digitalis. When the symptoms subside, the ligature is cautiously loosened, and if they reappear, again tightened and further stimulation administered. In some cases amputation has been performed. Calmette believes that the toxins of all snake venom are the same, and that they can be neutralized by the same antitoxin. This antitoxin (antivenene) is made by injecting into a horse increasing doses of the mixed venom of the cobra, 80 per cent., and viper, 20 per cent. Other observers believe each species of snake has a specific venom, and that an antitoxin would have to be prepared for each. It seems certain, however, that Calmette's antivenene is effective not only in cobra bites, but in any form of snake bite, so that it should be used whenever possible. From 10 to 40 cc. are injected into the region of the bite, or if much time has elapsed, directly into a vein. Calmette advises injections, into and around the seat of inoculation, also of from 20 to 30 cc. of a fresh 1 per cent. solution of chlorid of gold and calcium, and, after removal of the ligature, thorough irrigation of the part with a solution of sodium hypochlorite or calcium chlorid.

CHAPTER XI.

CHEMICAL, THERMAL, AND ELECTRICAL INJURIES.

BURNS AND SCALDS.

Burns and scalds are injuries due to heat, scalds to fluids or gases, burns to flames, heated solid bodies, or radiated heat (e.g., from open fires or exposure to the sun). Injuries due to chemical substances, such as strong acids and alkalies, also are called burns. Burns are divided into three degrees: (1) Erythema (combustio erythematosa), the best example of which is sunburn, is accompanied by all the signs of inflammation, which subside in a few days and are followed by brownish discoloration or desquamation. (2) Blistering (combustio bullosa) is best seen after scalds. The blisters, or vesicles, develop at once or not for several days. (3) Charring or carbonization (combustio escharotica) is usually due to direct contact with flames or heated solids. The burned part is hard, anesthetic, and yellow, brown, or black, being surrounded by burns of the first and second degrees. The destroyed mass is finally separated from the living tissues by ulceration. Dupuytren's classification is as follows: (1) Erythema; (2) blistering; (3) partial destruction of the skin; (4) destruction of the entire skin; (5) destruction of the subcutaneous tissues and part of the muscles; (6) carbonization of the entire part.

The surgeon should bear in mind the danger of these injuries when using hot-water bags, hot douches, and the hot-air apparatus, and the danger of using ether, ethyl chlorid, or collodion near a naked flame or the actual cautery.

The **symptoms** of burns and scalds may be studied under three headings: (1) Those the direct result of the injury; (2) those occurring during the stage of inflammation and sloughing; (3) those occurring during the stage of repair.

1. The symptoms of the first stage are intense pain, and shock varying with the extent and severity of the burn.

2. If the patient survives the shock, fever develops, due at first to the absorption of toxins, the result of destruction of the tissues, and later to the suppuration which follows. There is a marked leukocytosis and polycythemia, and an increase in the coagulability of the blood, which sometimes leads to extensive thrombosis and subsequently to embolism. The internal organs in a severe burn become congested, and actual inflammation of some of the viscera may ensue. Congestion of the brain or lungs is not infrequent, but the viscera most apt to be affected are the kidneys, giving rise to albuminuria and decreased quantity or even suppression of urine, and the gastrointestinal canal, causing vomiting and diarrhea, and later ulceration, especially in the duodenum (*Curling's ulcer*). Duodenal ulcer is supposed to be due to the irritation of toxin laden bile; it has the same symptoms and treatment as that due to other causes. Delirium or convulsions may occur from congestion of the brain. During this stage, which lasts from two to five weeks or longer, there is active suppuration with the separation of sloughs.

3. During the stage of repair there may be no constitutional symptoms

except, perhaps, weakness or anemia, unless the wounds are very large and freely suppurating, when there will be some fever (hectic), and possibly amyloid disease if the suppuration persists for a long time.

The *prognosis* depends upon the age and general condition of the patient, and the extent, severity, and location of the burn. In the young, the old, or the debilitated, limited burns of the first degree may prove fatal. If a burn of the first degree extends over more than two-thirds of the surface of the body, death is likely to follow, the same result is probable in a burn of the second or third degree involving one-third of the surface of the body. Burns of the thorax or abdomen are much more serious than those of the limbs. Death may be due to asphyxia from smoke at the time of the accident, to shock immediately after the accident, and later to sepsis, exhaustion, or internal complications. Burns of the third degree are always followed by scars, which, when extensive, tend strongly to contract, causing flexures of joints, ectropion, ankylosis of the jaw, etc.

Treatment.—A person whose clothing is on fire should be thrown on the floor and rolled in a rug, overcoat, shawl, or blanket, in order to smother the flame; water should not be used, as the steam will produce scalding. In *trivial burns* of the first or second degree the principal indication is to relieve the pain; this is best done by the use of cold lead-water and laudanum or aqua hamamelidis, the application of a bandage to exclude the air, and by elevation. Ointments (zinc, boracic, vaselin, lanolin) are soothing, and if applied before exposure to heat will protect the skin from burns of the first degree. Blisters may be punctured with an aseptic needle, allowing the epidermis to settle back on the cutis vera; partly detached shreds, however, should be removed with scissors. Picric acid may be used in limited burns of the first and second degree, but not in extensive or deep burns, as poisoning may result. Lint or gauze is soaked in a 1 per cent. watery solution of picric acid and applied to the burned part, and over this sterilized cotton or gauze is bandaged. The dressing is left in place several days.

In *severe burns* the indications are, in the *first stage*, to relieve pain by the hypodermatic injection of morphin and to react from shock; no attempt should be made to dress the burn until reaction has been obtained. In the *second stage* the indications are to prevent or, as this is rarely possible, to limit infection, to combat the toxemia, and to watch for and treat the complications. The clothing should be cut, and, if it sticks, should be soaked in sweet oil or salt solution and allowed to drop off. The dressing of one part should be completed before exposing an additional area. If there is much charred tissue, the patient may be anesthetized and the devitalized parts cut away. The ideal dressing would be aseptic or mildly antiseptic, would provide free drainage, would not macerate or stick to the tissues, and would not necessitate frequent changing. Unfortunately it does not exist. Wet dressings macerate, dry dressings stick to the tissues, and ointments have the same objections here as in the treatment of ulcers, although, it must be confessed, they are often employed because they are comforting to the patient. The first three methods mentioned below come as near the ideal as any. When the burn is not too large the dressing used for splinting skin grafts (see skin grafting) may be employed. More extensive burns may be dressed with strips of sterilized rubber tissue about an inch broad, allowing a fourth inch between each strip, and placing over this sterile gauze which has been wrung out in warm, sterile, salt solution. The gauze is changed as often as it becomes saturated with discharges, leaving the rubber tissue in place, thus eliminating much of the pain and distress which is always an unpleasant feature in the dressing of these cases. When most of the body is burned the patient may be kept in a warm bath (100° to 105°). Carron oil (equal parts of linseed oil and lime-water), to which oil of eucalyptus in the proportion of 1 to 10 has been added for its antiseptic properties, makes a good application. Menthol 1, olive oil 9, and lime-water 10, has been recommended as an antiseptic and analgesic; a saturated solution of bicarbonate of soda or of boric acid also may be employed. Recently satisfactory results have been obtained by exposing burns to the air and simply dusting them with stearate of zinc, removing scabs when pus collects beneath them. Because of their poisonous properties, dressings containing acetanilid, antipyrin, carbolic acid, carbonate of lead, cocain, creolin, iodoform, phenol sodique, picric acid, or lead-water and laudanum, should not be used on extensive burns. If a limb has been completely carbonized, amputation should be performed as soon as shock has subsided. The toxemia is combated by giving concentrated liquid food, and plenty of water, by mouth or rectum, or, if need be, subcutaneously or intravenously; and by administering stimulants as they may be required. Complications should be met according to general indications. In the *third stage* the indications are to promote healing and prevent contractures. It may become necessary to use stimulating applications or to remove prominent granulations, as described in the chapter on ulceration. In an extensive granulating wound skin grafting not only hastens cicatrization, but limits subsequent contraction. Splints should always be used in burns about joints, to lessen the tendency towards contraction.

In *burns by acids*, a weak alkali, such as lime-water, and in *burns by alkalies*, a weak acid, such as a dilute solution of acetic acid, should be applied. In carbolic acid burns alcohol, if applied at once, will act as a neutralizing agent. *Yellow phosphorus* sticks to and burrows into the skin, and bursts into flame on being exposed to the air; the part should be put under cold water, to which should be added a solution of chlorid of iron, or liquor sodæ chlorinatæ. *Burns of the mouth, pharynx, glottis, and esophagus* are usually produced by chemicals, although the accident may occur from boiling fluid or superheated steam. These cases are treated by having the patient suck bits of ice, by the application of ice externally, and in a burn of the mouth by antiseptic washes. One should watch for *edema of the glottis*, and treat it according to the directions on p. 434. In burns of the esophagus the chemical should be neutralized, and the patient fed on albumin water or by rectum; the danger of passing a stomach tube should be recalled. In two or three weeks bougies should be cautiously passed, in order to anticipate the formation of a stricture.

X-ray burns (see chapter I).

THE EFFECTS OF COLD.

Locally, cold contracts the blood vessels and, when intense, causes thrombosis and disorganization of the blood. According to the changes which follow, **frost bite,** like burns, may be divided into three degrees: (1) Erythema, or redness; (2) blistering, or bleb formation; (3) sloughing, or gangrene.

The **symptoms** of freezing are first coldness, then numbness, and finally anesthesia; owing to the contraction of the vessels the parts become deathly pale. In frost bites of the first degree the parts, when warmed, are the seat of burning, itching, or tingling pain, and become red and swollen, due to the overfilling of the paretic blood vessels. This inflammation disappears in the course of a few days, but may recur on slight exposure to heat or cold (*chilblain, or pernio*), and is most frequent on the toes, ears, fingers, and nose. Chilblains itch and burn and sometimes ulcerate. In frost bites of the second degree reaction is attended with greater swelling, a livid color, and the formation of blisters, or blebs. In the majority of these cases frost bite of the third degree, or gangrene, occurs. *Gangrene* is due to the direct effect of cold or to the reactionary inflammation. In the former instance thrombosis occurs in the vessels and the part becomes pale, anesthetic, and brittle; fingers and toes may break like glass. Reaction does not occur because the blood cannot again enter the part, which now undergoes the changes incident to dry gangrene. In the latter instance severe inflammation follows, and the gangrene is due principally to the obliteration of the vessels by the pressure of the inflammatory exudate; owing to the large amount of fluid in the tissues, the gangrene is of the moist variety.

The **treatment** of *frost bite* is the gradual restoration of circulation, so that the vessels may have a chance to recover their tone before a large amount of blood enters the part. The frosted area should first be rubbed with ice water or snow; as the circulation is restored, it may be very gradually warmed by omitting the snow and using the hand only. The temperature of the room should be slowly elevated, and the part wrapped in cotton. When marked inflammatory reaction follows, free incisions should be made to relieve tension. If *gangrene* occurs, wait for the line of demarcation and amputate, unless it be moist, septic, and rapidly progressing, when immediate amputation becomes mandatory.

Chilblains are treated by attention to the general health, which is often below par, and by warm coverings at the first approach of cold weather. The part may be rubbed with alcohol and water, belladonna liniment, whisky and salt, soap liniment, or menthol and olive oil 1 to 10; or tincture of iodin, ichthyol, contractile collodion, adhesive plaster, or diachylon may be applied. Massage is often useful. When ulcers form they should be treated antiseptically.

The **constitutional effects of cold** are drowsiness, slowing of the pulse and respirations, and dilatation of the pupils. The blood is driven from the surface to the internal organs, which become markedly congested. Death is probably due to cerebral anemia from failure of the circulation. The *treatment* of freezing of the whole body is brisk rubbings with cold cloths, and afterwards with the warm hands. The patient should first be taken into a cool room, the temperature of which is very gradually elevated, as sudden reaction may result in embolism, or in rupture of blood vessels, especially those of the brain. Artificial respiration may be needed, and stimulation should be given hypodermatically, or by mouth as soon as the patient is able to swallow. The extremities should be elevated in order to limit gangrene.

INJURIES BY ELECTRICITY.

Lightning stroke is produced by an aërial current of electricity. A person may be struck directly by the primary current, or injured by an induced current when the lightning strikes some neighboring object. The accident is most frequent in the open country, where there are few buildings, trees, etc., to divide the current. The mortality is about 50 per cent. Lightning either kills directly or causes severe burns or extensive lacerations, sometimes tearing a limb completely from the body. Lightning marks are brownish-red, zigzag, or arborescent lines, radiating from the point struck along the course of blood vessels, and are due to the decomposition of the red corpuscles, with the subsequent transudation of the coloring matter through the vessel walls.

The **symptoms** in a case not immediately fatal are those of profound shock and compression of the brain. Various nervous disturbances, such as paralysis, anesthesia, blindness, insanity, hysteria, etc., may be seen. Excepting blindness and lesions due to hemorrhage into the brain or spinal cord, these phenomena usually disappear after a greater or lesser interval.

The **treatment** is symptomatic; first of all it is necessary to react from shock. It is important to remember here, as in opium poisoning and drowning, that a person may be apparently dead, and yet be revived by prolonged artificial respiration. When reaction has been obtained, the patient should be carefully examined for fractures, lacerations, burns, etc. Burns are often slow in healing, probably owing to the effect of the electricity on the trophic nerves; the treatment is that of burns from other causes. The *effects of artificial currents* are similar to those of lightning and are treated in the same way. When a person is ensnared with a live wire, the current should be turned off; if this is not possible, the wire may be removed with thick rubber gloves, mackintosh, thick and dry woolen cloth, or dry wood, or occasionally the current may be short circuited by dropping some object, such as an iron bar, on the two wires.

CHAPTER XII.

GENERAL CONDITIONS AND SPECIAL INFECTIONS FOLLOWING WOUNDS.

SHOCK.

Shock is a sudden general prostration of the vital powers the result of injury or emotion. *Local shock* is numbness or anesthesia of a part which has been injured, and is seen most frequently in gunshot wounds. *Collapse* is the final stage of shock, or profound shock coming on acutely. *Exhaustion* presents similar symptoms to shock, but comes on gradually, often following some exhaustive disease, such as carcinoma or tuberculosis.

The **causes** of shock are afferent impulses transmitted along the sensory or sympathetic nerves, or in emotional shock along the nerves of special sense, to the vital centers, especially the vaso-motor centers, which are thus weakened or exhausted (shock), or paralyzed (collapse); consequently there are marked lowering of the blood pressure, weakening of the propelling force of the heart and arteries, collection of the blood in the veins, especially the large abdominal veins, and anemia of the brain, lungs, and superficial parts of the body.

The **symptoms** vary in intensity according to the severity and situation of the injury, the psychical condition, age, sex (women are more susceptible), and previous general condition of the patient, and according to various other factors, such as hemorrhage, exposure to cold, etc. In *torpid or apathetic shock* there are marked pallor of the skin and mucous membranes, cold clammy perspiration, elongated, pinched, expressionless face, half open mouth, half closed shrunken eyes, lusterless cornea, dilated pupils reacting slowly to light, weak and rapid pulse, accelerated (occasionally slow) shallow and irregular respirations, mental apathy, subnormal temperature, impaired sensation of the skin, retention of urine, and sometimes incontinence of feces. If the shock is due to or aggravated by hemorrhage, there may be great restlessness and other symptoms commonly associated with the loss of a large quantity of blood. During the period of reaction there may be vomiting, great restlessness or excitement, and even delirium (*erethistic shock*), particularly in conditions like extensive burns, in which a toxic factor is added. Shock which does not appear for several hours (*delayed or secondary shock*) is most frequently seen after railway accidents, alcoholic intoxication, and severe emotional storms. After operation delayed shock is almost always due to hemorrhage.

The symptoms of hemorrhage are practically identical with those of shock, in fact the condition after hemorrhage is shock due to loss of blood. In concealed hemorrhage one does not see the blood, and the question arises whether the symptoms are due to shock alone, or to shock the result of hemorrhage. In hemorrhage there is apt to be greater restlessness, and instead of torpidity, great anxiety and foreboding on the part of the patient, who complains of loss of sight, asks for water, and gasps for air; the skin and mucous membranes are excessively pale, and the pulse, although very frequent, is likely to be larger and more compressible than that of shock. The hemoglobin is greatly lessened in hemorrhage (but not for a number of hours) and unreduced in shock. The most reliable signs are those of fluid in a cavity, i.e., in the chest or abdomen. In case of doubt, especially after an abdominal operation or injury, an exploratory incision should be made.

The **prophylaxis** of shock is possible in surgical operations. In addition to reassuring a nervous patient, the physical condition may be improved, and such examinations made as are described under technic. With the patient in poor condition shock may be anticipated by the application of warm water bags, the hypodermatic injection of strychnin and atropin, the careful covering of the patient during operation, the avoidance of excessive purgation and prolonged abstention from food before operation, and by celerity, gentleness, and careful hemostasis during the operation. The part to be operated upon may be placed in a slightly higher position than the rest of the body in order to lessen hemorrhage. The use of a local anesthetic for the prevention of shock in extensive operations is of doubtful value, as the fright of the patient, and the increased time necessary for the performance of the operation, owing to the struggles of the patient, more than counterbalance any depressing influence of a general anesthetic. In head operations Crile applies a temporary clamp to the carotid, places the patient in a pneumatic rubber suit, and elevates the upper part of the body 45°. In operations on the dangerous area of the larynx, in which sudden collapse may follow from reflex inhibition of the heart and respiration as the result of stimulation of the superior laryngeal nerve, he advises a preliminary dose of atropin, or the application of cocain to the nerve endings in the larynx; in the extremities he blocks the nerve trunks by injecting into them cocain.

The **treatment** of shock consists in raising the feet and lowering the head; the application of carefully protected warm water bags; the hypodermatic injection of ether 1 ʒ, brandy 1 ʒ, strychnin gr. $\frac{1}{20}$, digitalin gr. $\frac{1}{10}$, atropin gr. $\frac{1}{100}$, ergotin ♏x, pituitarin 1 cc., or camphorated oil 1 ʒ; inhalations of ammonia, alcohol, or oxygen; the rectal injection (enteroclysis) of hot coffee 1 pint, whisky 1 ounce, or turpentine ½ ounce with salt solution; and autotransfusion, hypodermoclysis, or intravenous infusion (Chap. XV) of adrenalin chlorid in the strength of from 1 to 50,000 to 1 to 100,000 in salt solution. As a rule from 10 minims to a half dram of a 1 to 1000 solution is dropped into two quarts of salt solution, which is slowly injected into a vein. *Autotransfusion* is the application of bandages to the extremities for the purpose of driving the blood to the vital centers. Mustard plasters may be put over the heart and on the extremities, and stretching the sphincter ani has been recommended. If the respirations fail despite stimulation, artificial respiration should be performed. Transfusion of blood and massage of the heart (Chap. XV) have been employed in a few cases. Operations are not, as a rule, performed during the presence of shock, unless it is known that the shock is being increased by the condition for which the operation would be performed, e.g., hemorrhage, perforation of a hollow viscus, and some cases of crushed extremities.

AUTOINTOXICATION.

Autointoxication usually means that form of toxemia resulting from the absorption of putrefying intestinal contents, but includes also many other varieties of intoxication, such as those due to deficient elimination from the kidneys and other excretory organs, to the absorption of disintegrating portions of the body when sterile (aseptic wound fever), and to interference with glands like the thyroid. Most of the autointoxications are strictly medical, but are of great interest to the surgeon because of the frequency with which they complicate surgical conditions. In order to prevent autointoxication, the excretory organs should receive proper investigation and care.

Traumatic diabetes may follow injuries and operations, involving not only the brain, spinal cord, liver, pancreas, and kidney, but also other organs and parts. It generally appears within a day or two and is transient, seldom leading to serious consequences.

The only other autointoxication with which we shall deal here is aseptic fever.

Aseptic fever (*reactionary, simple traumatic,* or *resorption fever*) is seen after subcutaneous injuries, such as contusions, fractures. and sprains, and after aseptic operations. It is due to the absorption of sterile products of cellular disintegration, chiefly fibrin ferment, from extravasated blood or from exudate, hence is apt to be of greater degree after the use of strong antiseptics. The only symptom is a slight rise in temperature, rarely more than 101° F., which disappears by the end of the second or third day. If the fever persists beyond this time, especially if other symptoms appear, it is almost surely due to some other cause, most likely infection of the wound. The erythematous and urticarial rashes which are sometimes described in connection with this condition are probably due to intestinal derangement, as they subside after the bowels have been freely evacuated. Aseptic fever requires no treatment.

SEPSIS.

Sepsis, or "blood poisoning," includes sapremia, septic intoxication, septicemia, and pyemia. The former two are due to the presence of toxins alone in the blood (*toxemia*), the latter two to the presence of toxins and bacteria (*bacteremia*). These toxins and organisms may be of any variety, but in the following paragraphs septic intoxication and septicemia are defined in their restricted sense as referring to pyogenic toxins and pyogenic bacteria.

Sapremia is due to the absorption of the products of putrefaction; hence, properly speaking, autointoxication from decomposing intestinal contents is sapremia. Saprophytic organisms are rarely found alone in surgical affections, consequently a pure form of sapremia is rarely seen. The best example is that due to the absorption of ptomains from a decomposing placenta after child birth, although a more or less pure form may be seen as the result of putrefaction of blood clots, wound secretions, or large tumors. Since sapremia is so frequently linked with other septic processes, and is clinically indistinguishable from septic intoxication, the term should be discarded.

Septic intoxication (*pyogenic toxemia*) is due to the absorption of pyogenic toxins. The usual cause is pus under pressure, e.g., an unopened abscess or a badly drained, suppurating wound. As granulation tissue blocks lymphatic spaces, toxins are not readily absorbed from its surface, unless pressure be added; thus in a completely drained abscess there are no constitutional symptoms; if the drainage be defective, however, or if the lymph spaces be opened by curettage, absorption takes place. *Chronic septic intoxication* is hectic fever.

The **symptoms** appear usually in from one to three days, and vary in degree according to the character and virulency of the toxin, the amount of absorption, and the resistance of the individual. They manifest themselves as *fever*, or *pyrexia*, which is a syndrome characterized by a rise in temperature (often preceded by a chill), quickening of the pulse and respirations, headache, backache, diffuse muscular soreness, general weakness; by disordered secretions, causing dryness of the mouth, coating of the tongue, thirst, impaired appetite (sometimes vomiting), constipation or diarrhea, scanty high colored urine containing an excess of urea and urates, dryness of the skin or sweating; and by nervous disturbances varying from delirium to coma. There is a leukocytosis unless the intoxication is slight or overwhelming, but no organism in the blood. In the young and robust the symptoms are apt to be active (*sthenic fever*); in the debilitated, in the old, and even in the young they, when protracted, are apt to be of a low type and associated with marked exhaustion (*typhoid state, asthenic or adynamic fever*). The *local symptoms* are those of inflammation, and, if there be a wound, usually a copious and foul smelling discharge.

Septicemia (*pyogenic bacteremia*) is septic intoxication plus the presence of living pyogenic bacteria in the blood stream, and differs from pyemia only by the absence of secondary abscesses. The organisms gain entrance to the blood by the lymph vessels as the result of pressure in an abscess (*secondary septicemia*), or possibly in some cases pass directly into the open capillaries without the existence of suppuration (*primary septicemia*). *Cryptogenic septicemia* presents no wound or focus of suppuration; a forgotten needle puncture, or an abrasion on the skin or one of the mucous membranes may be responsible for these cases, which become fewer as the surgeon increases in experience and investigates with more care. Bacteria in the circulating blood are devoured by the leukocytes, or dissolved by the bacteriolytic action of the blood serum, thus terminating the process; or, if sufficiently numerous or virulent, and especially if the individual has not sufficent resistance to manufacture antibacterial serums or opsonins, they multiply, continue to elaborate toxins, and are distributed to various parts of the body, where they may cause secondary or metastatic abscesses (pyemia); some are eliminated by the excretory organs, and some are destroyed by the tissue cells. There is no specific micro-organism of septicemia, any one of the pyogenic bacteria seemingly being capable of producing the condition, although the streptococcus bears the worst reputation in this respect.

The **symptoms** may be noticed a few hours after a wound, or not for several days. There is usually a chill, with a rapid rise in temperature to 104° or 105° F.; the fever persists, being less in the morning and greater in the evening; in many cases there are violent chills at irregular periods, followed by high temperature and drenching sweats. The pulse increases in rapidity and decreases in tension. In severe cases the pulse rate reaches 150 or more, finally becoming so rapid and weak that it cannot be counted. There is often marked depression of the nervous system, the patient being stupid and quiet (typhoid state); or delirium, restlessness, picking at the bed clothes and twitching of the tendons; in either case coma precedes death. Although the respirations are quickened, signs of imperfect oxygenation of the blood are often seen in the face, which may be cyanotic. The tongue is dry, coated, red at the edges, pointed at the tip, and sordes are present upon its dorsum and upon the lips. There are loss of appetite, occasionally vomiting, often diarrhea. Petechiæ may appear in the skin and mucous membranes, and, owing to the disintegration of red blood cells, hematogenous jaundice may develop. The skin may present eruptions also in the form of vesicles or pustules, or simulating urticaria, measles, or scarlet fever. The urine is scanty, high colored, and contains albumin, toxins, and frequently bacteria; the spleen and often the liver are enlarged, and there may be leukocytosis. Bacteria may be discovered in the blood by cultural methods.

The *local manifestations* vary from slight inflammation to the graver forms of cellulitis and are not always characteristic, although in many cases the wound discharges a thin pus, while the activity of the lymphatic vessels is shown by red lines of lymphangitis running to the nearest lymph glands, which are swollen and tender, or even suppurating. The veins about a suppurating wound may become inflamed, and blocked with coagulated blood (thrombophlebitis). Bacteria may invade and soften this thrombus, portions of which may be washed into the blood stream as emboli.

Pyemia is septicemia plus secondary or metastatic abscesses, due to the bacteria lodging in various parts of the body, or to septic emboli the result of a thrombophlebitis; these abscesses may be found in any part of the body, but are most frequent in the bones, where bacteria are readily deposited from the capillaries owing to the slowly moving blood current, and in those organs which have terminal arteries, such as the brain, spleen, kidney, and lung. Emboli arising in the area drained by the portal vein lodge in the liver (see embolism). Compared with preantiseptic days, pyemia is comparatively rare at the present time, but is especially prone to follow thrombophlebitis of the facial veins in infections in this neighborhood, thrombophlebitis of the lateral sinus the result of middle-ear disease, and pylephlebitis the result of inflammations about the rectum, appendix, etc.

The **symptoms** are those of septicemia, plus the secondary abscesses, which usually appear during the second week; they are generally announced by an additional chill, but may develop insidiously, sometimes without even pain or tenderness, and they are commonly small and multiple. Pyemia may run its course in a few days (*acute pyemia*), or it may last a number of months (*chronic pyemia*). It is usually fatal, although recovery has occurred despite the presence of secondary abscesses in the internal organs. In pyemia there is said to be a characteristic sweet odor not unlike that of hay.

Surgical scarlatina is the name given to the scarlet rash, probably the result of vaso-motor disturbance, seen in cases of sepsis. True scarlatina may, however, occur after operations and accidental wounds, especially in children. Since the period of incubation is shorter than in the non-surgical form, it may be that the micro-organism of scarlet fever enters through the wound. Scarlet rashes may occur likewise from the absorption of ether, bichlorid of mercury, carbolic acid, and iodoform.

The **diagnosis of sepsis** is made by finding the causative lesion and excluding other febrile maladies. The *causative lesion* is sometimes difficult to locate, particularly in the so-called cryptogenic or spontaneous form, in which it may be necessary to review the entire body before finding the source of infection. Regions especially liable to be overlooked are the ear, nose, accessory sinuses, teeth, tonsils, throat, urethra, prostate, rectum, in women the pelvic organs, and in children the bones, particularly the tibia. An insignificant wound that has healed may be the starting point of even the gravest forms of sepsis, and, conversely, a wound, even if suppurating, may be complicated by other forms of fever. Here it should be noted that tonsillitis may be the cause and pneumonia, endocarditis, etc., the result of sepsis. The *exclusion* of aseptic fever is made by the healthy appearance of the wound and the brief duration of the fever, of autointoxication by stimulating the excretory organs. When there is marked depression of the nervous system and general exhaustion, typhoid fever (Widal reaction, leukopenia) and miliary tuberculosis may be simulated, while the occurrence of chills is often wrongly interpreted as malaria; in the last a blood examination will reveal the presence of malarial parasites. The occurrence of skin rashes, particularly in children, will bring up the question of the acute exanthemata, especially measles and scarlet fever. The *form of sepsis* is toxemia (sapremia or septic intoxication) if, in the presence of an inflamed or suppurating wound, the symptoms promptly subside after thorough drainage and disinfection. If the wound does not show evidences of irritation, the constitutional disturbance may be due to septicemia, but is more probably the result of some medical complication. The continuation of fever after the opening of an abscess or wound, excluding medical complications, usually means inefficient drainage, that is, a continuation of the septic intoxication, or, if the wound is perfectly drained, septicemia. In the latter instance, the absorption of bacteria may be evidenced by red and tender lymph vessels coursing along the surface and ending in inflamed lymph glands; the constitutional symptoms are more severe than in septic intoxication, and chills are more likely to occur. A positive diagnosis can be made only by recovery of the organisms from the blood stream, or from the excretions, particularly the urine. Leukocytosis occurs in all forms of sepsis, as does also iodophilia. The diagnosis of pyemia is made by the metastatic abscesses, which, when superficially situated, are easily detected; but when deeply seated in the viscera, they are apt to be small and numerous, and often their presence can only be suspected.

The **treatment of sepsis** is first *prophylaxis.* All wounds accidentally received should be carefully disinfected and the most scrupulous antiseptic or aseptic precautions taken during operations and the delivery of pregnant women. After labor the placenta should be carefully inspected to make sure that none of it has been left behind, after miscarriage curettage of the uterus is often done with the same end in view. It is important before operations also to increase the resistance of the patient by suitable treatment.

The *local treatment* is that of the causative lesion, viz., inflammation, suppuration, gangrene, etc. Uncomplicated sapremia or septic intoxication rapidly subsides if the local cause be found and removed. If the symptoms continue, all the putrefying material has not been removed, drainage is not efficient, or bacteria are elaborating toxins in the blood stream (septicemia). In the last the outlook is always grave, although, as has already been indicated, destruction of bacteria and recovery may follow. In pyemia secondary abscesses should be incised and drained, but unfortunately, in the viscera, this is often impracticable owing to their multiplicity. An accessible vein the subject of thrombophlebitis should be excised, or (e.g., lateral sinus) opened, the clot removed, and the cavity packed with gauze; in order to prevent the further dissemination of septic emboli, the vein may be tied between the thrombus and the heart; in the extremities amputation may be required.

The *general treatment* is (1) specific, (2) eliminative, (3) symptomatic. (1) *Specific treatment* aims to destroy bacteria in the blood stream or to neutralize their toxins. Unfortunately, pyogenic bacteria in the blood stream are inaccessible. The *injection of antiseptics* into the circulation, in sufficient strength to be of value, is dangerous. *Antistreptococcic* serum, which at first seemed to give much promise, has been found to be ineffectual; it may, however, be employed in 10 cc. doses repeated every three or four hours, particularly if bacteriological examinations prove the infection to be due to streptococci; like diphtheria antitoxin, which, too, has been used in septic conditions without success, it may produce erythematous or urticarial eruptions and pains in the joints, and several cases have been reported in which sudden death followed the injection of the serum. *Vaccine* treatment is still on trial. Quinin, iron, and large doses of alcohol (whisky or brandy) are regarded by many as almost specific in septic processes. (2) The most efficient means of combating sepsis is by *elimination* of the micro-organisms and their products. *Purgation*, especially by calomel and salines, lowers the blood pressure, drains off toxins through the bowel, and clears the intestinal tract of material which may be absorbed and aggravate the symptoms. If nature has anticipated the physician by the production of a diarrhea, such should not be checked unless excessive. *Diuretics*, such as calomel, caffeine, squill, sweet spirits of niter, acetate of potassium, and large quantities of water by mouth or rectum, are of great value in removing toxins from the blood. in lowering temperature, and in reducing blood pressure. When both the stomach and rectum are irritable, the same principle may be utilized by injecting salt solution into the subcutaneous tissues, or, exceptionally, directly into a vein. *Diaphoretics* are not often used, as when they are indicated in septic conditions profuse sweats are generally present. *Venesection* is occasionally employed to lessen the amount of toxin in the circulating blood, especially when followed by the intravenous injection of salt solution. It should never be used in infancy, old age, or in the debilitated. (3) *Symptomatic treatment* depends upon the indications. Rest in bed, predigested liquid food, and proper nursing are always required in severe cases of sepsis. The best *anodyne*, if the condition is to last but a short time, is opium or one of its derivatives. In most surgical inflammations pain severe enough to prevent sleep calls for incision and drainage of the affected part. Nervousness is best met by the bromids, and sleeplessness not caused by pain by sulphonethylmethane or sulphonmethane. The coal-tar products and chloral, because of their depressing effects, are usually to be avoided. The best *antipyretic* is an ice cap on the head, and general sponging with ice water, or equal parts of alcohol and water; drugs should be rarely employed. Persistent fever usually means that further search for the source of infection, with proper incisions, disinfection, and drainage, should be carried out. In many cases *stimulants*, such as alcohol, strychnin, ammonium carbonate, and digitalis will be needed.

DELIRIUM.

Mental aberration after an operation or injury may be due to many causes. The delirium of sepsis should be excluded, and careful inquiry made into the previous mental condition of the patient, and into previous habits, especially regarding the use of alcohol, opium, and cocain; delirium may follow ether and chloroform, and may be due to iodoform or carbolic acid absorption. *Delirium* is due to an intoxication in a person who has some bodily illness, and should not be confused with *insanity*, which is a disease of the mind, often in an otherwise healthy body.

Delirium tremens (mania a potu) is of frequent occurrence in chronic alcoholics after accidents or operations which require confinement to bed, especially when the individual's customary dose of alcohol is not given. At first there are restlessness, insomnia, and nightmare. In the course of two or three days the patient becomes delirious; there are incessant incoherent talking, constant motion, a characteristic tremor of the hands and of the tongue when protruded, and hallucinations of sight and often of hearing; the patient sees grotesque individuals making grimaces, or more commonly fights snakes, rats, or insects, which he imagines are crawling over and about him. The pulse increases in rapidity, and the temperature rises, rarely above 103° F., except in fatal cases, in which all the symptoms increase in intensity, death occurring from exhaustion. Recovery is the rule unless the patient is otherwise in bad health, or develops pneumonia, which is a frequent complication.

The prophylactic **treatment** in alcoholic subjects who are to undergo operation, or who have sustained an injury, consists in the administration of their customary tipple, tonics, and nourishing food; if alcohol has been withheld it, with bromids, should be given at the first appearance of tremor, restlessness, or insomnia, and the patient carefully watched, because at the outbreak of delirium, he may tear off his dressings, or get out of bed and jump through a window. In some cases alcohol seems to make the condition worse, or at least has no effect in checking it. When the attack has once developed, the indications are to quiet the nervous symptoms, to sustain the strength, and to maintain a constant watch. The nervous sedatives most frequently employed are the bromids, sulphonethylmethane, and sulphonmethane; chloral is too depressing to the heart, and morphin, because of its effects upon the secretions, should be used only in exceptional cases or in extreme mania. Paraldehyde and hyoscin are highly recommended by some authorities. The strength is maintained by nourishing liquid food, strychnin, and digitalis, while capsicum is usually given for its effect upon the stomach. Although strapping the patient in bed aggravates the nervous symptoms, it is usually necessary. Careful attention, of course, should be given to the bowels and kidneys.

Traumatic delirium, or delirium nervosum, is an afebrile delirium occasionally encountered after injuries or operations, particularly in children, the senile, and the hysterical. Many individuals become flighty from pain alone. Delirium nervosum appears several days after an operation or injury and may last a week, very rarely terminating in death. It is closely allied to the "*delirium of collapse*," which is seen in some cases of shock, or after the sudden fall of a high temperature, and which may last a few hours or a few days. The *treatment* of delirium nervosum is nervous sedatives, attention to the general health, and the removal of any local irritation which may be present.

Genuine **insanity** occasionally develops after an operation or injury; it is usually of the confusional type, but may be of any variety. The prognosis is good unless there are systematized delusions, a strong ancestral history of insanity, or unless there has been previous trouble with the intellect.

ERYSIPELAS.

Erysipelas (**St. Anthony's fire**) is an acute contagious and infectious inflammation of the skin, and occasionally of the mucous membranes.

The **cause** is the streptococcus erysipelatis (identical with the streptococcus pyogenes), which lodges in an abrasion or wound, and, passing into the capillary lymphatics of the skin, gives rise to inflammation of these vessels and, by contiguity, of the remaining dermal structures. Chronic alcoholism, kidney affections, and other causes of general debility, favor the development of the disease, and in certain individuals there is a natural predisposition, the disease breaking out repeatedly on the slightest provocation. It is most prevalent in the spring, and is especially prone to occur in epidemics in overcrowded hospitals with defective sanitation. *Idiopathic erysipelas* is that form in which no port of entry can be found. Infection through sound skin or mucous membrane is possible, but in the vast majority of the idiopathic cases it is probable that the abrasion is so slight or so situated, e.g., just within the nostrils, that it escapes detection.

The **symptoms** appear within a few hours or not for several days after infection. They may be inaugurated by a chill, with headache and malaise, the rash appearing a number of hours later, but in many cases the local changes first attract attention. The wound will have a dry, dirty-yellowish appearance, and be surrounded by a bright red, shiny swelling, which spreads irregularly, resembling a growing map; the redness disappears on pressure, and there is a sensation of burning, tension, or stiffness, but no acute pain, unless dense structures like the scalp are invaded; there is edema, which, in loose structures like the scrotum and eyelids, becomes very great. Owing to the intensity of the dermatitis, vesicles and bullæ frequently develop and often contain a purulent fluid. Suppuration, however, is not common unless the organism gains access to the subcutaneous tissues, when the condition is called *cellulo-cutaneous or phlegmonous erysipelas* (see cellulitis). The skin is hot and tense, the margins of the swelling abrupt and sharply defined, and the adjacent lymph glands swollen and tender. The fever is of the continuous variety and, especially in facial erysipelas, is apt to subside by crisis. In those whose health has been depressed by general illness, in alcoholics, and in erysipelas about the head and face, great prostration with delirium is likely to develop. As the rash spreads it fades in those areas which were first attacked, leaving a brownish discoloration and a branny desquamaton. Erysipelas of the *fauces* causes great swelling, which may spread to the glottis and produce severe dyspnea. Occasionally erysipelas will spread from its point of origin, successively involving contiguous areas (*ambulant, erratic, migratory, or wandering erysipelas*). Again it may jump from one region of the body to some distant region (*metastatic erysipelas*). Erysipelas which begins in the cicatrizing umbilicus of the new-born (*erysipelas neonatorum*) is very fatal. Every now and then a malignant growth, chronic ulcer, or ancient skin disease will disappear after it has been invaded by erysipelas (*erysipelas salutaire*). The disease lasts from a few days to several weeks. The mortality is from 5 to 7 per cent. Death is usually the result of toxemia, although it may arise from a complication, such as meningitis, pneumonia, endocarditis, nephritis, or pyemia.

The **diagnosis** of erysipelas is rarely difficult. It is most frequently confused with cellulitis, in which the redness is more dusky, the margins not so abrupt and irregular, and the pain deeper and more throbbing.

Treatment.—The *prophylactic treatment* consists in the isolation of cases of erysipelas which develop in a surgical ward. During an epidemic none but imperative operations should be performed. Those who nurse or dress cases of erysipelas should not come in contact with surgical or obstetrical patients.

The *local treatment* consists in the careful disinfection of any existing wounds and the application of antiseptic fomentations. The various solutions and ointments which have been recommended seem to have little effect upon the progress of the disease; the most popular of these is ichthyol, 25 per cent. Cataplasm of kaolin makes a comfortable application. Evaporating lotions and cold compresses ease the pain, but should be used cautiously in asthenic cases. Irritating medicaments, e.g., iodin, turpentine, etc., should not be applied to the inflamed area. In order to prevent the spread of erysipelas, the inflamed area has been surrounded by a circle painted with a strong solution of silver nitrate or tincture of iodin, by injections of a 3 per cent. carbolic acid solution or other antiseptic, by incisions, and by a circle burned with the cautery. All these methods aim to produce a barrier of leukocytes, in other words, an inflammation is produced to stop an inflammation. The results of this homeopathic form of treatment do not justify its continuance. The application of pressure by collodion or strips of adhesive plaster is occasionally effective in limiting the inflammation. When suppuration is threatened, or in the cellulo-cutaneous variety, incisions are indicated. *Erysipelas of the fauces* should be treated by sprays or gargles of mildly antiseptic solutions, and by the application of ice externally; the patient should be carefully watched for evidences of edema of the glottis, which may require tracheotomy.

Constitutional treatment should be conducted on general lines, i.e., elimination should be attended to, stimulation and nervous sedatives used if necessary, liquid food given at frequent intervals, sponging and cold employed for excessive fever. Tincture of chlorid of iron, 10 to 20 drops three or four times a day, is regarded by some as a specific, especially when combined with quinin. Pilocarpin given internally has been recommended for its action on the skin. Antistreptococcic serum should theoretically be of great value. Mormorek, the originator of antistreptococcic serum, has treated 423 cases of erysipelas with his serum, with a mortality of 3.87 per cent. The serum has been injected around the area of inflammation, as well as in indifferent portions of the body.

Erysipeloid is an infective dermatitis caused by inoculation of a wound or abrasion with putrid animal matter, hence is most frequent on the hands of cooks, butchers, and fish dealers. The swelling is red, painful, and sharply defined, and tends to spread over the rest of the hand. Suppuration, lymphangitis, and the formation of vesicles do not occur, and general symptoms are slight or absent. The treatment is disinfection of the wound and mildly antiseptic dressings.

CELLULITIS.

Cellulitis, or inflammation of the areolar connective tissue, may be found in any region in which there is cellular tissue (see cellulitis of the neck, pelvic cellulitis, periproctitis, etc.), but here we refer only to the subcutaneous variety. It may be acute or chronic. *Chronic cellulitis* is always circumscribed; it may follow the acute form, but is more often seen as a thickening of the tissues about some long-continued source of irritation, e.g., a chronic ulcer, and subsides when the cause is removed. *Acute cellulitis* may be circumscribed or diffuse. *Acute circumscribed cellulitis* occurs about inflamed wounds, spreading ulcers, and tight stitches. The inflamed tissues occasionally suppurate or slough, but the process remains localized and promptly subsides with appropriate treatment.

Acute diffuse cellulitis (*diffuse phlegmon, phlegmonous suppuration, purulent infiltration*) is a widespread suppurative inflammation of the subcutaneous cellular tissue. It is usually caused by the infection of wounds with the streptococcus pyogenes, and is indistinguishable clinically from *cellulo-cutane-*

ous, or phlegmonous erysipelas. The less severe varieties are due to staphylococci. In either case the dose and virulency of the organism and the general condition of the patient determine the extent and severity of the process.

The **symptoms** may appear within a few hours or not for two or three days after the infection of a wound. The inflammation spreads rapidly, and may extend over a whole limb. There are intense pain, great swelling and edema, dusky redness, and elevation of the local temperature. The lymphatic vessels running from the infected area may be tense, red, and tender, and the glands into which they empty, painful and swollen. The suppuration may spread not only beneath the skin, but between muscles, beneath fascia, and even to the bone. The subcutaneous tissue sloughs, and gangrene of the skin may occur from the cutting off of its blood supply. When the tendency to gangrene is excessive and, as the result of infection with aërogenic bacteria, gas is present in the tissues, the condition is called *gangrenous cellulitis, emphysematous gangrene,* etc. (q.v.). The constitutional symptoms are those of septic intoxication or septicemia; occasionally pyemia develops.

Treatment.—Cellulitis may be prevented by the scrupulous disinfection of all abrasions and wounds, and their exclusion from septic contamination by sterile or antiseptic dressings. It may be aborted by opening, disinfecting, and draining inflamed wounds. When it has once gained headway, free incisions should be made, whether there be suppuration or not, in order to relieve tension and drain the tissues of the inflammatory exudate and bacterial products. In the milder varieties early incisions may prevent suppuration, in the severer forms they will at least limit it; these incisions are disinfected by peroxid of hydrogen, followed by hot bichlorid of mercury solution, 1 to 1000, and are lightly packed with gauze, the whole part being covered with a bichlorid dressing. The limb should be elevated, frequently dressed and irrigated, and further incisions made if spreading continues. Inflamed lymph vessels and glands may be covered with ichthyol ointment; if the glands suppurate, they should be freely extirpated. If there is a tendency to sloughing, warm antiseptic fomentations should be applied, and the sloughing tissue removed as quickly as it forms. Constant irrigation with a mild antiseptic solution, which descends, by means of a gauze wick, from a reservoir suspended over the part, and then is caught in a suitably arranged sheet of rubber to be drained into a receptacle on the floor, is sometimes of service, as is also immersion of the part in a continuous warm bath. The treatment of gangrenous cellulitis is given in the section on traumatic spreading gangrene. The constitutional treatment is that of sepsis (q.v.).

TETANUS.

Tetanus (lockjaw) is an infectious disease characterized by tonic spasms of the muscles, especially those of mastication.

The **cause** is the bacillus of tetanus, which is a rod-like organism, usually presenting a distinct enlargement at one end, owing to the presence of a spore (drumstick bacillus). It is an anaërobe, a fact which explains the frequency of tetanus after punctured wounds, which quickly heal at the surface and form an ideal chamber for the growth of the organism. In the absence of air it may be slightly motile, owing to the presence of flagellæ.

It is most frequently found in cultivated earth and in the feces of animals, hence the susceptibility of hostlers and "sons of the soil." The predisposition which is supposed to be possessed by the negro is probably due to this fact. As heat favors the development of the organism, the disease is particularly prevalent in the tropics. Aside from punctured wounds, the bacillus finds a most favorable field for development in septic wounds, owing to the absorption of oxygen by other organisms present (symbiosis). Punctured wounds of the sole of the foot are notorious for the frequency with which they are followed by tetanus, because the vulnerating body, often a rusty nail, has become contaminated by lying in contact with the earth. Blank cartridge wounds are particularly dangerous, no doubt because the wads are often made of horsehair felt. Tetanus has followed also the injection of gelatin for aneurysm, the injection of diphtheria antitoxin, and vaccination. Gelatin, it will be recalled, is derived from the hoofs, hides, etc., of cattle; diphtheria antitoxin from the blood serum of horses; and the virus used for vaccination, from cows. Occasionally no wound can be found (*idiopathic tetanus*), although it is possible in these cases that the bacilli enter the tissues through an ulcer or abrasion in the alimentary canal. The bacilli have little tendency to migrate from the point of inoculation, being rarely found in the blood. *Tetanotoxin* is composed of two bodies, viz., *tetanospasmin*, which produces convulsions, and *tetanolysin*, which destroys red blood cells. The toxin reaches the ganglia of the central nervous system, not by the blood, but by the motor nerves, along the axis cylinders of which it slowly creeps, thus explaining the long incubation and the congested appearance of the nerves leading from the wound. The sensory nerves take no part in the process. That portion of the toxin which finds its way into the general circulation is not absorbed directly by the ganglia, but is distributed to the ends of the motor nerves throughout the body, then passing upward along these nerves to the cord; thus the period of incubation is the same when the toxin is injected into even the subarachnoid space.

The period of incubation of **acute tetanus** varies from a few hours to two weeks, usually being within ten days. The first symptom is stiffness of the lower jaw, which later becomes fixed, the patient being unable to open the mouth (*trismus, or lockjaw*). The spasm extends more or less rapidly to the other voluntary muscles of the body. Spasm of the muscles of expression moulds the face into a characteristic grin (*risus sardonicus*). As the muscles of the back are the more powerful, generalized convulsions usually cause the patient to rest upon the head and heels (*opisthotonos*), but the whole body may be stiff and straight (*orthotonos*), bent to one side (*pleurosthotonos*), or curved forward (*emprosthotonos*). Spasm of the pharyngeal muscles causes dysphagia, of the diaphragm girdle pain, of the laryngeal muscles dyspnea, of the sphincter vesicæ retention of urine, of the sphincter ani constipation. The mind is clear, and the pain very great, owing to the cramp-like contracture of the muscles, which never entirely relax, and which are thrown into more acute contraction by the slightest irritation, such as a draught of air, an attempt to take food, etc. During these convulsions the patient is cyanotic from spasm of the respiratory muscles, the body is covered with sweat, the eyes protrude, and muscles may be ruptured, teeth broken, or the tongue bitten through. The temperature is usually normal at the beginning, but generally rises before death, and continues to rise after death, often reaching 108° or 110° F. The end usually comes within four or five days, from heart failure or asphyxia during a convulsion, or from exhaustion.

Chronic tetanus has a longer period of incubation than the acute form, milder symptoms, and a much better prognosis. Sometimes the spasms are limited to that portion of the body in which the infection has taken place. In cephalic tetanus (*tetanus paralyticus, kopf tetanus, tetanus hydrophobicus*), which follows injuries in the area supplied by the cranial nerves, trismus and dysphagia are often accompanied by facial paralysis, from neuritis of the seventh nerve. Chronic cephalic tetanus presents a fairly good prognosis (25 per cent. mortality), but in some cases it is acute and associated with generalized convulsions, and is then quite as grave as ordinary acute tetanus.

Tetanus neonatorum, or trismus nascentium, is tetanus in the new-born, due to infection through the navel.

The *mortality* of acute tetanus is from 80 to 90 per cent., of the chronic variety from 40 to 50 per cent. A long period of incubation, a normal temperature, and limitation of the spasms to the head and neck are favorable signs. If death does not occur within a week, recovery may be expected.

Diagnosis.—*Trismus*, or closure of the jaws, arising from inflammatory troubles, etc. (see closure of the jaws), is not accompanied by rigidity of the neck or generalized convulsions, and the cause, e.g., tonsillitis, unerupted wisdom tooth, etc., will readily be found upon examination. In *strychnin poisoning* there is complete relaxation between the spasms, including the jaw muscles, so that the mouth may be widely opened; the convulsions are more abrupt in onset, and the hands are tightly contracted, an unusual sign in tetanus; and there may be hyperesthesia of the retinæ with green vision. In *hysteria* there may be blindness, laughing or crying spells, loss of consciousness, and during the spasm closure or quivering of the eyelids. Occasionally the patient is rigidly fixed in one position and remains so for hours (*catalepsy*). Wood states that in hysteria the feet are crossed and the toes inverted; in spasm of all the muscles of the leg the feet are turned out, because the muscles of eversion are stronger. *Tetany* is characterized by tonic local spasms, especially of the hands and feet, and trismus is rarely present. In *hydrophobia* the convulsions are limited to the muscles of respiration and deglutition, are clonic and not tonic, and are associated with mania. Bacteriological examination of any existing wound may be of value in doubtful cases.

The Treatment.—The *prophylactic treatment* consists in the careful disinfection of all wounds. Punctured wounds, unless produced by an evidently clean instrument, should be enlarged by incision, disinfected, and drained. They should not be cauterized, because the resulting eschar excludes the air from the deeper portions, and thus favors the development of the tetanus bacillus. In wounds in which infection by the tetanus bacillus is suspected, viz., those contaminated by earth or manure, and those due to the blank cartridge, the most scientific procedure is to take a smear and a culture from the wound before disinfection; if tetanus bacilli are recovered, the wound should be excised and antitoxin administered, 10 cc. daily for two weeks. It must be noted, however, that Reynier has reported 41 cases in which the prophylactic injection of antitoxin has failed. Reference has already been made to the treatment of blank cartridge wounds. Gelatin and various antitoxins should not be used subcutaneously until they have been proved free from tetanus by injection into susceptible animals. Vaccination against small-pox should be performed by washing with soap and water, then with alcohol, and finally with sterile water; a sterile knife or needle should be employed, and the virus used should be that which comes in hermetically sealed tubes; after application to the scarified surface, it should be allowed to dry, and the wound then dressed with sterile gauze.

When the disease has once manifested itself, the wound should be excised and the part dressed with antiseptic fomentations. In wounds too large for excision, and even in smaller wounds, amputation may properly be considered. The most useful antiseptics in wounds which are not excised, are strong tincture of iodin, 1 per cent. solution of silver nitrate, and bichlorid of mercury, 1 to 500. Stretching the main nerve trunks supplying the affected part has been employed with occasional success; it may be that this procedure interferes with the transference of the toxin along the nerves. Far better, at least theoretically, is the injection of antitoxin into these nerves; for this purpose the patient should be chloroformed, and the motor nerves which supply the region primarily infected exposed as near the cord as possible and each injected by a fine hypodermic needle with from 5 to 10 or 20 cc. of antitoxin (Rogers). This procedure may be repeated daily if there is no improvement in the symptoms. In urgent cases Rogers has injected from 20 to 30 cc. of antitoxin into the lowest portion of the cervical cord. When injected subcutaneously, the antitoxin neutralizes only that portion of the toxin which is in the circulating blood, and not that which is in the nervous system, as it is not absorbed by the nerves as is the toxin. Antitoxin has been injected also around the infected part, directly into a vein, into the subarachnoid space, and, after making a small trephine opening in the skull, directly into the frontal lobes of the brain. The antitoxin has been introduced also into the lateral ventricle. Of 124 acute cases treated by antitoxin the mortality was 71.77 per cent., of 138 chronic cases 15.94 per cent. (Lambert). Tetanus antitoxin is manufactured by immunizing a horse with ascending doses of the toxin; the antitoxin is contained in the blood serum, and is sold either as a fluid or as a powder. The dose is from 20 to 30 cc. subcutaneously, intravenously, or subdurally, and 5 cc. when injected directly into the brain. The dried serum may be given in doses of from 3 to 4 grams repeated daily. It is probable that with the onset of symptoms the tetanus toxin has already fatally embraced the cells of the central nervous system, and that antitoxin administered in any form is quite impotent to repair the damage already done. Emulsions of fresh brain tissue have been injected hypodermatically, on the principle that the toxin would unite with these nervous cells and thus become neutralized.

Even though antitoxin is employed, the patient should be isolated in a darkened chamber and guarded from all forms of irritation. Bromids, chloral, and morphin should be regularly administered, and the convulsions controlled by chloroform. Section of the phrenic nerves in the neck and tracheotomy have been advised for menacing cramp of the respiratory muscles, but should be unnecessary if one has an intratracheal insufflation apparatus. If trismus is marked, nasal feeding may be adopted, by the passage of a rubber catheter into the pharynx through the nose, or food may be administered by rectum. Other drugs which have been recommended are curare, cannabis indica, gelsemium, physostigma, and iodoform. Baccelli claims satisfactory results from the hypodermic injection of from 10 to 30 drops of a 1 per cent. solution of carbolic acid every three or four hours. Venesection to lessen the amount of toxin in the circulating blood, followed by intravenous infusion of salt solution, is occasionally employed. The subarachnoid injection of magnesium sulphate, cocain, etc., as in spinal anesthesia, also has been used and appears to be of some value in controlling the convulsions.

HYDROPHOBIA.

Hydrophobia (rabies, lyssa) is an infectious disease resulting from the bites of animals, especially the dog, cat, and wolf. The specific micro-organism is probably identical with the so-called Negri bodies (*vide infra*). The virus is found in the saliva, in the central nervous system, and occasionally in the lachrymal gland, pancreas, and mammary gland. It is not found in the blood, and further resembles the toxin of tetanus in that it has a marked affinity for the central nervous system, to which it is conveyed by the nerves. As in tetanus, the wound is often punctured, and may heal before the onset of symptoms, and again become painful as the disease develops. Between 10 and 25 per cent. of those bitten by rabid animals subsequently develop hydrophobia. Cases have been reported in which the disease has followed the mere licking of the hand by a rabid dog. Bites through clothing, which may wipe the virus from the teeth of the animal, are less dangerous than those on exposed parts, while bites in parts richly supplied by nerves, such as the face and hands, are the most dangerous. The virus is present in the saliva for several days, sometimes as long as eight, before the development of symptoms, thus sustaining the popular belief that hydrophobia may follow the bite of a dog which later becomes rabid. The period of incubation in man varies from a few weeks to several months, the average being forty days. The disease is most frequent during the summer months. The gross changes usually found after death are those of congestion of the brain and membranes. Microscopically, the most important findings are (1) aggregations of embryonic cells in the motor nuclei of the medulla and cord (rabic tubercles of Babés); (2) degeneration of the cerebrospinal and sympathetic ganglia, especially the plexiform ganglia of the pneumogastric nerve and Gasserian ganglion, the nerve cells being replaced by proliferated endothelial cells derived from the capsule; and (3) Negri bodies (thought by Negri to be protozoa and the cause of rabies), which are small bodies found in the cells of the central nervous system, particularly in the Purkinje cells of the cerebellum and in the large ganglion cells in the region of Ammon's horn. Noguchi claims to have cultivated the Negri bodies, and reproduced the disease with the cultures. The degenerative lesions of the ganglia and the Negri bodies are pathognomonic, so that a positive diagnosis may be made by the examination of an animal after death. In order that these changes may occur, the animal should not be killed, but allowed to die from the disease. The head may then be removed and sent to a reliable pathologist for diagnosis, which may be further confirmed by injecting an emulsion of the nervous tissue into a susceptible animal. In animals the presence of foreign bodies, such as stone, hair, etc., in the stomach, owing to the depraved appetite characteristic of the disease, strongly points to rabies.

In the dog the symptoms appear usually in from three to five weeks after infection. In the *raging, or maniacal rabies*, there is first a stage of depression, characterized by irritability, restlessness, abnormal appetite (for rubbish, etc.), dysphagia, and nausea. This stage lasts for two or three days, and is the dangerous one for man, because the disease may not be suspected. This is followed by a stage of madness, or frenzy, lasting three or four days, in which the dog charges about, barking furiously with a hoarse bark, and biting anything with which it comes in contact; this stage terminates in paralysis and death. From the beginning there is a large quantity of ropy saliva secreted. In the *quiet, or melancholy form*, the disease skips from the first to the third stage, death occurring within two or three days from the beginning.

In man the symptoms of the first stage are restlessness, excitability, a vague terror, insomnia, anorexia, and occasionally some thickening of the cicatrix, which may be the seat of a burning or itching pain. These symptoms last about twenty-four hours, and are succeeded by the second stage, in which there are dysphagia owing to spasm of the pharynx, and dyspnea from spasm of the respiratory muscles. The spasms are clonic in character may become more or less generalized, and are precipitated by the slightest irritation, especially by attempts to swallow liquid, hence the term hydrophobia. As in the dog, there is a large quantity of ropy mucus and saliva secreted. Owing to the spasm of the respiratory muscles, noises, which have been likened to the barking of a dog, may be produced. During this stage there are outbreaks of mania with lucid intervals. There is usually very little fever, and at the end of from one to three days death occurs from a rapidly ascending paralysis. No authentic case of infection of man by man has been reported. The disease invariably results in death.

The Treatment.—In the *prophylactic treatment* should be mentioned the muzzling of dogs. A wound produced by a supposedly mad dog should be squeezed and sucked, and disinfected with formaldehyd solution, 5 per cent. which, according to Cumming, is a specific; cauterization is not recommended. When on an extremity a ligature should be placed above the bite until the wound has been disinfected. Excision is preferable, and may be efficacious even a number of days after the injury, as the virus tends to remain localized and merely creeps along the nerves. The animal should not be killed, but allowed to die of the disease, if it be really present, when a positive diagnosis may be made. As soon as possible after inoculation the patient should be given *the Pasteur treatment* (*antirabies vaccination*), which is prophylactic and not curative. It is founded on the principle of inducing active immunity by the injection of ascending doses of the virus. The most virulent virus obtainable is secured by passing the poison from a dog through a succession of rabbits, until the incubation period is shortened from three weeks to seven days. When the virus has reached its maximum intensity, it is called *virus fixe*, in contradistinction to the virus in accidentally infected animals, whose strength is not known. The spinal cords of rabbits which have died after inoculation with the *virus fixe* gradually lose their virulence by drying, until at the end of fourteen days they are practically innocuous. The vaccine consists of about 1 cm. of the spinal cord of a rabbit killed by the fixed virus, emulsified with 5 cc. of sterile broth or salt solution. About 3 cc. of this emulsion are used as an injection twice a day. On the first day 3 cc. of a fourteen day cord and 3 cc. of a thirteen day cord are injected, and the strength is gradually increased, until on the eighteenth day 2 cc. of a three day cord are used. In bites about the head and face, in which the period of incubation is shorter, the virulency of the injections may be increased more rapidly. If the patient lives within a day's journey of a reliable Pasteur Institute, the virus may be sent to him by mail and injected by the family physician. Of 104,347 cases in which the Pasteur treatment has been used, but .73 per cent. developed hydrophobia (Bernstein). The serum of artificially immunized sheep has been recommended, both for prophylactic and curative purposes, but has apparently never been used in man. After the symptoms have once appeared, chloroform, chloral, and morphin should be employed, and the patient carefully guarded from all forms of irritation.

Pseudohydrophobia, or lyssophobia, is a mixture of hysteria and fright, and is invariably followed by recovery.

ANTHRAX.

Anthrax (*malignant pustule, wool-sorter's disease, splenic fever, charbon, Milzbrand*) is an acute infectious disease occurring in animals, particularly cattle, and occasionally communicated to man. Dogs, cats, pigs, the majority of birds, and cold blooded animals are naturally immune to anthrax. The disease is common in Russia, Hungary, and certain parts of France and Germany, and comparatively infrequent in England and the United States. It is caused by the *anthrax bacillus*, a non-motile, facultative anaërobe with square or slightly cupped ends, which is equal in length to the diameter of a red blood corpuscle or even longer, and which has a tendency to form chains. When cultivated outside the body it forms spores, which have the greatest resistance to all forms of antiseptics. The bacillus is found in local lesions, in the circulating blood, and in the various organs of the body. In animals it enters the body through the gastrointestinal tract with the food. More rarely the lungs are infected by inhalation.

FIG. 79.—Anthrax pustule on the arm of a man who worked in hides. (Pennsylvania Hospital.)

In man the organism usually lodges in a wound or abrasion, although the gastrointestinal and pulmonary varieties may occur. Infection may be conveyed by flies, and by catgut prepared from diseased animals. Farmers, butchers, veterinary surgeons, and those who handle hides, wool, horsehair, etc., are predisposed to infection.

In *external anthrax*, the usual lesion in man, **the symptoms** appear in from a few hours to five or six days or even longer. The character of the local lesion largely depends upon the structure of the part; thus in dense, highly vascular tissue *anthrax carbuncle*, or *malignant pustule*, results, and in lax parts, with a poorer blood supply, *anthrax edema* occurs. *Malignant pustule* (Fig. 79) begins as a small, red, burning or itching pimple, capped by a vesicle, which rapidly grows in size. The surrounding tissues become infiltrated, and a secondary ring of vesicles develops around the primary vesicle, which soon bursts and turns black, forming a slough; in the meantime the lymphatic glands enlarge and grow tender. The process may be arrested at this point, the slough separating and the resulting ulcer healing by granulation. *Anthrax edema* is characterized by a rapidly spreading, livid edema, which is associated with vesicles filled with dark bloody serum, and followed by gangrene of the skin and subcutaneous tissues. In either form of external anthrax pain is slight and suppuration absent, and in many instances the constitutional symptoms are few and mild. When the process spreads and bacteremia develops, there are symptoms of general intoxication, such as high temperature, rapid pulse, vomiting, embarrassed respiration, and delirium, the patient dying in from one to seven days from the onset. *Internal anthrax* also occurs in two forms. In intestinal anthrax there are vomiting and blood stained diarrhea; in the pulmonary form cough, rapid respiration, cyanosis, and physical signs of pneumonia; the symptoms in either instance rapidly progressing to collapse and death.

The **diagnosis** should always be confirmed by bacteriological examination. Ordinary carbuncle is distinguished from anthrax by the presence of pain, numerous points of suppuration, and a chronic course. The spreading forms of cellulitis differ from anthrax edema by the greater pain, the marked tendency to suppuration, and the absence of the characteristic adherent sloughs. The *prognosis* of external anthrax is more favorable in the carbuncular form than in anthrax edema. The mortality is 25 per cent. Recovery is rare after infection of the lungs or intestinal canal.

The **treatment** is excision whenever possible, the resulting wound being cauterized with the actual cautery or with nitric acid. In other cases free incisions should be made, and bichlorid of mercury, 1 to 1000, iodin, 1 to 2 in water, or carbolic acid, 2 or 3 per cent., injected into and around the infected tissues. The wound should be dressed with wet bichlorid compresses, 1 to 1000. Ipecac has been used locally and internally. The constitutional treatment is that of septicemia. The patient should be isolated, dressings burned, and discharges disinfected. After removal of the patient a room should undergo the most rigid disinfection, owing to the great resistance of the spores. Very favorable results have recently been reported from the use of Sclavo's serum, which is made by immunizing asses with attenuated cultures of the bacillus; 30 to 40 cc. are injected into the flank in three or four different places, or in severe cases directly into a vein. Cattle are protected from anthrax by inoculating them with a virus weakened by heat.

GLANDERS.

Glanders (*Farcy, Equinia, Malleus*) is an infectious, contagious disease occurring in animals, particularly horses, asses, and mules, and occasionally transmitted to man. The specific organism, the *bacillus mallei*, is an amotile, facultative anaërobe, looking somewhat like the tubercle bacillus. It gains entrance to the tissues through a wound or abrasion of the skin, or through the unbroken mucous membrane of the conjunctivæ or respiratory passages. The period of incubation is four or five days. Glanders may be acute or chronic, and is characterized by the development, under the skin or mucous membrane, of nodules that suppurate and give rise to ulcers, which may burrow deeply and attack the bone. These nodules may be scattered also in the various viscera. The term *farcy* is sometimes restricted to the cutaneous form, when the nodules, which develop chiefly along the lymph vessels, are called "farcy buds." The constitutional symptoms are those of septicemia. Death may occur within a week in acute glanders. In the chronic form the lesions are more circumscribed and develop more slowly, recovery occurring in 50 per cent. of the cases.

Diagnosis.—Acute glanders may be mistaken for such suppurative affections as small-pox, although the lesions are deeper and there is absence of umbilication. In the ulcerative stage it may be confused with syphilis or tuberculosis. In doubtful cases a history of exposure to infection, a bacteriological examination, and inoculation of the pus into a guinea-pig will settle the diagnosis. In animals mallein, a bacterial product made like tuberculin, is injected subcutaneously, causing fever and localized swelling if glanders is present.

Preventive **treatment** consists in the destruction of infected animals. In man nodules are extirpated, ulcers curetted and disinfected, and abscesses opened and cauterized. The constitutional treatment is that of septicemia.

ACTINOMYCOSIS.

Actinomycosis is an infectious disease, occurring principally in cattle (*lumpy jaw*), and occasionally in man. The cause is the *ray fungus, or actinomyces,* which belongs to the streptothrices, a group of micro-organisms lying between the moulds and bacteria. It is anaërobic, and occurs in clumps consisting of a central mass, with radiating threads or mycelia with club-like ends. The ray fungus is widely distributed in nature, but is most frequently found in various forms of grain, from which it enters the tissues through the respiratory tract (e.g., by inhaling dust during the grinding of corn), through the alimentary tract (from the chewing of raw grain,) or through an abrasion or wound of the skin.

Pathologically the process resembles a chronic inflammation, which, owing to the abundant round-celled infiltration and proliferative changes in the connective tissue cells, forms tumor-like masses. The ray fungus is probably not pyogenic, but suppuration is prone to occur, as the result of secondary infection with pus germs. The disease occurs most frequently in the lower jaw and adjacent tissues, less frequently in the respiratory tract and intestines, and rarely in the skin.

The **symptoms** are those of a firm and painless swelling that gradually increases in size and finally breaks down at various points, giving rise to sinuses that discharge pus having a peculiar earthy odor and containing minute, gritty, sulphur-yellow bodies, which under the microscope are found to be masses of actinomycetes. The lymphatic glands are not at first involved, but may become so later, owing to mixed infection, which is responsible also for the constitutional symptoms. The process spreads from its point of origin, involving tissues by contiguity irrespective of their structure. Rarely it may break into a vein, causing a general dissemination of the actinomycetes (*actinomycotic pyemia*). If all the organisms are discharged by suppuration, spontaneous recovery may occur; indeed this may happen in portions of the mass, giving a nodular and puckered appearance, which has been regarded as almost pathognomonic. When involving the cervico-facial region trismus is frequently seen. The *prognosis* is favorable if the disease is so situated as to be accessible to surgical treatment, and exceedingly unfavorable in regions like the internal organs, in which it cannot be completely eradicated, death occurring from exhaustion, sepsis, or pyemia.

The **treatment** is excision, if the lesion be small; in other cases the sinuses should be widely opened, curetted, swabbed with tincture of iodin or cauterized with pure nitrate of silver, and packed with iodoform gauze. The constitutional treatment consists in the use of large doses of iodid of potassium, which is given for one week, then discontinued for three or four days, and given for another week. The interruptions allow resistant spores to develop into adult forms, when they are more readily destroyed by the drug. Iodid of potassium in 1 per cent. solution may be used as an injection into and around the focus of infection. The X-rays also have been used.

MYCETOMA OR MADURA FOOT.

Mycetoma, or madura foot, is an infectious disease, almost invariably attacking the foot, and occurring most frequently in India and rarely in America. The disease is closely related to actinomycosis, being caused by the *streptothrix maduræ*. Following an injury to the foot, there develops a nodular inflammatory swelling that breaks down and forms sinuses discharging a watery pus, which contains masses of the organism in the form of whitish or black granules. In the former instance the disease is called ***pale, or ochroid***, in the latter ***black, or melanoid mycetoma***. The foot becomes greatly enlarged and deformed, and the leg atrophied. In very early cases the area may be excised; later amputation is the only treatment.

LEPROSY.

Leprosy (*lepra, elephantiasis Græcorum*) is an infectious and feebly contagious disease caused by the *bacillus lepræ*, which closely resembles the tubercle bacillus, though it is more readily stained and less frequently curved. Excepting some of the Gulf states and portions of the Pacific coast, leprosy is very rare in the United States, but is common in Mexico, South America, Norway and Sweden, and in the Orient. It occurs in two forms, the tubercular and the anesthetic, which are often associated. The period of incubation is generally from three to five years. ***Tuberculated, or cutaneous leprosy***, occurs most frequently on the face, hands, feet, and extensor surfaces of the elbows and knees. After a period of feverishness with digestive disturbances, there appear little hyperemic nodules, which may disappear only to reappear. Later the redness fades and the nodules increase in size, occasionally becoming as large as a hen's egg, and break down to form indolent ulcers, or are converted into contracting cicatricial tissue, which causes hideous deformities, that of the face being characteristic (*leontiasis leprosa*); the mucous membranes and the viscera likewise may be involved, and there is atrophy of the testicles or ovaries with loss of sexual power. ***Anesthetic, or nervous leprosy***, begins with neuralgia and tenderness of certain peripheral nerves, most frequently the median, ulnar, saphenous, and peroneal. Later there are anesthesia, paralysis, and trophic disturbances, the last involving the bones, joints, and muscles, as well as the skin, and producing great deformity. Whitish or brownish spots appear on the skin, and gradually grow larger and coalesce. As the result of injuries to the anesthetic areas, various secondary infections may occur, producing widespread ulceration, or even gangrene (*lepra mutilans*). Death occurs in from one to twenty years, from exhaustion, or from some complication, not uncommonly tetanus or tuberculosis.

The **treatment,** in addition to isolation of the patient, is symptomatic, no specific drug being known. Of the many remedies which have been tried, chaulmoogra oil, 15 to 20 drops daily, on bread, seems to be the most beneficial. Oudin is a warm advocate of radiotherapy. In the very earliest stages excision of the diseased areas may be considered. In the anesthetic variety nerve stretching has been recommended. Ulcers, gangrene, etc., are treated according to general surgical principles; amputations and other operations may be required, the wounds in such cases healing without mishap.

SYPHILIS.

Syphilis is a highly contagious disease due to the *spirocheta* (*treponema*) *pallida* (Schaudinn and Hoffman), an actively motile, unicellar, spiral parasite (probably a protozoon), varying from 4 to 14 μ in length, and possessing pointed ends and from 3 to 12 curves. The spirocheta may be found in the primary and in all secondary lesions, also in the blood, urine, saliva, lymph glands, and internal organs. It has been found in small numbers in gummata and in large numbers in still-born syphilitic fetuses. It has been cultivated in artificial media (Noguchi) and produces syphilis in apes, from the lesions of which it can again be recovered.

Methods of Infections.—Excepting (1) "*conceptional syphilis,*" in which a mother is contaminated by a syphilitic fetus (the father having the disease) through the placental circulation, *acquired syphilis* is always (2) initiated by a chancre, the result of infection of an abrasion or other solution of continuity of an epithelial surface, usually of the genital organs during sexual intercourse. *Syphilis insontium* is a term applied to the disease innocently acquired, the chancre in these cases often being extragenital, e.g., on the lip from the use of an infected glass or pipe. The disease may be carried by a third person who does not acquire the disease; thus an uncleanly surgeon may convey the virus on his finger from one patient to another. *Congenital, or hereditary syphilis,* does not present a chancre; it is (1) the result of syphilis in one or both parents previous to conception, or (2) of infection through the placenta in case the mother acquires the disease subsequent to conception. The disease is actively contagious for several years, i.e., during the primary and secondary stages. When the tertiary stage has been reached the disease is said to be no longer contagious, although the organisms have been demonstrated in the lesions. The germ of syphilis is difficult to kill, thus a wound will frequently be the site of a chancre though carefully disinfected within even a few hours after its infection.

The views concerning **immunity** to syphilis have been revolutionized since the discovery of the Wassermann reaction. It was formerly taught that one attack of the disease conferred immunity against subsequent attacks, that a woman might have a syphilitic husband and syphilitic children without becoming tainted (*Colles' immunity*), and that healthy children might be born to syphilitic parents (*Profeta's immunity*). It is now known that in all these instances the so-called immunity is not immunity, but insusceptibility due to latent syphilis, as the individuals in question react to the laboratory tests for syphilis. In other words, immunity to syphilis does not exist, and this means, if we are to believe the salvarsan enthusiasts, that reinfection, which was very rare with the older forms of treatment, because the patients were not cured, will become much more frequent after the recoveries that are now being obtained with salvarsan.

The **period of incubation** is from one week to three months, the average being twenty-one days. During this time the breach of surface through which the organism has entered the body heals and no signs of trouble are manifest, unless there has been at the same time infection with chancroidal or pyogenic bacteria.

The disease itself is divided into three stages: The *primary stage* comprises the chancre and indolent bubo. The time elapsing between the appearance of the chancre and the second stage, usually about six weeks, is called the period of *secondary incubation.* The *second stage* consists principally of superficial lesions of the skin and mucous membranes. It lasts from one to three years, and is followed by recovery, or by a latent or *intermediate period,* lasting from a few months to many years (usually two to four years), in which the symptoms are slight or absent. The *third stage,* the duration of which is indefinite, consists of gummatous degeneration or diffuse sclerotic changes in various parts of the body. In some cases the secondary merges with or overlaps the tertiary stage, so that no distinct line can be drawn between them.

The typical **chancre,** or initial lesion, begins as a minute, erythematous, painless papule, which, as it enlarges, becomes indurated and loses its epithelial covering, appearing as a round, oval, or linear erosion, whose center is covered by a grayish, glistening film, and whose border is the color of raw muscle. Suppuration is slight or absent, the discharge being scanty, thin, and watery. Chancre is usually, but not invariably, single. When multiple all the chancres appear at the same time, as the infection is not autoinoculable. A chancre does not always present the same appearance, being modified according to its situation and the presence or absence of complications, which are rare. On the skin a chancre not exposed to maceration or irritation does not ulcerate, or at most simply desquamates, forming a scab. When subjected to irritation or maceration it ulcerates (*Hunterian, or ulcerative chancre*), then being oval or round, with sloping edges. The characteristic features of a chancre may be masked by the presence of phagedena or other forms of infection; in a "*mixed chancre,*" in which chancroidal and syphilitic organisms are both present, the diagnosis can rarely be made from appearances alone. The induration of a chancre, which is due to sclerosis of the blood vessels and hyperplasia of the connective tissue cells, is circumscribed and of the consistency of hard rubber or cartilage, but varies in thickness according to the structure of the affected part; thus on the glans penis it may feel like a piece of paper (*foliaceous induration*) or a visiting card (*parchment induration*), while in laxer tissues it is greater in extent and may feel like a foreign body in the tissues (*nodular induration*). In rare cases induration does not occur for several weeks after the appearance of ulceration; in fact, in very rare instances it may never occur. With the healing of the chancre (usually in from four to six weeks) the induration gradually disappears, but if originally extensive, it may still be detected for months or years. Little or no scar results, unless the corium has been destroyed by ulceration. Ulceration or reinduration at the site of the original chancre (*chancre redux*) may occur after years as the result of reinfection (very rare) or gummatous degeneration. The most frequent situation of chancre in the male is the balanopreputial fold, in the female the inner surface of the labia majora. Fournier, however, has seen chancre on every part of the body except the sole of the foot. A chancre may be easily overlooked, e.g., when on the os uteri, when of the non-ulcerating or desquamating variety, and when situated in some extragenital region.

The **syphilitic bubo** (*satellite bubo*) is a constant consort of the chancre, appearing with its induration. The enlarged glands appear in the groin when the lesion is upon the external genitals, in the submaxillary region when on the lip, and in the axilla when on the breast or hand. They are (1) small, (2) non-inflammatory (painless, freely movable, not covered by adherent or reddened skin, and do not suppurate), (3) hard (induration of the chancre transferred to the lymphatic glands), and (4) polyganglionic (pleiad of Ricord), feeling like a group of almonds (amygdaloid) beneath the skin. An inflammatory bubo the result of any other form of infection, including chancroid and gonorrhea, pursues an acute course, with pain, greater swelling, fixity of the glands, adherent and reddened skin, boggy induration, edema, and eventual suppuration, and does not respond to syphilitic treatment.

The **diagnosis of chancre** may be confirmed (1) by finding the spirocheta pallida in the discharge, (2) by the Wassermann (or Noguchi) serum reaction, which is present in from 80 to 90 per cent. of cases of active syphilis, and only occasionally in other infections (yaws, leprosy, narcosis, scarlatina, pneumonia, tuberculous cachexia, Hodgkin's disease, myeloid leukemia, recurrent fever, lead poisoning, sleeping-sickness), (3) by the therapeutic test (i.e., prompt response to antisyphilitic treatment), or (4) by waiting for secondary symptoms. If one can have the laboratory tests mentioned above made there can be no excuse for waiting until the secondary symptoms appear before making a diagnosis. If the Wassermann test is negative, the spirochetes can be found; the tests are supplementary. It may be that the luetin test, described by Noguchi, also will prove an important diagnostic aid. Noguchi says it is of the greatest value in tertiary and latent syphilis, while the Wassermann reaction is more constant in primary and secondary syphilis. *Extragenital chancres* occur most frequently about the mouth, breasts, and anus, and are usually larger, but less indurated, than the genital chancre. The discharge is more profuse, the base of the ulcer covered with a dirty membrane or scab, the adjacent lymph glands are apt to be larger and more tender, and the constitutional symptoms more severe. Of particular interest to surgeons and obstetricians is *chancre of the finger*, which is frequently mistaken for a whitlow, as it is often accompanied by considerable pain and discharge. It is distinguished by its sharp circumscription, dense induration, long duration, failure to react to antiseptic treatment, and by enlargement of the epitrochlear gland.

Chancroid has no period of incubation, is rarely seen except on the glans penis or prepuce, commences as a pustule or ulcer, is frequently multiple, and is autoinoculable; it is usually irregular in shape, punched out, and excavated, with a dirty yellowish, uneven base and a copious purulent discharge; if induration is present, it is softer than that of chancre, fades off gradually into the surrounding tissues, and disappears with the healing of the ulcer; it is painful, does not confer immunity against a second attack, is more frequently complicated by extensive ulceration and suppurative bubo, is healed by local measures and uninfluenced by mercurial treatment, and the bacillus of Ducrey may be found in the discharge.

Herpetic ulceration about the genitals follows fevers, neuralgia, or irritation from dirt or discharges, and has no period of incubation. It commences as a number of vesicles, which may run together, forming a large irregular ulceration whose edges are made up of segments of circles. The discharge is purulent but not abundant, vesicles which have not burst may be found, bubo is commonly absent, the ulceration is painful, superficial, not indurated, and it heals under local treatment.

Urethral chancre may be mistaken for urethritis. The period of incubation of chancre is over ten days, that of urethritis under one week. In chancre the pain is felt only at the meatus, in urethritis it extends along the whole urethra; chordee is absent in the former and present in the latter. The discharge in chancre is scanty, serous, and sometimes bloody; in urethritis it is profuse, purulent, and less frequently blood stained. The characteristic induration may be felt, and superficial ulceration seen, in chancre, generally in one of the lips of the meatus. The bubo of chancre is constant and practically never suppurates; in urethritis bubo is absent, or if present, usually suppurates. Chancre is followed by constitutional symptoms, which are absent in urethritis. Microscopic examination of the discharge may reveal the spirocheta or the gonococcus, and the blood may be examined for the Wassermann reaction.

Labial chancre may be confused with epithelioma. Chancre in this region shows no marked preference for either sex; it may be seen on either lip and is more frequent in the young. The general health is unaffected and pain is slight or absent. The ulcer is smooth, with elevated, sloping, regular borders, a glistening or varnished base, and sharply defined, characteristic induration; it matures in two or three weeks. Enlargement of the submaxillary glands is usually found from the beginning, a history of exposure to syphilis may be obtained, and the diagnosis may be corroborated by finding the spirochetæ, by the Wassermann and therapeutic tests, or by waiting for the secondary symptoms. Epithelioma is more frequent in males (20 to 1), is practically always upon the lower lip, is seen after middle life, affects the general health, and may be painful; the borders are irregular, thickened, and everted, and the base is covered with scabs, removal of which discloses bleeding, fungous granulations; the induration is not as hard as that of chancre and gradually diffuses into the surrounding tissues; the ulcer requires months for its development, the submaxillary glands are usually not palpable for four or five months or even longer, a history of chancre in youth may be obtained, the growth is uninfluenced by mercurial treatment, secondary symptoms do not occur, and microscopical examination will give the picture of epithelioma.

Tuberculous ulceration of the tongue is distinguished from chancre by the presence of the lesion on the inferior surface of the tongue (chancre being more frequent on the dorsum), and the presence of several ulcers; by its greater extent, deeper invasion, irregular outline, steep or undermined borders, yellowish uneven base, absence of induration, excessive pain, and yellowish tubercles; by the absence of secondary symptoms of syphilis, of the spirocheta, and of the Wassermann reaction, and the failure of mercurial treatment; and by the diagnostic methods given under tuberculosis.

The **secondary stage** of syphilis consists of lesions of the skin (syphilides), mucous membranes (mucous patches), appendages of the skin (onychia, paronychia, alopecia), enlargement of the lymph glands in different parts of the body, neuralgic pains, inflammation and thickening of the periosteum, arthropathies, iritis (rarely other forms of eye disease), epididymitis, and interference with the general health (fever, anemia, disorders of digestion) and with the process of reproduction. Retinitis, choroiditis, affections of the acoustic nerve, and meningitis are being reported as secondary manifestations with increasing frequency, whether as the result of salvarsan treatment or more careful observation is a matter of dispute. During this period the disease is not serious for the patient, but is dangerous for those with whom he comes in contact and for his offspring. Abortion is frequent, or if the child goes to term, it is apt to die soon after birth. The lesions during this period are widely scattered, almost always superficial, and tend towards recovery even without treatment.

The first symptom may be the rash on the skin, fever, or neuralgic pains. The "*fever of eruption*" is usually trivial and falls with the development of the eruption; syphilitic fever occurring later may be intermittent, remittent, or continuous, and has been mistaken for such diseases as rheumatism, malaria, and typhoid fever. With the onset of secondary symptoms the *lymphatic glands* all over the body enlarge and assume the features of the original bubo. The post-cervical and epitrochlear glands are of diagnostic value, because they are seldom enlarged from local pyogenic infection. The blood contains the organism, and shows a slight leukocytosis with a diminution in the red cells and hemoglobin.

Syphilides generally appear in from six to seven weeks after the appearance of the chancre, occasionally earlier, and sometimes, notably when mercurial treatment has been administered from the beginning, not for several months. The secondary skin rashes (*syphilodermata*) may (1) ape any form of cutaneous eruption, but are always an imperfect counterfeit; they are (2) often apyretic, (3) slow in evolution, (4) non-inflammatory, (5) seldom itching or painful, (6) often of a ham or copper color, (7) apt to occur in circles or segments of circles, and (8) when affecting the extremities, most frequent on the flexor surfaces (which includes the sole of the foot and the palm of the hand); (9) they tend to recover, and are (10) superficial, (11) profuse, (12) disseminated, (13) polymorphous, (14) symmetrical, and (15) desquamating; (16) syphilis in other parts of the body may exist, (17) the rash responds to mercurial treatment, (18) the Wassermann test may be present, and perhaps (19) the spirocheta may be found. For the features of the tertiary syphilides see the tertiary stage.

The chief *varieties of the syphilides*, progressing from the early and superficial to the late and deep, are as follows: 1. *Erythema* (diffuse redness) or *roseola* (maculæ or spots) occurs principally upon the trunk; there is no elevation of the surface and the redness disappears upon pressure. 2. *Papules* may be small and miliary (*syphilitic lichen*) or large (occasionally four or five inches in diameter); they may desquamate (*papulo-squamous syphilides*), or in moist regions, as about the genitals, they may become excoriated (*moist papules, mucous patches of the skin*, or *flat condylomata*). Papulo-squamous syphilides upon the palms and soles are called palmar and plantar psoriasis; papules on the forehead the *corona Veneris;* and when the size of lentils *lenticular papules.* 3. *Vesicles* rarely form in syphilis, but a *herpetiform syphilide* is described. 4. *Pustules* arise from breaking down papules, hence *syphilitic acne* when the apex of the papule suppurates, *syphilitic impetigo* when the whole papule breaks down, and *syphilitic ecthyma or rupia* when the true skin is deeply invaded. In rupia successive layers of scabs resembling an oyster shell form. In ecthyma, if a scab forms, it is easily detached, exposing a punched out ulcer surrounded by a red zone of hyperemia. 5. *Tubercular syphilides* are large papules or small gummata. 6. Besides these types of eruption, discoloration of the skin, peculiarly of the neck, may occur (*pigmentary syphilides*).

The *mucous membranes* are affected somewhat like the skin. The sore throat of secondary syphilis consists of a reddening of the fauces or tonsils, which is sharply limited, reniform in shape, and often followed by ulceration, the ulcerated area being shallow with a grayish color and steep edges. *Mucous patches* are papules due to the overgrowth of papillæ, which, owing to the sodden condition of the epithelium, are white in color; they are circular or oval in outline, may progress to ulceration, originate a highly contagious discharge, and are commonly seen in the mouth and about the anus and genitals. *Condylomata* are large tubercles due to hypertrophy of papillæ; they look somewhat like warts, often appear in cauliflower-like masses, and occur most frequently about the anus and genitals. Eruptions or inflammations in the larynx produce syphilitic hoarseness, in the ears transient deafness.

Syphilitic alopecia is usually detected at the time of the sore throat and skin eruptions. It may involve the head alone or the entire body. It occurs as a general thinning of the hair or in irregular patches. The skin is apt to be scaly. As the follicles are not destroyed, the hair is usually reproduced.

The *nails* may be shed owing to inflammation of the matrix (*onychia*), or the skin around the base of the nail may be inflamed or ulcerated (*paronychia*).

The *bones* in various regions may be the seat of fugitive pains, which are usually more severe at night (*osteocopic pains*). Nodes due to periostitis may form, especially on the skull, clavicle, and tibia. In the *joints* a symmetrical synovitis may be noticed.

Syphilitic iritis makes its appearance in from three to six months after the chancre. It affects one eye at first, but is very apt to spread to the other. There are pain, impairment of vision, photophobia, lachrymation, a pericorneal zone of hyperemia, blurring of the pupil, often a change in color of the iris, and irregularity of the pupil, which is usually small and fails to react to atropin.

Syphilitic epididymitis may occur late in the secondary period, and consists of gummatous nodules which are quickly dispersed by mixed treatment; it may affect one or both sides. *Syphilitic orchitis* (*syphilitic sarcocele*) is a diffuse sclerosis of the testicle itself and belongs to the tertiary period.

In the **intermediate period** the symptoms may be latent, or there may be "reminders," such as the syphilides, principally syphilitic psoriasis, and epididymitis. *Retino-choroiditis* and *endarteritis* may occur, the latter producing various forms of paralysis, owing to anemia of the motor centers.

The **tertiary stage** is characterized by diffuse sclerosis or gummatous degeneration of any part of the body. The lesions are discrete, widely separated, and larger and less common than in the secondary stage; they are often serious to the patient but not to others. Although any of the *syphilides* may occur, the cutaneous eruptions are almost always tubercular or gummatous. The tertiary resemble the secondary syphilides except in the following particulars: They involve the whole thickness of the skin, do not so readily respond to treatment, appear irregularly, tend strongly to ulcerate and spread, and are monomorphous, asymmetrical, irregular in distribution, and not so widely disseminated. The ulcers are excavated, having sharply cut or undermined edges and a ragged base; they are painless, circular, or semilunar in shape, often covered by thick crusts or a tough, adherent, dirty yellow slough, and are not apt to enlarge the lymphatic glands; and they leave permanent scars which are smooth, white, and depressed below the level of the surrounding skin. Tertiary ulcers may take on a phagedenic action, boring deeply into the tissues, or eating along the surface in circles or undulating lines (*serpiginous*). Severe tertiary are said to follow mild secondary symptoms, and mild tertiary, violent secondary symptoms.

FIG. 80.—Ulcerating gumma of hand. Note punched out appearance.

In *diffuse sclerosis* chronic inflammatory changes are followed by hyperplasia of the fibrous tissue, giving rise to endarteritis, and disease of the testicle (sarcocele), liver, spleen, kidneys, heart, nervous system, and other tissues or organs.

The *gumma* is a nodular mass (in reality a large tubercle) consisting of proliferated connective tissue cells, leukocytes, and sometimes giant cells, which, owing to the thickening of the blood vessels and the cutting off of the blood supply, undergoes necrotic changes (*fatty or gummatous degeneration*). With proper treatment this mass may be absorbed, or the necrotic tissue becomes semi-fluid and breaks through the skin, leaving a circular ulcer with red, undermined edges, and a characteristic, dirty, yellowish-white, adherent slough (Fig. 80). In some of the internal organs, such as the brain, testicle, and liver, the necrotic tissue may become encysted and calcified. Gummata may be single or multiple. Occasionally, instead of a well localized nodule, there may be a diffuse gummatous degeneration of a considerable area. The scars resulting from gummata, when situated in a canal of the body, may produce stricture.

Parasyphilis and *metasyphilis* are terms applied to what some call the quaternary stage, in which lesions of the skin (e.g., leukoderma), of the mucous membranes (e.g., leukoplakia), of the nervous system (e.g., tabes and dementia paralytica), and of other structures may occur, lesions which are the result of syphilis, but are no part of the disease itself, as they do not react to specific treatment.

Tertiary lesions affecting special structures are noticed in subsequent pages as occasion demands.

The *diagnosis of tertiary lesions* is made (1) by the local features mentioned above; (2) by the history, in the taking of which, if chancre is denied, one should inquire particularly whether there has been transient loss of hair, sore throat or mouth, skin rashes, and in women frequent miscarriages; (3) by evidences of previous syphilis, e. g., periosteal nodes (especially on the skull, clavicle, and tibiæ), iritis, old scars, and patches of induration on the genitals; (4) by the therapeutic test, which is not always reliable; (5) by the Wassermann reaction; and possibly (6) by recovery of the spirocheta and (7) the luetin test.

The *prognosis* of syphilis is favorable if proper treatment be administered in the early stages for a sufficiently long period, it being generally believed that cure will result in the large majority of these cases. When the disease comes under observation late, when the patient fails to carry out the treatment, when there is an associated general disease, notably tuberculosis, often the best that can be done is to keep the disease under control. Some cases seem to be malignant and do not recover though proper treatment be given from even the beginning. A patient should not be permitted to marry until the disease is cured, i.e., absence of symptoms and of the Wassermann reaction for at least one year after the cessation of treatment, and never within four years of the date of the chancre.

The best prophylactic measure, according to Metschnikoff, is the rubbing of calomel ointment (calomel 33, lanolin 67) into the site of inoculation; this is said to prevent chancre if performed within 18 hours of the intercourse. The **treatment** of the disease itself consists in the employment of mercury during the primary and secondary stages, and of mercury and iodids during the tertiary stage. In view of the difficulty of making a positive diagnosis from the appearance of the chancre alone, many surgeons used to withhold constitutional treatment until the appearance of secondary symptoms. Now in even the earliest stages a positive diagnosis can be reached by the detection of the spirocheta and the Wassermann reaction. Some prefer *intermittent treatment*, believing that after a time the mercury ceases to be effective and the tissues need a rest. Protiodid of mercury, grain $\frac{1}{3}$, is given daily for six months, then a rest of a month is taken, and treatment again given for three months, nine months of treatment being given during the first year, and eight months during the second. In the *continuous method* protiodid of mercury, grain $\frac{1}{5}$, is given in pill form three times a day after meals, the dose being increased one pill each day, so that on the second day the patient takes $\frac{4}{5}$, on the third 1 grain, and so on, until the gums become tender, the breath fetid, and the bowels loose. The dose is then cut in half and the patient kept on this for two years. If in the absence of other symptoms diarrhea tends to persist, opium, grain $\frac{1}{12}$, may be added to each pill. Any of the other preparations of mercury may be used in a similar way. When mercury is not well borne by the stomach, it may be used by *inunction*, 1 dram of the ointment being rubbed into a different portion of the body each day, so as to avoid irritation of the skin; the method is highly efficacious but dirty. *Intramuscular injections* are often painful, and sometimes produce inflammation, necrosis, or embolism. They may be indicated when a very rapid effect is desired, e.g., when a lesion is on the face or threatens life; or when, owing to gastrointestinal irritation, mercury cannot be administered by mouth and, at the same time, inunctions cannot be given. Many prefer the insoluble preparations, as they are absorbed slowly, hence need be given only at comparatively long intervals. Five minims of a mixture of calomel 1 and albolin 4, 10 minims of a mixture of salicylate of mercury 1 and albolin 10, or 10 minims of gray oil may be injected once a week. The site of injection must be recorded, because if symptoms of salivation appear it will be necessary to excise the tissues containing the unabsorbed portion of the drug. Bichlorid of mercury is the soluble salt usually employed. The ordinary dose is from $\frac{1}{12}$ to $\frac{1}{4}$ of a grain. "This is injected daily, since absorption is rapid, and must be repeated in appropriate doses until the symptoms disappear, after which it is continued in series of six doses with intervals of six days' rest for the first year, and in series of three doses with intervals of nine days' rest for the second year, the quantity being increased or diminished in accordance with the clinical indications" (Martin). The injections are made deeply into the muscles of the back or the buttocks, selecting a new site for each injection, and using a needle with a large lumen if an insoluble salt is employed. In order to avoid embolism, the needle, unattached to the syringe, should first be introduced, and allowed to remain a short time, to see if it has entered a vein. Mercury has been used also by *fumigation;* a dram of calomel is volatilized from a water bath, which is placed under a cane seat chair upon which the patient sits naked, the fumes being confined by a blanket which reaches from the patient's neck to the floor. In somewhat the same way mercury has been introduced into the body through the skin by means of *baths* ($Hg\ Cl_2$ ℥ss to a bath-tub full of water), in which the patient lies for an hour or longer. *Intravenous injections* should not be employed. Unsuccessful attempts have been made to treat syphilis with the *serum* of naturally immune animals, or of human beings in the tertiary stage.

In all cases, at least during the early stages, the patient should be seen frequently, or cautioned as to symptoms of *mercurialism* (*hydrargyrism, ptyalism, salivation*), which owing to the presence of an idiosyncrasy, may rapidly follow even small doses. The gums become soft, spongy, tender, and bleed easily; there is an excessive production of thick saliva, with fetid breath, metallic taste in the mouth, colicky pain in the abdomen, and diarrhea. In more severe cases the teeth loosen, the alveolar process becomes necrotic, and severe ulceration of the mouth develops. *Chronic mercurialism* is manifested by digestive disorders, salivation, loss of weight, albuminuria, mental depression, tremor, and general weakness. These symptoms may be prevented by careful regulation of the dose of mercury, by having the teeth put in order, by cleansing the mouth several times a day with tooth powder and tooth brush, by the use of a mouth-wash containing chlorate of potash, and by prohibiting the use of tobacco. Salivation is treated by discontinuing the mercury, by giving a saline purge, and by the use of antiseptic and astringent mouth-washes. Albuminuria calls for an intermission or a great reduction in the dose of the mercury.

The general health should not be neglected, and if necessary tonics should be employed. The contagious nature of the malady should be impressed upon the patient, who should be directed to have separate eating and toilet utensils, to avoid kissing, to sleep alone, and to bathe frequently, paying special attention to naturally moist parts of the body, such as the axillæ and the perineum. At the end of two years the patient should take *mixed treatment* (hydrarg. chlor. cor. gr. i, potassium iodid ℨss, syrup sarsaparillæ comp. fℨiii-fℨi, in water after meals) for six months or longer, or if there have been symptoms, the mixed treatment should continue for six months from the last symptom.

The lesions of *tertiary syphilis* are controlled by mixed treatment. The mercury is used for its antisyphilitic action and the iodids for the absorption of gummatous tissue. Iodid of potassium or sodium may be given in a saturated watery solution, each drop of which contains 1 grain of the iodid. It is customary to begin with 5 or 10 drops of this solution in plenty of water after meals, and increase the dose 1 drop each day, until in some intractable cases as much as 60 or more grains a day are given. Toxic effects are manifested by coryza, fetid breath, disorders of digestion, and cutaneous eruptions (acne, vesicles, bullæ). The iodid should be discontinued and elimination stimulated. Belladonna and arsenic have been used to prevent the skin eruptions.

All forms of syphilis are said to yield with astonishing rapidity to *salvarsan* (Ehrlich's "606"), which is a yellowish powder containing 34.16 per cent. arsenic, the chemical name being dioxydiamidoarsenobenzoldihydrochlorid. Salvarsan is given subcutaneously, intramuscularly, or, as preferred by most syphilographers, intravenously. At first one dose was thought to be sufficient to effect a cure, as the spirochetæ disappeared in a few days, and the Wassermann reaction became negative. Relapses followed, however, and now it is customary to repeat the injections, sometimes as often as once a week, until the Wassermann reaction becomes negative, or to follow the primary injection by the regular mercurial treatment. It is possible, according to Fordyce, to cure primary syphilis within six months, with from two to four doses of salvarsan, or with salvarsan and mercury, although to make sure of this result serologic observations should be made for at least one year after the first negative reaction. During the secondary stage the infection is more difficult to overcome, although even then cure may be effected by more intensive treatment, e.g., five or six doses of salvarsan at intervals of from one to four weeks, followed by a course of mercurial injections or inunctions; "as the disease grows older, the time required for its eradication grows progressively longer." The simplest method of preparing the drug for injection is that of Alt, slightly modified. The powder, which comes in glass ampoules containing 0.6 gram, the average dose, is shaken with 30 c.c. of warm normal salt solution, in a glass-stoppered bottle, until dissolved. About 2 cc. of normal sodium hydroxid solution is then added. This precipitates a yellowish sediment, which is redissolved by adding more of the sodium hydroxid solution, drop by drop, until the fluid is clear. If the intravenous route is chosen, enough salt solution should be added to bring the quantity up to 250 cc. A large vein is made prominent by compression, punctured with a platino-iridum needle, and, after a few drops of blood have escaped, the needle attached by means of a rubber tube to a graduated glass reservoir containing salt solution. As soon as the salt solution begins to flow into the vein, the rubber tube is pinched, the salt solution poured from the reservoir, and the prepared salvarsan introduced. The drug must be prepared immediately before injection, and should not be given to those with nonsyphilitic organic diseases, especially of the kidneys, heart, blood vessels, optic or auditory nerves, or central nervous system, or to those who have previously had arsenical treatment or who possess an idiosyncrasy to arsenic. The patient should be kept in bed for 24 hours after the injection. Intravenous injections are often followed by a chill, subcutaneous and intramuscular injections by a painful induration and occasionally by sloughing, and all methods of administration by fever and sometimes by vomiting and watery stools. Among the more serious symptoms which have been noted are blindness, deafness, hematemesis, melena, albuminuria, vesical paralysis, irregularity of the heart, jaundice, and convulsions. A number of deaths following injection have been reported, and no doubt there are a number which have not been reported. It is not possible at the present time to determine the real value of "606"; some think it a specific which will cure in one or two doses, others that it is not superior to mercury. It is possible, however, to decide that it is a very powerful drug capable of producing alarming symptoms and even death, that it is still in the experimental stage, and that it should be used with great caution and only by those who have learned the technic of administration from the experienced. Perhaps less dangerous arsenical preparations, given more often and in small doses, will prove to be as efficient even if slower. Murphy has obtained remarkable results with sodium cacodylate, which may be given in doses of 1/4 to 2 grains, in pills, hypodermically, or by enema, repeated at intervals of three or four days.

Ehrlich has recently put forth a new preparation, called *neosalvarsan*, which is "a very soluble form of salvarsan obtained by the addition of formaldehydsulphoxylate of soda. It is claimed to be fully as efficacious as the old remedy and possesses certain decided advantages in the simplification of the technic of its preparation and the greater tolerance to it, permitting much larger doses at shorter intervals. Neosalvarsan is extremely soluble in water. Neutralization with caustic soda is not necessary as with old salvarsan, as the new product is neutral when in solution. It is prepared by dissolving 0.15 gm. in 20 c.c., or 1.5 gm. in 200 c.c. of freshly distilled water; 0.8 gm. in 22 c.c. gives an isotonic solution." In view of Wechselmann's discovery that stale water or saline solution may contain molds or saprophytic bacteria which can give rise to symptoms resembling acute arsenical poisoning, Ehrlich insists that only freshly distilled and sterilized water be used.

"As the preparation oxidizes readily and the oxidation products are more toxic than the drug itself, the following precautions are suggested: In making the mixture it should be gently agitated and not vigorously shaken. It should not be warmed after it is made up, and it must be used immediately. Four doses are administered in succession with an interval of one day between. Schreiber's procedure is to give 0.9 gm. for the first dose, 1.2 gm. for the second, 1.35 gm. on the third day and 1.5 gm. on the fourth. This equals 6 gm. of neosalvarsan or 4 gm. of salvarsan within one week. Women receive from 0.75 to 1.2 gm., children 0.15 to 0.35 and infants 0.05 gm. In cases of meningitis or involvement of the cerebrospinal system the patient's susceptibility should be cautiously tested with small doses. Owing to its less irritating properties neosalvarsan lends itself more readily to intramuscular use. For this purpose 0.9 gm. are dissolved in about 30 c.c. of water. Several c.c. of a 1 per cent. novocain solution are first injected; the needle is left *in situ*, and the neosalvarsan injected through it several minutes after. Schreiber has observed edema after its use, but never infiltration or necrosis. He prefers, however, the intravenous method. Two weeks after treatment the Wassermann reaction is to be taken and, if negative, is to be repeated at monthly intervals. If it becomes positive, an intensive course of mercury is to be inaugurated followed by two more injections of neosalvarsan. If it still is positive two weeks after the first series of injections, the above plan is to be put into immediate effect" (Fordyce).

Local treatment in syphilis is of secondary importance. Excision of the chancre is not recommended by most surgeons, as it has no influence on the general symptoms. As pointed out by Martin, however, excision must remove a quantity of the infective material, and it provides a bit of tissue from which a diagnosis can be made. If the chancre is not excised it should be cleansed by immersion in a 1 to 5000 bichlorid of mercury solution and dusted with an antiseptic powder. Syphilitic buboes require no local treatment, unless they suppurate because of mixed infection. Mucous patches in the mouth and syphilitic sore throat may be touched with nitrate of silver, 30 grains to the ounce, and astringent and antiseptic mouth washes used; mucous patches in other regions and condylomata should be disinfected with peroxid of hydrogen and bichlorid of mercury and dusted with calomel. Non-ulcerative tertiary lesions are treated by the application of mercurial ointment. Gummata should not be opened, as even when fluctuating, absorption from the internal administration of potassium iodid is still possible. Ulcerating gummata should be kept scrupulously clean, since secondary infection may make them exceedingly foul, inaugurate a phagedena, or markedly interfere with their healing. In some of these cases hectic fever with amyloid degeneration of the viscera occurs.

Congenital or inherited syphilis results from the disease in either or both of the parents. Formerly it was thought that parents who had completed the secondary stage, i.e., after three or four years, were no longer capable of transmitting the disease to their offspring, although exceptions to this rule were noted, and that it was possible for parents in even the contagious period to bring forth healthy children. It is probable, considering the observations previously made on immunity, that in most of these cases serologic investigation would reveal latent syphilis.

Active *fetal syphilis* generally results in death of the fetus and abortion; or if the fetus goes to term, in death at or soon after birth. Although *infantile syphilis* may be manifest at birth, or may not show itself for a number of years, the first symptoms are usually noticed within a few weeks or months of birth. Any of the lesions of syphilis, excepting, of course, the primary chancre, may be encountered when the disease is inherited and the spirochetæ have been demonstrated in these lesions. Of peculiar diagnostic value are the wrinkled, shriveled up, old man appearance, marked anemia, the hoarse cry due to inflammation of the laryngeal mucous membrane, and snuffles due to inflammation of the nasal mucous membrane. The last may go on to ulceration and be associated with destruction of the nasal bones and cartilages, causing a falling in of the bridge of the nose (Fig. 81). The spleen and liver are usually enlarged. Mucous patches about the lips may leave radiating scars (*rhagades*), especially at the angles of the mouth (Fig. 82). Pemphigus, particularly on the palms and soles, is one of the earliest and most characteristic skin eruptions. Inflammation and thickening at the epiphyseal junctions of the long bones, and periosteal nodes, which, on the cranium, give rise to the *natiform skull* also are common. Many die during this, the secondary stage, and those that survive may pass through an intermediate or latent period of variable length, sometimes lasting until the second dentition, puberty, or even longer.

Among the tertiary phenomena which require special mention are sudden deafness in both ears without pain or discharge, interstitial keratitis (cornea

FIG. 81.—Congenital syphilis showing necrosis of skull and facial bones with saddle nose.

FIG. 82.—Congenital syphilis showing necrosis of facial bones and rhagades. (Jefferson Hospital.)

has a ground-glass appearance, and later a salmon color due to vascularization, both are usually involved), Hutchinson teeth (the permanent upper and median incisors are dwarfed, separated, and narrower at the crown than at the root, the cutting edge being curved with the convexity upwards), and dactylitis (chronic painless enlargement of a finger or toe, due to gummatous infiltration or syphilitic osteomyelitis—Fig. 220).

The **treatment** should be not only antisyphilitic, but also tonic, including such drugs as cod-liver oil, iodid of iron, and the phosphates. Mercury is best administered by rubbing 5 or 10 grains of the ointment into the soles of the feet daily, or by placing it on the inner side of the belly band. If there is much irritation of the skin, hydrarg. cum creta, grain $\frac{1}{8}$, with 1 grain of sugar, may be given three times a day after nursing. Potassium iodid, $\frac{1}{2}$ to 1 grain, in simple syrup, gradually increased, is given three times a day with the onset of tertiary symptoms. The treatment should be continued for at least two years, and recommenced at each outbreak of symptoms. Salvarsan or neosalvarsan also may be administered.

TUBERCULOSIS.

Tuberculosis is an infectious and contagious disease caused by the bacillus of tuberculosis. The *tubercle bacillus* is a rod-shaped facultative anaërobe, measuring from 1.5μ to 3.5μ in length. It may be straight or curved and is frequently seen in pairs; it is non-motile and probably develops only in living tissues, although capable of maintaining its vitality for a long time outside the body. Its toxin is, as yet, little understood. The bacillus enters the body through wounds on the exterior, through the respiratory tract, through the alimentary canal (infected milk or meat), or in the fetus, through the placenta. The most frequent method is by the inhalation of dust, along with which the bacilli are carried. Animal tuberculosis differs in some respects from human tuberculosis, but is probably only a modified form of the same disease; that the two are intercommunicable seems to be proved. Tuberculosis is exceedingly common, indeed some would have us believe that we all are at least a little tuberculous. Naegeli found tuberculosis of some sort in 97 per cent. of 700 autopsies. There seems to be no way to avoid taking these organisms into the body, but something more than the tubercle bacillus is required for the development of the disease, viz., inherited susceptibility, poor food, overcrowding, depressed vitality following prolonged illness or mental strains, or local injuries. The disease is rarely, but the predisposition frequently, transmitted from parent to child. Those who possess this predisposition (*strumous*, *scrofulous*, or, better, *tuberculous diathesis*) are often frail, anemic, and precocious; the skin is apt to be delicate, the complexion fair, the hair fine, the lashes long, the head large, the cranial bosses prominent, the nose short and broad, the lips thick, the lower jaw small, the muscles soft, the bones slender, the epiphyses enlarged, the chest small and flat; and there is frequently a tendency to eczema, catarrhal inflammation of the mucous membranes, non-tuberculous enlargement of the lymphatic glands, corneal ulcers, granular lids, and carious teeth.

Tuberculosis may occur at any age, and in any portion of the body, but is most common in early life and in the respiratory apparatus, genitourinary organs, bones, joints, lymph glands, serous membranes, brain, liver, and spleen. The so-called "*senile tuberculosis*" presents no essential difference from the disease in the young.

Tuberculosis is characterized by the formation of nodules or **tubercles,** which vary in size from 1 or 2 mm. to masses as large as a pea, and by the occurrence of inflammatory changes between and around these tubercles; in truth, the inflammatory changes may constitute the whole process, the tubercles being inconspicuous or absent. A tubercle is formed as follows: The bacilli lodge in the intima of the small vessels, in which inflammatory changes occur, leading to a proliferation of the endothelial cells (endarteritis), and subsequently to a proliferation of the connective-tissue cells and of the leukocytes which have wandered from the blood vessels; thus a little mass, or tubercle, is formed, which is *grayish* in color and more or less translucent. A typical tubercle contains one or more *giant cells*, which are due to the fusion of epithelioid cells and show many nuclei; surrounding these cells are the *epithelioid cells* (proliferated connective-tissue cells), which are midway in size between the giant cells and the leukocytes and contain a single nucleus; the outermost zone is made up of proliferated leukocytes (*lymphoid cells*). The bacilli may be found in the giant cells and occasionally in the epithelioid cells. The giant cell is by no means characteristic of tuberculosis, as it is found in many other pathological conditions. With the onset of necrotic changes in the tubercle, the bacilli are no longer demonstrable, but they or their spores are undoubtedly present, for the injection of such material into guinea-pigs produces tuberculosis. As the vessel from which it started becomes obliterated by the proliferated cells, a tubercle is avascular; and as no new vessels are formed owing to the anemia and the specific action of the bacillus, degenerative changes occur. There is at first a hyaline change, then coagulation necrosis, next fatty degeneration, and finally the production of cheesy material (*caseation, or caseous necrosis*). A tubercle undergoing caseation is called a *yellow or crude tubercle. The fate of a tubercle* is largely influenced by the general and local resistance of the tissues. In favorable cases it may undergo atrophy and completely disappear, or become encapsulated by dense scar tissue, the cheesy material either being absorbed or calcified. In the latter instance the healed-in tuberculous material may remain latent for a long time and again be awakened to activity. In unfavorable cases the caseous material liquefies, forming tuberculous pus (see suppuration).

Tuberculosis extends by continuity or contiguity of tissue, possibly aided by the ameboid movements of the leukocytes, as the bacillus itself is non-motile; in other instances it gains entrance to the lymph or blood stream and is transported to distant parts. When the bacilli enter the blood stream and produce multiple tubercles widely distributed throughout the body (*acute general*, or *miliary tuberculosis*), a sort of tuberculous pyemia results, a condition which closely resembles and is often mistaken for typhoid fever.

The **diagnosis** may be considered under the following headings: (1) The *history* of a family predisposition, of previous tuberculous lesions, of an unfavorable occupation, of unhygienic surroundings, of habitual association with tuberculous individuals; (2) *general symptoms*, such as weakness, anemia, loss of appetite, indigestion, progressive loss of weight, and slight afternoon rise in the temperature; (3) the *type of patient* (p. 145); and (4) *evidences of tuberculosis elsewhere* in the body are all suggestive but not conclusive. (5) The *local features*, which will be described in connection with the disease in special structures, and which may require special means, e.g., the X-ray, cystoscope, etc., for their demonstration, are often distinctive; sometimes the tubercules can be seen. The insidious onset, marked chronicity, and tendency to recurrence which characterizes most forms of surgical tuberculosis should be noted in this place. (6) *Recovery of the tubercle bacillus* assures the diagnosis, but even when these are not demonstrable, (7) *inoculation* of a guinea-pig may result in generalized tuberculosis. (8) *Microscopic examination of the diseased tissues* will usually show the characteristic structure of the tubercle. (9) *Cytologic examination* of tuberculous fluids may reveal an excess in the number of lymphocytes. (10) *Blood examination* may show a relative lymphocytosis. Leukocytosis and iodophilia are indicative of mixed infection. Tubercle bacilli are rarely found in the blood. The value of the agglutination test is doubtful. A persistently low tuberculo-opsonic power of the blood, according to Wright, means tuberculosis. (11) The *tuberculin test* may be performed in four ways: (a) *subcutaneous injection* causes, in a tuberculous subject, a reaction which consists of a rise of temperature of from 1° to 3°, and a general feeling of illness, occasionally with nausea and vomiting. The tuberculous lesion itself undergoes inflammatory changes. The method should rarely be employed, because of the disagreeable reaction, the possibility of stimulating the process or of inoculating the patient with tubercle bacilli, and because of the uncertainty of the test (the margin of error has been estimated at 10 per cent.). It cannot be employed when the patient's temperature rises to or above 100° F. The dose for diagnostic purposes is .1 mg. for delicate individuals, and 1 mg. for those who are fairly robust; if no reaction is obtained from smaller doses, they may be increased to 5 or 10 mg. (b) The *Calmette method* consists of instilling one drop of a 1 per cent. solution of tuberculin into the eye; if conjunctivitis follows the test is positive. The method is not without danger, particularly if the eye is not normal. (c) The *Von Pirquet method* consists in inoculating the tuberculin into the arm after scarifying the skin; in the tuberculous a papule forms at the site of vaccination. (d) The *Moro test* is performed by rubbing into the skin of the chest or abdomen, over an area of four square inches, a small quantity of an ointment consisting of 5 cc. of old tuberculin and 5 grammes of anhydrous wool fat. In a day or two a number of small papules appear, if the patient is tuberculous.

The **prognosis** is good if the lesion is localized and so situated as to be susceptible of eradication by surgical means; the danger of recurrence, however, is always present. In general, it may be said that the prognosis is better in children than in adults. Undoubtedly many cases of unsuspected tuberculosis recover without treatment, but when the process has extended sufficiently to be recognizable, particularly in medical tuberculosis, it has gained such a foothold that recovery is always doubtful.

The **treatment** is local and constitutional. The most important measure in the *local treatment* is rest. Of some value is the injection into the lesion of various drugs, among which may be mentioned carbolic acid (3 per cent.), tincture of iodin, chlorid of zinc (1–10), balsam of Peru, oil of cloves (1–10 in olive oil), and epecially iodoform emulsion (10 per cent.). It is probable that by irritation these medicaments stimulate the fibroblasts, and thus produce firm fibrous tissue which encapsulates the tubercles. Bier claims good results from the production of a permanent congestion, by a rubber tourniquet placed on the limb above the tuberculous area, the principle being based on the fact that a congested lung does not become tuberculous. (See Bier's treatment, under inflammation.) *Radiotherapy* (X-rays, radium), *phototherapy* (the Finsen light), and *heliotherapy* (exposure to the direct rays of the sun) have proved of value in suitable cases. Heliotherapy is best administered on a high mountain (helioalpintherapy). According to Rollier the ultraviolet rays are the real factor in healing tuberculosis; these cause pigmentation, and the pigment acts as a sort of filter, which prevents injury to the skin by the rays of short wave-length, and allows the others to penetrate, causing an inflammatory reaction in the tissues and a positive chemotactic leukocytosis. As tuberculosis is always a general disease, Rollier always gives general sun baths, beginning, however, gradually. On the first day the feet are exposed three or four times for five minutes, later the legs, and so on, until finally the whole body may be exposed for six or eight hours. Brilliant results have been obtained with this form of treatment, but it takes two or three years, and in many cases operation acts just as well within a much shorter time; of course the two may be combined. The operative measures, e.g., incision and curettage, excision, amputation of a diseased limb, and removal of destroyed organs, will be discussed more fully on the pages devoted to regional surgery.

The *constitutional treatment* consists of fresh air, good food (meats, milk, eggs, cream, butter), and plenty of sunshine, which is really a form of heliotherapy. Tonics are usually indicated, and a prolonged stay at the seashore, particularly in surgical tuberculosis, is of the greatest value. The discharges should be carefully disinfected, and susceptible individuals should not associate with those in whom the disease is active. Koch's *tuberculin* is probably of some value in the early stages of tuberculosis, but is rarely employed by surgeons. It, of course, is impotent against the pyogenic organisms which are found so frequently in tuberculous lesions, and it should never be employed alone, but always in conjunction with other remedial measures. The dose of the old tuberculin is 0.001 cc., injected under the skin of the back; if the patient fails to react, the doses are gradually increased. The dose of the new tuberculin (T.R.) is 0.002 mg. every second day, increased gradually until 20 mg. is reached, so that a rise in temperature of more than a half degree is avoided. The treatment may then be discontinued or repeated after a long interval. The old tuberculin (T.) is a glycerin extract of tubercle bacilli from which the bacteria have been removed by filtering through porcelain. The new tuberculin (T. R.) is made by triturating dried bacilli in an agate mortar, the resulting powder being put into distilled water and the solution centrifugalized. The upper portion of this fluid is the tuberculin O. (*Oberer*), which has the same properties as the old tuberculin; the remaining fluid, tuberculin R. (*Rückstand*), causes a general but not a local reaction, its curative effect being due to the production, in the blood, of antibodies to the tubercle bacilli. Koch's latest tuberculin, B. E. (*Bazillenemulsion*), is an emulsion of ground tubercle bacilli in equal parts of glycerin and water, the dose being that of T.R. Klebs claims good results from the use of *tuberculocidin, or antiphthisin*, which is tuberculin from which the noxious portions have been separated. Antituberculous serum made by immunizing animals with toxins of the tubercle bacillus have been employed, notably by Maragliano and Marmorek; the value of these serums has not been determined. Among the drugs which have been used internally in tuberculosis may be mentioned arsenic, iodin, creosote, guaiacol, cod-liver oil, lacto-phosphates, hypophosphites, strychnin, animal and vegetable digestive ferments, iron, mineral and fruit acids, vegetable tonics, and nucleins.

Tuberculosis of special structures is considered under various headings throughout the book.

CHAPTER XIII.

TUMORS AND CYSTS.

A tumor, or neoplasm, is a mass of newly formed pathological tissue which tends to persist or grow and which performs no physiological function. Clinically, however, the word tumor is often applied to a swelling of any sort. An inflammatory swelling differs from a neoplasm in that it has a definite cause and tends to subside; a hypertrophy, in that it is the result of increased work and persists only so long as the demand for such work exists. The tissue of a neoplasm has its prototype in the human body, either adult or embryonic (*Müller's law*), and its cells invariably originate from preëxisting cells of the body (*Virchow's law*).

The **cause** of neoplasms is not known. *Cohnheim's inclusion theory* is that an excess of embryonic cells is manufactured during intrauterine life, and that those which are not used in the construction of the fetal tissues remain in the body in a latent condition, until some irritation stimulates their development. The influence of *heredity* is probably much less important than was formerly believed. *Injury and irritation* are undoubtedly important factors in some instances; thus sarcoma may follow a single injury, carcinoma some form of constant irritation, e.g., epithelioma of the lip, the result of smoking a short stemmed, clay pipe. Many unsuccessful attempts have been made to establish the *infective nature of tumors*, distinctly sarcoma and carcinoma. Sarcoma is most frequent during the early half of life, or the period of *physiological activity;* carcinoma, during the later part of life, or the period of *physiological decline.*

Clinically tumors may be divided into the benign and the malignant.

A benign, innocent, adult, or typical tumor may be multiple, strongly resembles in structure the tissue from which it springs, grows slowly, is encapsulated, does not infiltrate surrounding tissues, is usually movable (not adherent), seldom ulcerates, does not cause metastases in the lymphatic glands or in distant parts of the body, does not recur after thorough removal, and is serious only when so situated as to press on important structures.

A malignant, atypical, or embryonic tumor is usually single, is composed of cells resembling those found in the embryo, grows rapidly, is not encapsulated, infiltrates the surrounding tissues (fixed), and often progresses to ulceration, causes metastases in adjacent lymph glands or in distant parts of the body, frequently recurs after excision, is always serious, and ultimately destroys life no matter what its position.

Tumors may be classified according to their origin as follows:

(I) **Epithelial tumors** (derived from the epiblast or the hypoblast).

(A) *Benign, or innocent tumors* (those composed of adult epithelial tissue).

(1) Papilloma, or warty growth.

(2) Adenoma, or glandular tumor.

(B) *Malignant tumors*, or carcinomata (those composed of embryonic epithelial tissue).
(1) Epithelioma.
(2) Glandular carcinoma.
(chorioepithelioma.)

(II) **Connective tissue tumors** (those derived from mesoblastic tissue.)
(A) *Benign* (those conforming to types of adult mesoblastic structures).
(1) Fibroma (fibrous tumor).
(2) Lipoma (fatty tumor).
(3) Chondroma (cartilaginous tumor).
(4) Osteoma (bony tumor).
(5) Myxoma (mucous tumor).
(6) Myoma (muscle tumor).
(7) Hemangioma (tumor composed of blood vessels).
(8) Lymphangioma (lymphatic vessel tumor).
(9) Neuroma (nerve tumor).
(10) Odontoma (tooth tumor).
(11) Glioma (tumor of neuroglia).
(B) *Malignant tumors*, or sarcomata (those conforming to embryonic mesoblastic tissue).
(Endothelioma).
(Hypernephroma).

(III) **Mixed tumors, or teratomata** (those composed of epiblastic, mesoblastic, and hypoblastic structures).

1. **Epithelial tumors,** or those derived from the epiblast or the hypoblast.

(A) **Innocent Epithelial Tumors.**—(1) **Papillomata,** or warts, are derived from cutaneous or mucous papillæ, which they closely resemble in structure. They are essentially benign, but may become carcinomatous during the later half of life. They occur at any age, may be single or multiple, are often due to irritation (e.g., *venereal warts* from acrid discharges, warts of the hands from uncleanliness), and sometimes disappear without treatment. *Skin warts* are usually dark in color owing to the deposition of pigment. Condylomata and mucous patches are papillomatous in nature. *Villous warts* consist of branching tufts resembling chorionic villi, are most frequent in the bladder, and are very vascular and covered by a thin epithelial layer which is easily broken, causing frequent and occasionally fatal hemorrhages. Villous warts are found also in the pelvis of the kidney, and in cysts, more particularly those arising in connection with glands, such as the breast, thyroid, and ovary.

The *treatment* is removal by caustics, carbon dioxid snow, fulguration, radiotherapy, knife, scissors, or special instruments, according to their location.

(2) **Adenomata** spring from glandular tissue, which they closely resemble in structure. They grow slowly, are benign, occasionally follow an injury, and are encapsulated. They may undergo fatty, cystic (*cystadenoma*), mucoid (*adenomyxoma*) or carcinomatous degeneration (*adenocarcinoma*). Sarcomatous degeneration of the fibrous stroma produces an *adenosarcoma*. Adenomata may occur in any gland, but are most frequently found in the breast, prostate, thyroid, parotid, ovary, testis, and in the lachrymal, cutaneous, and mucous glands. There are two varieties, the *acinous*, or *racemose adenoma*, which consists of communicating sacs, or acini, lined with epithelium, and the *tubular adenoma* (found principally in the intestine, where there

are numerous tubular glands), which consists of tubules lined with cylindrical epithelium; the latter are peculiarly liable to become carcinomatous (*adenocarcinoma*). When the connective tissue is excessive in amount, the tumor is known as a *fibroadenoma*.

The *treatment* is excision.

(B) **Carcinomata, or cancers,** consist of masses, or nests, of epithelial cells surrounded by fibrous tissue in the form of alveoli, which communicate with one another and with the lymphatics, thus accounting for the frequency of secondary growths in the lymphatic glands. The epithelial cells are loosely thrown together and are not separated by an intercellular matrix. The blood vessels run in the fibrous stroma, have distinct walls, and do not communicate with the alveoli. The growth spreads by infiltrating the surrounding tissues in the form of processes (roots) and is never encapsulated. It is at first local and usually single, hence curable by excision; later the lymphatic glands become involved and finally metastases occur in distant parts of the body (*carcinomatosis*). On reaching the surface carcinoma ulcerates, giving rise to a foul, purulent, and often bloody discharge which rapidly exhausts the patient, causing emaciation, a sallow color of the skin, and an anxious expression of the face (*cancerous cachexia*). In carcinoma of the viscera, particularly of the digestive tract, cachexia is earlier in onset and more rapid in progress, because of the interference with nutrition. It may be that the cachexia is in part due to the absorption of toxins from the malignant growth. Carcinoma is most frequent after the thirty-fifth year. Of the secondary changes that may occur fatty degeneration is the most important, indeed it may be said to be almost constant in the later stages of large cancers. Cutaneous epithelioma may undergo a horny transformation. Mucoid and colloid degeneration may occur, and occasionally pigmentation, cyst formation, or calcification. Cancer of the penis in rare instances may be due to cancer of the cervix uteri, and under favorable circumstances a portion of the growth may be grafted upon another portion of the patient's body, but the disease is by no means contagious in the ordinary sense of the word.

(1) **Epithelioma** may be squamous- or cylindrical-celled.

Squamous epithelioma may occur on any portion of the skin or mucous membrane, but most frequently arises where skin and mucous membrane meet, or where two varieties of epithelium come together. The favorite sites are the nose, lower lip, penis, scrotum, vulva, anus, tongue, palate, gums, tonsils, larynx, pharynx, esophagus, bladder, and os uteri. The epithelial cells grow from the surface into the lymph spaces in the form of columns, and are prone to arrange themselves into globular masses called *pearls*. The disease begins as a nodule or fissure which quickly ulcerates; in fact the ulceration may progress more rapidly than the epithelial proliferation, so that in a strict etymological sense, the term tumor cannot be applied. With the exception of rodent ulcer, which will be described under diseases of the skin, epithelioma presents all the features of malignancy mentioned above. The ulcer is irregular, with a non-granulating base, hard, everted edges, and an irritating discharge, which, on the skin, may form a scab. On section the surface is firm and white. It contains but little fluid, but on pressure may exude fine, white, worm-like masses. Epithelioma is less malignant than glandular carcinoma, the disease sometimes lasting for years. The most marked exception to this statement is epithelioma of the tongue, which may cause death in a few months. Epithelioma arising from an old ulcer or a cicatrix is called *Marjolin's ulcer*. Lymphatic glands are often not involved for a number of months, and metastatic growths in distant portions of the body are not common.

Cylindrical- or columnar-celled epithelioma (malignant adenoma) might properly be classified with glandular carcinoma; it arises from cylindrical epithelium on the surface or in the glands of the mucous membranes, being most frequent in the uterus and intestinal tract. The growth is less common than squamous or glandular cancer but occurs much earlier in life, a fact which is particularly true of the rectum. It consists of little cavities or tubules lined by a number of layers of epithelium without a basement membrane.

(2) **Glandular, or acinous carcinoma,** springs from glandular epithelium, and consists of acini, or alveoli, of connective tissue filled with epithelial cells. It is usually nodular, the degree of hardness varying with the amount of fibrous tissue. A *simple carcinoma* is one in which the epithelium and connective tissue exist in about the same proportion as in the normal gland. In a *scirrhus*, or hard cancer, there is an excess of fibrous tissue. On section the surface becomes concave owing to the contraction of the fibrous tissue, is white and glistening, creaks under the knife, and exudes a milky fluid containing degenerated epithelium and oil globules. A scirrhus is a dense nodular growth firmly imbedded in the tissues, causing, when just beneath the skin, a puckering or dimpling owing to the contraction of the fibrous tissue. In some cases this contraction is so marked that the tumor decreases in size (*atrophic, or withering scirrhus*), without, however, markedly interfering with general dissemination of the growth. Scirrhus is most frequent in the breast and alimentary canal, particularly the pylorus. *Encephaloid, medullary, or soft cancer* contains an excess of epithelial cells; consequently it is a soft nodular mass which grows very rapidly (hence the term *acute cancer*), quickly involves the lymphatic glands, and is speedily fatal; after ulceration it presents a fungating, bleeding surface (*fungus hematodes*). On section it looks not unlike brain tissue into which hemorrhages have occurred. The central portion of the growth may be semi-fluid, or in some instances actual cysts may be found. It is much less common than scirrhus, and is most frequent in the breast and testicle. *Colloid, or gelatinous cancer*, is the result of a colloid or myxomatous degeneration of any glandular carcinoma. It is most frequent in the abdominal cavity, and is occasionally found in the breast.

Chorio-epithelioma (*deciduoma malignum, syncytioma malignum*) may be placed provisionally among the carcinomata because it is epithelial in origin and malignant in nature. The tumor arises from the chorionic epithelium following pregnancy, and resembles in appearance the placental tissue, blotched with blood. In nearly half the cases there has been a hydatidiform mole. It quickly gives rise to secondary growths in distant portions of the body by breaking into the blood vessels.

The **treatment of carcinoma** is early and wide excision, together with the lymphatic glands into which the infected area drains; in one mass if possible, in order not to sever the lymphatic vessels, as such an accident may sow the wound with cancer cells and cause recurrence. If operation be early and thorough, cure may be expected, but as most cases come to operation late, complete eradication is often not attained and recurrence follows. Even in cases in which cure cannot be expected, removal of the growth is often indicated to relieve pain or to take away a foul-smelling, bleeding, ulcerating mass. Superficial epithelioma of the skin, notably rodent ulcer, may be cured by the X-rays or radium, and in such cases only should these agents be used alone when the growth is operable; after excision, however, it is often advisable to employ radiotherapy, with the hope of preventing or retarding recurrence.

In the *treatment of inoperable carcinoma* it is often possible only to relieve pain by such drugs as morphin and to disinfect ulcerating surfaces. In some cases removal of large portions of the growth by excision or curettage, followed by cauterization with zinc chlorid or the actual cautery, or by fulguration, may be indicated for pain, hemorrhage, or fetor. Fulguration (de Keating-Hart), which "consists in projecting on the operative field a shower of sparks supplied by an alternating current of high frequency and high tension," causes a superficial necrosis and is probably no better than cauter-

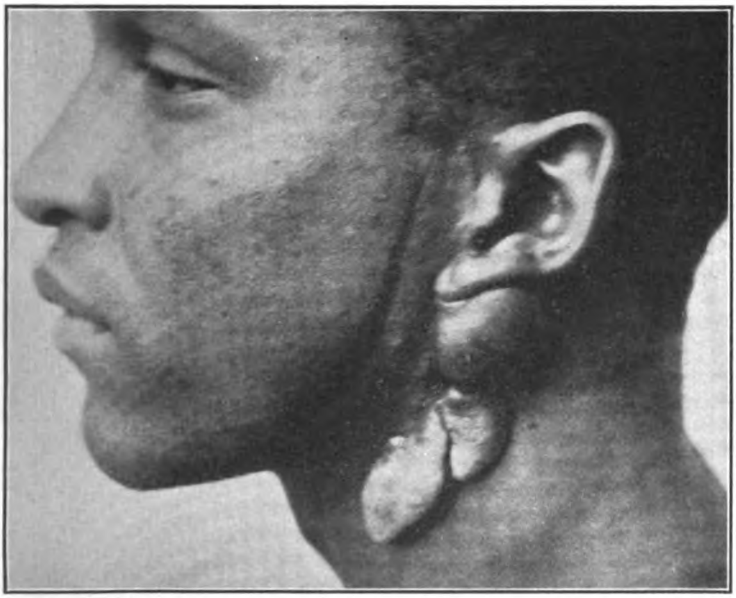

FIG. 83.—The upper rounded growth is a hard fibroma, the lower lobulated growths are soft fibromata.

ization; it requires chloroformization, as ether is dangerous because of the sparks. In other cases pain may be abolished by severing the nerve which supplies the affected region, and occasionally life may be prolonged by ligation of the principal arteries nourishing the part. In inoperable growths about the face and jaws Dawbarn excises both external carotids. Among palliative operations may be mentioned gastrostomy for cancer of the esophagus, gastroenterostomy for cancer of the pylorus, inguinal colostomy for cancer of the rectum, and tracheotomy for cancer of the larynx. In inoperable carcinoma of the breast Beatson removes the ovaries, with temporary benefit in some cases. The various cancer serums have proved of value in the hands of their inventors only. Coley's fluid may be tried in inoperable cancer, but it finds its chief indication in sarcoma (q.v.). The injection of drugs, such as pyoktanin, thiosinamin, methyl violet, etc., is of such little value that their use may be ignored. Radiotherapy is often of decided benefit in mitigating pain, lessening discharge, and diminishing fetor.

II. Mesoblastic, or connective-tissue tumors, are those derived from mesoblastic tissue.

(A) Innocent connective-tissue tumors. (1) **Fibromata** are tumors composed of fibrous tissue. The growth may be *hard or soft* (**Fig.** 83) according to the density of the fibrous tissue and the amount of liquid which it contains. Fibromata may arise from fibrous tissue in any part of the body, but are most comomnly found in connection with the periosteum (e.g.,

FIG. 84.—Huge fibrolipoma, springing from the periosteum of the clavicle, and undergoing necrosis.

fibrous epulis of the jaw), skin and subcutaneous tissues, submucous tissues (*fibrous polypi* of the rectum and nasopharynx), nerve sheaths (*false neuroma*), tendons, uterus, ovaries, and kidneys. *Keloid* is a hard fibroma of the skin developing spontaneously (*true keloid*) or attacking scar tissue (*cicatricial, or false keloid*). *Molluscum fibrosum* (see neurofibromatosis, Chap. XVII) is a soft fibroma, which may occur as numerous small nodules, or as a diffuse form in which the skin hangs in pendulous folds (*pachydermatocele*). Fibromata are usually rounded, lobulated, encapsulated, and of slow growth. With the exception of keloid (see chapter on skin) and fibromata which contain sarcomatous elements, recurrence does not take place after removal, which, again excepting keloid, is in general terms the treatment. Fibroma is often associated with other forms of tumor growth, giving rise to compound terms, such as fibrolipoma (Fig. 84) fibromyxoma, fibromyoma, and fibrosarcoma, while cystic, colloid, and calcareous degenerations may occur.

(2) **Lipomata** (Fig. 85) are composed of fat resembling that of the epiploic appendages. A lipoma is soft, lobulated, and elastic, often presenting pseudo-fluctuation; it is delicately encapsulated, and when situated in the subcutaneous tissues is ovoid in shape, and causes a dimpling of the skin when moved, owing to the numerous fibrous strands which pass from the capsule to the skin. A fatty tumor may contain an excess of fibrous tissue (*fibrolipoma*), or a large number of dilated blood vessels (*nevolipoma*). They grow slowly, sometimes reach a very large size, are commonly single but may be multiple (Fig. 87), and are most frequent in mid-life but occur also as congenital growths. Among the secondary changes are calcification, ossification, ulceration, inflammation, mucoid softening, and cystic degeneration. Lipomata occasionally change their location as the result of gravity, and sometimes become pedunculated. *Subcutaneous lipomata* are most common on the back and about the shoulders. *Submucous lipomata* are rare. *Subsynovial lipomata* may project into a joint in the form of a villous growth (*lipoma arborescens*) and be associated with an increase in the joint fluid (*synovitis lipomatosis*). *Subserous lipomata* of the abdomen may form large retro-peritoneal tumors, or, when occurring anteriorly, may insinuate themselves through congenital openings in the abdominal wall or even make for themselves an opening (e.g., epigastric hernia) and draw the peritoneum after them, thus producing a hernia. *Subfacial lipomata* of the palm or sole may be mistaken for a compound ganglion. Fatty tumors beneath the occipitofrontalis are often connected with the periosteum, and are most frequent on the forehead. *Intermuscular lipomata*, which often spring from the periosteum, are frequently mistaken for a chronic abscess or a sarcoma. *Diffuse lipoma* (Fig. 86) is a localized obesity, frequently occurring in the cervical region as double chin or double neck. The fat in this variety is granular and resembles omentum. *Xanthoma* is classified as a fibroma by some authors.

FIG. 85.—Large lipoma of arm.

It is composed of connective-tissue cells infiltrated with fat, and is a small, flat (X. planum), or elevated (X. tuberosum) yellowish growth, seen most frequently on the eyelids. It may be single or multiple, and is sometimes associated with disease of the liver or diabetes. Large xanthomata are very rare, occur most often on the knee and the heel, and contain sarcomatous elements.

The *treatment* of lipoma is excision, which, in the ordinary, circumscribed subcutaneous variety, is readily done by incising the capsule and enucleating the growth with the finger; adhesions, however, may make this difficult. In the diffuse variety dietetic measures may be tried, and liquor potassæ, m.

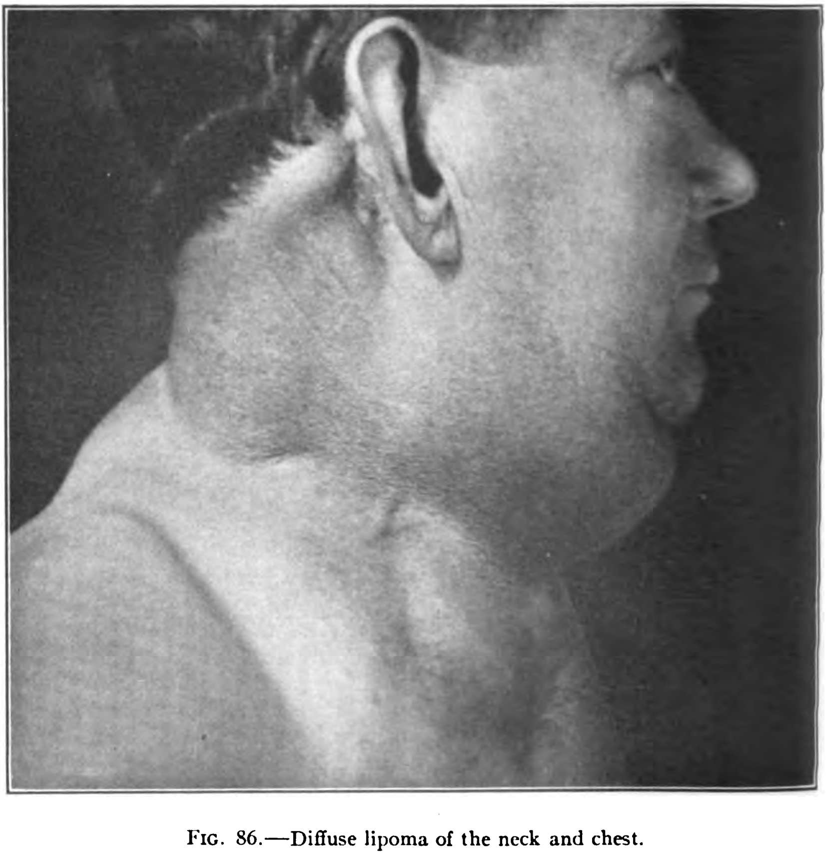

FIG. 86.—Diffuse lipoma of the neck and chest.

10 t.d., for a prolonged period has been advised. These measures, however, will be found of little use, and complete excision, which is often troublesome, offers the only chance of cure.

(3) **Chondroma** is a tumor composed of cartilage, often occurs at puberty, is found most frequently growing from bones, particularly those of the hand, foot, femur, and pelvis, and is occasionally seen in the salivary glands, breasts, ovaries, testicles, tendons, and muscles. The secondary changes which may take place are fatty, mucoid, calcareous, and cystic degenerations, while

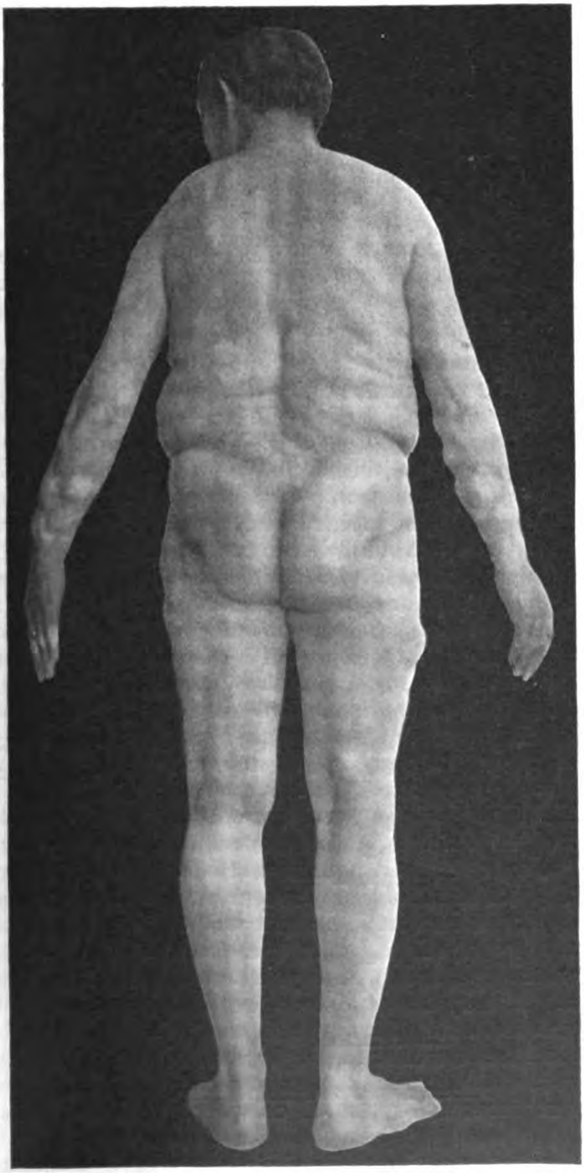

FIG. 87.—Multiple subcutaneous lipomata. (Pennsylvania Hospital.)

ossification is not infrequent, particularly in those which spring from the epiphyseal lines of long bones. In the parotid and testicle mixed tumors may occur, i.e., the growth may be associated with myxoma or sarcoma, or both. *Ecchondroma, or ecchondrosis,* occurs as a spur or rounded out-growth from bones or cartilages. *Enchondroma* springs from the inner surface of bone, projecting into the marrow cavity. All forms are hard and inelastic, grow slowly, and may be single, symmetrical, or multiple. The *treatment* is removal. In mixed tumors recurrence may be expected.

(4) **Osteoma** (bony tumor) is really an ossified chondroma, hence subject to the general statements made in the preceding paragraph. It usually develops where bone and cartilage meet, either projecting from the exterior of the bone (*exostosis*) or from the interior (*endostosis*); and is composed of compact bone (*osteoma durum*), cancellous bone (*osteoma spongiosum*), or extremely dense bone in which no blood vessels or Haversian canals are found (*eburnated osteoma*). Osteoma rarely reaches a large size, and usually ceases growing when adult life is reached. Bursæ not infrequently develop over an exostosis as the result of pressure. A subungual exostosis, most frequently seen beneath the nail of the great toe, is exceedingly painful and necessitates removal of the nail in order to expose and remove the growth. Diffuse hypertrophy of the bones of the face (*leontiasis ossea*) and the bony growths found in muscles and tendons as the result of irritation (*myositis ossificans*) are osteomatous in nature. The *treatment* is removal, except in cases in which a formidable operation would be necessary for a growth which is producing but little annoyance.

(5) **Myxoma** is composed of mucoid tissue, resembling the Wharton's jelly of the umbilical cord or the vitreous humor of the eye. It is most common in the subcutaneous, subserous, and submucous tissues, and in the perineurium, and is a soft gelatinous growth which may be sessile or pedunculated, in the latter instance forming a polyp. Hydatid moles are due to myxomatous degeneration of chorionic villi. Myxoma is often associated with other forms of tumor, and not infrequently recurs after removal, owing to the presence of sarcomatous elements; for this reason the *treatment* should be early and thorough extirpation.

(6) **Myoma** occurs as leiomyoma (smooth non-striated muscle cells) or as rhabdomyoma (striated muscle elements). *Leiomyoma* is most common in the uterus (where, owing to the quantity of fibrous tissue present, it is called *fibromyoma*), gastrointestinal tract, and prostate. It is encapsulated, firm in consistency, reddish on section, and frequently stratified or concentric in arrangement. Among the secondary changes which may occur are inflammation, ulceration or necrosis, and cystic, fatty, myxomatous, or calcareous degeneration. It may be excessively supplied with large blood vessels (*myoma cavernosum*). *Rhabdomyoma* is, as a rule, chiefly sarcomatous, the proportion of striped muscular fiber being small; it is rare, mostly congenital, and is found in the kidney, ovary, and testicle. The *treatment* is excision.

(7) **Hemangiomata,** or tumors composed of blood vessels, occur in three forms.

(a) *Simple nevus, or angioma telangiectaticum,* consists of dilated capillaries, arterioles, and venules. When the arterioles are principally involved, the growth is bright red (*nevus flammeus, or strawberry mark*); when the venules predominate, the color is dark red (*nevus venosus, or port wine mark*). These tumors are slightly elevated, usually located on the face or neck, and are commonly congenital, hence the terms *birth mark, mother's mark.* A nevus may remain unchanged, disappear, or rapidly increase in size. Violent hemorrhage results from injury or ulceration.

(b) *Cavernous angioma* is composed of irregular sinuses, and resembles in structure the corpus cavernosum, indeed may, like it, be erectile. The arteries empty immediately into the venous spaces without the intervention of capillaries. Such growths occur in the skin (*nevus prominens*), subcutaneous tissue, and in the viscera, particularly the liver, but are seldom congenital. A simple angioma may become cavernous in type. The term *telangiectatic* is applied to various tumors which contain an excess of blood vessels, cavernous to those in which these blood vessels are of very large calibre; these changes are most frequent in sarcomata, fibromata, and carcinomata. An angioma occasionally becomes sarcomatous. A cavernous angioma may be emptied on pressure, and sometimes there are pulsation and bruit. Spontaneous cure from inflammation is possible, the process leading to thrombosis with subsequent organization of the clot.

(c) *Plexiform angioma* (*racemose aneurysm, aneurysm by anastomosis, cirsoid aneurysm*) is really not a tumor but a varicose condition of arteries, which become elongated, thickened, and convoluted. *Arterial varix* is a varicosity of one artery only (see chapter on vascular system).

The *treatment* of hemangiomata is *excision* whenever possible. Elliptical incisions are made around the growth in the healthy tissues, and the resulting wound sutured. *Ligation* by placing a pin through the base of the nevus and winding a ligature beneath, or by tying the base of the nevus in sections, is much less preferable than excision. *Cauterization* with fuming nitric acid, ethylate of soda, or the actual cautery, may be employed if the growth is minute and superficial. The *injection* of coagulating fluids, such as Monsel's solution, carbolic acid, and boiling water may produce embolism, and possesses no advantages over *electrolysis*, which is useful in cases in which, owing to the extent of the growth, excision is impossible, and in cases in which a minimum of scarring is desired. One or more needles connected with the positive pole of a battery are inserted into the growth, while a large electrode connected with the negative pole is placed on some indifferent part of the body; the needles should be insulated to near the point in order to protect the skin. From 25 to 200 milliampères may be used for from ten to fifteen minutes; an anesthetic may be required. The mass becomes firm owing to the coagulation of blood, and the hardness gradually disappears with the absorption of the thrombus. The number of applications will vary with the size of the growth, the interval between the séances being about ten days. Payr recommends, particularly in inoperable angiomata, the *introduction of slivers of magnesium* in all directions through a small wound; the metal is absorbed and induces coagulation. Pusey freezes small nevi with *carbon dioxide snow*, which is collected in a piece of chamois from a metal cylinder and moulded to the shape of the lesion, to which it is applied with forceps for from ten to thirty seconds. After the scab which forms drops off little or no scarring

FIG. 88.—Congenital cavernous lymphangioma.

follows, unless the freezing has been prolonged. *Radiotherapy* has given satisfactory results in some superficial growths.

(8) **Lymphangioma** is a tumor made up of dilated lymph vessels (*lymphangiectasis*), or more frequently lymph spaces (*cavernous lymphangioma*—Fig. 88). Lymphangiomata are very prone to inflammation and this sometimes results in their disappearance. The condition may be seen in the tongue (*macroglossia*), in the lip (*macrocheilia*), or in the skin (*nevus lymphaticus*). *Congenital cystic hygroma* is due to dilatation of lymph spaces. *Lymphadenoma, or lymphoma,* and *lymph edema* and *varicosities* due to obstruction of lymph vessels, are described with the diseases of the lymphatic system. The *treatment* of lymphangioma is that of hemangioma.

(9) **Neuroma** (see Chap. XVII).

(10) **Odontoma** is a tumor composed of dental tissue. Sutton describes seven varieties: 1. *Epithelial odontoma* (*fibrocystic disease of the jaw*) springs from the enamel organ and forms an encapsulated cystic tumor, usually in the lower jaw. The growth may be very large and has been mistaken for sarcoma. This variety, although of epiblastic origin, is mentioned here so as not to separate it from the other odontomata, which arise from mesoblastic structures. 2. *Follicular odontoma* (*dentigerous cyst*) is a cavity containing an unerupted permanent tooth. 3. *Fibrous odontoma* is a thickening of the fibrous capsule of the tooth sac, which may become so great as to prevent eruption of the tooth; it is said to occur in rickety children. 4. *Cementoma* encases the tooth in cement; it is seen in ruminants but rarely in man. 5. *Radicular odontoma* arises from the tooth papilla after eruption of the crown, and consists of cementum and dentine. 6. *Compound follicular odontoma* is a fibrous tumor containing numerous denticles which erupt at intervals. 7. *Composite odontoma* is composed of a mixture of enamel, dentine, and cementum. The *treatment* of dentigerous cyst is removal of the anterior wall, with cauterization and packing of the cavity. In other forms of odontoma excision may be indicated.

(11) **Glioma** is a tumor springing from the neuroglia; it consists of round cells, from which fine processes extend, forming an interlacing reticulum. *Gliosis* refers to a diffuse gliomatous change, such as is seen in the spinal cord in syringomyelia. A glioma may become infiltrated with blood, develop cysts, or undergo a sarcomatous change, indeed some authors believe it to be always sarcomatous, hence the term *gliosarcoma.* Glioma of the eyeball, a growth which springs from the retina in children, is always a round-celled sarcoma. The *treatment* of glioma in suitable cases is excision.

(B) **Sarcomata, or malignant connective tissue tumors,** are composed of embryonic or immature tissues of mesoblastic origin. They are often smooth, regular in outline, and enclosed by a pseudocapsule, but may be infiltrating in character. They resemble flesh in consistency and color, hence the term, but these features vary with the number and character of the cells, and the presence or absence of secondary changes, such as hemorrhages, formation of cysts, myxomatous degeneration, and necrosis, all of which cause softening. Those containing bone, cartilage, or much fibrous tissue are hard in consistency and pale on section. Sarcomata are usually strikingly deficient in the amount of intercellular substance compared with the number of embryonic cells, which vary in size and shape, are nucleated, and are usually without a limiting membrane. The blood vessels are numerous and may cause the tumor to pulsate; they consist of channels, the walls of which are the sarcomatous cells, separated from the blood stream by a single layer of endothelium, thus accounting for the fact that sarcoma spreads by the blood vessels, and for the frequency of hemorrhagic extravasation. Melanotic sarcoma and sarcoma of the tonsil, testicle, thyroid, and lymph glands may spread by the lymphatics. Sarcomata may occur at any age, but are more frequent in the first half of life; they possess all the features of malignancy. When the growths are multiple and widespread the condition is called *sarcomatosis.* Although some forms of sarcoma exude a whitish fluid on section, it never resembles the milky juice of cancer. It is often difficult for the microscopist to distinguish between round-celled sarcoma and inflammatory tissue, indeed inflammatory tissue may become sarcomatous, and sarcomatous tissue may develop into the maturer forms of connective tissue. Sarcomata are divided according to the size of the cells into (1) the round-celled (small and large), (2) the spindle-celled (small and large), and (3) the myeloid, or giant-celled.

(1) The *round-celled sarcomata* (Fig. 89) are soft, have an abundant blood supply, may pulsate, grow very rapidly, and give rise to early metastases, owing to the facility with which the small cells are washed away by the blood stream. *Lymphosarcoma* is a round-celled sarcoma attacking lymphatic glands and other lymphadenoid tissues, which it resembles histologically, the intercellular stroma forming a reticulum. *Chloroma* is a lymphosarcoma springing from the periosteum of the skull, and giving rise to metastatic growths in other portions of the body; on section it has a greenish color, the nature of which is not known. The blood changes may be those of lymphatic leukemia. *Alveolar sarcoma* also may be classed among the round-celled sarcomata, although spindle-cells likewise are found in the growth; it resembles cancer in the formation of fibrous alveoli in which the cells are nested. The blood vessels run in the walls of the alveoli. The growth is most common in the skin, often developing from moles or warts. *Glioma* is regarded as a form of sarcoma by some authors. *Mycosis fungoides* has been described as multiple sarcomata of the skin, the histological picture being that of a network derived from the connective tissue, in the meshes of which are lymphoid cells. Many authors believe it to be bacterial in origin.

FIG. 89.—Round-celled sarcoma of thigh in a child. (Pennsylvania Hospital.)

(2) *Spindle-celled sarcoma* consists of large or small spindle cells frequently arranged in bundles; the stroma may be quite evident, giving the growth a fibrous appearance (*fibrosarcoma*). These growths are apt to originate in dense connective tissues (tendons, fascia, periosteum), and, when composed of large cells, often show a slight degree of malignancy, recurring after excision but not giving rise to metastases.

(3) *The giant-celled sarcoma* consists of multinucleated giant cells (myeloplaques) and round or spindle cells. Owing to the frequency with which it occurs in bones, it is often called *myeloma*, or *myeloid sarcoma*. *Epulis* is usually a giant-celled sarcoma. The growth is relatively benign;

secondary growths rarely occur and complete recovery may follow excision. Some pathologists describe myeloma as a benign tumor composed of tissue identical with the red marrow of young bone.

Melanotic sarcoma, or melanosarcoma (Fig. 90), is usually alveolar in type, but the architecture may be that of any of the varieties described above. The tumor becomes dark in color owing to the deposition of black or brown pigment in and between the cells. This pigmentation should not be confused with that due to extravasation, which is common in all forms of sarcoma. The growth frequently originates in pigmented structures, such as moles, warts, or the retina. Beyond its pigmentation and its great virulency, the tumor differs from other sarcomata only in the fact that it spreads by the lymph vessels.

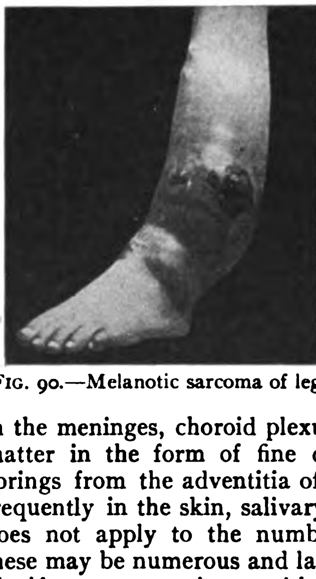

FIG. 90.—Melanotic sarcoma of leg.

Endothelioma springs from the endothelium of blood vessels (*hemangioendothelioma*), lymph vessels (*lymphangioendothelioma*), or serous membranes, most frequently that of the meninges, pleura, or peritoneum, but may be found in many other situations. Histologically the growth strongly resembles carcinoma, the endothelial cells being nested in acini, hence the term *endothelial cancer;* owing to its mesoblastic origin, however, it may be classed among the sarcomata. When the endothelial cells are clumped in small nodules of a glistening pearl-like appearance, it is known as *cholesteatoma. Psammoma* (sand tumor), or *duraendothelioma*, occurs in the meninges, choroid plexus, and the pineal gland; it contains calcareous matter in the form of fine concretions. *Perithelioma,* or *angiosarcoma,* springs from the adventitia of blood or lymph vessels and is seen most frequently in the skin, salivary glands, and serous membranes. The term does not apply to the number of blood vessels in the growth, although these may be numerous and large (*telangiectatic sarcoma*). *Clylindroma, or plexiform sarcoma,* is a perithelioma in which hyaline or mucoid degeneration takes place in the cells surrounding the blood vessels, the sections presenting a plexiform arrangement. Many endotheliomata grow slowly without causing metastases, but recur after excision; others are highly malignant.

Hypernephroma springs from the suprarenal gland, or from aberrant rests of suprarenal tissue, which may be found in many portions of the body, particularly in the genitourinary tract. It is said to be the most common malignant tumor of the kidney. It is usually lobulated, of a grayish-red or yellow color, and frequently infiltrated with extravasated blood, giving rise to blue or black areas or cyst-like cavities. The tumor is generally encapsulated; it may remain small and benign, or grow rapidly and cause metastases in the lungs, liver, bones, and other parts.

The **treatment of sarcomata** is early and thorough excision, which in the least malignant varieties may be followed by permanent recovery, but in the small round-celled and melanotic growths will very likely be followed by recurrence. In those growths which affect the lymph glands, these should be removed with the tumor.

In *inoperable sarcoma* measures similar to those mentioned in the treatment of inoperable cancer may be tried. In rare instances growths believed to have been sarcomata have undergone spontaneous resolution; but in making this statement one should not fail to call attention to the difficulty often experienced by the pathologist, as well as the surgeon, in differentiating sarcoma from syphilis and chronic inflammations. Owing to the fact that sarcomata occasionally disappear after an attack of erysipelas, these growths have been treated by inoculations with the streptococcus of erysipelas. More recently the toxins instead of the living organisms have been used. *Coley's fluid* is a sterilized culture of the streptococcus of erysipelas and the bacillus prodigiosus. The initial dose is ½ minim injected into or around the growth; the dose is gradually increased until a reaction of from 101° to 103° F. is obtained, then repeated every two or three days for three weeks, when it should be discontinued if there is no improvement. If the growth diminishes in size, the injections may be continued until the tumor has disappeared, or until it begins to grow again. The spindle-celled sarcoma offers the best prospects for cure, while the round-celled and melanotic forms are probably influenced little if at all. Coley's fluid seems to be of undoubted value in a few cases, and deserves a trial in inoperable, but never in operable growths. The X-rays or radium may be employed, but seem to have less effect than in carcinoma.

(III) **Teratomata** are congenital tumors composed of epiblastic, mesoblastic, and hypoblastic structures, and are most frequent in the ovary, testicle, and sacral region. The tumor may contain any tissue, adult or embryonic, hence may be benign or malignant. The simpler forms contain dermal structures (dermoid cyst) and are due to the healing in of epiblastic tissue in the deeper structures, the more complex forms are probably due to the inclusion of a blighted ovum or rudimentary twin (fetus in fetu). They are to be treated by excision.

CYSTS.

A **cyst** is a new growth consisting of a wall and fluid or semifluid contents. Cysts arise from (A) the distention of preëxisting spaces or are (B) of new formation.

(A) **Distention cysts** may be due to (1) retention, (2) exudation, or (3) extravasation.

(1) **Retention cysts** are caused by the obstruction of the duct of a gland, the duct beyond or the acini becoming distended with the normal secretion, which in the course of time may be altered in appearance and surrounded by new fibrous tissue. Such cysts are most common in sebaceous glands (*wens*), mucous glands, salivary glands (*ranula*), and in the breast, pancreas, testicle, kidney, and liver.

(2) **Exudation cysts** are due to the accumulation of fluid in preëxisting cavities which are not provided with an excretory duct. Serous cysts, acquired bursæ, and hygromata are the result of dilatation of lymph spaces, ganglion and hydrocele the result of exudation into closed serous cavities. Exudation into functionless canals is typified in cysts of the urachus, vitello-intestinal duct, parovarium, paroöphoron, Kobelt's tubes, Gärtner's duct, branchial clefts, and thyro-glossal duct. Certain cysts of the thyroid and ovary (those arising from the Graafian follicles) are exudation cysts.

(3) **Extravasation cysts** follow hemorrhage into a preëxisting cavity, e.g.,

tunica vaginalis testis (hematocele). Extravasation of blood into tumors or other tissues also may give rise to cyst-like cavities.

(B) **Cysts of new formation** arise in various ways.

(1) **Dermoid cysts** are lined by epithelium and contain epithelial products, such as hair, nails, teeth, sebum, mucus. (a) *Sequestration dermoids* arise from the inclusion of a portion of the epiblast in situations where embryonic segments unite, e.g., in the middle line of the body and in the region of the facial and branchial clefts. In the face the most common situation is just behind the external angular process of the frontal bone (orbito-nasal cleft), in which region an opening may persist in the skull and the dermoid be connected with the dura mater. (b) *Tubulo-dermoids* are those developing in functionless ducts or obsolete canals, the most common situations being the thyro-glossal duct and the post-anal gut. (c) *Ovarian dermoids* may contain not only dermal structures, but also mesoblastic structures, such as bone and cartilage; in the latter instance they are supposed to be due to the inclusion of a blighted ovum (*teratoma*). (d) *Implantation dermoid* (*acquired, or traumatic dermoid*) is due to the thrusting of epithelial cells into the subcutaneous tissues, usually as the result of a punctured wound.

(2) **Blood cysts** may arise from extravasation of blood (hematoma). A second variety often found in the neck is of doubtful origin; it has a thin wall and communicates with the interior of a vein.

(3) **Cysts due to foreign bodies** are an effort on the part of nature to encapsulate these alien substances. Under this heading may be considered also *parasitic cysts*, two of which require notice.

Hydatid cyst is caused by the *echinococcus*, the larva of the tape-worm of the dog (*tenia echinococcus*). The ova are taken into the human alimentary canal with food or water; the embryo is then freed, enters the blood or lymph stream, and finally lodges in an organ where it forms a cyst. The wall of the cyst is composed of three layers, externally a layer of fibrous tissue, then a cuticular or lamellar layer (*ectocyst*), and lining these a parenchymatous germinal layer (*endocyst*) which acts as a budding or brood membrane. From this inner layer heads, or scolices, with four suckers and a circle of hooklets develop, either singly or in groups (*brood capsules*), and form daughter cysts (Fig. 91). The fluid of a hydatid cyst is clear, 1009 to 1015 in Sp. Gr., neutral or alkalin in reaction, and contains a trace of albumin and a large quantity of sodium chlorid. Microscopically the characteristic hooklets may be found. Even large hydatid cysts may be sterile, i.e., contain no daughter cysts; the walls, however, show the characteristic lamination. A multilocular hydatid consists of numerous small cysts not inclosed by a mother cyst; they are most frequent in bone and in the spinal cord. Hydatid cysts may grow to a large size before the parasite dies, the contents then become inspissated, and may disappear, or be converted into a mortar-like mass with calcification of the wall of the cyst. The symptoms of a hydatid cyst are those of pressure on surrounding parts, eosinophilia, and, in the event of suppuration, sepsis. If rupture occurs hydatid urticaria or hydatid toxemia may ensue. Hydatid cysts are exceedingly rare in the United States, and are most common in Iceland and Australia. Any part of the body may be attacked, but the disease is most common in the liver, lungs, kidney, and brain. The *treatment* is excision if possible; in other cases, evacuation, removal of the endocyst, and drainage.

The *cysticercus cellulosæ*, which is the larva of the *tenia solium*, or pork

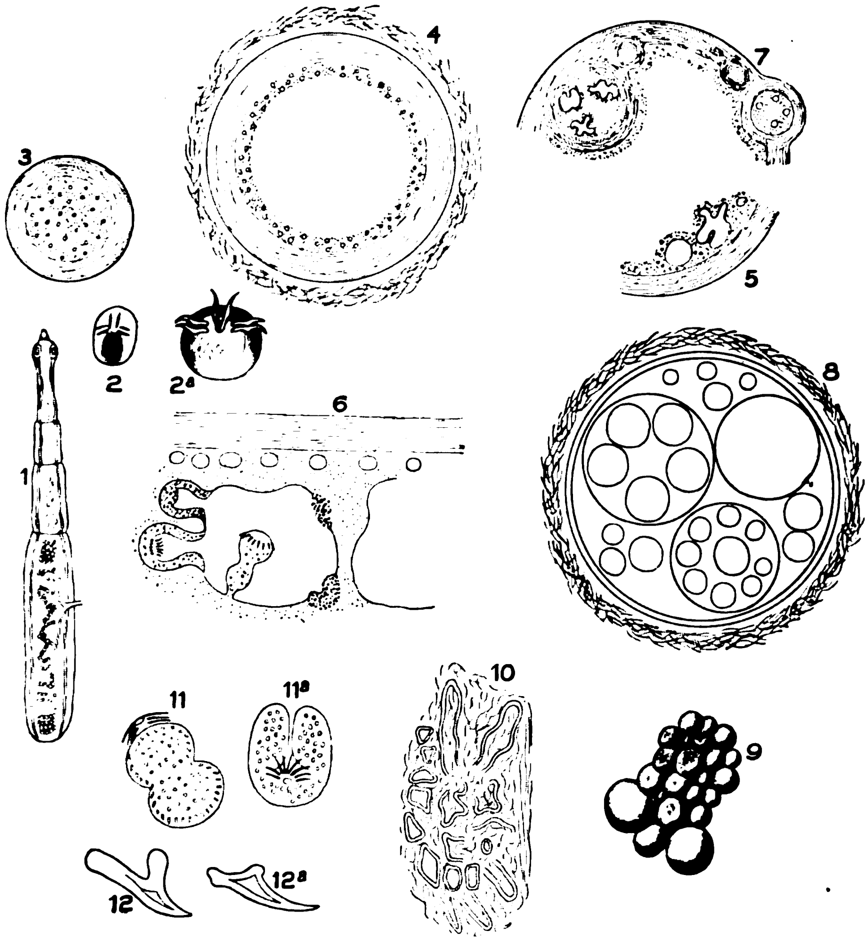

FIG. 91.—Diagrams of echinococcus cycle (after Leukart, Ziegler, and Lendon).

1. The tape-worm, about 6 mm. in length, appearing like chalk-white dots in the duodenum of the dog. 2. Ovum, about 0.01 mm. in diameter, showing six-hooked embryo. 2a. Embryo free from its shell. 3. Cyst differentiated into outer laminated layer and parenchyma. 4. Acephalocyst stage. An outer laminated layer and an inner parenchymatous layer, both now vascular, enclosing fluid. 5. Brood capsules. 6. Brood capsules showing development of scolex or tape-worm head. 7. Daughter cysts. 8. Daughter and grand-daughter cysts. 9. Grape-like mass of daughter cysts, mother cyst having disappeared. 10. Shrinkage of mother cyst, causing parasitic wall to be folded, and between these folds is vascular fibrous tissue belonging to the adventitious cyst, the whole forming a semi-solid or solid mass, having a honeycomb-like foliated appearance on section, compared to the heart of a cabbage, or resembling colloid cancer. 11. Scolices, with rostellum and hooklets protruded or retracted, like a vorticella, just visible as specks when the fluid is held up to the light, and measure about 0.3 mm. 12 and 12a. Hooklets, highly magnified. (Walsham.)

tape worm, gains entrance to the tissues in the same way as the echinococcus. Cysticerci from the *tenia saginata* also have occurred in a few cases. Cysticerci, i.e., the cysts, are usually multiple, hard, and rarely as large as a hazelnut. The symptoms are due to pressure and depend upon the situation. The favorite sites are the subcutaneous tissues, the central nervous system, and the eye. Calcification and suppuration are possibilities. Eosinophilia occurs. If favorably located cysticerci should be excised.

(4) **Cysts of degeneration** such as arise in tumors require no special comment.

DIAGNOSIS OF TUMORS.

One must first be sure that a pathologic swelling is present. Neurotic individuals sometimes imagine they have a tumor when they discover for the first time an inequality in the ribs, a self-inflated stomach, the roll of epigastric fat, or the lobules of the breast which can be picked up between the fingers (p. 449). Phantom tumor (p. 487) and pregnancy may occasionally deceive even the most able clinician. Other forms of tumors besides neoplasms and cysts are mentioned in the following paragraphs, because in practice one must often consider all these swellings before making the diagnosis of a new growth.

History.—(1) The *family history*, (2) *age*, (3) *nationaltiy*, (4) *sex*, (5) *occupation*, (6) *previous history* of the patient, and (7) *previous treatment* of the swelling may have some bearing on the diagnosis (see Chap. i and p. 149).

(8) *Onset.*—(a) *Sudden onset* can take place only when normal structures or contents of structures are suddenly displaced, e.g., fractures of bone; ruptures of muscles or other parts; dislocation of organs (hernia, prolapse), joints, muscles, tendons, nerves; escape of air (emphysema, pneumatocele), blood (hematoma, hematocele, traumatic aneurysm), or other fluid (extravasation of urine, spurious meningocele) into the tissues. A neoplasm never springs suddenly into existence, but having been present some time it may be suddenly noticed, or having been concealed it may be abruptly extruded from its hiding place, e.g., polyps, hemorrhoids, loose bodies in joints, tumors of the spermatic cord lying within the abdomen. A cold abscess likewise may apparently arise instantaneously when it perforates a dense fascia. (b) *Rapid onset* occurs in acute inflammatory processes, edema from nervous (angioneurotic) or hemic disturbances or from interference with the circulation, and in obstruction to the ducts of actively functionating glands, e.g. swelling of the salivary glands or gall bladder from calculus, caked breast, retention of urine from stricture. It should be recalled that the constant irritation produced by inflammation, calculi, etc., may be the cause of neoplasms, especially carcinoma, and that inflammation, edema, and obstructive distention of ducts or glands may be the result of new growths. We have seen several cases of acute cancer and round-celled sarcoma, notably about the jaws and breast, which owing to their rapid development have been incised for abscesses. Many of the conditions mentioned under (a) may arise rapidly instead of suddenly when the causes are less active. (c) *Slow onset* is characteristic of chronic inflammation, hypertrophies, some forms of edema, most neoplasms and cysts, aneurysm, varix, and of swellings due to gradual displacement of parts, e.g., kyphosis, exophthalmos, and many herniæ. Chronic inflammatory masses due to the irritation of a ligature or other foreign body have occasionally been excised for neoplasms.

(9) The *duration* of a neoplasm is generally a matter of months or years; in the former instance, if large, it may be malignant, in the latter it is probably benign. Tumors dating from birth, i.e., congenital, are usually the result of malformation or maldevelopment, e.g., hernia, hydrocele, branchial cysts, congenital dislocations, meningocele, and teratomata, but include also hemangeioma, lymphangeioma, lipoma, fibroma, hypertrophies, and masses of callus from intrauterine fractures. Occasionally tumors of congenital origin do not appear or are not noticed until some time, perhaps years, after birth.

(10) The *progress* is indicated by the rate and manner of growth. *Stationary* neoplasms are benign. *Diminution in size* may occur (a) *suddenly* when the contents of a swelling escape from rupture of the tumor (e.g., ovarian cyst, intraperitoneal abscess), from dislodgement of an obstruction in a duct (e.g., distended urinary or gall bladder), or from displaced parts slipping back into their normal place (e.g., hernia and prolapse), or (b) *gradually* from absorption of fluid (pus, blood, serum, milk, etc.) or solids (fibrin, granulation tissue, callus, etc.), or from contraction of fibrous tissue (e.g., masses of adhesions, withering scirrhus).

Increase in size depends upon the activity of the underlying cause and the resistance of the surrounding tissues. (a) *Sudden enlargement* of a tumor may be due to inflammation, hemorrhage into its interior, obstruction of circulation (e.g., ovarian cyst with twisted pedicle), partial obstruction of a duct becoming complete (e.g., sudden swelling of a hydronephrotic kidney), augmentation of contents made up of normal structures (e.g., hernia, prolapse), or rupture of the tumor (e.g., aneurysm). (b) *Rapid enlargement* occurs in inflammatory processes, many forms of edema, some cysts, and in acute carcinomata and small-celled sarcomata. Other malignant tumors develop quickly but not so fast as the last mentioned. (c) *Slow growth* generally indicates a benign neoplasm, a chronic inflammatory process, an aneurysm, a varix, a cyst, or a hypertrophy, but may occur in malignant neoplasms of low virulency. The rate of growth changes from slow to rapid when a benign neoplasm becomes malignant, or a malignant tumor breaks through a dense barrier, such as fascia or bone. (d) *Intermittent enlargement* may be due to intermittent obstruction of a duct (e.g., hydronephrosis and recurrent distention of the gall bladder from ball-valve calculus), intermittent activity of a gland whose duct is partly obstructed (e.g., swelling of the parotid after meals in salivary calculus), intermittent interference with the circulation (e.g., recurrent varix in repeated pregnancies), successive attacks of inflammation, increased displacement of normal structures (e.g., hernia and prolapse), vascular dilatation in growths with a rich blood supply (e.g., nevus, goiter, some sarcomata), or to adventitious pouches (e.g., esophageal diverticulum).

The *direction of the growth* is well defined by fascia or other dense structures in many abscesses, notably psoas and palmar abscess, in extravasation of urine, hernia, effusions into closed cavities, and in some neoplasms; or it may follow the path taken by the structures involved, e.g., lymphadenoma, varices, diffuse lipoma, hypertrophies, sarcoma of muscle (in the early stages). Carcinomata, as a rule, extend most rapidly in the direction of the lymph stream, but both carcinoma and sarcoma grow in all directions and infiltrate contiguous tissues irrespective of their structure. Benign tumors do not infiltrate, they expand, and push aside or compress adjacent parts without invading them with tumor cells.

(11) The amount of *pain* depends more upon the sensitiveness of the tissue involved, the structure of the part, whether loose or unyielding, the

rapidity of the growth, the presence or absence of inflammatory or obstructive complications, and the temperament of the individual, than upon the nature of the tumor, although with equal circumstances the pain in malignant disease, owing to its infiltrating character, is more severe than in benign neoplasms. It must be emphasized, however, that many malignant tumors, especially in the early stages, are painless. The interpretation of the situation and the character of pain is given on p. 6.

Local Examination.—(1) The *situation* of a tumor is important to establish not only the anatomical but also the pathological diagnosis. Epithelial growths, unless secondary, can arise only in epiblastic or hypoblastic tissues; connective-tissue tumors only in mesoblastic tissues. Certain tumors have a predilection for certain structures or organs, e.g., a tumor arising from a nerve is almost sure to be a neuroma, a fibroma, a myxoma, or a sarcoma; a tumor of the stomach, a carcinoma. The tumors common in other organs are mentioned in the sections on regional surgery. The position of a swelling may correspond with one of the cavities of the body or with the site of fetal relics or folds and thus betray its nature, e.g., synovitis, bursitis, hydrocele, distended urinary or gall bladder, branchial cysts, meningocele. Change of position may occur as the result of gravity in lipoma and hematoma; of a long pedicle in ovarian cysts, floating kidney, wandering spleen, and similar tumors; of attachment to freely movable structures like the intestine or omentum; of muscular contraction in intussusception, and foreign bodies or fecal masses in the intestine; of continued growth (see "direction of growth" above); or as the result of reducibility of the tumor (see "reducibility" below). The situation of a superficial tumor may be apparent at a glance. Deep tumors may sometimes be located by palpation, by bougies (e.g., in the urethra, bladder, esophagus), by instruments for inspecting the interior of cavities (e.g., cystoscope, proctoscope, etc.), by distending a viscus (e.g., bladder, stomach, colon) and studying its relations with the mass, by the X-ray, and sometimes only by the pressure symptoms.

(2) The *pressure symptoms* depend upon the size and situation of the growth. The *skin* may be stretched, thin, bloodless, and sometimes ulcerated. *Arteries* are more often displaced than compressed, although diminution or abolition of the pulse beyond the tumor and possibly gangrene may occur. A delayed pulse is not caused by pressure but by aneurysm. Obliteration of *veins* leads to edema, varix, and dilatation of collateral branches; of *lymph vessels* to edema which pits but slightly on pressure. *Nervous structures* are irritated (pain, hyperesthesia, spasm, increased reflexes) or destroyed (anesthesia, paralysis, trophic changes, loss of reflexes). *Muscles* and other soft tissues may be stretched, distorted, or atrophied, *bones* expanded, eroded, or absorbed, sometimes leading to spontaneous fracture, and *joints* dislocated or rendered useless. *Organs* may be displaced (exophthalmos, hernia, prolapse) or the parenchyma degenerated, leading to grave functional disturbances. Pressure on the *bladder* may lessen its capacity and cause frequent micturition, on the *birth canal* dystocia, on *ducts* retention of secretion, on the *air passages* cough and dyspnea, on the *esophagus* dysphagia, and on the *bowel* symptoms of intestinal obstruction.

(3) The *size* of a tumor from a diagnostic standpoint is of value only when considered with its duration (indicating the rate of growth) and the symptoms; malignant tumors rarely attain a large size without causing serious general symptoms or local degenerative changes.

(4) The *shape* of a swelling may correspond with that of a normal organ

(e.g., sarcoma of the ovary, spleen, kidney) or cavity (e.g., in synovitis and hydrocele). The form is often hemispherical in abscess; globular in cysts, sacculated aneurysm, and soft malignant tumors; ovoid in lipoma; warty or villous in papilloma; lobulated in lipoma, adenoma, chondroma, epiplocele, ganglia, and swellings due to inflammation or retention of secretion in acinous glands (e.g., breast and parotid); nodular in scirrhus; cauliflower in intracystic papilloma and in ulcerating malignant tumors; polypoid in papilloma, fibroma, and myxoma.

(5) The *margins* are sharply defined in encapsulated and benign growths, diffuse and ill-defined in infiltrating growths and inflammatory processes.

(6) *Mobility* of a growth under overlying and over subjacent parts is generally indicative of benignity or of its presence in or attachment to movable structures. In the latter instance it will be immovable in the direction in which the structure is immovable (e.g., tumors of muscle, tendons, nerves, and vessels are movable perpendicularly to but not in the axis of these structures), or when the structure is made tense (e.g., muscle, tendon), or when the structure is fixed with the other hand (e.g., the breast). A tumor attached to a muscle or its tendon moves during contraction of the muscle; to the trachea (e.g., goitre), during deglutition; to the liver, spleen, or kidney, during respiration. A tumor which disappears when a muscle is contracted lies beneath it, one which is made more prominent is either a hernia or lies superficial to the muscle. *Immobility* means attachment to a fixed structure (e.g., bone), inflammation or inflammatory adhesions, neoplastic infiltration (i.e., malignancy), or confinement beneath tense structures like muscle or fascia. The last may be recognized by relaxing the muscle or fascia, when the tumor becomes movable.

(7) The *consistency* of a *solid* benign tumor is that of the tissue of which it is composed, viz., bone, cartilage, fibrous tissue, fat, etc. Malignant growths may be as hard as bone or so soft that they give a deceptive sense of fluctuation; the softer the tumor the more malignant it is. *Pitting on pressure* indicates edema (p. 5), dermoid cyst, blood clot, or impacted feces. A soft *doughy sensation* may be noticed in gaseous or fecal tumors, blood clot, dermoid cysts, and in tuberculous affections of serous or synovial cavities, The consistency of tumors may sometimes be revealed by the *X*-ray. The significance of *crepitation* and alteration of the *local temperature*, which may be noticed at this time, are given on pages 6 and 7 respectively, and of *pulsation*, *thrill* and *bruit* (which is audible thrill) on p. 5, 6 and in the section on aneurysm (Chap. XV).

Fluid tumors are recognized by fluctuation (p. 5), translucency (p. 5), exploratory puncture, or in some cases by emptying a viscus by the natural route, e.g., catheterization in distended bladder.

Gaseous swellings are due to the presence of a gas-containing viscus, as in pneumocele and enterocele; to a leak in an air-containing structure, as in cutaneous emphysema and pneumatocele; to the introduction of the gas from without, as in emphysema after closing a large wound or after a careless hypodermoclysis; or to aërogenic bacteria, as in emphysematous gangrene and physometra. The tumor is generally yielding and elastic, hence often gives a deceptive sense of fluctuation, and it is often reducible. Crepitation may be obtained when the gas is finally divided, as in pneumocele and cutaneous emphysema; gurgling, when it is mixed with fluid, as in enterocele; and a tympanitic note on percussion, when sufficient gas is present. Occasionally the gas can be seen, e.g., in emphysematous gangrene, and in certain cases it may be evacuated by puncture, incision, or when in the bladder or uterus by catheterization.

Variation in consistency indicates the presence of normal tissues of different structure, as in enteroepiplocele; several types of tumor formation, as in teratoma, adenomyxoma, cystadenoma, etc.; or the changes to be mentioned in the next paragraph.

Change in consistency, involving either a portion of or the whole tumor, results in hardening or softening.

Hardening arising (a) *suddenly or rapidly* and associated with an increase in size may be due to any of the conditions mentioned above under "sudden" and "rapid enlargement," except rupture of tumors. (*b*) *Gradual hardening* with increase in size may be due to the increased tension attending the growth of cysts and encapsulated tumors, or to change in the type of tissue composing the tumor, e.g., when a lipoma becomes a fibrolipoma or the embryonic cells of a sarcoma developed into maturer forms of connective tissue (fibrous, cartilaginous, osseous). *Gradual hardening with decrease in size* is the result of absorption or solidification of the fluid contents of a swelling: e.g., in cysts, abscesses, hematomata, aneurysms, thrombophlebitis; of resolution of inflammatory processes; of organization of granulation tissue; of ossification of callus; or of the contraction of fibrous tissue, e.g., in cicatricial masses and withering scirrhus.

Softening arising (a) *suddenly* with increase in size is generally due to edema. *Sudden softening with decrease in size* may be due to rupture of a cyst, aneurysm, or abscess into a normal cavity, to the partial dislodgment of an obstruction in a duct or canal, or the partial reduction of a hernia. (b) More or less *gradual softening with increase in size* may occur when a benign growth becomes malignant, when a malignant growth breaks through firm fascia or bone, when a tumor, usually malignant, undergoes degenerative changes (cystic, mucous, fatty, colloid, necrotic), or when an inflammatory mass suppurates. It should be noted that neoplasms and cysts may become inflamed and suppurate, and that necrotic changes, particularly in carcinoma, may result in the formation of a puruloid material which may lead to the diagnosis of acute abscess, the presence of the growth being overlooked. *Gradual softening with decrease in size* points to the absorption of the contents of a swelling whose walls remain of the same size, e.g., serous and synovial effusions.

Intermittent hardening and softening is due to muscular contraction, e.g., in intestinal obstruction, particularly intussusception, and in pregnancy (see also "intermittent enlargement" above).

(8) The *reducibility* of a swelling in part or as a whole may suggest its nature. Reduction may be effected by *compression or manipulation* in angiomata, varix, aneurysm, tumors with a rich blood supply, edema, meningocele, reducible hydrocele, bursæ communicating with joints, tumors of the spermatic cord, partly descended testicle, certain abscesses (e.g., psoas, empyema necessitatis), and in dislocations of normal structures (nerves, tendons, muscle, bone, cartilage, hernia, prolapse); by *position*, e.g., elevation or the recumbent posture, in many of the swellings just mentioned, and flexion of the knee in bursæ about this joint; by *pressure on the artery* feeding the tumor in aneurysm and telangiectatic growths; by *pressure on the vein* supplying the swelling in varix and venous tumors (in applying this test one must be sure of the direction of the venous current since it may be reversed, as in varix of the leg (q.v.); by *catheterization* in distended hollow viscera, e.g., the urinary

bladder; by *purgation* in fecal impaction; or by *anesthesia*, e.g., in phantom tumor.

The *phenomena attending reduction* should be noted. An enterocele disappears with a gurgle, certain varices with a thrill, synovial effusions containing rice bodies with a peculiar crepitus, swelling due to dislocated joints, muscles, or tendons often with an audible snap, and meningocele sometimes with symptoms of cerebral compression.

Most reducible swellings reappear or increase in size when maneuvers opposite to those mentioned above are attempted, and those communicating with the cerebrospinal canal, thorax, and abdomen may swell when the patient strains and have an impulse on coughing. It is important not to mistake a false for a true impulse on coughing, the former is nonexpansile.

(9) *A number of tumors*, if such are all primary, usually points to benignancy, but it should be recalled that one of these tumors may undergo malignant changes. Multiple malignant tumors are almost always secondary.

(10) The *skin* over the growth may be *adherent* because the tumor lies in this structure, because of inflammation, or because of infiltration with cells of malignant tumors. A sebaceous cyst is always attached to the skin at one point, a subcutaneous lipoma at many points, as is shown by dimpling of the skin when an attempt is made to pinch it up between the fingers; the latter should not be confused with the multiple depressions, apparent without raising a fold of skin, which occur in scirrhus (see carcinoma of the breast). Mere tension exerted by a large tumor may make the skin apparently adherent. The *color* of the skin (p. 4) and the presence or absence of *precancerous dermatoses* (Chap. XIV) should be noticed. Distention of the superficial veins over a growth may be caused by any tumor which obstructs the deeper veins, or by tumors with an abundant blood supply, conspicuously sarcoma; in the former the veins distal to the growth also are enlarged and perhaps edema may be present, in the latter the venous engorgement is confined to the growth

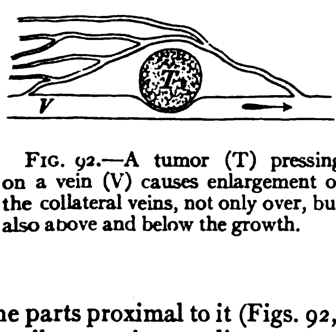

FIG. 92.—A tumor (T) pressing on a vein (V) causes enlargement of the collateral veins, not only over, but also above and below the growth.

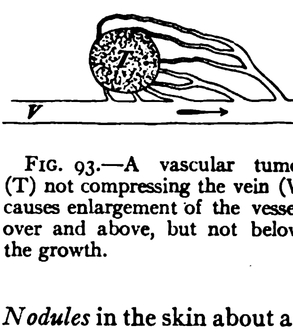

FIG. 93.—A vascular tumor (T) not compressing the vein (V) causes enlargement of the vessels over and above, but not below, the growth.

and the parts proximal to it (Figs. 92, 93). *Nodules* in the skin about a tumor are usually secondary malignant growths. *Ulceration* of a benign tumor may occur from friction, pressure, or pyogenic infection; it may be due to one of the infectious granulomata, notably syphilis and tuberculosis; and it is common in malignant tumors (see diagnosis of ulceration). *Bleeding* from an ulcerating tumor, aside from hemangioma and villous papillomata, points strongly to malignancy.

(11) Adjacent *lymph glands* may be enlarged in any form of ulceration (see diagnosis of ulceration, and of chronic lymphadenitis); if ulceration is not present the growth is probably carcinoma, although as already stated certain sarcomata may spread by the lymph vessels (see sarcoma).

(12) *Exploratory incision* to expose the growth is employed particularly in abdominal tumors. Incision of the swelling itself is sometimes indicated before proceeding to extirpation; cases have occurred in which the tongue or breast has been excised and the swelling found to be simply a cold abscess; again, cases of fibrocystic disease of the lower jaw and chronic inflammatory swellings due to foreign bodies have been subjected to formidable operations with the belief that the swelling was sarcomatous.

(13) *Excision* of a portion of the tumor for microscopic examination is occasionally necessary to establish a correct diagnosis. In these cases, whenever possible, the patient should be prepared for a radical operation and a section of the growth removed, frozen, and examined at once. Allowing days to elapse between the exploratory excision and the extirpation, in cases of malignant disease, may permit of dissemination of the tumor cells from the cut surfaces. If delay must be accepted the raw surfaces should be cauterized. Here we may mention the possibility of making a diagnosis by chemical and bacteriological, as well as microscopic, examinations of fluids obtained by aspiration (e.g., in ranula, galactocele, pancreatic cyst, hydatid disease, hydronephrosis, tuberculous abscess); of secretions (e.g., examination of the stomach contents in gastric carcinoma); of excretions (e.g., by recovery of portions of the growth); and of discharges (e.g., in the infectious granulomata).

General Examination.—*Cachexia* occurs in malignant tumors, but as a late sign, hence its absence should not influence the diagnosis in the early stages. *Metastases* should be sought for, not only in lymph glands, but in other portions of the body, particularly the lungs, the liver, and the bones; and a search made for evidences of diseases, like syphilis and tuberculosis, which might cause a localized swelling. The *heart* is examined as a matter of routine; in many cases of fibromyoma of the uterus it undergoes brown atrophy. *Blood examination* may reveal anemia, leukocytosis, and the hemolytic reaction in the later stages of malignant disease, lymphocytosis in chloroma, tuberculosis, exophthalmic goiter, or any disease of the lymph glands, the Wassermann reaction in gummata, and eosinophilia in parasitic cysts. Apart from local conditions the urine may show the Bence-Jones albumose in myeloma, sugar and the Cammidge reaction in pancreatic tumors.

CHAPTER XIV.

SKIN AND CUTANEOUS APPENDAGES.

Excepting erythema nodosum, affections of the skin which do not demand operative treatment, and those which are dealt with in other sections of the book, e.g., erysipelas, syphilodermata, burns, frost bites, etc., are not included in this chapter.

Erythema nodosum must be mentioned, because its local manifestations may be mistaken for abscesses, gummata, or bruises. It is most frequent in young females, and is characterized by fever, and the formation of nodules, varying in size from that of a pea to that of a pigeon's egg, usually on the shins, but occasionally on other portions of the body. These nodules are at first bright red, painful, tender, and often so soft as to give a sense of fluctuation, but they should never be opened, as spontaneous resolution always takes place in the course of a few weeks. As the swelling subsides, the color passes through the various shades of a bruise, hence the term *erythema contusiformis*. The disease is probably an angioneurosis, and is often associated with rheumatism. The treatment is rest in bed, lead water and laudanum locally, and salicylates internally.

Purpura appears as minute hemorrhages (petechiæ) in the skin and the mucous membranes. It is a symptom of many diseases, for a full list of which the student is referred to a text book on medicine or dermatology. The surgeon is interested in purpura for four reasons. (1) As an indication of spontaneous hemorrhage (q.v.) it forbids any but the most urgent operation. (2) It may be encountered in surgical conditions like hemophilia, cholemia, septicemia, snake bite, lightning stroke, carcinomatous or tuberculous cachexia, traumatic asphyxia, and stasis from venous obstruction; and it may follow the administration of antipyrin, bromids, belladonna, copaiba, ergot, mercury, or quinine. (3) It may give rise to errors of diagnosis, unless one looks for the spots in the skin. In purpura hemorrhagica there may be bleeding from the nose, the stomach, the bowel, or the kidney. In Henoch's purpura there may be fever, slight leukocytosis, tenderness and rigidity of the abdomen (suggesting appendicitis), vomiting (sometimes of blood) and constipation (simulating intestinal obstruction), or diarrhea with bloody stools (aping mesenteric thrombosis); the articular manifestations may be misinterpreted as due to some other joint affection. The purpuric rash is often the last symptom to appear, and even when present may not be noticed. Notwithstanding the possibility of making a mistake, however, if the abdominal symptoms are strongly indicative of a grave surgical lesion a laparotomy must be performed. Mitchell has collected 20 cases in which the abdomen was opened. In some the intestine appeared normal, in some there were petechiæ and edema, in eight there was an intussusception. (4) In the treatment of purpura the surgeon may be requested to transfuse blood.

Sporotrichosis is caused by the sporothrix schenckii, which is found around barn yards, on vegetables and grain, and which enters the body through a wound or with the food. In the tissues these organisms are seen as oval bodies, often with budding processes; on artificial media mycelial filaments and spores are formed. The disease occurs in horses, mules, dogs, and rats, as well as in man. In man the lesions may resemble those of syphilis, tuberculosis, or rarely those of blastomycosis. The dermal form follows a trivial wound; a rat bite or a thorn wound is highly suggestive. Painless, cutaneous or subcutaneous nodules appear along the course of the lymphatics, and ultimately soften, discharging a seromucoid pus. In the osseous and the articular forms there may be eburnation, cold abscesses, or a gummatous-like degeneration. The disease may occur also in any of the other tissues of the body. If one only suspects the condition, the diagnosis can be made readily by the bacteriologist. The treatment is potassium iodid internally, with a weak iodin wash locally. Curettage or more extensive surgical measures may occasionally be necessary.

Blastomycosis is an infectious disease due to blastomycetes, and is most commonly found in the skin of the upper extremities and face. A few cases of general infection have been reported. The organism is spherical or oblong, surrounded by a double capsule, and may contain a nucleus or spore-like body, vacuoles, and granules. Multiplication takes place by budding. Beginning as a small papule the lesion becomes pustular and discharges a glairy, sticky secretion. The ulcerating surface gradually enlarges and becomes covered with soft, friable papillæ. The margin, one of the characteristic features, is raised, indurated, and a dusky red in color, and scattered through it may be seen small miliary abscesses. The disease may last for years. The diagnosis is confirmed by microscopical examination of the pus. The *prognosis* is good, provided the treatment is instituted early, when a cure may be expected in from three months to a year. The *treatment* is excision, or when this is not possible, the continued use of potassium iodid with local antiseptics and the Röntgen ray (Ricketts).

A boil, or furuncle, is an acute inflammation of a limited portion of the skin and subcutaneous tissue around a hair follicle, sweat or sebaceous gland. Infection is commonly due to the staphylococcus pyogenes aureus. Bright's disease, diabetes, and, in fact, any condition which lowers the general resistance predispose to crops of boils. A boil may be preceded by a slight wound or abrasion, such as that which follows shaving, scratching, or irritation from a collar button, but in many instances no such history can be obtained. Secondary boils are caused by infection of surrounding hair follicles by organisms from the primary boil.

The **symptoms** are a stinging and itching sensation due to the formation of a small red pimple, which increases in size, becomes more painful, and forms a conical elevation, deep red in color and very tender. Occasionally the process extends no further and the inflammation gradually subsides without suppuration (*blind boil*). As a rule the pain and swelling increase, the color becomes more dusky, and a pustule forms; this ruptures and exposes a "*core,*" or slough, consisting of a necrotic sebaceous gland or hair follicle. After separation of the slough the cavity heals by granulation.

The **treatment** is hot fomentations, and incision when maturation occurs. Tonics are required, and calx sulphurata, grain $\frac{1}{10}$ t. d., and fresh brewer's yeast, f℥i before or during meals, have been recommended to hinder the formation of new boils, Vaccine treatment is still on trial.

Oriental boil (*aleppo boil, Buska button, Dehli sore*) is confined to the tropics and is contagious. It begins as a papule, which ulcerates, the ulcer healing only after months and leaving an ugly scar. The treatment is cauterization or excision.

Carbuncle is an acute inflammation of a limited portion of the skin and subcutaneous tissue, with the formation of multiple sloughs. Like a boil it is due to the staphylococcus pyogenes aureus and occurs in individuals whose general resistance is depressed by diabetes, Bright's disease, or any other debilitating condition; in fact, a carbuncle is a boil with multiple cores. Carbuncles are most frequent on the back, nape of the neck, and buttocks. The infection enters a hair follicle, reaches the subcutaneous tissue through the little column of fat in which the hair follicle ends, then spreads laterally, and again finds egress through columns of fat (*columnæ adiposæ*) to the surface, thus giving a sieve-like appearance.

The **symptoms** at the outset may be those of a boil, or there may be a deep infiltration of the subcutaneous tissues. In either event the process spreads until in some cases it reaches the diameter of six or more inches. All the symptoms of acute inflammation are present. While the process is still extending, the central portion becomes more soft and develops numerous pustules, which, bursting, uncover grayish sloughs, so that at this stage a carbuncle resembles a sponge, the meshes of which are filled with pus and necrotic tissue. Many of the openings coalesce while new ones are forming at the periphery. In a favorable case the inflammation subsides, the sloughs separate, and the cavity heals by granulation. The constitutional symptoms are those of septic intoxication, septicemia, or pyemia. Carbuncles occurring in vascular regions, such as the face and lips, are more serious because of the danger of septic phlebitis, which in facial cases is prone to spread to the cavernous sinus. The mortality of facial carbuncle is said to be 50 per cent.

The **treatment** is excision in those cases which are seen early and in which the carbuncle is favorably situated; the wound is allowed to granulate under antiseptic dressings. In other cases the honey-combed mass should be opened freely by crucial incisions, and as much of the necrotic tissue as possible removed by forceps and scissors. The wound should then be disinfected with peroxid of hydrogen and bichlorid of mercury solution, 1 to 1,000, and dressed with warm antiseptic fomentations. The constitutional treatment is that of sepsis.

Multiple areas of cutaneous gangrene may occur in certain skin diseases, (*gangrenous urticaria, herpes, erythema*, etc.); in acute infective fevers, possibly as the result of embolism; in hysteria, perhaps from self-inflicted injuries with caustics; and they may arise spontaneously or from some obscure change in the nervous system. The sloughs should be allowed to separate under antiseptic fomentations, and treatment directed to the underlying cause.

A clavus, or corn, is a circumscribed hypertrophy of the epidermis with the projection into the skin of a horny plug of the same material. A *callosity* differs from a corn in the absence of the ingrowing central plug. Corns are the result of long continued pressure, and are rarely seen except on the feet. *Hard corns* occur on the dorsal surface of the toes, particularly the little toe, *soft corns* between the toes, where they become sodden from the constant presence of moisture. Both varieties are painful, and may become inflamed and suppurate.

The **treatment** is removal of pressure by the wearing of well fitting shoes or the application of a circular corn-plaster of felt. The corn itself may be removed with a sharp knife after the parts have been softened by soaking in hot water. Any existing deformity, e.g., hammer-toe, should be corrected. Corns may be treated also by the application of tincture of iodin, silver nitrate, or salicylic acid; the first and second may be used in a pure form, the last in a mixture consisting of salicylic acid ʒi, extract of cannabis indica gr. x, and collodion ʒi. These applications may be used daily for a week or longer. When the corns are between the toes, the part should be frequently washed, dried, dusted with stearate of zinc, and the toes separated by cotton.

Horns (*cornu cutaneum*) are dry and solid outgrowths from the skin and consist of cornified epithelium. They sometimes arise from warts or from sebaceous glands. They should be excised.

A **wart** (*verruca*) is a papilloma of the skin, which is commonly pigmented and often seen on the hands of young persons (*v. vulgaris*) and on the back and arms of the elderly (*v. senilis*). It may be broad and flat (*v. plana*), filamentous, notably about the face (*v. filiformis*), divided into finger-like processes, particularly on the scalp (*v. digitata*), or conical (*v. acuminata*), especially about the mouth, anus, and genitals (venereal warts p. 629). The surface may be smooth, cauliflower-like, or horny (*wart-horn*). Warts are often multiple and appear and disappear without cause. They may be treated by daily cauterization with lactic, chromic, nitric, or glacial acetic acid, by carbon dioxid snow, by radiotherapy, or by excision.

A **mole** is a circumscribed hypertrophy of the skin, usually congenital, pigmented (*nevus pigmentosus*), and covered with hair (*nevus pilosus*). White moles are often hairless (*nevus spilus*) and acquired. A mole may have a papillary surface (*nevus verrucosus*) or be infiltrated with fat (*nevus lipomatodes*). The most interesting point about a mole is that its base strongly resembles in structure an alveolar sarcoma; in fact, it may in later life originate such a growth, usually of the melanotic variety. Moles so situated as to produce disfigurement may be excised; moles which are spreading rapidly must be excised.

Tuberculosis of the skin occurs in a variety of forms (macules, papules, pustules, tubercles), many of which, e.g., lichen scrofulosum, eczema scrofulosum, etc., belong strictly to a work on dermatology. Only those tuberculous lesions of the skin which more particularly concern the surgeon will be described here.

Tuberculosis ulcerosa (*ulcère des phthisiques*) is an uncommon form of tuberculous ulceration, occurring almost exclusively at muco-cutaneous junctions as the result of internal tuberculosis. The ulcers are shallow, generally very painful, and have irregular edges. The base is bathed in a scanty seropurulent discharge and occasionally shows miliary tubercles. The treatment is that of tuberculosis, with local applications of silver nitrate.

Verruca necrogenica (*anatomical tubercle, butcher's wart*) occurs upon the dorsal surface of the hand of pathologists, surgeons, butchers, or others, as the result of local infection with the tubercle bacillus. It consists of a warty-like mass often presenting small pustules. The *treatment* is excision.

Scrofuloderma (tuberculous gummata) is the result of infection of the skin or subcutaneous tissues, and consists of a tuberculous mass of variable size, which breaks down and eventuates in an ulcer. These *tuberculous ulcers* have bluish, undermined, irregular edges, and are often covered by a crust, under which may be found pulpy and edematous granulations. Healed tuberculous ulcers are characterized by puckering or inversion of the skin. The *treatment* is removal of the congested and undermined skin and of the edematous granulations, the wound being packed with iodoform gauze.

Lupus vulgaris is a tuberculous infection of the skin, rarely beginning after the age of thirty, and most frequently seen upon the face, particularly the nose and cheeks, although other portions of the body, notably the extremties, may be attacked. The disease is essentially a local one, although generalization of the tubercle bacilli may occur. It begins as a pinkish or brownish-yellow nodule (*lupoma*); other nodules form, usually along the course of the blood vessels. Thus the resulting patches are often irregular or serpiginous. Pain is absent and the lesion may feel firm or soft. When resolution takes place without ulceration, the nodules shrink, producing a thin scar covered by scaly epithelium (*lupus exfoliativus*). Ulceration with subsequent cicatrization is more common, the periphery breaking down as the older portions are healing. Ulceration may be excessive (*lupus exulcerans, or lupus exedens*), or there may be a tendency towards the formation of exuberant fungoid granulations (*lupus hypertrophicus*). The disease may invade adjacent mucous membranes or destroy adjoining cartilage; a nose thus affected presents a "lopped-off" appearance, in contradistinction to the "sunken-in" nose of syphilis. A *lupoid ulcer* is irregular, owing to the fact that it progresses at one side while healing at the other. The base is covered by "apple jelly" granulations, originating a sero-purulent discharge that forms a thick brownish crust. The margins are elevated and thickened, and contain the lupoid tubercles or consist of cicatricial tissue. The surrounding parts are congested and yellowish-red in color, and adjacent lymph glands may be enlarged. The scar resulting from the healing of a lupoid ulcer is puckered, yellowish, and possesses but little vitality, reulcerating on the slightest provocation.

Diagnosis.—*Lupus erythematosus* is generally regarded as non-tuberculous in origin, although possessing some features in common with lupus vulgaris. When occurring on the face, the usual situation, it appears as a symmetrical erythema, which has been likened to a butterfly with outstretched wings. It begins after puberty and is attended with a branny desquamation, the scales of which are inspissated sebum, derived from plugs which distend the orifices of the sebaceous glands. Although ulceration is very rare, recovery is attended by the formation of thin cicatricial tissue. The remaining conditions to be differentiated from lupus vulgaris are *syphilitic ulceration*, *epithelioma*, and *blastomycosis* (q.v.).

Treatment.—The general health should be attended to, and the X-ray, radium, or the Finsen light applied locally. If radio- or phototherapy cannot be employed, the lesion may be scarified, excised, or, after thorough curetting, cauterized with the actual cautery or chemical caustics.

Epithelioma of the skin occurs as a superficial, or flat form, and as a deep-seated, or nodular variety.

Superficial epithelioma develops primarily as yellowish-red or brownish patches scattered over the surface, or as a secondary affection attacking warts, scars, nevi, fissures, etc.

Rodent ulcer (*Jacob's ulcer*) is a peculiar form of superficial epithelioma, almost invariably limited to the upper two-thirds of the face (Fig. 94). It occurs in old age, and begins as a little nodule which ulcerates. The ulcer is round, oval, or irregular, with indurated everted edges and a smooth, glossy, pinkish surface; the discharge is slight, pain is absent, adjacent lymph glands are not involved, metastases do not occur, and the general health is unimpaired except in the later stages, death resulting from hemorrhage or from the local destruction of important organs. The disease progresses very slowly, sometimes lasting thirty or forty years, and occasionally cicatrizes in spots, the scars later breaking down. The ulcer advances principally along the surface, although in the later stages it extends deeply and destroys everything in its path, including the bones. The disease may originate in any of the epidermal structures.

Deep-seated, or nodular epithelioma, may follow the superficial form, or begin primarily as a nodular growth involving the whole skin and invading the subcutaneous tissues. Ulceration occurs, producing an irregular, offensive, easily-bleeding excavation, with an indurated base; pain is present and involvement of the lymph glands and metastases occur. These growths occur most frequently on the scalp, forehead, lips, tongue, penis, scrotum, labia, back of the hand, and in cicatrices.

Lenticular carcinoma is best seen as recurrences in the neighborhood of the scar following amputation of the breast; it is alveolar in structure, and appears as hard, glistening, reddish or brownish nodules, which subsequently ulcerate, invade the lymphatics, and destroy life.

FIG. 94.—Rodent ulcer. (Pennsylvania Hospital.)

The **treatment of carcinoma of the skin** is early and thorough excision, with, in the deep-seated form, the adjacent lymph glands. Caustics and radiotherapy should never be employed in operable cases of deep-seated epithelioma. Superficial epithelioma, conspicuously rodent ulcer, may be cured by the X-ray, radium, or the Finsen light. When the above measure cannot be carried out, cauterization with the thermocautery, or by means of caustic pastes containing potassium hydrate, chlorid of zinc, or arsenic, may be used.

Precancerous dermatoses are illustrated by *Paget's disease* of the nipple (see diseases of the breast); by the *soot-warts* which precede chimney sweeps' cancer of the scrotum; by the dry, thickened skin, often covered with an acne-like eruption, which precedes the tar-and-paraffin cancer seen on the hands and forearms of those who work in coal-tar and paraffin; by *keratosis senilis*, in which the epidermis becomes thickened, horny, and discolored; by *xeroderma pigmentosum*, which begins with freckle-like pigmentations on the face and hands; and by the roughened, fissured, glossy skin following *chronic X-ray burns*. The areas of telangiectasis, pigmentation, keratosis, and atrophy resulting from *hypersensitiveness to light*, and scars, warts, and pigmented moles all predispose to malignant changes. *De Morgan's spots* are bright red nevoid spots often seen on the chest and abdomen of cancerous subjects; they may, however, occur in healthy individuals. In this connection may be mentioned the white patches (*leukoplakia*) which occur on the mucous membrane of the mouth, and which are often followed by epithelioma.

Sarcoma may arise from the connective tissue of the skin or occur as secondary metastatic nodules. Moles sometimes form a starting point for the melanotic variety; some authorities, however, believe that the majority of pigmented growths resulting from moles are carcinomatous. Primary sarcoma may be single or multiple; secondary sarcoma is always multiple. *The treatment* is excision whenever practicable; in the melanotic variety the neighboring lymph glands also should be removed. Amputation may be required. In inoperable cases the X-ray and Coley's fluid may be tried.

Idiopathic multiple hemorrhagic sarcoma appears first on the hands and feet as minute reddish-brown tumors, which, as they enlarge, become bluish-red, sometimes resembling angiomata. The growths are sometimes confluent and may form extensive areas of infiltration; occasionally some of them atrophy, leaving deeply pigmented spots. The pigmentation is due to hemorrhage. The disease spreads slowly to the trunk and terminates in death. no treatment being of avail.

Mycosis fungoides, which is thought to be sarcomatous in nature, is characterized by the development of an urticarial or eczematoid eruption, the lesions changing to reddish or bluish tumors and ultimately undergoing fungoid ulceration. No treatment has any influence on the disease, which is always fatal.

FIG. 95.—Keloid following a burn.

Leukemic tumors, which are probably sarcomatous, may be widely scattered in the skin in leukemia and pseudo-leukemia,

Keloid is a hyperplasia of scar tissue, classified as a fibroma. It is covered with glistening epithelium, is pinkish in color, freely movable over the subcutaneous tissues, and frequently extends into the surrounding skin by claw-like projections, hence the term. The surface of the growth may be flat, tuberous, or, more frequently, irregularly trabeculated (Fig. 95). Theoretically a distinction is made between *true, or spontaneous keloid (morphea)*, which does not arise from a scar, and *false keloid*, which always springs from a cicatrix. The belief is common that spontaneous keloid is always preceded by a minute scar which has escaped detection. Keloid occurs most frequently in the colored race, is painless, grows slowly, and occasionally atrophies in old age. It recurs after excision but never gives rise to metastases. The best *treatment* is radiotherapy. Excision is almost useless, even when followed by skin grafting. Local injections of thiosinamin, electrolysis, elastic compression, and the internal administration of thyroid extract have been tried with occasional success.

A **sebaceous cyst** is due to occlusion of the excretory duct of a sebaceous gland by dirt or inspissated sebum. It is rounded, usually firm but elastic, freely movable on the deeper parts unless inflamed, and invariably attached to the skin at one point. The orifice of the obstructed duct can often be seen, and occasionally sebaceous matter can be expressed from it. These cysts may be found wherever there are sebaceous glands, but are most common on the scalp (*wens*). They may reach a large size, are often multiple, and may become inflamed and suppurate. When the overlying skin ulcerates, the contents putrefy and a fetid ulcer results; this has been mistaken for epithelioma and, indeed, occasionally undergoes carcinomatous degeneration. Calcification sometimes occurs. When the sebum projects from the orifice of the duct, it may dry and gradually form, by addition from below, a *sebaceous horn*. *The treatment* is enucleation after incising the overlying skin. This is usually very simple, unless adhesions with the surrounding parts have been contracted as the result of inflammatory changes. If any of the cyst wall remains, recurrence is apt to take place. Some surgeons transfix the cyst, and after emptying it, seize the cyst wall with hemostatic forceps and tear it out. Horns and ulcerating and inflamed cysts should be excised.

Onychia (*ungual whitlow, run-around*) is an inflammation of the matrix of a nail, usually beginning at one side (*paronychia*), and frequently followed by suppuration which extends beneath and around the semilunar fold and loosens the nail. It is an affection to which surgeons and nurses are peculiarly liable, particularly when run down in health. The *treatment* is removal of the loosened portion of the nail and disinfection of the suppurating focus, together with attention to the general health.

Onychia maligna is a chronic fungating inflammation of the matrix, usually of syphilitic or tuberculous origin. The *treatment* is removal of the nail, antiseptic fomentations, and attention to the underlying diathesis.

Onychauxis is hypertrophy of the nails, in length, breadth, and thickness. It may be congenital, and sometimes occurs in syphilis and ichthyosis. The nails are often furrowed and yellowish or brownish. *Onychogryposis* (claw nail) is most frequently seen in later life; it commonly affects the great toe, and is frequently preceded by injury or neglect. The *treatment* is trimming of the nails by strong scissors or bone forceps, or removal of the entire nail.

Ingrowing toe-nail (*onychocryptosis*) is caused by narrow shoes and by cutting the nail at the corners instead of straight across. The edge of the nail, usually that of the great toe, is buried in inflamed or ulcerating soft parts at the side of the toe. The *treatment* in the early stages is the introduction of small pieces of cotton or gauze beneath the overgrowing soft parts, the use of square-toed shoes, and trimming the nail square across; adhesive plaster may be so arranged as to press the skin from the edge of the nail. In the presence of ulceration the best treatment is removal of a wedge-shaped piece of tissue, consisting of the affected third of the nail and the underlying matrix, so that recurrence cannot take place. This may be done under local anesthesia. The lips of the wound may be approximated by sutures placed proximal and distal to the nail.

Plastic surgery in its broadest sense includes all operations for the correction of deformities, the filling of deficiencies, and the removal of redundant tissue. Plastic operations involving other tissues than skin, mucous membrane, and fat, and plastic operations for special conditions, e.g., hare-lip, hypospadias, etc., are dealt with in other sections of the book. It may be stated here, however, that in general the nearer a tissue is histologically to connective tissue and the poorer its normal blood supply, the better it stands transplantation, thus skin, fat, fascia, tendons, blood vessels, peritoneum, cartilage, and bone can be completely separated from the body and after reimplantation survive or be replaced by identical material, while highly developed cells like those of parenchymatous organs and the nervous system usually perish quickly from a sudden failure of nourishment.

Plastic operations for cutaneous defects are performed by stretching (Figs. 96 to 99) or sliding (Figs. 100 to 104) the skin about a wound after it has been undermined, by transplantation of pedunculated flaps (Figs. 105 to

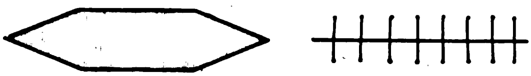

FIG. 96.

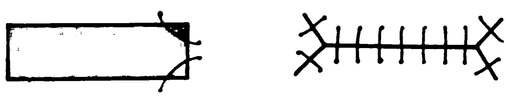

FIG. 97.

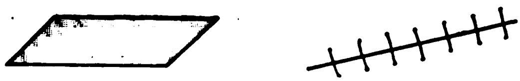

FIG. 98.

FIG. 99.

Plastic operations by stretching the margins of skin. (Esmarch and Kowalzig.)

108), by relaxation incisions (Figs. 109, 110), or by skin grafting (free transplantation). Success in all plastic operations depends upon strict asepsis (antiseptics devitalize the cells), the relief of all tension, thorough freshening of the parts to be united, rigorous hemostasis (blood clot interposes a barrier to healing), gentle handling of the flaps or grafts, as few sutures as possible (so placed as not to cut off the blood supply, and for the same reason tied loosely), and the proper selection of cases; the debilitated, the syphilitic, and those with infected wounds are unfit for such operations.

The use of pedunculated flaps from near or distant parts is illustrated in the various methods of rhinoplasty (q.v.); such flaps consist of the entire thickness of the skin, should be about one-sixth larger than the area to be filled in order to provide for shrinkage, and should be so arranged as to have a free blood supply without twisting the pedicle. A double pedunculated flap may be employed for certain defects (Fig. 111). In order to insure its viability, a flap may be separated from the underlying tissues by oiled silk until its survival is assured, when one of the pedicles may be divided and the flap transferred to the defect.

Skin grafting is the use of entirely detached portions of the skin for covering raw surfaces. Autoplastic grafts, i.e., those taken from the same individual, are the most successful. Homoplastic grafts, i.e., those contributed by relatives or friends, or obtained from a recently amputated limb, seldom "take," probably because the tissue fluids of the patient have a cyto-

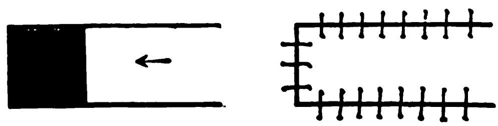

FIG. 100.

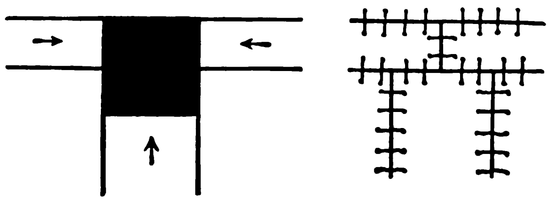

FIG. 101.

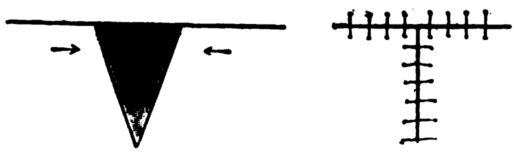

FIG. 102.

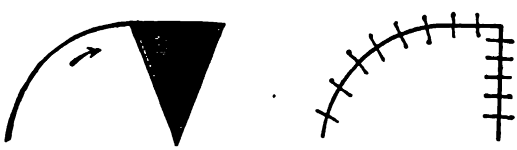

FIG. 103.

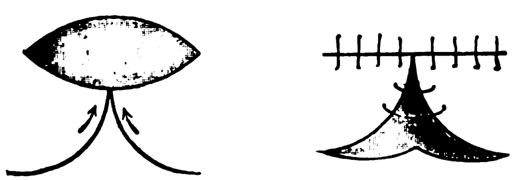

FIG. 104.

Plastic operations by sliding flaps. (Esmarch and Kowalzig.)

lytic effect on the graft, just as the blood of one individual may cause hemolysis when mixed with that of another. When skin is transplanted from a negro to a white man the pigment gradually disappears and vice versa. Heteroplastic grafts, i.e., those taken from the lower animals, almost always become necrotic.

Wolf's method (free transplantation of skin) consists in excising a piece of kin one-sixth larger than the area to be filled, removing all fat from its under urface, and placing it in the defect, from which all scar tissue should have een removed, and in which the graft is held by the pressure of the dressings. t is preferable, according to Lexer, to leave the fat if, e.g., on the face, an

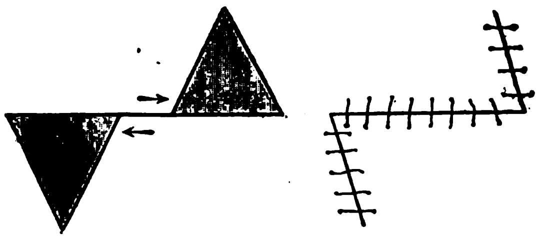

FIG. 105.

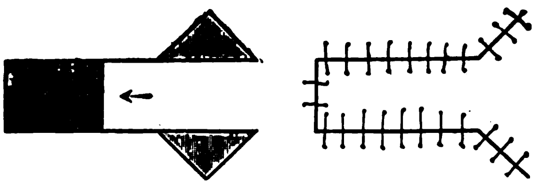

FIG. 106.

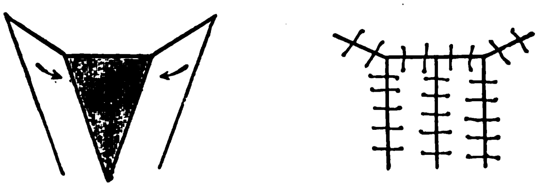

FIG. 107.

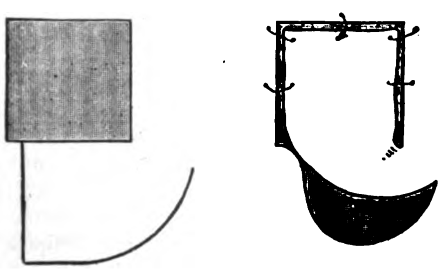

FIG. 108.

Plastic operations with pedunculated flaps. (Esmarch and Kowalzig.)

indentation is to be filled. Healing is complete in from three to five weeks. Hair transplanted with the graft usually falls out, and regenerates irregularly, and the graft becomes whitish or yellowish. Many of these grafts perish, and when the dimensions are over 5 or 6 cm. necrosis is almost certain to occur. Thus the indications for the Wolf graft are restricted, despite its advantages, as compared with the Thiersch graft, of greater resistance, less shrinkage, and better cosmetic effect.

Thiersch's method (free transplantation of epidermis) is quicker (healing occurs in one or two weeks) and more certain than the Wolf method, and is generally used for fresh or granulating surfaces. It should not be employed, however, when the part, e.g., the palm or the sole, is to be subjected to pressure; in these cases, if the area is too large for a Wolf graft, the raw surface should be covered with a pedunculated flap, taken for example

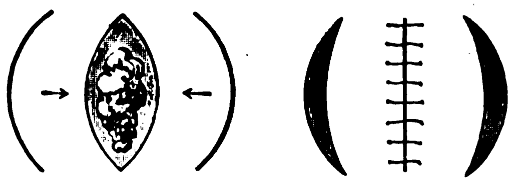

FIG. 109.

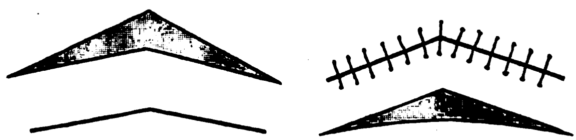

FIG. 110.
Plastic operations. Incisions to relieve tension. (Esmarch and Kowalzig.)

from the abdomen in the case of the palm, from the other leg in the case of the sole, the pedicle being cut after union has occurred, i.e., after two or three weeks. Epidermal grafts are best taken from the arm or thigh. After the raw surface has been disinfected no antiseptic should be used. Exuberant granulations are removed with a sharp curette or, better, with a razor, which causes less injury to the remaining cells, and bleeding stopped by pressure with hot pads. The parts from which the grafts are to be taken should be

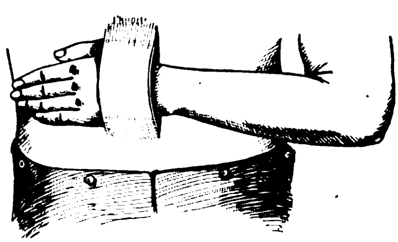

FIG. 111.—Double pedunculated flap. (Binnie.)

sterilized and then washed with salt solution. The skin is stretched by pressure with the hand, and a long strip of epidermis, as thin as possible, is shaved off with a sharp razor (Fig. 112). The graft lies on the blade of the razor in a series of plaits and is slid onto the raw surface by fixing one end of the graft by slight pressure and carrying the razor close to and parallel with the wound (Fig. 113). All air bubbles should be pressed from beneath the graft, which is then covered with strips of rubber tissue or silver-foil, and dry sterile gauze. The wound may be entirely covered with such grafts.

The dressing is changed at the end of a week unless infection occurs. Recently we have been splinting grafts with a single layer of gauze fastened at the margins of the wound with collodion, thus securing free drainage into the outer dressings, preventing maceration, and allowing change of the outer dressing and irrigation with salt solution if the discharge be copious.

Reverdin's method is performed by lifting a small portion of the skin with a needle and removing it with curved scissors. The upper layer of the cutis vera should be included. A number of these grafts are placed on the granulations, raw surface downwards, and the wound dressed as in the Thiersch method. These grafts at first apparently disappear owing to disintegration of the epidermis, but later appear as bluish white spots, from which the epithelial growth proceeds in all directions. The method is rarely used at the present time.

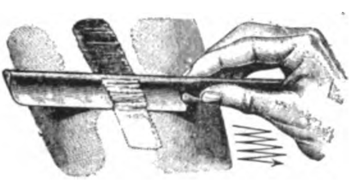
FIG. 112.

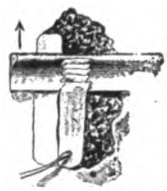
FIG. 113.

Thiersch's skin grafting. (Esmarch and Kowalzig.)

Mangoldt's method consists in "scraping the sterilized skin with a razor, down to the papillary layer, and spreading the mixture of epithelial cells and blood thus obtained upon a clean, bloodless, non-granulating wound."

Mucous membrane from man or animals also has been successfully transplanted, and skin has been used to take the place of mucous membrane. When flaps are used for the latter purpose, the skin should be hairless.

Free transplantation of fat is followed by partial (when autoplastic) or complete degeneration (when homoplastic) of the transplant, the degenerated cells being replaced by new cells which spring from the old fat cells or from the accompanying connective tissue (Rehn). As the transplant shrinks to some extent it should be cut a little larger than seems necessary, and it should not be placed immediately under a suture line. Fat transplantation has proved of value for filling cavities, e.g., in the face after fracture of the zygoma, in the breast after the excision of benign tumors, in bone after the removal of necrotic or carious areas, in the orbit after enucleation of the eye; for the prevention of adhesions, e.g., between joint surfaces (arthroplasty), around nerves and tendons, between the brain and overlying structures; for the control of bleeding from parenchymatous organs, the fat being used as a tampon, which is sutured in place; and, when inserted between the pleura and the chest wall, for producing compression in the treatment of bronchiectasis and pulmonary tuberculosis.

CHAPTER XV.

VASCULAR SYSTEM.

In the present chapter we have freely used the article by LeConte and the author, in the "American Practice of Surgery," on the "Surgery of the Heart and Blood Vessels," to which the reader is referred for an extended discussion of the subjects herein treated.

THROMBOSIS.

Thrombosis is the formation of a clot (*thrombus*) within the circulatory apparatus during life.

The **causes** in the order of their importance are, (1) *changes in the vessel walls*, the result of inflammation, necrosis, degeneration, neoplastic infiltration, or trauma; (2) *changes in the blood*, the result of toxemia or anemia; (3) changes in *the blood current*, resulting in retardation, e.g., from diminution in the calibre of the vessels, cardiac weakness, or prolonged maintenance of the horizontal position, or resulting in the production of eddies, e.g., when the blood flows into an aneurysm or varix. As coagulation of blood depends upon the presence of fibrin ferment, which causes the fibrinogen and the calcium salts of the plasma to unite and form fibrin, and as fibrin ferment is liberated by diseased or injured endothelial or blood cells, slowing of the circulation alone, without either of the other factors, will not cause thrombosis, indeed, a vessel may be ligated at two points without coagulation taking place for a long time between the ligatures. As a matter of fact, one of the other factors is almost always present; thus, slowing of the blood current is in itself capable of inducing nutritive changes in the vessel walls, and in the enfeebled circulation attending fevers there is toxemia and often degenerative alterations in the vascular tunics.

The **nature of the thrombus** depends upon whether it is formed slowly from a moving current of blood (*white thrombus*) or is the result of complete stasis (*red thrombus*). The white thrombus is composed of gradually deposited white corpuscles and fibrin; when a considerable number of red corpuscles enter into its formation it is called a *mixed thrombus*. The clot which is first formed (*primary, or autochthonos thrombus*) usually begins as a *parietal mural thrombus*, which gradually enlarges until it fills the lumen of the vessel (*occluding, or obturating thrombus*). It may then by subsequent additions (*induced thrombus*) become a *continued, or propagating thrombus*, usually extending in the direction of the blood current. The term *secondary* is applied to induced thrombi and to those forming about an embolus. A thrombus is generally adherent to the vessel walls and its advancing end conical. The end, e.g., when it projects into a collateral vessel, may be washed away as an embolus (Fig. 114), or the entire thrombus may loosen and float into the blood stream. The terms *infective* and *aseptic, or bland,* refer to the presence or absence of bacteria.

The changes which a thrombus may undergo are (a) *organization*, i.e., the clot is replaced by fibrous tissue as in repair elsewhere; (b) *canalization* as the result of incomplete organization, thus re-establishing the circulation; (c) *calcification*, forming in the veins phleboliths and in the arteries arterioliths; and (d) *liquefaction or softening* the result of aseptic degeneration (simple softening) or suppuration (septic softening), causing embolism and in septic softening pyemia.

Localization of Thrombi.—*Cardiac thrombi* are of no practical importance to the surgeon. *Arterial thrombi* are most frequent in the lower extremity as the result of injury, endarteritis, or the impaction of an embolus (see gangrene and embolism). *Venous thrombi* are much more common than the other varieties, because of the comparatively sluggish circluation in the veins, the presence of valves, and the composition of venous blood, especially the increased amount of CO_2. Venous thrombosis, unlike that occurring in the arteries, usually attacks the veins on the left side of the body. The left lower limb is the favorite site, owing to the greater length and obliquity of the left common iliac vein, which is crossed by the right common iliac and the left internal iliac arteries, and which may be pressed upon also by a loaded rectum. *Capillary thrombi* are generally due to local conditions, such as injuries, severe inflammations, etc.; when the larger vessels are blocked, the capillaries remain patent unless gangrene follows.

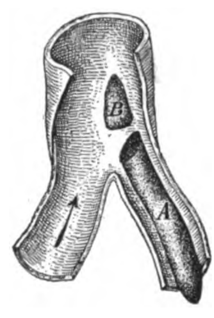

FIG. 114.—*A*. Thrombus. *B*. Embolus resulting from detachment of the end of the thrombus which projected into the larger vessel. Arrow indicates direction of blood stream.

The results of thrombosis depend upon the location and the extent of the thrombus, the rapidity with which it is formed, and the condition of the collateral vessels. Apart from the constitutional symptoms, which vary according to whether the thrombus is septic or aseptic, and the liability to embolism, the phenomena are mainly those of obstruction to the blood stream, the symptoms and treatment of which are given in the sections on embolism and contusions of arteries and in the section on phlebitis. Thrombotic gangrene is discussed under gangrene, post-operative thrombosis under phlebitis.

EMBOLISM.

Embolism is the sudden blocking of a blood vessel by a foreign body (*embolus*) which has been brought by the blood stream from some more or less distant part. Emboli are usually detached portions of thrombi, but they may be vegetations from the valves of the heart, detached atheromatous plates, fat globules, air bubbles, portions of tumors, cells from some of the normal structures of the body, masses of bacteria, or parasites, such as the scolices of the echinococcus and the filaria sanguinis hominis. Various forms of dust when inhaled, and particles of paraffin and insoluble preparations of mercury when injected subcutaneously, may float off into the blood stream as emboli.

The **site of impaction** of an embolus depends on its origin. Those arising in the area drained by the portal vein lodge in the liver; those arising in the general venous circulation pass through the right heart and lodge in the lungs; and those from the left heart or aorta may lodge in any portion of the body. Rarely an embolus originating in a vein finds its way into the arterial circulation through a patent foramen ovale (*crossed, or paradoxical embolism*) and still more rarely is it transported in a direction opposite to that of the blood stream (*retrograde embolism*). An embolus usually lodges at the point where a vessel suddenly diminishes in size, e.g., where a large branch is given off or where bifurcation takes place.

The **effects of embolism,** which depend upon the size, seat, and nature of the embolus, and the condition of the collateral circulation, may be studied under two headings: (1) *At the seat of impaction* an embolus induces secondary thrombosis, and the mass may undergo the changes already described under thrombus. Non-absorbable foreign bodies, if minute, may be transported by the leukocytes to the liver, spleen, or bone marrow; larger foreign bodies are encapsulated with fibrous tissues. Animal parasites perish and are absorbed or encapsulated, or penetrate the vessel wall and develop in the surrounding tissues. Tumor cells may proliferate and give rise to metastatic growths. Bacteria may produce changes identical with those at the original point of infection. Embolic aneurysms are thought to be caused by a softening of the vessel wall, the result of bacterial activity (see aneurysm). (2) *The parts supplied by an embolized artery* become anemic, but if there is an efficient collateral circulation the anemia may disappear and no harm result. If an embolus blocks a terminal artery (i.e., one having no collateral anastomoses, except capillary, with adjacent arteries, such as occur in the brain, retina, spleen, kidney, and lung) or one with a poor collateral circulation, the part beyond becomes gangrenous; in the viscera this area is called an infarct, and is wedge-shaped with the base towards the periphery of the organ. The infarct may remain bloodless (*white, or anemic infarct*), or become infiltrated with blood (*red, or hemorrhagic infarct*) which comes from adjacent capillaries and passes through the altered vessel walls of the part. In either case subsequent organization occurs and the area remains as a scar, which may be pigmented in the hemorrhagic infarct, or calcified, especially in the lungs; occasionally infarcts in the brain form cysts. If the embolus is septic the infarct undergoes moist septic gangrene or forms an abscess (*metastatic abscess*).

The **symptoms** of embolism are sudden severe *pain* at the point of impaction or in the ischemic area; *absence of pulsation*, which may be detected not only in obstruction of superficial arteries but also in embolism of any artery having superficial branches; *hardening of the vessel* at the site of the embolus; increase, after a time, in the number and size of *the collateral vessels;* rise in the general *blood pressure* at the time of occlusion of a large artery (causing, if the abdominal aorta is affected, acute dilatation of the heart, edema of the lungs, bloody stools, etc.), gradually diminishing with the establishment of the collateral circulation; and in the ischemic area *pallor, fall of temperature, hypesthesia,* and *paresis,* followed, in the event of gangrene, by the discoloration of *gangrene, anesthesia,* and *paralysis. Hemorrhage,* as a manifestation of infarction, may show itself externally when the lung (hemoptysis), kidney (hematuria), or bowel (bloody stools) is affected. The remaining symptoms of infarction are impairment or abolition of the special functions of the organ affected. Pulmonary embolism is discussed below, mesenteric embolism on page 494; for the details of infarction of other viscera the student is referred to a text-book on internal medicine.

Diagnosis between Embolism and Thrombosis.—The *onset* is sudden in embolism, gradual in thrombosis. It may, however, be slow in the former if the embolus does not at once completely occlude the artery, and abrupt in the latter if the thrombus forms rapidly. The *duration of the symptoms* may be brief in embolism, because the collateral vessels promptly dilate. When an artery is slowly occluded the collateral vessels progressively enlarge, so that by the time the blood stream is completely arrested, they are incapable of the further dilatation required to nourish the affected part, hence the symptoms are permanent or of long duration. If, therefore, the *collateral* vessels are enlarged at the onset the condition is probably thrombosis. The *finding of the causative lesion* may be difficult or impossible. Embolism is so much more frequent in arteries that, in the absence of a definite cause for thrombosis, the condition is generally regarded as embolism, even when the source of the embolus cannot be discovered.

The **treatment** is first prevention (see pulmonary embolism). The measures to be taken to prevent gangrene in embolism of the arteries of the extremities are identical with those mentioned under senile gangrene. Removal of an embolus in an accessible region is possible. The treatment of embolic gangrene is given on page 92, of mesenteric embolism on page 494. The treatment of other forms of visceral infarction belongs to the physician, if we except the incision of secondary abscesses and the excision of organs whose main artery is blocked, e.g., spleen and kidney.

Pulmonary embolism may follow thrombosis due to disease or injury (see thrombosis and phlebitis); labor, owing to the increased coagulability of the blood, the trauma of childbirth, the wide veins of the uterus, and the contractions of the uterus; the injection of coagulating fluids into venous tumors, of paraffin for cosmetic purposes, and of mercury in syphilis; and certain operations (see postoperative phlebitis).

The **symptoms,** excluding infective emboli which give rise to septic processes, depend upon the size of the embolus and the condition of the pulmonary circulation. 1. Minute emboli give no symptoms. 2. Emboli large enough to block a medium sized branch of the pulmonary artery may be followed by trifling symptoms, owing to the number and large size of the capillaries which supply the affected area. If, however, the pulmonary circulation is sluggish, hemorrhagic infarction may occur, the symptoms being those of pleuropneumonia. Bloody expectoration may be absent and necrosis of the infarct does not necessarily follow. Many cases of pleurisy and mild pneumonia, appearing within a few days or a week after operation, are in reality due to embolism. 3. A large embolus occluding the pulmonary artery or one of its main branches causes death within a few minutes. If the vessel is not completely blocked life may be prolonged for hours, or recovery may follow. In these cases the patient suddenly complains of severe pain about the heart and dyspnea; the respirations are rapid, the face cyanotic, the eyes protruding, the pupils dilated, the cervical veins swollen, and the pulse quick, weak, and perhaps irregular. In other cases there is delirium, coma, or convulsions. At the onset examination of the chest may reveal nothing abnormal; later, signs of edema of the lungs appear. Excluding injuries to the major veins, emboli sufficiently large to block the main pulmonary vessels rarely occur before the second or third week of phlebitis or after the sixth week. The accident often follows some movement, particularly sitting up in bed, which necessitates acute flexion of the groin, thrombosis being most frequent in the left femoral vein. The prophylactic **treatment** is that of phlebitis. Embolic pneumonia is managed like ordinary pneumonia. In occlusion of the pulmonary artery or one of its large branches, if the patient live long enough, cardiac stimulants, oxygen, and perhaps bleeding may be employed. Trendelenburg suggests thoracotomy, incision of the pulmonary artery, and extraction of the embolus; this has been attempted in several cases, without, however, a single recovery.

Air embolism may occur during the administration of an intrauterine douche after labor, during intravenous infusion, and especially during operations at the base of the neck when the veins are gaping from pathological change, anatomical disposition, or the result of traction. The amount of air which might be introduced into a vein by the ordinary hypodermic syringe would probably be insufficient to cause serious trouble. It is necessary that a large amount of air be introduced suddenly.

The **symptoms** are a gurgling sound due to the sucking of air into the vein, extreme pallor or lividity of the face, marked acceleration and then cessation of the pulse and respirations, and occasionally a gurgling sound over the heart. There may be convulsions preceding death, which usually takes place within a few minutes, although it may be postponed for several hours or even days. The cause of these symptoms is overdistention of the right heart and the pulmonary vessels with air, and air embolism of the coronary and cerebral arteries.

The **treatment** is immediate pressure on the wounded vein to prevent the further entrance of air. Blood may be withdrawn from a vein of the arm to relieve the distention of the heart, cardiac stimulants given subcutaneously, and artificial respiration performed. Puncture of the right auricle with an aspirating needle has been proposed.

Fat embolism, according to some authors, may, despite the obstacle presented by the lymph glands, be the result of lymphatic absorption alone, but most, while conceding that lipemia may thus arise, believe that in fat embolism the fat usually enters the blood stream solely or principally through the open ends of veins. The condition may follow injuries of fatty tissue in any part of the body, but is most frequent after fractures of long bones, because of the abundant liquid fat in the medulla of these bones, because the injured osseous veins remain gaping, because of the great pressure exerted by extravasated blood and inflammatory exudate confined to a bony canal, and because of the motion to which a broken bone is subjected during transportation, diagnosis, and reduction. Next in etiologic frequency ranks the forcible bloodless correction of deformities, especially of the knee, during which the spongy epiphyses are violently compressed and perhaps crushed. Fat embolism is rare in infancy and old age, owing to the small quantity of adipose tissue in the medulla at these periods. As with air, it is probable that a large quantity of fat must be introduced into the circulation in a short time in order to produce serious symptoms; indeed, a small quantity of fat is normally present in the blood. The **symptoms** are similar to those produced by other forms of emboli. The fat is washed through the right heart to the lungs, where it fills the vessels, producing sudden death; or, if the quantity be smaller, severe pain, dyspnea, rapid pulse, hurried, shallow respirations, cyanosis, and sometimes hemoptysis. At the onset the temperature is apt to be subnormal, but later it ascends. The physical signs are at first indefinite; there may be a normal percussion note, restriction of the respiratory excursion, and coarse rales; if the patient survives, the later signs are those of consolidation. If the oil globules are forced through the pulmonary capillaries, there may be fat in the urine or total suppression of urine, and symptoms of embolism of the brain (convulsions, paralysis, coma, etc.). In the pulmonary form the symptoms may appear in from one to several hours after the trauma;

in the cerebral form the onset may be delayed for a day or two. This free interval serves, in differential diagnosis, to exclude shock and concussion of the brain, both of which immediately follow an injury. The relatively brief duration of the free interval distinguishes fat embolism from clot embolism, which is usually postponed for a week or longer after an operation or injury. In the cerebral form, however, this free interval has been misinterpreted, and the patient trephined for intracranial hemorrhage, a condition that may be recognized by the symptoms of compression of the brain.

In order to prevent fat embolism, injured fatty tissues should be kept at rest, and if there is much tension, the result of accumulation of wound fluids, stitches should be removed or incisions made. In dealing with ankylosis of large joints, particularly if the X-ray shows marked osseous atrophy, gradual correction or arthroplasty may be safer, at least so far as fat embolism is concerned, than forcible bloodless correction, which is particularly dangerous if several large joints are attacked at the same time. Reiner suggests that before removing the Esmarch band at the completion of an orthopedic operation, a cannula be introduced through the saphenous vein into the femoral vein, in order to allow any fat that may have entered the vein to escape. The **treatment** of the condition itself, in the acute cases, is external heat, cardiac stimulants, and artificial respiration. The wound should always be opened to prevent the fresh entrance of fat into the circulation. The later treatment is that of the complications. In a case of fat embolism following a fracture of the radius Wilms, who accepts the lymphatic theory of fat absorption, created a temporary fistula of the thoracic duct in the neck. The patient recovered.

THE HEART AND PERICARDIUM.

Overdistention of the heart with blood, the result of acute pulmonary affections, or with air from air embolism, has been treated by tapping the cavity of the heart. As the right auricle suffers most from this overdistention owing to the thinness of its walls, it is selected for puncture (*paracentesis auriculi*). The needle may be introduced in the third intercostal space at the right edge of the sternum and pushed directly backwards. It traverses the anterior edge of the right lung and the pericardium before reaching the auricle. The operation is attended with the danger of a fatal hemorrhage and should rarely, if ever, be performed.

Wounds of the heart may be produced by penetration from without, e.g., by gunshot or stab wounds, fractured ribs, or by foreign bodies from the esophagus, stomach, or bronchus. The heart may burst as the result of blunt force to the thorax or epigastrium, and it may rupture spontaneously (disease of the myocardium or coronary artery, neoplasms, gummata, echinococci, abscess, aneurysm, etc.).

Symptoms.—*Instantaneous death*, which probably results from injury to the nervous mechanism of the heart, is very rare, and more apt to follow a severe blow over the heart or epigastrium than a penetrating wound (so-called *concussion of the heart*). The symptoms in a case not immediately fatal are those of acute anemia or of compression of the heart, depending upon whether the blood escapes into the pleural cavity or externally, or upon its retention in the pericardium. Occasionally the patient may walk or even run for a considerable distance before falling to the ground. When the blood escapes into the pleural cavity (the pleura is injured in over 90 per cent. of the cases) there will be, in addition to the symptoms of *acute anemia* (see hemorrhage), the signs of a pneumo-hemo-thorax. Palpation may detect the apex beat. A whizzing sound due to the presence of air in the pericardium, a friction sound, or a bruit not unlike that heard over an aneurysm may be heard. If the blood escapes externally it may do so in jets, but a continuous stream accentuated by coughing, movements of the patient, and similar efforts, is more common. When the blood is confined to the pericardium the phenomena are those of *compression of the heart.* The pulse is slow, irregular and feeble, or absent, the apex beat imperceptible, the breathing hurried and superficial, the face cyanotic, the cervical veins dilated, and the patient unconscious, but the senses return on providing an exit for the blood. There may be a splashing sound disappearing with the filling of the pericardium, at which time the area of precordial dulness will be vastly increased (see pericardial effusion). *Death after several days or weeks* is usually the result of sepsis (pericarditis, empyema, pneumonia, etc.), although secondary hemorrhage is a possibility, and clot, but not air, embolism has been reported. *Spontaneous recovery* occurs in 1 per cent. of penetrating and nine per cent. of non-penetrating wounds. The wound is repaired by fibrous tissue, not muscle, hence the possibility of subsequent aneurysm, rupture, and of murmurs from alterations of the cardiac orifices. Pericardial adhesions probably always follow wounds of the pericardium, but cause symptoms in only a few of the cases.

The **diagnosis** is not always easy. The superficial wound may be in the abdomen or back and the general symptoms, at least in the beginning, slight. External bleeding may be profuse and spurting from an intercostal or internal mammary artery and absent in a wound of the heart. The only safe procedure in doubtful cases presenting a wound in the region of the heart is to enlarge the wound, ascertain if it penetrates the chest wall, and if there be symptoms of hemorrhage or "heart tamponage," to explore the pericardium and the heart.

The **treatment** is suture of the heart. An anesthetic should be employed unless the patient be unconscious. The heart may be exposed extrapleurally, but the pleura is usually wounded by the vulnerating instrument, and the patient's condition is not such as to sustain an operation protracted by a small opening in the chest wall and by the careful manipulations necessary to avoid the pleura. Collapse of the lung could be prevented by positive or negative pressure (see pneumothorax), but such has not yet been used in an operation for suturing the heart. An atypical osteoplastic flap with the base towards the sternum, either in the right or left chest according to indications, and including as many ribs as may be necessary for proper exposure, usually from two to four, will be indicated in most of the cases. The wound in the pericardium is enlarged and the bleeding from the heart controlled by a finger, by compression of the heart, by dislocating it forward, or by pressing it against the sternum. Rehn says the operation may be made bloodless by compressing the venæ cavæ, at their junction with the right auricle, between two fingers; in animals this procedure has been continued for ten minutes without permanent harm following. The sutures may be of silk or catgut, introduced by means of a curved, intestinal needle. A continuous suture may be applied more rapidly than an interrupted and presents fewer knots on the surface of the heart. The heart may be steadied by the fingers, by forceps, or by sling sutures. If the heart ceases to beat it should be sutured quickly and massage performed. After removing the blood from the pericardium and pleura, these cavities may be closed, or if thought advisable, drainage may be introduced. We have sutured the heart in five cases with three recoveries.

Massage of the heart, by compressing the ventricles between the thumb and fingers, 60 times to the minute, has been employed for suspended animation due to anesthetics, wounds of the heart, etc., the heart being exposed by thoracotomy, or manipulated through the diaphragm after opening the abdomen. The thoracic route should be selected only when a breach in the thoracic wall already exists, e.g., in operations on the heart and lungs; in all other instances the subdiaphragmatic method is easier and safer. Of fifty-three cases collected by Macquet eleven were successful. Cardiac massage may be performed also by making rhythmical pressure (60 per minute) over the third, fourth, and fifth costal cartilages on the left side. In all cases it is important to maintain the respirations and the bodily heat by artificial means.

Pericarditis is caused by contusions or wounds; infectious diseases, such as pyemia or septicemia, rheumatism, tuberculosis, and pneumonia; and by the extension of infectious processes in the neighborhood of the pericardium. The nature of the primary infection determines the character of the microorganism found. Primary pericarditis is very rare.

The **symptoms** are often masked by those of the primary illness and the condition is frequently overlooked. There are dyspnea, cough, fever, leukocytosis, small weak pulse, occasionally the pulsus paradoxus, frequently delirium, pain and tenderness over the heart, pain radiating down the left arm or into the epigastrium, and a friction sound, perhaps with fremitus, disappearing as the sac fills with effusion. In **pericardial effusion** the precordial dulness increases and becomes pear-shaped, the precordium bulges, the cardiac sounds become faint and distant, and there may be aphonia and dysphagia; the apex beat is above the lower boundary of dulness or is absent; dulness in the fifth right interspace close to the sternum (*Rotch's sign*) may be present; percussion reveals flatness with marked resistance; an area of dulness with bronchial breathing near the angle of the left scapula (*Bamberger's sign*) may be present, as may also *Ewart's sign*, in which the first rib is separated from the clavicle so that the former may be palpated its entire length. The effusion may sometimes be demonstrated with the X-ray. If the fluid becomes purulent, there may be intermittent fever and edema of the chest wall. Exploratory puncture will confirm the diagnosis. The most common conditions for which pericardial effusion is mistaken are dilatation of the heart, pleural effusions, and pneumonia. When the pain is referred to the abdomen, such conditions as appendicitis, perforation of the intestine, and acute gastritis, may be simulated.

The **treatment,** in the absence of effusion, is medical. *Serous effusion,* when excessive, demands aspiration. *Hemorrhagic effusion* (*hemopericardium*) arising immediately after a wound demands exploratory pericardotomy. At a later period tapping may suffice, although even then pericardotomy may be necessary to remove clots if the symptoms persist. Nontraumatic hemopericardium, excluding scurvy, is generally due to a fatal malady (e.g., rupture of the heart, bursting of an aneurysm, tuberculosis, cancer, Bright's disease), hence relief from tapping is only temporary. In *purulent effusion* (*pyopericardium, empyema of the pericardium*) pericardotomy is required. Puncture, as in pleural empyema, should not be used, except for diagnosis, or for palliation in cases too ill to stand pericardotomy.

Paracentesis Pericardii (tapping of the pericardium).—The diagnosis of pericardial effusion can be assured only by exploratory puncture, which should be made with an ordinary hypodermic syringe. Large trocars are dangerous. A fine needle may fail to evacuate thick pus, but it will rarely fail to obtain enough for diagnostic purposes. Although puncture of the heart with a fine needle is generally harmless, death may follow, either immediately from injury to the coördination center, or later from hemopericardium. The needle should be introduced in the fourth or fifth left interspace close to the edge of the sternum, so as to avoid the pleura and internal mammary artery (LeConte). If no fluid is withdrawn, it may be entered in the fifth intercostal space, two inches from the left border of the sternum. Never should the puncture be made at the spot where friction is heard, or where the heart sounds are very distinct. If the fluid is serous or sanguineous an aspirator should be connected with the needle; if pus is recovered pericardotomy is mandatory.

Pericardotomy (incision of the pericardium) without resection of a costal cartilage is indicated when the patient is unable to stand a general anesthetic. The tissues should be infiltrated with Schleich's fluid, and an incision made in the fourth or fifth intercostal space, beginning at a point one inch from the sternal border and extending to a point an inch within the nipple line. This avoids the internal mammary artery, which runs parallel with, and a half inch external to, the edge of the sternum, but may injure the pleura; the two layers of pleura, however, are frequently adherent at this point in pyopericarditis, and the wound will be of no consequence. The pericardium is incised and a rubber drainage tube inserted. When a general anesthetic is employed a portion of the fourth or fifth costal cartilage may be resected close to the sternum, ligating the internal mammary vessels if necessary. Roberts advises turning up a flap, consisting of the fourth and fifth costal cartilages, the soft tissues of the third interspace being used as a hinge. Irrigation with salt solution may be cautiously used for the removal of clots or masses of fibrin.

Cardiolysis is a resection of varying amounts of bony tissue (ribs and sternum) in order to unfetter a heart bound to the chest wall by chronic mediastinopericarditis, which manifests itself by dyspnea, ascites, and other symptoms of cardiac insufficiency, together with systolic retraction of the intercostal spaces, retraction of the lower lateral and lower posterior portions of the chest (*Broadbent's sign*), diastolic shock or rebound, absence of respiratory movements in the epigastrium, pulsus paradoxus (*Kussmaul's sign*), and diastolic collapse of the cervical veins (*Friedreich's sign*). In the few cases in which this operation has been performed the results have been gratifying.

THE VEINS.

Phlebitis, or inflammation of a vein, may be acute or chronic.

Acute phlebitis is caused by inflammatory affections in the neighborhood of a vein (periphlebitis), injuries, primary thrombosis (thrombophlebitis), varix, and by such constitutional affections as rheumatism, gout, and the infectious fevers. *Post-operative phlebitis* is sometimes due to infection, but most of the cases following aseptic operations are, we think, to be ascribed to non-bacterial changes in the blood and slowing of the circulation, because the operations most likely to be followed by thrombophlebitis are those involving varices, those on anemic patients, especially hysterectomy for bleeding fibromyoma, and those necessitating a prolonged stay in bed, e.g., abdominal section, and because, like thrombosis from other general conditions, the process is usually located in the left femoral and iliac veins, the reasons for which are given under thrombosis. Phlebitis of the lower extremity complicates 2 per cent. of all abdominal operations, 30 per cent. of these following hysterectomy, 15 per cent. oöphorectomy, 10 per cent. appendicitis, and 5 per cent. renal operations. Large emboli are detached in about 2 per cent. of the cases, and of these about one-third are fatal (see pulmonary embolism).

The **pathological changes** usually begin in the intima, because it is the first to yield in contusions and is directly exposed to toxins circulating in the blood. The endothelial cells degenerate and liberate fibrin ferment, and this with the concomitant roughening of the intima leads to thrombosis. The fate of the thrombus has been mentioned under thrombosis. The outer coats swell owing to the dilatation of the vasa vasorum and the subsequent exudation. The inflammatory exudate and the thrombus may be absorbed or organized (*exudative phlebitis*), or undergo suppuration (*suppurative phlebitis*). The former is responsible for the massive emboli which cause sudden death, the latter for the small septic emboli which cause metastatic abscesses (pyemia). Phlebitis may be sharply localized to a small segment of a vein, notably in varix of the leg, or it may involve most of the veins of an extremity, e.g., in phlegmasia alba dolens. If it begins in a small vein it spreads in the direction of the blood current, if in a large vein in both directions. Sometimes, however, it jumps from one segment to another, particularly in gouty phlebitis. Multiple patches of phlebitis in various parts of the body may occur also in rheumatism, chlorosis, and tuberculous or cancerous cachexia.

The **symptoms** are local and general. The *local symptoms* are (a) those of inflammation, viz., pain and tenderness along the vein, which may be felt as a firm cord when the vein is superficial, elevation of the local temperature and redness when the perivascular tissues are involved, and fluctuation in the event of suppuration, and (b) those of obstruction to the venous current, viz., edema and passive congestion in the region distal to the thrombus, and ultimately enlargement of the collateral veins. Other symptoms, referable to disturbance of special functions, arise when the visceral veins are affected. The *general symptoms* vary from a slight rise of temperature to the severer forms of septicemia. A progressive increase in the pulse rate, even without fever (Mahler's symptom), should make one suspect a beginning phlebitis. Embolism causes sudden death, pulmonary infarction (see pulmonary embolism), or, in the case of septic emboli, pyemia.

The **prophylaxis of post-operative phlebitis** includes careful preparatory treatment, especially of the heart and lungs if they are functionally impaired; asepsis, rigorous hemostasis, protection from cold, and avoidance of rough manipulations of the tissues during operation; and after operation attention to shock, the secretions, and the bowels, and allowing the patient to resume the regular diet and to sit up as early as possible. When a prolonged stay in bed is necessary centripetal massage, active movements of the arms and legs, and breathing exercises may be ordered. If conditions favorable for thrombosis exist, citric acid, 30 grains three times daily, may be given to lessen the coagulative tendency of the blood, or the milk may be decalcified by adding to each pint 30 grains of citrate of soda (Wright and Knapp).

The **treatment** of phlebitis itself is attention to any existing constitutional disease, absolute rest in the recumbent posture to lessen the force of the circulation and prevent the detachment of emboli, elevation of the part, and the application of cataplasma kaolini, lead-water and laudanum, or other evaporating lotion, or equal parts of ichthyol, belladonna, mercury, and lanolin, which should be laid on, not rubbed in, and held in place with a loose bandage. Tight bandaging, inunctions, and massage are dangerous. Sitting up is not absolutely safe until the clot has become organized or absorbed (six to eight weeks), when gentle passive motions and light frictions may be employed to hasten absorption of the edema. An elastic bandage should be worn for the same purpose. In suppurative phlebitis the vein should be excised, or, if this is not possible, incised and disinfected, and a ligature placed between the area of inflammation and the heart, in order to prevent pyemia; thus in thrombosis of the lateral sinus due to otitis media, the internal jugular vein should be tied in addition to the opening and disinfection of the sinus.

Chronic phlebitis, or phlebosclerosis, is a condition similar to arteriosclerosis. The vein walls are thickened as the result of acute inflammation, or of overdistention, e.g., in varicose veins or other forms of obstruction. Like arteriosclerosis it may be widespread as the result of such conditions as syphilis, gout, alcoholism, etc. The treatment is that of the cause.

Varix (varicose veins, phlebectasia) is an elongated, permanently dilated, tortuous vein with thickened walls. It is most frequent in the internal and external saphenous veins of the leg (Fig. 115), and it is with such that we shall deal at the present time, other manifestations of this abnormality, such as varicocele and hemorrhoids, being discussed in other sections of the book.

The **causes** of varix are, (1) *weakness of the walls* of the veins, either hereditary or acquired (phlebitis); (2) *retardation of the venous circulation*, e.g., by cardiac or pulmonary disease, prolonged standing, and obstructions, such as garters, tumors, pregnant or displaced uterus, etc.; (3) *compensatory dilatation*, such as occurs in the superficial veins of the leg when the deep veins are blocked; and (4) *an abnormal opening between an artery and vein*, such as occurs in aneurysmal varix. The condition is frequently present in youth, but usually gives no trouble until middle life is reached. Women are more liable to varix than men, owing to the influence of pregnancy.

Pathology.—The dilatation induces at first hypertrophy of the tunica media and finally chronic inflammatory changes with proliferation of the connective-tissue elements. The new tissue causes the vessel walls to thicken and elongate, and the elongation eventuates in tortuosity. Owing to the distention of the vein, and to the crippling of the valves by the sclerotic process, the latter structures become incompetent, and the walls of the vein must support a column of blood extending to the heart, and bear the brunt of every sudden increase in the intravenous blood pressure, e.g., by coughing, straining, etc. In old cases periphlebitis, causing the vein to adhere to the environing tissues, is always present, and the inflammatory changes may extend to the remaining structures of the leg. Lymphangitis seriously augments the edema, renders it firmer in character, and sometimes leads to enormous hyperplasia of the subcutaneous tissues (pseudo-elephantiasis). The arteries may suffer like the veins and even become thrombosed. The nerves and muscles may be attacked by interstitial inflammation, and the bones beneath ulcers may be the seat of osteoporosis or even caries.

FIG. 115.—Varicose veins of the lower extremities. The veins in the patient's left leg and thigh were inflamed and filled with clot (thrombophlebitis).

The skin is thickened, often pigmented owing to rupture of dilated vasa vasorum, and frequently reddened, eczematous, or ulcerated.

Symptoms.—Varices usually develop insidiously, although in acute obstructive lesions and in arteriovenous aneurysm they may arise quickly. Both legs are affected in 70 per cent. of the cases, the left alone in 20 per cent., and the right alone in 10 per cent. Even when bilateral, however, the affection is generally more pronounced on the left side, for the same reasons that venous thrombosis (q.v.) is more frequent on this side. In an uncomplicated case there may be pain in the leg and sole of the foot, heaviness of the limb, and edema, particularly after walking or standing, and sometimes muscular cramps. When varices begin in the deep veins, the usual point of origin according to some authors, these symptoms may be misinterpreted until the superficial veins dilate, when the condition is readily recognized. The veins are at first uniformly distended, but subsequently become fusiform in places or even sacculated. Valvular incompetence may be demonstrated by striking the upper part of the vein with a finger and palpating the fluctuation wave thus induced at a lower level, or by noting the impulse transmitted along the blood column when the patient coughs. Trendelenburg's test is as follows: After the patient lies down and elevates the limb, compression is applied to the upper part of the saphenous vein and the patient told to stand. If the vein slowly distends from below upward the valves are competent; if it remains empty and, after the compression is removed, suddenly fills from above downward the valves are incompetent and the circulation reversed. Chevrier says that if, in the Trendelenburg test, the varices fill slowly from below upward while compression is maintained on the upper part of the saphenous vein, the valves of the anastomotic branches between the superficial and deep veins are normal, but that if the varices distend quickly the same valves are incompetent; this is the deep, or ascending reflux, in contradistinction to the superficial, or descending reflux, of Trendelenburg.

Complications.—*Rupture* of a deep varix in the calf occurs under similar circumstances, gives the same symptoms, and requires the same treatment as rupture of the plantaris (q.v.). Rupture of a superficial varix may result from trauma, ulceration, or simply from coughing or straining; in the last instance usually where the vein is greatly thinned as the result of a saccular dilatation. The bleeding is more profuse than under normal conditions, because of the incompetent valves and the rigidity of the vein, which prevents its collapse; and when the circulation is reversed the hemorrhage is more copious from the upper end of the vein.

Thrombophlebitis, usually exudative and localized to a segment of the vein, is a frequent complication, owing to the sluggish circulation and the alterations in the walls of the vein, and one which may result in obliteration of the vessel and spontaneous recovery. Embolism is not as menacing as in a non-varicosed vein, thanks to the frequency of reversal of the circulation.

Ulceration, the type of which has been described on page 86, is the most frequent complication. It may follow the rupture of a superficial varix or a perivenous abscess, or start in a scratch, area of eczema, or minute spot of necrosis. The last is due to capillary thrombosis consequent upon the blood pressure in the veins equalizing that in the arteries.

Eczema and kindred dermatoses, *lymphangitis*, and inflammatory changes in the other tissues of the leg have been mentioned in the paragraph on pathology.

The **treatment** may be palliative or radical. *Palliative treatment* consists in removal of circular garters and all forms of dress which constrict the abdomen, gentle massage if the skin is healthy, attention to constipation and any existing cardiac or pulmonary affection, and the application of an elastic stocking or bandage. The bandage should be taken off at bedtime and the skin rubbed with alcohol; after the morning bath the limb should be powdered with stearate of zinc and the bandage reapplied.

The radical treatment, or operation, is followed by the best results in a unilateral circumscribed varicosity. In addition to these cases, operation is indicated when there are thin-walled diverticula which threaten to burst; when ulcers or eczema refuse to heal; when there is great pain; when thrombosis occurs; when portions of the varix are situated over the crest of the tibia, where as the result of injury they may rupture or become inflamed; and when the valves are incompetent as shown by the tests already described. Excluding the general condition of the patient, operation is contraindicated when the varicosity is compensatory to thrombosis of the deep veins, as this would lead to permanent edema. In many of these cases elastic compression also increases the circulatory difficulties. *Excision* of a circumscribed varix is performed by incising the skin, ligating the vein or veins above and below with catgut, and removing the varix. Total saphenectomy necessitates an incision extending from the saphenous opening to the ankle, or better, a succession of incisions, the vein being enucleated beneath the skin lying between the cuts. Instead of using the finger for enucleation Mayo threads the vein on a ring which is attached to a handle and pushed along the vein beneath the skin. Babcock employs a long pliable probe, with an acorn tip at each end, one larger than the other. After tying one extremity of the section of vein to be removed, the small end of the varix extractor is pushed along within the vein as far as possible, at which point the vein is exposed by an incision, clamped below the end of the probe, and opened, so that the probe may be drawn out. The other end of the venous segment is then tied beneath the larger acorn tip, which is cuffed to catch the vein, and the vein is extracted from beneath the skin by pulling on the smaller end of the probe. Marmourian passes a probe, eye first, through the vein between the cutaneous incisions, fixes the vein to eye of the probe with sutures, and extracts the vein, at the same time turning it outside in, by pulling on the probe. These ingenious methods for assisting saphenectomy are of the most value in the thigh; below the knee the veins are often so convoluted that an instrument cannot be passed along them, and, moreover, the varices are often so intimately adherent to the skin that subcutaneous enucleation is impossible and a section of the skin must be removed with the veins. *Trendelenburg* breaks the long column of blood which the veins of the leg must support by excising about four inches of the internal saphenous vein at the juncture of the middle and lower thirds of the thigh. The latest statistics for this operation (Goerlich) show that 79 per cent. were symptomatically cured or vastly improved, although the varicosities recurred in about half the cases. *Phelps* uses multiple ligatures (thirty or forty). *Schede* encircles the leg with an incision at the junction of the upper and middle thirds, ties all visible veins, and sutures the wound. *Friedel* makes a long spiral incision, encircling the leg a number of times, from the foot to the knee, and ties all of the exposed veins. *Cecca* aims to support the saphenous vein by suturing the deep fascia over it. *Katzenstein* sews the margins of the sartorius together over the vein, thus providing it with a muscular canal that, by its intermittent contractions, urges the blood along the vein. *Delbet* suggests, in cases of valvular insufficiency, ligating the internal saphenous 12 cm. below the saphenous opening and anastomosing the distal end with the femoral vein (end-to-side), thus permitting the blood to flow into the femoral below competent valves, of which there is always at least one pair between the original and the new site of anastomosis.

The *choice of operation*, in small varices, is excision of the varix. When the veins are extensively involved the patient should be ordered to wear an elastic bandage or stocking for several days; if this increases the trouble there is probably thrombosis of the deeper veins and operation is contraindicated, unless the veins are enormous, in which event it might be advisable to support the vessels by the Cecca or the Katzenstein operation. If the varix is not compensatory and there is a descending without an ascending reflux the Trendelenburg operation may be performed; in all other cases it is contraindicated. If there is only an ascending reflux, circumscribed excision of the varices, which necessitates ligation of the deep anastomotic branches, is the best operation. If there is both a descending and an ascending reflux the only procedure of value is total saphenectomy, which, of course, is effective also when there is only a descending or only an ascending reflux, but which, because of its magnitude, should be reserved for the cases in which the less extensive operations are impotent.

Venesection (phlebotomy), or the opening of a vein to abstract blood, has two principal indications, (1) to relieve overdistention of the right heart from any cause, and (2) to diminish the amount of toxins in the body in conditions like uremia. In the latter instance bleeding is generally followed by the intravenous injection of salt solution. The operation is usually performed at the bend of the elbow upon the median basilic vein, which is larger and more distinct than the median cephalic, but has the disadvantage of lying directly over the brachial artery, which may be wounded if the knife is thrust too deeply. A bandage is tied around the arm above the elbow, just tight enough to arrest the venous return without interfering with the arterial supply. The patient grasps a bandage or makes a hard fist so as to press the blood from the muscles into the superficial veins. The vein is steadied with the left hand, and opened with the right hand by an oblique incision. The blood is collected in a graduated receptacle until a sufficient quantity has been withdrawn, when a finger is placed over the bleeding point, the bandage above the elbow removed, and a sterile gauze pad bandaged over the wound.

Transfusion of blood has proved of value in acute hemorrhage and shock and in pathological hemorrhage, but in blood diseases and toxemias it seems of little use. In other words, transplanted blood constitutes a fluid for the heart and the arteries to act upon, and is an efficient hemostatic, but that it has a hematopoietic, antibacterial, or antitoxic effect is very doubtful; the nourishment it contains should be temporarily beneficent. Before transfusion the donor's blood should be subjected to the Wasserman test for syphilis, and as there is some danger of hemolysis and agglutination the effect of the donor's blood upon that of the recipient should be studied. If, owing to lack of facilities or time, these tests cannot be made, intravenous infusion of salt solution should be employed. Transfusion may, of course, be performed later if such seems to be indicated. There are two methods, the *direct*, or *immediate*, in which the blood is conveyed directly from the vessels of one individual into those of another, and the *indirect*, or *mediate*, in which the blood of one individual is first drawn into a receptacle before it is injected into the vessels of the second individual.

Direct transfusion may be performed by anastomosing the radial artery of one individual with any convenient superficial vein of another. Under local anesthesia both artery and vein are exposed, tied below, and secured with an arterial clamp above. Each is then cut above the ligature and the adventitia of the central end pulled down and snipped off with scissors. The vessels may then be united by the Carrel method. Crile uses a little tube which has two grooves in its outer surface. The central end of the vein is pulled through the tube, turned back over it like a cuff, and held in place by a ligature which is tied in the second groove. The artery is next drawn over the everted vein and secured by a ligature in the first groove. The clamps are then removed and the anastomosis covered with a hot moist sponge, to relax the artery. The time the blood is allowed to flow depends upon the effects noted, but is usually from 20 to 40 minutes. In order to prevent acute dilatation of the heart, which sometimes follows the rapid introduction of a large quantity of blood into the circulation, Dorrance and Ginsburg suggest vein-to-vein instead of artery-to-vein transfusion. As the veins are larger than the arteries, venovenous is much easier to perform than arteriovenous anastomosis, but, owing to the composition of venous blood, the chances of thrombosis are probably greater.

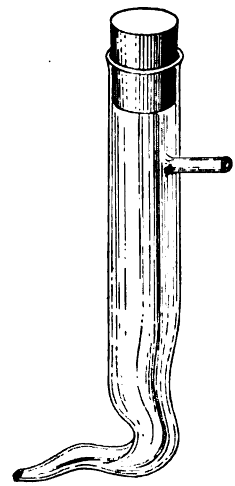

FIG. 116.—The glass cylinder, of whatever capacity desired, is closed above by a cork. Below the upper end is a side tube. The lower end is fashioned into a cannula.

In performing *indirect transfusion* Kimpton uses a number of glass cylinders (Fig. 116), the inner surface of which is coated with stearin, paraffin, and vaselin, in the proportion of 1–2–2, after the cylinders have been heated over a Bunsen burner and the paraffin mixture liquefied by placing the jar in which it is kept in a basin of hot water. A prominent vein is exposed at the bend of the elbow of the donor and donee, and two ligatures placed under each vein. A tourniquet is drawn around the donor's arm just tight enough to produce congestion, and the proximal ligature tied. The distal ligature, untied, serves, when drawn upon, to close the vein. A slit is made in the donor's vein between the ligatures, and the cannula inserted toward the hand. In the course of two or three minutes the cylinder is full of blood, during which time the vein of the recipient is tied distally, and opened, the proximal ligature being employed in the same manner as the distal ligature on the vein of the donor. The cannula of the full cylinder is now inserted into the vein of the recipient, care being taken during the transference to place the thumb over the side tube, and to keep the side tube uppermost and on the same level as the cannula. The cylinder is held upright and, with the aid of a rubber bulb which is attached to the side tube, emptied. The cannula is withdrawn while still filled with blood. As many cylinders as may be needed are filled and emptied, using the same veins. Weil aspirates blood from a vein and mixes it, in order to prevent clotting, with a 10 per cent. watery solution of sodium citrate, in the proportion of 1 cc. of the solution to 10 cc. of blood. He has injected from 10 to 350 cc. of this citrated blood, sometimes fresh, and sometimes several days old. Hirudin also has been employed to prevent the clotting of blood. In addition to clot embolism, hemolysis, agglutination, and acute dilatation of the heart, the possible dangers of transfusion are infection from faulty technic, a danger common to all operations; recurrent bleeding, if the transfusion is performed for post-hemorrhagic anemia and the source of the bleeding has not been controlled; and transmission of disease from one individual to another, which can be avoided, at least in one direction, by selecting a healthy donor. Occasionally, after transfusion the patient has a chill, followed by fever, urticaria, erythema, or a similar eruption.

Intravenous infusion of salt solution, the preparation of which is given under technic, finds its chief indication after severe hemorrhages, but is used also in shock, in toxemic conditions, after venesection, in order to "wash the blood," and as a diuretic when little or no urine is being secreted. The infusion apparatus consists of a graduated reservoir connected with a blunt beveled cannula by means of a rubber tube. In an emergency a fountain syringe or an ordinary funnel and an aspirating needle may be employed. The entire apparatus should be sterilized by boiling, or if sterilized by chemical means, all traces of the antiseptic should be removed by flushing with normal salt solution before use. The fluid may be injected into any vein of sufficient calibre, but the median basilic or the internal saphenous is usually the most convenient. A bandage is tied around the limb in order to make the veins prominent, and the vein exposed by an incision and two ligatures of catgut passed beneath it. One ligature is pulled into the lower angle of the wound and tied. The vein is then opened by a transverse incision, and the cannula inserted after some of the solution has been allowed to flow through it in order to exclude air. The upper ligature should be tied about the cannula by the first half of a surgeon's knot, so that at the completion of the operation it may be tightened and secured by a second turn after the cannula has been withdrawn. The temperature of the fluid should be 110° F. in the reservoir, as it loses some heat before entering the vein. The amount injected will usually vary between one and two quarts, according to the results noted. If the cannula is in the vein, and the bandage around the limb has been removed, the fluid flows readily with the reservoir elevated several feet and no pumping apparatus is necessary. At the completion of the operation, the wound is sutured and a sterile dressing applied. Intravenous infusion may be accomplished also by plunging a fine hollow needle through the skin, directly into a vein that has been made prominent by compression. Kuettner suggests introducing oxygen with the salt solution. "A reservoir is filled with 1000 c.c. of salt solution, and oxygen allowed to flow in from a tank until 100 c.c. of the solution is displaced. The reservoir is then closed and shaken until the oxygen is absorbed by the solution." The dangers of intravenous infusion, excluding air embolism and infection, which can be prevented by proper technic, are hemolysis if the solution is hypotonic, salt poisoning if the solution is hypertonic (vide infra), poisoning from the products of dead organisms if stale water is used to make the solution, acute dilatation of the heart and edema of the lungs and brain if too much solution is introduced, and recurrence of bleeding if all wounded vessels have not been secured. The chill which sometimes follows intravenous infusion is apparently harmless.

Hypodermoclysis, or the subcutaneous injection of salt solution, and **enteroclysis,** in which the fluid is introduced into the rectum, may be used to substitute or supplement infusion when time is not an element of great importance. Hypodermoclysis is performed with the same precautions as intravenous infusion, by introducing an aspirator needle into the loose connective tissue of the buttock, back, abdomen, or axilla. The needle is connected with a reservoir by means of a rubber tube, and the reservoir held several feet above the point of insertion of the needle, so that the fluid is slowly forced into the tissues, forming a swelling which gradually subsides as the fluid is absorbed. If more than a pint is injected, the needle should be introduced in another situation; or, in order to save time, two needles, each connected with one limb of a Y-shaped tube may be employed. Occasionally suppuration or sloughing follows, particularly in septic cases. Enteroclysis must never be performed quickly, otherwise the fluid will be rejected. Eight fluid ounces may be given every three or four hours, in a slow trickle, so that from 20 to 30 minutes will be consumed during the injection; or the continuous method may be adopted, as described in the section on the treatment of peritonitis (Chap. XXVII). We prefer the intermittent plan, as it is less disgreeable to the patient, and use water, or peptonized milk or other fluid food, instead of salt solution. Salt solution when introduced in enormous quantities is not entirely free from danger. As much as 48 pints, which contains six ounces of salt, has been given in one day, and this is too much, especially in view of the case recently reported by Brooks, in which, after a simple appendectomy, death followed the injection of an enema containing 9 ounces of salt, a strong stock solution having been carelessly substituted by a nurse for the physiologic solution. A somewhat similar case is reported by Campbell: A mother ignorantly gave her child an enema containing a pound of salt, this was followed promptly by thirst, fever, purging convulsions, and death.

Contusions of veins may result in fissuring of the intima and thrombophlebitis, particularly if the vein is diseased, as in varix. The symptoms and treatment of thrombosis from injury are those of phlebitis. Sloughing of the vein and secondary hemorrhage are most frequent after infected gunshot wounds.

Wounds of veins are classified like wounds of arteries. The symptoms and treatment are given in the section on hemorrhage. The dangers are severe or fatal primary hemorrhage, air embolism, clot embolism (which if septic will lead to pyemia), phlebitis, edema, gangrene, and secondary hemorrhage.

Free venous transplantation (usually the internal saphenous or the external jugular) has been employed 13 times to replace a segment of an artery (popliteal, femoral, external iliac, axillary, brachial) removed for aneurysm or tumor, with eight successful results, and once with success to reestablish the continuity of a vein (Moure). Segments of a vein have been used also to drain the lateral ventricle in hydrocephalus, and the peritoneal cavity in ascites, to act as a conduit between the ends of a severed nerve, to prevent adhesions after neurorrhaphy and tenorrhaphy, to reinforce the suture line after urethrorrhaphy. Attempts to restore the urethra, the ureter, and the common bile duct by a free venous graft have failed, although the urethra and Steno's duct (q.v.) have been repaired by a pedunculated venous graft.

THE ARTERIES.

Arteritis, or inflammation of an artery, may be *acute* or *chronic*. Anatomically, it may be divided into periarteritis, mesarteritis, and endarteritis, but as all three coats are usually more or less affected at the same time, this classification is of little value.

Acute arteritis may be suppurative (necrotic) or productive (plastic). **Acute suppurative arteritis** results from suppurative lesions in the neighboring tissues, or from an infected embolus. In the smaller vessels the process usually leads to thrombosis, in the larger arteries the walls may give way and serious hemorrhage result. Secondary hemorrhage is practically always due to this cause. An acute infectious endarteritis resembling malignant endocarditis, with which it is usually associated, has been described. **Acute productive, or plastic arteritis,** occurs as the result of injury or the lodgment of an embolus, in the absence of infection. It is nature's method of closing vessels after ligation, torsion, and wounds. The vasa vasorum dilate, exudation occurs, the intima proliferates, and the clot becomes organized, the new connective tissue obliterating the lumen of the vessel (see arrest of hemorrhage). Acute arteritis, manifested by pain, tenderness, and occasionally redness and swelling along the course of an artery, particularly of the lower limb, occasionally occurs during the course of, or just subsequent to, the infectious fevers. In these cases thrombosis and gangrene may develop. The **treatment** of acute arteritis occurring in the course of infectious fevers is that of phlebitis. The treatment of threatened gangrene from arteriothrombosis has already been discussed. Acute suppurative arteritis is seldom suspected until the occurrence of secondary hemorrhage.

Chronic arteritis (*arteriosclerosis*, *chronic endarteritis*, *atheroma*) is a chronic inflammatory and degenerative process of the arterial walls. The disease may involve the capillaries as well as the arteries (*arteriocapillary fibrosis*) and may invade even the veins (*angiosclerosis*).

The **causes** of arteriosclerosis are old age, and chronic intoxications, among which may be mentioned syphilis, gout, alcoholism, lead poisoning, nephritis, rheumatism, and diabetes. The increased blood pressure incident to habitual overeating and muscular overwork is said to be of etiologic importance and the disease is sometimes found after acute infections, such as scarlet fever, typhoid fever. and influenza.

Arteriosclerosis may be *circumscribed* or *diffuse*. In the former, commonly seen in the large vessels, particularly the aorta, the deeper layers of the intima proliferate and give rise to more or less nodular patches, which may become fibrous, calcified (*atheromatous plate*), or fatty; in the last event a cheesy mass may be formed (*atheromatous abscess*), which on discharging leaves a necrotic patch (*atheromatous ulcer*). The middle coat of the artery is invaded by the disease and the outer coat is thickened. *Diffuse arteriosclerosis* more commonly attacks the small vessels. The entire arterial wall becomes thickened, and the internal coat undergoes fatty degeneration (*atheroma*) and may subsequently become calcified.

Arteriosclerosis is recognized by increased arterial tension, hypertrophy of the heart, accentuation of the aortic second sound, and by feeling the superficial arteries, which are found to be thickened, rigid, or even calcified. Calcareous arteries can be demonstrated by the X-ray.

Although the treatment belongs to the physician, the **surgical relations of arteriosclerosis** should not be overlooked. Chronic arteritis results (1) in dilatation or rupture when the degenerative changes in the musculo-elastic median coat predominate; (2) in narrowing or obliteration when the proliferation of the subendothelial layer is in excess (*endarteritis obliterans*); or (3) simply in loss of elasticity, without alteration of the lumen, when these changes are equalized.

1. Aneurysm is most frequently due to syphilitic arteritis. *Syphilitic arteritis* attacks a series of vessels, a single vessel, or a segment of a vessel, and is sometimes bilateral; the middle coat is most affected, being invaded with round cells, and its fibres degenerated, atrophied, or fragmented; rupture may follow, as in apoplexy, or, if only the middle coat gives way, a scar results, which may subsequently yield and form an aneurysm; the latter applies particularly to large arteries; the tendency in small vessels is towards obliteration.. The possibility of arterial rupture should be kept in mind when attempts are made to reduce an old dislocation or to straighten a contracted joint, in an individual with atheroma.

2. Narrowing of the arteries may be responsible for many nutritional disturbances, among which may be mentioned, as of surgical interest, neuralgia, pancreatitis, gastric and intestinal ulceration, arteriosclerotic colic, intermittent claudication, and gangrene. Arteriosclerotic colic may simulate gallstones, appendicitis, and other abdominal affections. In advanced arteriosclerosis wounds are often slow in healing, and in these cases only urgent operations should be performed. Even a trivial operation on the toe may inaugurate gangrene, and after enterorrhaphy necrosis of the margins of the incision and fecal fistula are of frequent occurrence. Primary hemorrhage from a narrowed artery is comparatively slight, but, owing to the danger of cutting through of the ligature, secondary hemorrhage is relatively frequent. Diseased arteries are predisposed to thrombosis from injury, hence the danger of the Esmarch band, of Bier's treatment, and of tight bandages in those with arteriosclerosis.

3. Loss of elasticity in collateral arteries accounts for many of the bad results after ligation, thrombosis, and the impaction of an embolus. Diseased arteries may supply a part with adequate nourishment when it is at rest but fail to dilate in response to increased activity, thus lack of elasticity in the cerebral vessels may cause transient paralysis, in the cardiac vessels angina pectoris, in the abdominal vessels arteriosclerotic colic, and in the arteries of the leg intermittent claudication. The last manifests itself as attacks of pain and weakness, especially in the calf, and is a prodromal symptom of gangrene.

Injuries of arteries may be contusions or wounds.

Contusion of an artery varies in its results according to the violence of the injury and the state of the arterial walls. Normal arteries, owing to their elasticity, are not often seriously affected by a contusion unless it be of the severest grade. In atheromatous arteries a slight contusion may be followed by rupture of the inner coats and thrombosis, the detachment of an atheromatous plate, sloughing and hemorrhage, or aneurysm; if the artery be the main vessel of an extremity gangrene may ensue. The *treatment* of a contused artery consists in absolute rest, and preparations for the immediate control of hemorrhage should it occur. In the event of thrombosis prophylactic measures against gangrene should be taken. The treatment of thrombotic gangrene is given in Chap. IX.

Wounds of arteries may be incised, punctured, gunshot, or lacerated. Ruptures of arteries also come under this heading. **An incised wound** is followed by profuse hemorrhage, which is more severe in transverse than in longitudinal and oblique wounds. **Punctured wounds** produced by very fine instruments, such as an intestinal needle, cause but little hemorrhage, which is easily and permanently controlled by pressure applied for a short time. If the opening is of larger size the bleeding is copious and may exsanguinate the patient, or if the wound in the skin is closed by suture, clot, or dressing, a diffuse traumatic aneurysm may develop. **Gunshot injuries** are usually contusions (see above) or lacerations. The modern bullet may, however, produce a clean-cut wound and an alarming or fatal hemorrhage. **A lacerated wound** involving the entire circumference of an artery is usually followed by slight hemorrhage, owing to the curling up of the internal coat, the contraction of the middle coat, and the prolapse of the stretched external coat over the end of the artery. Secondary hemorrhage, however, is likely to occur unless the vessel is permanently secured by a ligature. Partial lacerations do not permit retraction and contraction, hence spontaneous hemostasis is uncommon. **Rupture** may follow severe injuries or strains, particularly in the presence of atheroma, and the surgeon should always have this injury in mind when reducing an old dislocation, when forcibly straightening a contracted joint, or when giving ether to an aged individual. *Partial rupture*, i.e., of the middle and inner coats, may be regarded as a contusion (p. 205). *Complete rupture* results in a lacerated wound. Unless the blood escapes through an external wound or into one of the large cavities of the body, a *diffuse traumatic aneurysm* (*false traumatic aueurysm, arterial hematoma*) develops, the *symptoms* of which differ somewhat from those of a true aneurysm, owing to the fact that the effused blood forms a soft clot which is constantly enlarged by the leaking artery. There is sudden and acute pain, followed by rapid swelling and, after a time, by ecchymosis of the skin. The size of the swelling is enormous when, as in the axilla, the tissues are lax, and small when growth is restrained by dense fascia, e.g., in the palm and at the bend of the elbow. It is tense, seldom fluctuates, cannot be reduced by pressure, and owing to the absence of a distinct wall is more irregular and not as sharply defined as a true aneurysm. Pulsation is usually present, thrill and bruit often absent, but these signs depend upon the size of the opening in the artery. Even when the wound does not involve the entire circumference of the artery, the pulse below may be absent as the result of pressure from the effused blood, and this leads to coldness, numbness, pallor, and partial paralysis of the limb. The constitutional symptoms, which are those of hemorrhage, vary with the amount of blood extravasated. The swelling may rupture, resulting in immediate death; suppurate with the same result; persist as an aneurysm; cause gangrene by pressure on the vessels of the limb; or the blood may coagulate, the opening in the vessel heal, and the clot be absorbed or organized.

The **treatment** of wounds of arteries is that of hemorrhage; ruptures are dealt with in the same way as open wounds, after making an incision to expose the source of bleeding.

Arterial varix corresponds to a varicose vein, a single artery is dilated, elongated, thickened, and tortuous. When a number of adjacent arteries are similarly affected, the condition is called cirsoid aneurysm. **Cirsoid aneurysm** (*plexiform angioma, racemose aneurysm, aneurysm by anastomosis*) is most frequently found in the scalp, and less commonly in the extremities, labia pudendi, and spermatic cord. Some cases develop from a preëxisting angioma, some after trauma, and some spontaneously. It can be mistaken for no other condition, as the pulsating varicose arteries are readily seen and felt. Thrill and bruit are often present, and pressure on the main feeding artery materially reduces the size of the mass and the force of the pulsation. The skin is usually thinned and sometimes ulcerates, giving rise to alarming hemorrhage. Excision is the best *treatment*, but is often impracticable. Among other methods which have been tried are ligation or compression of the main artery or arteries of supply, galvano-cauterization, electrolysis, the X-rays, and the injection of coagulating fluids. When affecting the hand amputation may be required.

Aneurysm is a hollow tumor containing blood and communicating with the lumen of an artery. Excluding the cirsoid variety, which has just been described and which is really a form of arterial varix, aneurysms are divided primarily into the *simple, or arterial*, and the *arteriovenous*. When referring to the former, however, it is customary to employ the term aneurysm without a qualifying adjective.

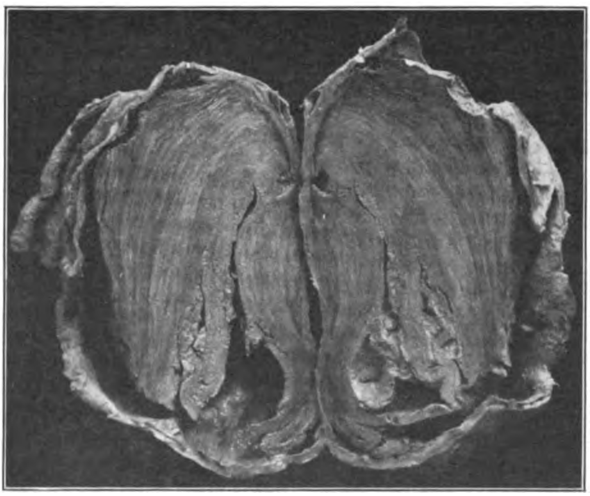

FIG. 117.—Thoracic aneurysm showing laminated clot. (Pennsylvania Hospital.)

The **parts of an aneurysm** are, (1) the sac wall, (2) the contents, and (3) the mouth. 1. The *sac wall* is composed of one or more of the arterial coats (*true aneurysm*) or of condensed perivascular tissues (*false aneurysm*). As a matter of fact, the walls of any aneurysm of large size consist, not of the walls of the vessel, but of fibrous tissue, and even a false aneurysm which has existed for any length of time may be lined by a structure identical with the intima. 2. The *contents* vary according to the size, character, and duration of the aneurysm. At first the contents is fluid blood only. As the aneurysm enlarges, however, and becomes more and more sacculated, particularly if the mouth remains small or is so located as to protect the walls from the full force of the circulation, the blood is thrown into eddies, and this leads to the separation of fibrin, which is deposited on the interior of the sac in concentric layers (Fig. 117), the outer and older layers being dry and light in color, the inner and younger soft and red. Spontaneous cure may be effected in this way. 3. The *mouth* of the sac is the portal through which the blood enters the aneurysm; upon its size and situation depends to a large extent the rapidity with which the aneurysm enlarges.

According to whether the whole or only a portion of the circumference of an artery is involved an aneurysm is said to be fusiform (tubulated) or sacculated.

Fusiform, or tubulated aneurysm, is a dilatation and elongation of a section of an artery. It is most frequent in the cranium, the thorax, and the abdomen, and is always spontaneous in origin. Although the walls are seldom coated with layers of fibrin rupture is unusual, death generally being due to pressure upon the surrounding organs.

Sacculated aneurysm springs from the side of an artery, rarely from the side of a fusiform aneurysm. There are two forms, the *circumscribed,* in which the sac wall is distinct and complete, and the *diffuse,* in which the blood has extravasated into the surrounding tissues. The latter is said to be *primitive* when due to rupture of an artery (*vide supra*), *consecutive* when due to rupture of an aneurysm (*vide infra*).

According to **etiology** aneurysms are divided into the traumatic and the spontaneous.

Traumatic aneurysm may be true or false, but is always sacculated. *True traumatic aneurysm* may result from an arterial contusion which causes the inner coats to rupture, or from a wound of the outer coats, leading to a hernia of the intima (*hernial aneurysm*). *False traumatic aneurysm* follows a penetrating wound or a complete rupture of an artery (p. 206).

Spontaneous, or idiopathic aneurysms, may be congenital or acquired.

Congenital aneurysms are rare, and due to defective development of the elastic elements of the arteries, hence often multiple.

Acquired spontaneous aneurysms, although occasionally due to infective softening of the vessel walls from the impaction of an embolus (*embolic aneurysm*), to ulceration of the outer coats (*aneurysm by erosion*), or of all the coats (e.g., when an artery perforates into an abscess), are almost always the result of chronic arteritis combined with an increase in the blood pressure. As has already been pointed out, chronic arteritis, particularly the syphilitic variety, causes marked degenerative changes in the musculo-elastic tunica media, and this, especially in the early stages, before compensatory thickening of the intima occurs, leads to aneurysmal dilatation. In *dissecting aneurysm,* which is a rare form confined almost exclusively to the aorta, the blood makes its way through an atheromatous ulcer and dissects the outer from the inner half of the middle coat, forming a sort of sac, which may again open into the artery through another atheromatous ulcer, or rupture into the perivascular tissues. Increase in the blood pressure, the result of hypertrophy of the heart, strains, laborious occupations, and violent exercise, is an important factor when combined with disease of the arteries, hence the predisposition of the male sex (7 to 1), and of the fourth and fifth decades, during which arteriosclerosis frequently begins, but during which the bodily condition is such as to lead to overexertion.

The **symptoms** of aneurysm are, (1) those peculiar to the aneurysm itself and (2) those due to pressure. 1. The *symptoms peculiar to the aneurysm* itself are, the presence of a swelling in the line of an artery; movability of the tumor, in the absence of adhesions, transversely to but not in the axis of the artery; reducibility on direct pressure and fluctuation, but only in the early stages when the walls are thin and the contents is fluid; pulsation synchronous with each cardiac systole and expansile in character, i.e., in all directions, so that the palpating fingers are not only lifted but separated; cessation of pulsation, with shrinkage and softening of the tumor, when proximal pressure is made on the artery, distal pressure acting in a reverse manner; the presence over the sac and along the artery of a systolic bruit, which is usually loud and harsh; occasionally a thrill corresponding with the bruit; and retardation of the pulse below, due, not to pressure, but to the additional time consumed by the blood current in passing through the aneurysm, hence almost a pathognomonic sign. 2. The *pressure symptoms* are similar to those of other tumors. Pressure on the *artery* causes diminution in the size of the pulse distal to the tumor, hence enlargement of the collateral arteries; on the *veins* edema and distention of their superficial branches; on the *nerves* pain and possibly paralysis and trophic disorders; on the *muscles* displacement and atrophy; on the *bones* erosion, severe, constant, boring pains, and occasionally spontaneous fracture; on the *trachea* dyspnea; on the *esophagus* dysphagia; on the recurrent laryngeal nerve change in the voice and brassy cough; on the cervical sympathetic nerve dilatation of the pupil and widening of the palpebral fissure, and later contraction of the pupil and ptosis (Fig. 118); on the thoracic duct inanition; on the phrenic nerve hiccough.

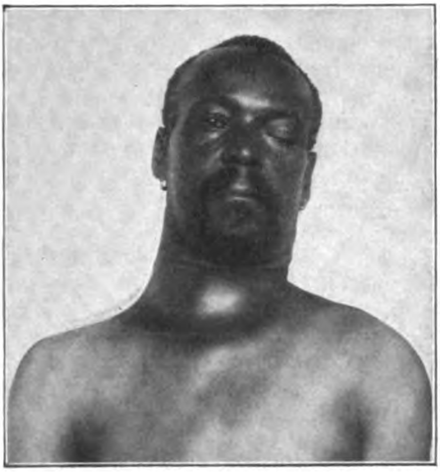

FIG. 118.—Aneurysm of the innominate artery treated by wiring and electrolysis. (Pennsylvania Hospital.) Note ptosis from pressure on the cervical sympathetic nerve.

The duration of aneurysm is usually a matter of some years, spontaneous recovery or death being the natural termination. *Spontaneous recovery* is rare. It may be due to obliteration of the sac with laminated fibrin; to suppression of the circulation within the sac, the result of the impaction of an embolus above or below the mouth, or the pressure of the aneurysm itself on the artery; or to inflammation of the sac. The aneurysm becomes solid, and is ultimately represented by a mass of fibrous tissue. *Death* is the result of rupture of the sac, pressure upon important structures, cerebral embolism, or sepsis from suppuration of the sac or gangrene of the parts nourished by the artery.

Rupture of an aneurysm is the result of stretching and thinning of the wall from intrasaccular tension, or of ulceration, suppuration, or gangrene of the sac. Rupture through the skin may be immediately fatal, or death may be deferred several days, the blood leaking from a small opening (*leaking aneurysm*), which is at times temporarily plugged by a clot. Rupture internally, into one of the cavities or hollow organs, causes sudden pain, symptoms of acute anemia, and death. If the aneurysm breaks into the esophagus or trachea blood will pour from the mouth. Rupture into the subcutaneous tissues is announced by severe pain, increase in the size of the swelling, indistinctness of its outline, diminution or disappearance of pulsation and bruit owing to coagulation of the blood, and cessation of the pulse below the swelling. Death from acute anemia follows, or if the surrounding tissues restrain the blood, a consecutive false aneurysm develops.

Inflammation of the sac, when mild in character, thickens the walls and encourages coagulation of the blood. In the severer form there is redness of the skin, pain, elevation of the local temperature, and edema, the last causing the aneurysm to become less distinct in outline. Suppuration or gangrene of the sac may follow.

Gangrene of the parts distal to the aneurysm may be caused by obliteration of the artery from the pressure of the aneurysm, from the pressure of extravasated blood when rupture occurs, from the impaction of an embolus derived from the aneurysm, or from thrombosis the result of inflammation.

The **diagnosis of aneurysm** may be difficult or even impossible, since pulsation and bruit may be absent in an aneurysm, and present in other tumors. Any swelling, whether pulsating or not, in the line of an artery must

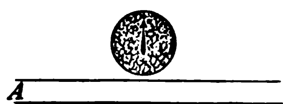

FIG. 119.—Transmitted pulsation. Tumor over artery (A). Arrow indicates direction of the pulsation.

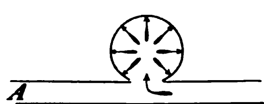

FIG. 120.—Expansile pulsation. Aneurysm springing from artery (A), from which it cannot be separated. Arrows indicate direction of the pulsation.

be carefully investigated for evidences of aneurysm. Perhaps the most frequent mistake is to take a non-pulsating inflamed aneurysm at the base of the neck for an abscess. A cyst, tumor, or abscess lying upon an artery may be lifted with each pulse beat, and cause a murmur by narrowing the artery, but the pulsation is not expansile, and it, with the murmur, ceases if the tumor can be lifted, or by posture made to fall away from the vessel (Figs. 119, 120). Compression of the artery above or below the tumor does not, as in aneurysm, affect the size and the consistency of the swelling, and after removing the proximal compression the first pulsation is of full strength, while in aneurysm it may take several pulse waves to distend the sac and make the pulsation as strong as it was before. Any tumor which presses on an artery may make the distal pulse smaller, but retardation is caused only by aneurysm, a sign which becomes more evident after temporarily compressing the artery above the swelling; in a non-aneurysmal tumor the pulse reappears at once, in an aneurysm several beats may be lost. The exploratory needle may sometimes be employed to determine the contents of the swelling. The X-ray shows a distinct shadow in aneurysm, the pulsation of which can be observed with the fluoroscope. Radiography is of particular value for the diagnosis of aneurysms in the cranium, the chest, and the abdomen. Angiomata and round-celled sarcomata may have expansile pulsation and bruit, but may not correspond to the line of an artery or affect the pulse below. Pressure on the artery proximal to the growth may cause it to shrink, but not so markedly as in aneurysm, and it may be more irregular, less distinct in outline, and more variable in consistency; a ruptured or an inflamed aneurysm also may be indistinct in outline. In sarcoma the superficial veins are dilated over and proximal to the growth, in an aneurysm causing pressure on the deep veins the superficial collaterals are most numerous distal to the swelling (Fig. 92), and the limb is edematous. The X-ray usually fails to demonstrate round-celled sarcoma, unless it has invaded osseous tissue. A cervical rib or a neoplasm under an artery may simulate an aneurysm, but only the artery, and not the growth which displaces it, pulsates. A cervical rib and certain forms of neoplasm may be shown by the X-ray. Aneurysmal pain has been mistaken for rheumatism, neuralgia, lumbago, etc.

The **treatment of aneurysm** may be medical or surgical.

Medical treatment aims to decrease the blood pressure and increase the coagulability of the blood. It is used as an auxiliary to surgical treatment, or when surgical treatment cannot be applied. *Tufnell's method* consists in absolute rest in bed for at least three months, and a daily diet of six ounces of bread, a little butter, three ounces of meat, and eight ounces of milk. Among the *drugs* recommended are iodid of potassium, especially in syphilitic cases, iron, acetate of lead, ergotin, aconite, veratrum viride, and calcium chlorid. Opium or the bromids are used for pain, purgatives to thicken the blood and prevent straining from constipation. Venesection has been employed when the blood pressure is very high. Eggs have been recommended to increase the coagulability of the blood. Lancereaux reports good results from the hypodermatic injection of a 1 or 2 per cent. solution of gelatin in normal salt solution; about 200 cc. are injected beneath the skin of the thigh every ten days, until from ten to thirty injections have been given. As twenty-three deaths from tetanus have followed this method of treatment (Dieulafoy), the gelatin should be thoroughly sterilized, or, better, since its coagulative effects are not destroyed by digestion, administered by mouth. Gelatin is said to be irritating to the kidneys, hence is contraindicated in the presence of renal disease. Many surgeons doubt the efficacy of this treatment.

The **surgical treatment** consists of (1) compression of the artery or the aneurysm; (2) the temporary or permanent introduction of foreign bodies; or (3) operative treatment.

1. **Compression** *of the sac* itself by bandages, or by flexion of the limb, e.g., in aneurysms at the bend of the elbow or knee, and *massage of the sac*, with the idea of occluding the artery with a fragment of the clot, are ancient methods which are apt to be followed by rupture or suppuration of the sac, or gangrene of the limb. *Reid's method* of rapid cure by compression aims to retain the blood in the sac until it coagulates. The patient is anesthetized, and an elastic bandage applied from the extremity to the root of the limb, excluding the aneurysm, which should be full of blood. A tourniquet is then applied above the band, and allowed to remain for an hour and a half, after which it is gradually loosened, so as to prevent a sudden gush of blood, which might wash away the clot. This method is occasionally successful, but is often followed by gangrene. *Pressure on the artery feeding the aneurysm* may be made by the thumb (*digital pressure*), a method which requires relays of assistants, or by means of tourniquets or compressors (*instrumental compression*), the pressure being continuous or intermittent. The skin should be protected with a piece of chamois and by shifting the point of pressure, and the main vein and nerves avoided. Although some assert that it is not essential to obliterate the pulse, complete suppression of the circulation through the sac gives the best results. In the *intermittent method* pressure is made for a

number of hours each day, but the patient allowed to sleep at night. In the *continuous method* pressure is sometimes maintained for two or three days, but if coagulation, which reveals itself by absence of pulsation and hardening of the aneurysm, does not occur within thirty-six hours the method should be abandoned. As the pressure is agonizing to the patient narcotics are required. Pressure upon the artery distal to the aneurysm may be employed as an aid to proximal pressure, or in cases, such as aneurysm of the root of the carotid, in which proximal pressure cannot be applied. Intermittent pressure is useful in dilating the collaterals before the application of a ligature, thus preventing gangrene. The treatment of aneurysm by proximal pressure is successful in about 50 per cent. of the cases and is attended by little danger, but is tedious, extremely painful, and is rapidly being displaced by the operative methods.

2. **The introduction of foreign bodies into the sac** should be performed only in inoperable cases. *Acupuncture* consists in the introduction of fine needles in such a way that they will cross one another and whip the fibrin from the blood; they are withdrawn after several days. *Macewen's method* consists in the introduction of a long needle, with which the whole lining membrane of the sac is scratched, the idea being to excite a mild inflammation which will cause the walls to thicken and the blood to coagulate. *Moore's method* consists in the introduction of a number of yards of coiled steel wire through a cannula; the wire assumes a spiral shape in the sac, and is allowed to remain permanently. Silk, horse-hair, catgut, and other materials have been used in a similar way. *Electrolysis* may be employed by introducing two needles which are insulated where they come in contact with the tissues. The points of the needles are slightly separated, and a constant current of from 5 to 6 milliampères passed through the sac for from one-half to two hours. A combination of the last two methods (*Moore-Corradi method*) has proven of some value in sacculated aneurysms of the aorta. The author has obtained marked and lasting improvement in one case, and one case has been reported in which cure apparently occurred. From five to fifteen feet of drawn gold wire, according to the size of the sac, is introduced through a gold cannula insulated with porcelain, and connected with the positive pole of a galvanic battery, the negative pole being applied to the abdomen or back. The current is gradually increased, often to 80 milliampères, and as gradually decreased to zero, from forty-five minutes to one and one-half hours being consumed in the process; the cannula is then withdrawn, and the wire cut off close to the skin, beneath which it is buried. The method is not without danger. *Coagulating injections*, such as Monsel's solution, acetate of lead, and tannin, have been employed while pressure is made upon the artery on both sides of the aneurysm. The method is not recommended in aneurysms of the extremities, which are better treated by operative measures, and in other cases it may be followed by very serious results owing to the dislodgment of emboli.

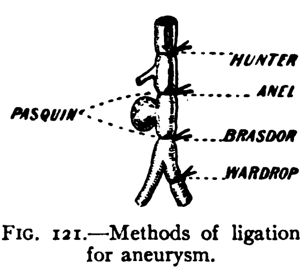

FIG. 121.—Methods of ligation for aneurysm.

3. **Operative treatment** includes ligation, incision, endoaneurysmorrhaphy, extirpation, arterial anastomosis, venous transplantation, and amputation.

Ligation may be performed in one of five ways (Fig. 121). *Anel's method* is ligation immediately above the sac. *Hunter's operation* is ligation above but some distance away from the sac, so that anastomotic branches will exist between the ligature and the aneurysm; thus the blood supply to the sac is not completely cut off, but is greatly diminished, allowing contraction and gradual consolidation. Although most surgeons prefer the Hunter to the Anel operation, we believe the former increases the danger of recurrence if the anastomotic branches between the ligature and the aneurysm remain pervious, and the danger of gangrene of the limb if these branches suffer obliteration. The objection that the artery is more diseased near the aneurysm is not a valid one, as the degenerative changes are often more marked in the segment which would be ligated in the high operation. Proximal ligation is contraindicated when serious disease of the heart or a coexisting internal aneurysm is present, because of the sudden rise of blood pressure that follows ligation of a large artery; when compression of the feeding artery does not materially diminish the pulsation; when the arteries are extensively diseased; when inflammation is present; when gangrene of the limb is threatened; and when the bone is deeply eroded. The accidents which may follow are secondary hemorrhage, suppuration and rupture of the sac, gangrene of the limb, and secondary aneurysm at the point of ligation. Return of pulsation in the sac is observed in the majority of cases after a day or two, owing to the establishment of a collateral circulation; in favorable cases as the sac contracts this diminishes and finally disappears. Pulsation beginning a number of days after operation generally means recurrence of the aneurysm. *Pesquin's method*, or ligation above and below the sac, is indicated only in cases which are better treated by extirpation. *Brasdor's operation*, or ligation of the artery distal to the sac, is employed only in cases in which a proximal ligature cannot be applied, e.g., aneurysm of the root of the carotid. *Wardrop's operation* is ligation of one of the branches of the artery distal to the sac, e.g., ligation of the subclavian in aneurysm of the innominate.

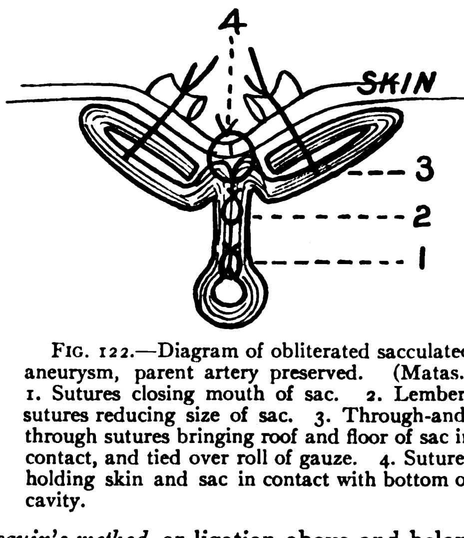

FIG. 122.—Diagram of obliterated sacculated aneurysm, parent artery preserved. (Matas.) 1. Sutures closing mouth of sac. 2. Lembert sutures reducing size of sac. 3. Through-and-through sutures bringing roof and floor of sac in contact, and tied over roll of gauze. 4. Sutures holding skin and sac in contact with bottom of cavity.

Incision of the sac (method of Antyllus), after ligating the artery immediately above and below, is indicated in the presence of suppuration. The sac is cleared of its contents, packed with gauze, and allowed to granulate.

Endoaneurysmorrhaphy (*Matas operation*) will probably be the operation of the future in all cases in which the circulation through the sac can be provisionally controlled. The circulation is arrested by means of a tourniquet or, when this is impracticable, by exposure and compression of the main artery on each side of the aneursym. The sac is then opened and emptied, and, according to the character of the aneurysm, an obliterative, restorative, or reconstructive operation performed. In the *abliterative operation*, which is indicated in a fusiform aneurysm, the orifices of the sac, and of any collateral arteries which may open into the aneurysm, are sutured with chromicized catgut, but the continuity of the artery is not restored. In the *restorative operation*, which is applicable only to a small mouthed saccular aneurysm, the mouth of the sac is sutured without impinging on the lumen of the vessel, thus curing the aneurysm without cutting off the circulation of the limb. In either case the walls of the sac with the overlying skin are inverted and so sutured as to obliterate the sac (Fig. 122). Matas suggests that in certain fusiform aneurysms it may be possible to *reconstruct* the arterial channel by suturing two folds of the sac over a rubber catheter, in a manner similar to the formation of the canal in the Witzel gastrostomy. The catheter is removed before the last sutures are tied. Even in cases in which the circulation through the main artery is stopped, gangrene is less likely to follow than after other methods of operation, because the collateral circulation is practically undisturbed. The state of the collateral circulation may be determined before any of the operations mentioned above by the Matas method (see indications for amputation, Chap. XXXI).

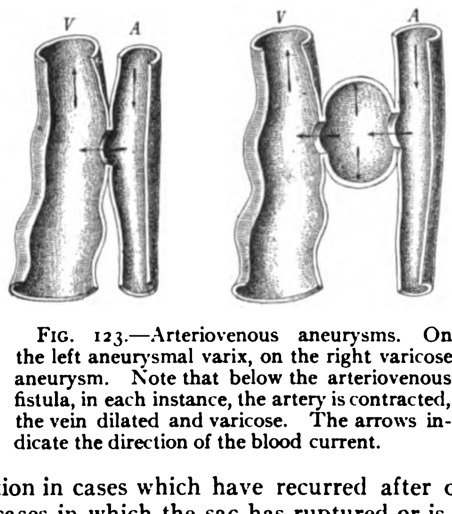

FIG. 123.—Arteriovenous aneurysms. On the left aneurysmal varix, on the right varicose aneurysm. Note that below the arteriovenous fistula, in each instance, the artery is contracted, the vein dilated and varicose. The arrows indicate the direction of the blood current.

Extirpation of the sac, after ligation of the artery above and below, is followed by permanent cure, but in a large aneurysm is a formidable operation which may seriously interfere with the collateral circulation and be followed by gangrene. It is the best operation for aneurysm of a small artery, e.g., the radial, and may be tried previous to amputation in cases which have recurred after other methods of treatment, or in cases in which the sac has ruptured or is inflamed and suppurating.

End-to-end anastomosis of the artery, after excising the sac, is indicated in small traumatic aneurysms, but in the spontaneous variety is less apt to succeed, because of the diseased state of the artery. Of nine operations of this character eight were successful (Abalos).

Venous transplantation has been performed in eleven cases in which, after excision of the sac, the interval between the ends of the artery was too great to permit end-to-end anastomosis. Six of the patients recovered. The internal saphenous or the external jugular is the best vein from which to take the transplant.

Amputation of the limb is indicated in gangrene, in marked erosion or dissolution of a joint, in some cases of rupture, suppuration, or secondary hemorrhage, and in a rapidly growing aneurysm which has resisted other means of treatment. Amputation of the arm has been performed to lessen the quantity of blood flowing through a subclavian aneurysm.

Arteriovenous aneurysm (Fig. 123) is the condition resulting from an abnormal communication between an artery and a vein. The *traumatic* variety usually follows a stab or gunshot wound; the *spontaneous* variety is rare and results from the rupture of an arterial aneurysm into a vein, the aorta and vena cava being the vessels most often affected. The artery may communicate directly with the vein (*aneurysmal varix*) or there may be an intervening sac (*varicose aneurysm*).

The important **symptoms** are pulsation of the vein, which becomes varicose, and a characteristic thrill and bruit, the latter resembling the buzzing of a fly. Both thrill and bruit are continuous, but reinforced at each cardiac systole, and transmitted along the vein, both centrally and peripherally. Proximal pressure on the artery, compression of the intermediary sac, or closure of the arterial opening by pressure on the vein, causes the swelling to shrink, and the thrill, bruit, and pulsation to cease; distal pressure intensifies these signs. Edema, cyanosis, and motor, sensory, and trophic disturbances are of common occurrence, while in arteriovenous aneurysm of the common carotid and jugular, headache, vertigo, and other cerebral symptoms may appear. The condition may slowly advance, or remain stationary for years. Rupture is more frequent in varicose aneurysm than in aneurysmal varix.

The **diagnosis,** even in the absence of venous pulsation, is assured if the characteristic thrill and bruit are present. The bruit of an arterial aneurysm is intermittent and, although sometimes propagated along the artery, is never transmitted towards the heart. The venous hum, occasioned by pressure or anemia, which is at times heard at the root of the neck, although continuous and transmitted towards the heart, is intensified, not by cardiac systole, but by diastole or inspiration. In cirsoid aneurysm pulsation is uniform and confined to the arteries, thrill and bruit weak or absent; proximal compression of the main artery does not wholly suppress these signs, and the condition is most frequent on the scalp and hand, where arteriovenous aneurysm seldom occurs. The differential diagnosis between aneurysmal varix and varicose aneurysm is seldom possible without exploratory incision, although a soft, oval, fluctuating, easily-reducible swelling points to the former, and a firm, irregular, immobile tumor which cannot be completely reduced, to the latter.

The **treatment** of aneurysmal varix is the application of an elastic bandage. If this does not check the progress of the growth, if pain is severe or rupture threatened, operation is demanded. Varicose aneurysm should never be treated expectantly. The ideal operation is separation of the vessels with suture of the openings, thus preserving the circulation. We have successfully performed this operation in one instance. When suture of the vessels is inapplicable extirpation, after tying both vessels above and below; is the best procedure. Proximal ligation of the artery, ligation of the artery above and below, or better, ligation of both vessels above and below may be indicated when, owing to dense adhesions or unfavorable situation, extirpation seems too formidable.

HEMORRHAGE.

Hemorrhage is divided, (1) according to its cause, into spontaneous and traumatic; (2) according to the vessels injured, into arterial, venous, and capillary; (3) according to the time following the injury, into primary, intermediary, and secondary; and (4) according to its location, into external and internal.

1.—*Spontaneous hemorrhage* is the result (1) of ulcerative, degenerative, or inflammatory diseases of the vessel walls; (2) of increase in blood pressure, e.g., hypertrophy of the heart, straining, coughing, vomiting, and convulsions; (3) of alterations in the constitution of the blood, e.g., certain forms of anemia, notably progressive pernicious anemia and leukemia, snake bite, phosphorous poisoning, malaria, yellow fever, jaundice, scurvy, septicemia, and purpura hemorrhagica; and (4) of obscure nervous influences, e.g., hysteria, vicarious menstruation, and certain other nervous conditions. The cause of bleeding in hemophilia is not known. *Traumatic hemorrhage* is the result of wounds of vessels, or of contusions which weaken the vessel wall and are followed by rupture.

2.—In *arterial hemorrhage* the blood is bright red, and is pumped from the vessel in spurts synchronous with the cardiac systole. If oxygenation of the blood is deficient from any cause, the blood may be dark in color, e.g., in deep narcosis and asphyxia. Pressure on the artery between the wound and the heart stops the bleeding, unless the collateral circulation is well developed; pressure distal to the wound augments the bleeding only when the artery is incompletely severed. In *venous hemorrhage* the blood is dark in color and flows in a steady stream. Bleeding from the central end of a severed vein soon ceases, unless the valves are incompetent or absent, or unless a large branch opens into the vein between the wound and the next valve above. Pressure on the vein below the wound checks the bleeding; proximal pressure, if the wound is lateral, increases the bleeding. The opposite is true, however, when, as in certain varices, the circulation is reversed. The application of a tourniquet to the limb above the wound makes the bleeding worse, unless the constriction is tight enough to compress the arteries, when the bleeding will cease, after the peripheral segment of the vein and its tributaries have emptied themselves. *Capillary hemorrhage* is characterized by a general oozing of blood. The term *parenchymatous* is sometimes applied to a free general oozing from all the vessels.

3.—*Primary hemorrhage* occurs at the time of injury. *Intermediary*, reactionary, recurrent, or consecutive hemorrhage is the bleeding which recurs within twenty-four hours of the cessation of primary hemorrhage. It is due to the cutting through (in friable, inflammatory, or neoplastic tissue, or in atheroma), slipping off, untying, or breaking of a ligature; to neglect of the distal end of a severed artery, which may start to bleed only after the collateral vessels have dilated; to dislodgment of a clot as the result of restlessness (local or general); or to the washing of coagula from the ends of the vessels as the result of increased blood pressure coincident with reaction from shock. *Secondary hemorrhage* occurs after twenty-four hours. It may be due to the causes mentioned above, but is usually the result of infection, which opens the vessels by ulceration or sloughing, by breaking down the coagulum, or by disintegrating an absorbable ligature. Secondary hemorrhage of the septic type is often delayed for a week or longer, and usually manifests itself by repeated bleedings, which are at first slight, but grow progressively more copious. The patient must never be treated expectantly, even though the bleeding is slight or has ceased, because it is almost certain to begin again.

4.—In *external hemorrhage* the blood escapes from an external wound. In *internal hemorrhage* it accumulates in the tissues (extravasation, diffuse traumatic aneurysm), in one of the cavities of the body (hematocele), or in one of the hollow viscera. Various other names are applied to hemorrhage according to its location, such as epistaxis (nose bleed), hematemesis (vomiting of blood), metrorrhagia (uterine hemorrhage between the menses), hemothorax (bleeding into the pleural cavity), etc.

The constitutional symptoms of *acute hemorrhage* are rapid, feeble, easily obliterated, dicrotic pulse; subnormal temperature with cold, clammy skin; increased and frequently irregular respirations with dyspnea (*air hunger*); marked pallor of the skin and mucous membranes; failing sight and dilatation of the pupils; ringing in the ears (*tinnitus aurium*); restlessness, muscular twitching, or convulsions; thirst, and sometimes nausea, vomiting, or delirium; recurring attacks of vertigo or syncope; and finally, in fatal cases, collapse and death. These symptoms vary in frequency and intensity according to the amount of blood lost and the rapidity with which such loss takes place. The most important symptoms are a rising pulse, a falling temperature, and increasing pallor. It should be noted, however, that the pulse may be slow in intracranial hemorrhage, owing to cerebral compression; in intrapericardial hemorrhage, owing to pressure on the heart; and in some cases of rupture of the liver, owing to biliary absorption; and that the temperature may be high in pontine hemorrhage. Pallor in the negro is detected by inspecting the conjunctivæ and the mucous membrane of the lips. A sudden violent hemorrhage may cause death in a few seconds, small but repeated bleedings may not effect the same result for years. It is said that loss of half of the blood (the total amount of blood is an eighth of the body weight) usually causes death. The effects of hemorrhage, however, are much greater in infants, in the aged, and in the debilitated, and much less in the plethoric, and in women during parturition. After a severe hemorrhage reaction is attended by a slight rise in temperature (*hemorrhagic fever*), the result of nervous influences or the absorption of fibrin ferment. There is sometimes a low form of delirium, and as the result of the asthenia, the patient is predisposed to infective processes. Although, owing to the contraction of the vessels and the absorption of fluids, the blood pressure is quickly restored, the number of red cells, the amount of hemoglobin, and the specific gravity of the blood are reduced, while the number of leukocytes is increased for a number of days, no doubt the result of the large quantity of lymph taken up by the circulation at this time.

The most important symptoms of *chronic hemorrhage*, i.e., frequently repeated small bleedings, are pallor, rapid dicrotic pulse, dyspnea, hemic murmurs over the heart, edema of the face and feet, predisposition to syncope on slight exertion, and, as pointed out above, the blood changes of secondary anemia.

Natural arrest of hemorrhage may be only temporary, or it may be permanent. *Temporary hemostasis* is effected in the following manner: A severed artery *retracts* within its sheath because of its elasticity; its orifice is diminished in size by *contraction* of the transverse muscular fibers in the media, by a curling up of the intima, and by the pressure of the perivascular tissues, and as the result of the fall in blood pressure and the increased coagulability of the blood consequent upon hemorrhage, a clot (*external coagulum*) gradually forms in and around the sheath, until it is sufficiently firm to resist the diminishing force of the circulation. The bleeding is now checked, and coagulation proceeds within the vessel (*internal coagulum*) until, in some cases, the first collateral branch is reached. This clot may be washed out with the increase in the force of the heart during the reaction from shock, hence overstimulation should be avoided. After wounds of veins the process is much the same, although, for the reasons pointed out under thrombosis, coagulation occurs more promptly. Capillary bleeding soon ceases as, owing to the minute size of the vessels, the smallest coagula readily fill their orifices.

Permanent hemostasis is the result of displacement of the internal clot by fibrous tissue, the changes being those already described under repair. For the fate of extravasated blood see section on contusions.

Delayed hemostasis, in addition to the conditions mentioned under spontaneous hemorrhage, may be due to a large wound in the tissues over the injured vessel, the tissues offering no obstacle to the free escape of blood; an incised wound, or incomplete division, of a vessel, the latter preventing contraction and retraction; gaping of a vessel because of rigidity of its walls, as in varix, or because of its attachment to environing structures, such as is normally the case with vessels in bones and in the scalp, with veins at the root of the neck, and with the cranial sinuses; infection of the vascular walls; increased blood pressure from plethora, inflammation, congestion, restlessness, cardiac stimulants, transfusion, or the introduction of salt solution into the circulatory apparatus; diminished coagulability of the blood the result of the ingestion of ammonia, acid fruit juices, or large quantities of water, inhalation of oxygen, restriction of food or lime salts, vegetarian diet, smoking tobacco, hyperthyroidism, leech bite, or the injection of hirudin (leech extract); or to motion of the part, which may prevent the formation of, or dislodge a clot.

Accelerated hemostasis may be due to a long narrow wound in the perivascular tissues; a contused or lacerated wound of a vessel, which increases contraction and retraction; atheroma, owing to the small calibre of the vessel and the roughened intima; decreased blood pressure, particularly that due to shock or hemorrhage; increased coagulability of the blood the result of asphyxia, hypothyroidism, the puerperium, certain forms of anemia (distinctly that due to hemorrhage), the ingestion of large quantities of milk, small quantities of water, or the medicaments listed below in the paragraph on styptics; or to immobility of the injured part.

The **diagnosis of hemorrhage** is attended with difficulty only when the bleeding is internal; it is then most likely to be mistaken for shock (q. v).

The **treatment of hemorrhage** is constitutional and local. The *constitutional treatment*, which is that of shock (q.v.), should be instituted while measures are being taken to control the bleeding, and not before, because of the danger of increasing the loss of blood. The *local treatment* embraces (1) cold, (2) heat, (3) elevation, (4) styptics, (5) compression, (6) acupressure, (7) forcipressure, (8) torsion, (9) ligature, and (10) suture of the vessel.

1. **Cold** in the form of ice, cold water, or evaporating lotions will hasten the arrest of hemorrhage from small vessels, but should not be used in open wounds because of the danger of sepsis. Exposure of a wound to air facilitates coagulation partly as the result of the lowered temperature. The ice bag is frequently employed in internal hemorrhages not suitable for operation.

2. **Heat** in the form of hot water (120° to 150° F.) is sometimes useful as a hemostatic; it, like cold, stimulates the muscular fibers of the vessels to contract. Warm water relaxes these fibers and encourages bleeding. The *actual cautery* should rarely be employed, as it causes sloughing, which interferes with the healing, and predisposes to secondary hemorrhage. When used, it should be at a dull red heat; if bright red it cuts like a knife and does not stop bleeding. *Electrohemostasis*, in which the tissues to be divided during an operation are crushed with special forceps and baked with an electric current, possesses no advantages over the ligature.

3. **Elevation** alone may stop hemorrhage from the larger veins; it is especially applicable in bleeding from the extremities.

4. **Styptics**, such as antipyrin, Monsel's solution (cotton containing Monsel's salt is called styptic cotton), alcohol, turpentine, tannic or gallic acid, silver nitrate, alum, sodium chlorid, vinegar, chlorid of zinc, and tincture of matico, are seldom applied to a wound by the surgeon, as most of them produce a tough coagulum which interferes with healing. Adrenalin chlorid, however, contracts the vessels, and is frequently employed, particularly in bleeding from mucous membranes. It may be applied by a swab or as a spray in the strength of from 1 to 1,000 to 1 to 10,000, or given internally in the dose of from 5 to 10 grains of the suprarenal extract. At least one case of poisoning has resulted from its use locally; when administered internally for a long time it is said to cause arteriosclerosis. Gelatin, 5 to 10 per cent., in normal salt solution (*Carnot's solution*), has been used locally as a hemostatic; reference has already been made to the importance of having it absolutely sterile and to its use internally. Among the other agents which increase the coagulability of the blood, or contract the vessels, when taken internally, are turpentine, oil of erigeron, stypticin, magnesium carbonate, opium, dilute sulphuric acid, acetate of lead, ergot, hamamelis, and chlorid of calcium. Chlorid of calcium, gr. x, t.i.d., is frequently employed to increase the coagulability of the blood previous to operation in cases of chronic jaundice. The injection of alien blood serum or transfusion of blood is of particular value in hemophilia (q.v.). Kocher and Fonio suggest coagulin as a hemostatic agent. It is a grayish powder made from the blood platelets of animals, and can be dusted on wounds, or used in a solution; in the latter instance the fluid may be boiled for one or two minutes for the purpose of sterilization, and can be injected intravenously. Radiotherapy and electrolysis are sometimes employed to check bleeding in uterine fibromyomata.

FIG. 124.—Catheter à chemise. (Heath.)

(5) **Compression** may be direct or indirect, i.e., upon the ends of the divided vessel, or upon the vessel some distance from the wound.

Direct compression may be made with the fingers, or with tampons, compresses, or pads. The ultimate principle of all hemostatic agents is, of course, pressure in some form. *Direct digital compression* will control the most violent hemorrhage from any part of the circulatory apparatus, and is to be employed in an emergency until more permanent hemostasis can be secured. Capillary hemorrhage, or a general oozing from small arterioles and venules, is quickly checked by the pressure of aseptic gauze which has been steeped in hot water. Firm *gauze packing* will control any venous and many forms of arterial bleeding. The *graduated compress*, which is made of layers of gauze successively increasing in size from below upwards, so as to form an inverted pyramid or cone, was at one time used to control arterial hemorrhage in regions in which incisions to expose the wounded vessels, e.g., the palmar arches, might injure important structures. The pressure exerted on oozing points by the apposition of a wound with *sutures* or sterile adhesive strips is frequently sufficient to control bleeding, especially when such pressure is reinforced by a firm bandage. *Bleeding from bone* may be controlled by plugging the openings with antiseptic wax, catgut, filaments of gauze, or fragments of bone produced by striking the bone with the blunt end of a chisel; a large canal may be filled with a bit of sterilized wood. In the *rectum* pressure may be made by introducing and inflating a rubber bag, e.g., the colpeurynter. The shirted cannula (*cannula à chemise*) is used after lithotomy, to make pressure and maintain drainage (Fig. 124); the shirted portion is stuffed with gauze. In *bleeding from a tooth socket* the cavity may be packed with gauze containing an astringent, and the pressure augmented by bandaging the jaws tightly shut. In the *urethra* pressure may be effected by inserting a large sound, or in the deep urethra by compressing the perineum. In oozing from the *brain* small particles of the temporal muscle may be plastered on the bleeding points; this not only obstructs the orifices of the vessels but probably has also a styptic effect; the same principle may be used elsewhere. Wounds of *parenchymatous organs* in the abdomen have been covered with a free transplant of fascia, or stuffed with omentum, muscle, or fat, held in place with sutures. A method for making direct pressure on the internal mammary artery is mentioned in the section devoted to wounds

FIG. 125.—Esmarch band.

FIG. 126.—Petit's tourniquet applied to the brachial.

of the chest. Other forms of direct pressure, viz., acupressure, forcipressure, ligation, etc., are dealt with later. *Indirect pressure* is employed chiefly to control bleeding until more permanent measures can be applied, or to prevent hemorrhage during operations. In the limbs a tourniquet (Figs. 125, 126), applied above the wound, is the most reliable procedure; in an emergency a belt, a pair of suspenders, or a handkerchief may be tied about the limb, and tightened by pushing a stick beneath the band and twisting it. A tourniquet should be applied above the elbow or knee, as the vessels in the forearm and leg are protected by bones and not so readily compressed. The dangers of the tourniquet, which are greater when the tourniquet is applied to the arm than when applied to the thigh, are injury to the nerves and soft tissues, especially if the limb is moved about; contusion or rupture of the artery, particularly in atheroma; and gangrene if the tourniquet is left in place for several hours. A disadvantage is the increased oozing of blood following the removal of the tourniquet. In operations the vessel may be compressed at a distance by a clamp, tape, or the fingers of an assistant. *Forced flexion* is seldom employed at the present time; a pad is placed in the popliteal space, groin, or bend of the elbow, and the limb secured in strong flexion by means of a bandage. *Indirect digital compres-*

sion, although lacking the disadvantages of the tourniquet, calls for a strong skilled hand and, if pressure must be continued for a long time, relays of assistants. The *common carotid*, the *vertebral*, and the *inferior thyroid* arteries may be compressed against the transverse process of the sixth cervical vertebra (*Chassaignac's tubercle*) at the anterior margin of the sternomastoid; the *facial*, against the lower jaw just in front of the masseter; the *labial* and *coronary*, by grasping the lip at the angle of the mouth between the fingers; the *temporal*, against the zygoma immediately in front of the ear; the *occipital*, against the skull about midway between the mastoid process and the external occipital protuberance; the *subclavian*, against the first rib, by the thumb, or by the padded handle of a door key, pressed downward, backward, and inward just behind the clavicle and to the outer side of the sternomastoid; the *axillary*, against the head of the humerus at the inner border of the coraco-brachialis, with the arm raised to a right angle; the *brachial*, against the humerus at the inner edge of the biceps; the *radial*, at the wrist, just outside of the flexor carpi radialis; the *ulnar*, in the same situation, just outside of the flexor carpi ulnaris; the *abdominal aorta*, if the patient is not too stout, against the vertebræ on a level with and just to the left of the umbilicus; the *external iliac*, against the brim of the pelvis, above the middle of Poupart's ligament; the *common femoral*, immediately below Poupart's ligament, by pressing upwards and backwards midway between the symphysis pubis and the anterior superior spine of the ilium; the *popliteal*, against the femur a trifle to the inner side of the middle of the popliteal space; the *anterior tibial*, midway between the two malleoli; the *posterior tibial*, half an inch behind the tip of the internal malleolus. When there is danger of secondary hemorrhage, the point for compression may be marked with ink or iodin, so that, in the event of bleeding, the nurse may press on the right spot at once. It is much better, however, in such cases, to apply an Esmarch band loosely to the limb; if hemorrhage occurs the band can then be tightened without regard to the situation of the artery.

(6) **Acupressure** is rarely employed. (1) A long needle may be pushed into the tissues, then over the vessel, and again into the tissues, in the same way that one fastens a flower to the lapel of a coat; (2) the needle may be passed into the tissues on one side of the vessel, twisted 180°, and reinserted into the tissues; or (3) the needle may be thrust under the vessel, and wire or silk passed over the ends of the needle in a figure-of-8 fashion.

(7) **Forcipressure,** or the crushing of the end of the vessel with hemostatic forceps, is frequently employed with very small vessels; thus, many of the little bleeding points caught with hemostatic forceps during an operation require no further attention after the forceps have been removed at the end of the operation. When ligation is very difficult and the vessel large, the forceps may be left in place for twenty-four or forty-eight hours, being, of course, protected with sterile dressings. Forcipressure before ligating *en masse* renders bleeding from shrinkage of the tissues much less likely to occur. Very powerful forceps (*vasotribe, or angiotribe*) are sometimes used for this purpose, and some surgeons do not even ligate after removing the instrument.

(8) **Torsion** is useful in certain plastic operations where the presence of knotted ligatures is undesirable. It should not be used in cases of atheroma. *Free torsion* is the twisting of a vessel several times after the application of hemostatic forceps; it is used chiefly for small vessels. Larger vessels are occluded by *limited torsion;* the artery is drawn from its sheath with a pair of

forceps, grasped close to the tissues with a second pair, then twisted with the first forceps. Torsion ruptures the inner and middle coats, which contract and curl up, and twists the outer coat; the end of the vessel should never be twisted off.

(9) **Ligation** is the method of choice when dealing with vessels large enough to be seen by the naked eye. Catgut is the material usually employed, although with very large arteries or with thick pedicles many surgeons prefer silk. Ligation may be *total, or circumferential*, when the vessel is occluded by the ligature, or *lateral* when a wound in the side of a vessel is closed without interrupting the circulation. A *circumferential ligature* is applied to the bleeding end of a vessel (*immediate ligation*), or to the vessel some distance from the wound (*ligation in continuity*, p. 225). In the former the end of the vessel is seized with hemostatic forceps, drawn a little from its sheath, when such exists, and the ligature tied above the forceps in a reef knot (Fig. 75). If catgut is used, a third knot always should be added. As it is difficult to catch small vessels without including a little of the surrounding tissue, the forceps should be removed as the first knot is tightened, otherwise the ligature may slip off when the forceps are removed. *A suture-ligature* (Fig. 127) is one passed through the tissues about an artery by means of a needle. It is used in dense tissues from which the vessel cannot be drawn; in necrotic tissues and in atheroma in order to prevent cutting through of the ligature; in tissues like the dura, mesentery, and omentum; and in any region in which there is danger of slipping of the ligature. A *lateral ligature* is one applied to the side of a vessel, generally a vein, after the edges of the wound have been drawn up in the form of a cone with hemostatic forceps (Fig. 128). In order to insure against slipping the ligature may, by means of a fine needle, be passed through the venous wall on each side of the forceps. The *effects of a ligature*, when it is tied tightly, are rupture of the inner and middle coats, which retract and invert, and the formation of a small thrombus, which is finally replaced by fibrous tissue. Atheromatous arteries and very large arteries, e.g., the subclavian and iliac, should be tied only firmly enough to approximate the walls, without rupturing the intima, else the ligature may cut through, or the vessel may dilate and rupture immediately proximal to the point of ligation; some surgeons apply this rule to all vessels. The ligature itself is encapsulated if of non-absorbable material. The ligation of a large artery causes a rise in the general blood pressure, which gradually falls as the collateral circulation is established.

FIG. 127.—Suture-ligature. (Esmarch and Kowalzig.)

FIG. 128.—Lateral ligature. (Esmarch and Kowalzig.)

(10) **Suture of blood vessels** (*angiorrhaphy*) is the ideal method of dealing with wounds of arteries whose ligation might lead to gangrene or other serious disturbance in the parts which they supply, e.g., the common

carotid, axillary, brachial, aorta, external iliac, femoral, popliteal, and large abdominal arteries. If, after the principal artery of a limb has been wounded, the limb is very pale, the peripheral end of the artery does not bleed, and congestion below the wound does not follow compression of the chief vein, the collateral circulation is probably incompetent to maintain the life of the limb, and arteriorrhaphy is mandatory (other methods for testing the collateral circulation will be found in the section on amputations). The danger of tearing out of the sutures, even in the presence of atheroma, is no greater than that of cutting through of a ligature, and if thrombosis occurs, the clot may form slowly enough to allow the collateral vessels to dilate, a distinct advantage over ligation. Although occlusion of the main veins of the limbs is usually followed by nothing worse than edema, gangrene may result if the collateral vessels are diseased or injured, if the circulation is sluggish from cardiac or pulmonary derangement, or if the vitality of the part is impaired by debilitating maladies, hence suture should be preferred to ligation. In wounds of the superior mesenteric, portal, vena cava above the origin of the renals, and both internal jugulars suture must be chosen, as ligation generally ends in death. The technic of angiorrhaphy, which includes *arteriorrhaphy* (suture of arteries) and *phleborrhaphy* (suture of veins) is as follows: After controlling the circulation by the application of a tourniquet, or by compressing the vessel above and below the wound between the fingers of an assistant or by rubber-coated clamps, the sheath is pushed back, but no further than is absolutely necessary, and the edges of the wound, if lacerated, made smooth with a sharp knife; scissors produce too much bruising. The sutures should be of fine silk, threaded on the finest needle, and sterilized by boiling in vaselin, as suggested by Carrel, who applies vaselin also to the margins of the wound to prevent drying. In a lateral wound the operation may be facilitated by passing a guide suture, to be held by an assistant, through each end of the wound. The continuous suture is more rapid and less apt to permit leakage between the points of insertion than the interrupted. The suture should penetrate all of the coats of the vessel, and slightly evert the margins of the wound so as to bring intima in contact with intima, the points of insertion being about one millimeter apart. The blood current is now slowly turned on while pressure is applied to the suture line until the stitch holes cease to bleed. The sheath is then sutured, then the fascia, then the skin. If more than one-third of the circumference of the vessel is cut, the section should be completed and an end-to-end anastomosis performed. Although various forms of special apparatus may be used for this purpose, the best method is that of Carrel. After cutting the ends of the vessel square across and trimming away any of the external coat which prolapses into the lumen, three guide sutures are passed through both ends of the vessel at points equidistant around the circumference, which, by traction on these sutures, is transformed into a triangle, whose sides, after being elongated as much as the elasticity of the vessel permits, thus preventing stricture, are sutured

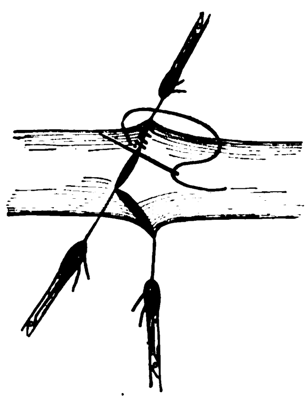

FIG. 129.—Carrel's technic for anastomosis of blood vessels.

with a continuous suture (Fig. 129). The author has successfully sutured the axillary artery in three instances, the abdominal aorta in one, the radial in one, the femoral in three, and the popliteal in one, four of these being end-to-end anastomoses.

Résumé.—The treatment of alarming hemorrhage from any *open wound* is, first, the immediate control of bleeding by the application of digital pressure to the vessels in the wound; then, in the extremities, the application of a tourniquet above the wound. Nothing further should be done until the patient has reacted from shock, when the parts may be carefully disinfected and the vessels ligated, enlarging the wound as much as may be necessary, and remembering that both ends of large arteries and veins should be tied and that, if the wound is a lateral one, the vessel must be ligated above and below the wound and severed between the ligatures, thus permitting retraction and contraction. The desirability of suturing important vessels instead of occluding them by ligation, should be borne in mind. A general oozing which seemingly comes from no particular point is controlled by firm gauze packing, or by suture of the wound and the application of a firm bandage. An artery capable of producing vigorous bleeding must be ligated in the wound, though even an operation is necessary for such purpose. Ligation in continuity for hemorrhage should be performed only under very exceptional circumstances, as it is often ineffectual, owing to a free collateral circulation; again the bleeding vessel may be a large vein, or an artery not derived from the vessel ligatured. Possibly in cases in which the tissues are rotten from infection, or in which packing fails to control permanently a bleeding artery whose exposure would necessitate the destruction of important structures, ligation in continuity may be indicated. In the former instance recurrence of bleeding would call for amputation. In regions such as the neck where elastic constriction is impracticable, digital compression must be maintained until the wound has been sufficiently enlarged to secure the vessel with hemostatic forceps. The patient may then be reacted from shock, and the hemorrhage controlled as outlined above. Dangerous hemorrhage in the *chest or abdomen* is treated, after opening these cavities, by ligation, suture, gauze packing, or, in rare instances, by the cautery; often an important organ, e.g., spleen, kidney, or uterus, must be removed. In these cases the surgeon must operate immediately, in the presence of even the most profound shock. Hemorrhage into the *cranium or spinal canal* is dangerous, not from the loss of blood, but from the pressure exerted upon the central nervous system; it is controlled, after trephining or laminectomy, by ligature or packing. The treatment of serious bleeding into the *subcutaneous tissues*, including *diffuse traumatic aneurysm*, is immediate digital pressure on the main artery above, until a tourniquet can be applied; after the patient has reacted from shock, the bleeding vessel is exposed by incision and ligated or sutured. *Serious bleeding from arterioles, venules, or capillaries* is dealt with under hemophilia.

Hemophilia (*hemorrhagic diathesis*) is a congenital and hereditary tendency to excessive bleeding, arising spontaneously, or from wounds of even the most trivial character. The cause is not known. It is far more frequent in males than in females, but females are much more liable to transmit the disease to their offspring; indeed a female belonging to a bleeder family, but who is not herself subject to the affection, is likely to beget bleeder children, especially if they be males. About 50 per cent. of those with hemophilia die before the tenth year, and only 10 per cent. reach maturity. The presence of hemophilia, which may be suspected from the history and confirmed by estimating the coagulation time of the blood, contraindicates all but the most urgent operations. Other forms of spontaneous hemorrhage are mentioned on page 215.

The **treatment** consists in the internal administration of tonics and the careful avoidance of all forms of injury; even the most trivial operations, like vaccination or circumcision, must be regarded as highly dangerous. In the presence of bleeding ergot, acetate of lead, gelatin, calcium lactate, or calcium chlorid may be given internally. Thyroid extract also has been recommended, although, according to Kocher, hyperthyroidism is accompanied by a decrease in the coagulability of the blood. Adrenalin or Carnot's solution and prolonged pressure with elevation are used locally. The application of coagulin, of clotting blood from a healthy individual may be tried, also transfusion of normal blood. Weil injects 10 to 20 cc. of normal horse serum into a vein, or 20 to 40 cc. beneath the skin; antidiphtheritic serum also has been used in hemophilia and other hemorrhagic diseases. Escharotics or the actual cautery may temporarily check the oozing, but it is very likely to recur with the separation of the sloughs. Petechiæ and ecchymoses require no local treatment; hematomata and hemarthroses should be protected from injury and never opened.

LIGATION OF ARTERIES IN CONTINUITY.

The *indications* for ligation in continuity are aneurysm, arterial hemorrhage under the circumstances mentioned above, malignant growths whose progress may be hindered by shutting off the blood supply, and operations on very vascular structures in order to reduce the loss of blood. In addition may be mentioned the very doubtful indications of enlarged prostate, for which the internal iliacs have been tied, trigeminal neuralgia, for which the carotid has been tied, and epilepsy, for which the vertebral has been tied. In cases in which the necessity for ligation is not pressing, the state of the collateral circulation may be determined before operation by the Matas method (see indications for amputation, Chap. XXXI). If the collateral circulation is inadequate it may be rendered more active by intermittent compression of the artery. Chromicized catgut should be used for all but the largest vessels, for which floss silk is the best material.

The **operation** is preceded by mapping out the course of the vessel by an imaginary line. The skin and fascia are then divided along this line, important structures drawn aside, and the vessel located by means of anatomical guides, e.g., a muscle, a bony prominence, a nerve, or another vessel. The artery itself is recognized by its pinkish color, the thickness of its walls, and by pulsation, the veins being dark in color, thin walled, and non-pulsating. The arteries of the upper extremity, the leg, and most of the smaller arteries of the trunk have venæ comites; those of the thigh, the head, and neck, except the lingual, have but one companion vein. Pressure upon the vessels will distend the vein and collapse the artery and obliterate the pulse below the point of pressure. The anatomical guides, however, are more reliable than the individual features of the artery, as even pulsation may be transmitted to the vein, or be absent in the artery as the result of pressure or hemorrhage. The sheath of the artery is opened for about half an inch by lifting it from the artery with forceps, and incising just beneath the forceps with the flat of the knife towards the artery (Fig. 130 A). The sheath is then held by forceps, and separated from the artery by an aneurysm needle

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armed with the ligature, which is carried around the vessel, in the direction away from the most important neighboring structure, which is usually the vein (Fig. 130 B). The ligature is then tied in a reef knot (Fig. 75) by placing the ends of the thumbs or index fingers upon the knot, and separating them by using the middle joint as the basis of support (Fig. 130 C). The second knot should be tied firmly, but should not be jerked, as such may break the ligature; a third knot always should be added when catgut is employed. With the smaller arteries the ligature may be tied with sufficient firmness to rupture the inner coats. With very large arteries this may result in the cutting through of the ligature, or in dilatation and rupture immediately proximal to the ligature. In these vessels the walls should be approximated only, the stay knot being employed (Fig. 131). The principal dangers following ligation in continuity are secondary hemorrhage and gangrene.

The **innominate** artery has been tied forty-three times with seven recoveries, the chief causes of death being sepsis, secondary hemorrhage, and cerebral lesions. An incision is carried for three or four inches along the anterior margin of the right sternomastoid to the episternal notch, then outward along the upper margin of inner third of the clavicle, severing the skin, platysma, and the superficial and deep fasciæ. The sternohyoid, sternothyroid, and inner edge of the sternomastoid are divided and retracted. The anterior jugular vein is severed between two ligatures, the carotid sheath opened, and the carotid artery followed to the bifurcation of the innominate. Resection of the sternoclavicular articulation may be necessary to expose the vessel properly. The inferior thyroid veins are tied or drawn aside, the right internal jugular and right innominate vein are pushed to the right, and the left innominate vein is displaced downwards. A strongly curved aneurysm needle is passed from without and below, upwards and inwards, care being taken not to injure the pneumogastric nerve and pleura, which lie to the right. The ligature should be of floss silk, tied in a stay knot.

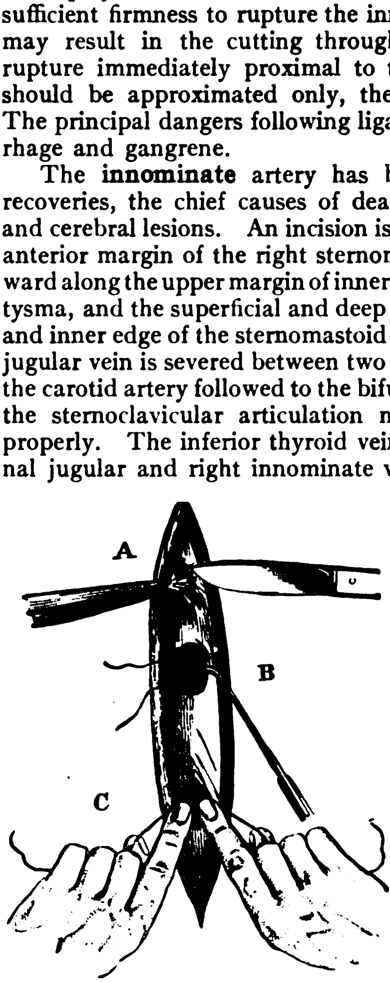

FIG. 130.—This diagram represents three distinct operations. A. Opening the sheath. B. Drawing ligature round the artery. C. Tying artery. (Moullin.)

The **common carotid** arises from the innominate on the right, from the arch of the aorta on the left. The *line of the artery* is from the sternoclavicular articulation to midway between the angle of the jaw and the tip of the mastoid, the vessel bifurcating at the upper border of the thyroid cartilage. Whenever possible the vessel is tied above the anterior belly of the omohyoid, i.e., in the superior carotid triangle, or the *triangle of election*, as here the vessel is more superficial and the operation less difficult. The triangle of election is bounded above by the posterior belly of the digastric, behind by the sternomastoid, and in front by the anterior belly of the omohyoid. The inferior carotid triangle, called the *triangle of necessity* because the vessel is tied here only when absolutely necessary, is bounded above by the anterior belly of the omohyoid, below by the sternomastoid, and in front by the median line. **Ligation in the triangle of election** (Fig. 132) is carried out with a sand pillow beneath the neck, the head turned towards the opposite side, and the chin raised. A three inch incision, the center of which is on a level with the cricoid cartilage, is made along the arterial line, severing the skin, and both layers of the superficial fascia, between which lies the platysma, and exposing the anterior edge of the sternomastoid, which is the *muscular guide* to the artery. After cutting the deep fascia which is attached to the border of the sternomastoid, this muscle is retracted outwards, the omohyoid drawn downwards, and the costal process of the sixth cervical vertebra (carotid tubercle of Chassaignac), which lies immediately under the artery at the point where it is crossed by the omoyhoid, felt with the finger. The sheath of the vessel is identified by means of the *descendens noni nerve*, which descends upon it, and opened on the inner side to avoid

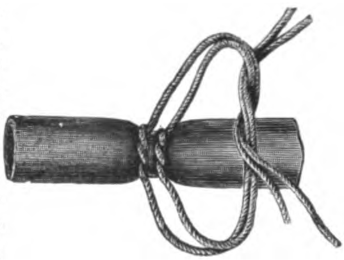

FIG. 131.—Stay knot. (Ballance and Edmunds.)

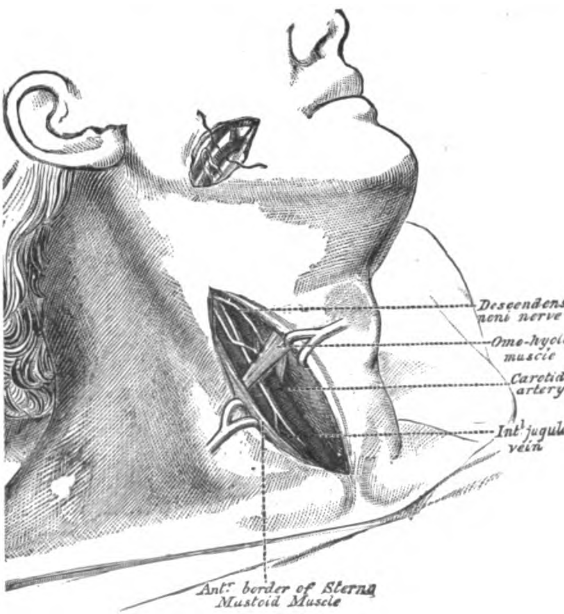

FIG. 132.—Ligature of the common carotid and facial arteries. (Moullin.)

the internal jugular vein, which lies to the outer side in a separate compartment. The pneumogastric nerve lies behind and between the artery and vein, in a separate compartment of the same sheath. The needle is passed from without inwards. **Ligation in the triangle of necessity** (Fig. 132) is performed by making a three inch incision downward along the arterial line from the level of the cricoid cartilage. The sternomastoid is drawn outwards, the sternohyoid and sternothyroid inwards, the omohyoid upwards. The sheath is opened on the inner side and the operation completed as described above. The inferior thyroid veins may be tied if they are in the way; in the lower part of the neck the anterior jugular, and on the left side, the internal jugular, lie in front of the artery and must be carefully retracted. The recurrent laryngeal nerve and the inferior thyroid artery are on a deeper plane and should not be encountered. Ligation of the common carotid, in one-fourth of the cases, results in cerebral complications, which may be immediate, such as collapse from cerebral anemia, or which take the form of cerebral softening, causing hemiplegia. One-half of those developing intracranial trouble die.

The **internal carotid** is rarely ligated. The *line* of the artery is parallel with and a trifle external (not internal as one would suspect from the name) to that of the external carotid. The *muscular guide* is the sternomastoid,

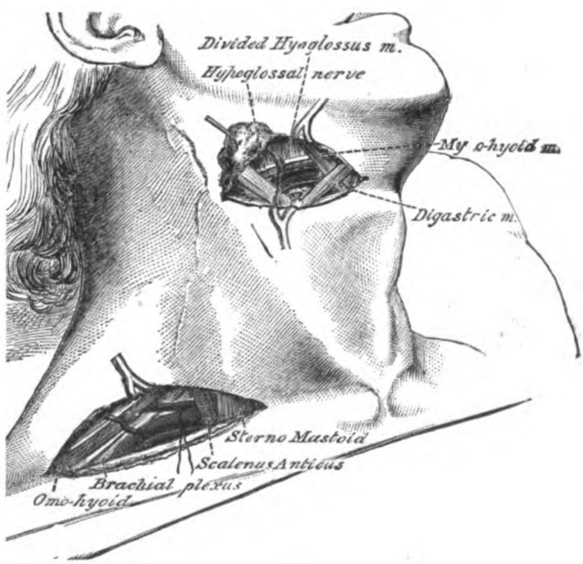

FIG. 133.—Ligature of subclavian and lingual arteries. (Moullin.)

and the incision that for the external carotid. The sternomastoid is retracted backwards, the posterior belly of the digastric upwards, and the external carotid forwards. The needle is passed from without inwards, avoiding the internal jugular vein, the pneumogastric nerve, the cervical sympathetic nerve, and the ascending pharyngeal artery.

The **external carotid** extends from the bifurcation of the common carotid, on a level with the superior border of the thyroid cartilage, to midway between the external auditory meatus and the condyle of the lower jaw. The *line* of the artery is the upper portion of that for the common carotid, the *muscular guide* the sternomastoid, and the position of the patient that for ligation of the common carotid. A three inch incision, with the center at the great cornu of the hyoid bone, is made along the arterial line, severing the skin, both layers of the superficial fascia, which includes the platysma, and the deep fascia. The sternomastoid is retracted outwards, the posterior belly of the digastric and the stylohyoid upwards, and the hypoglossal nerve inwards. The point of election for ligation is opposite to the tip of the great cornu of the hyoid bone, and between the superior thyroid and lingual arteries. The superior thyroid, lingual, and facial veins, which lie in front of the artery, should be avoided, and any lymphatic glands which are in the way removed. The needle is passed from without inward, carefully avoiding the superior laryngeal nerve, which lies behind the artery. The artery is distinguished from the common carotid and from the internal carotid by the presence of branches.

The **superior thyroid** arises from the external carotid close to its origin, passes upwards and inwards, then downwards and forwards to the thyroid gland. A two inch incision, with its center on a level with the upper edge of the thyroid cartilage, is made along the carotid line, and the external carotid exposed. The artery is then tied, care being taken to avoid the superior thyroid veins and the superior laryngeal nerve.

The **lingual artery** (Fig. 133) may be tied close to its origin through the incision for the exposure of the external carotid, or under the hyoglossus in the submaxillary triangle. In the latter operation the patient is placed in the same position as that for the ligation of the carotid. A curved incision, with its center opposite the greater cornu of the hyoid bone, is made from below and external to the symphysis menti, to below and within the point where the anterior edge of the masseter joins the lower border of the jaw, severing the skin, both layers of the superficial fascia, and the platysma. The submaxillary gland, which lies in a compartment of the deep fascia, is retracted upwards after severing the deep fascia, thus exposing the two bellies of the digastric, the posterior edge of the mylohyoid, and the hyoglossus. The digastric tendon is retracted downwards, and the *hypoglossal nerve* (the guide to the artery) and the ranine vein, which cross the hyoglossus, are pushed upwards; the hyoglossus is divided transversely between the nerve and the hyoid bone. The artery lies immediately beneath the muscle on the middle constrictor of the pharynx, and is tied by passing the needle from above downwards.

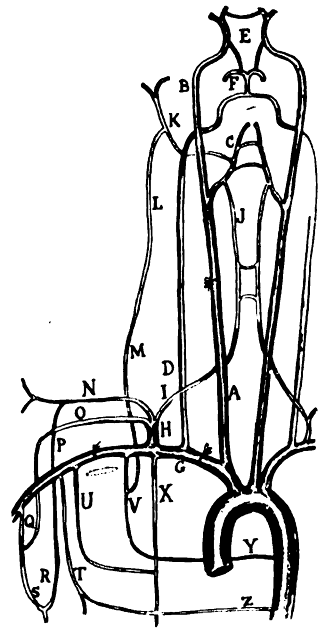

FIG. 134.—Diagram to show the collateral circulation after ligature of common carotid, subclavian, and axillary arteries. A. Common carotid. B. Internal carotid. C. External carotid. D. Vertebral. E. Circle of Willis. F. Basilar. G. Subclavian. H. Thyroid axis. I. Inferior thyroid. J. Superior thyroid. K. Occipital. L. Princeps cervicis. M. Deep cervical. N. Transversalis colli. O. Suprascapular. P. Posterior scapular. Q. Dorsalis scapulæ. R. Infrascapular. S. Subscapular. T. Long thoracic. U. Short thoracic. V. Superior intercostal. X. Internal mammary. Y. and Z. Aortic intercostals. (Walsham.)

The **facial artery** (Fig. 132) may be tied through the incision for ligation of the external carotid, or at the point where it crosses the lower border of the jaw immediately in front of the masseter, by making a small transverse incision through the skin, platysma, and fascia. The needle is passed from behind forwards, to avoid the vein, which lies behind.

The **temporal artery** may be tied in front of the auditory meatus at the point where it crosses the zygoma. A small vertical incision is made through the skin and fascia, between the tragus and the condyle of the jaw, and the vessel tied just above the root of the zygoma, avoiding the auriculotemporal nerve and branches of the temporo-facial portion of the seventh nerve.

The **occipital artery** may be tied at its origin, through the incision made for the external carotid, or behind the mastoid process. In the latter operation an incision is made from the tip of the mastoid upwards and backwards towards the occipital protuberance. The posterior fibers of the sternomastoid, the splenius, and the trachelomastoid are severed, and the vessel tied between the mastoid process and the transverse process of the atlas.

The **subclavian artery** (Fig. 133) arises from the innominate on the right, and the arch of the aorta on the left, and extends from the sternoclavicular joint to the lower border of the first rib. It is divided into three parts by the scalenus anticus, the first portion lying to the inner side of the muscle, the second behind, and the third to the outer side. The third portion lies in the subclavian triangle, which is formed by the clavicle below, the posterior belly of the omohyoid on the outer side, and the posterior border of the sternomastoid on the inner side. Ligation of the first or second portion is very rarely performed. The *line* of the third portion is from the posterior border of the sternomastoid to the anterior border of the trapezius, half an inch above and parallel to the clavicle. The *muscular guide* is the outer border of the scalenus anticus, which lies approximately behind the outer border of the sternomastoid. The *bony guide* is the tubercle on the first rib into which the scalenus anticus is inserted, the artery lying directly behind it. In ligation of the third part of the artery the thorax is raised, the neck extended, and the head turned to the opposite side. The size of the subclavian triangle is increased by pulling down the arm, and fixing it in this position by pushing the forearm under the back. An incision is made over the clavicle, from the outer margin of the sternomastoid to the inner margin of the trapezius, after the skin has been drawn down. This maneuver protects the external jugular vein, and when the skin is released leaves the wound half an inch above the clavicle. The incision involves the skin, superficial fascia and platysma, and the deep fascia. The external jugular vein is retracted inward or divided between two ligatures, the posterior belly of the omohyoid retracted upwards, and the scalenus anticus with the tubercle on the first rib identified. The transverse cervical and the suprascapular arteries should not be injured, as they assist in the collateral circulation. The subclavian vein lies in front of and below the finger as it rests on the scalene tubercle; the artery lies behind and can be felt pulsating on the first rib. The brachial plexus lies above and to the outside, the lower cord passing behind the vessel. With the finger guarding the vein, the needle is passed from above downwards close to the artery, to avoid the lowest cord of the plexus. There is also some danger of wounding the pleura.

The **internal mammary artery** courses downwards on the inner surface of the chest wall, about half an inch from the edge of the sternum. It may be tied after dividing the intercostal structures outwards from the edge of the sternum for an inch or more. In order to secure both ends of a divided internal mammary, which is absolutely necessary owing to the freedom of the collateral circulation, a portion of the costal cartilage may be resected.

The **vertebral artery** has been tied for wounds, secondary hemorrhage following ligature of the innominate, and for epilepsy. An incision dividing the skin, superficial fascia, platysma, and deep fascia, is made along the lower half of the posterior border of the sternomastoid. This muscle is retracted forwards with the external jugular vein and the scalenus anticus, upon which lie the phrenic nerve and the transverse cervical artery. The transverse process of the sixth cervical vertebra is defined, and the artery found below this point in the interval between the scalenus anticus and the longus colli. The vein lies superficial to the artery and is drawn to the outer side, the needle being passed from without inwards, care being taken to avoid the pleura and the thoracic duct.

The **inferior thyroid** may be tied through the incision made for ligation of the common carotid in the triangle of necessity. The sternomastoid and the carotid sheath are drawn outwards, the omohyoid upwards, and the sternohyoid and sternothyroid divided if necessary. The artery is found below the transverse process of the sixth cervical vertebra and behind the carotid sheath. Care should be taken not to injure the middle cervical ganglion, the recurrent laryngeal nerve, the esophagus, or, low down in the neck, the thoracic duct.

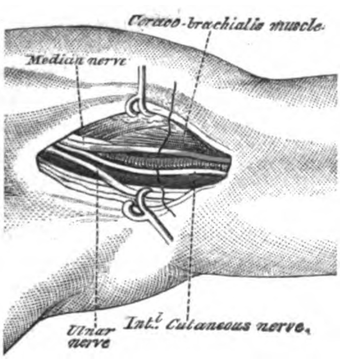

FIG. 135.—Ligature of axillary artery. (Moullin.)

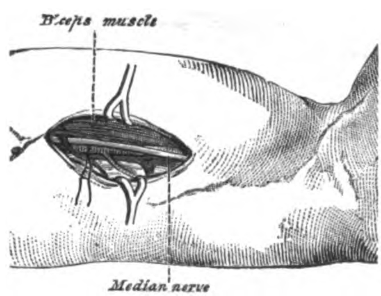

FIG. 136.—Ligature of brachial artery. (Moullin.)

The **axillary artery** extends from the lower border of the first rib to the lower border of the tendon of the teres major. It is divided into three portions by the pectoralis minor, the first portion being above, the second behind, and the third below that muscle. The line of the artery is from the middle of the clavicle to the junction of the anterior and middle thirds of the outlet of the axilla. The second portion of the artery is not tied, owing to its depth and to the fact that it is closely surrounded by large nerve trunks. **Ligation of the first portion** may be accomplished through an incision from the coracoid process of the scapula to within one inch of the sterno-clavicular joint, parallel with and half an inch below the clavicle. After dividing the superficial structures, the clavicular portion of the pectoralis major is severed and the costocoracoid membrane incised below the subclavius. The acromiothoracic artery and cephalic vein are avoided, the pectoralis minor drawn downwards, and the needle passed from below upwards to avoid the vein, which is below and to the inner side, while the finger guards the brachial plexus, which lies above and to the outer side. In

ligation of the third portion (Figs. 135, 560) the arm is abducted, and a three inch incision made along the inner border of the *coracobrachialis*, dividing the skin and fasciæ. The median nerve lies on the artery and, with the musculocutaneous nerve, which is more external, is drawn outwards. The axillary vein and the ulnar and internal cutaneous nerves, which lie to the inner side, are separated, and the ligature passed from within outwards.

The **brachial artery** underlies a line drawn from the junction of the anterior with the middle third of the outlet of the axilla, to a point midway between the two condyles of the humerus. The *muscular guide* is the inner border of the biceps. **Ligation at the middle of the arm** (Figs. 136, 559) is conducted with the arm abducted and the forearm supinated. There should be no support beneath the arm for fear that the soft structures might be pushed forwards over the artery and so complicate the operation. An incision two or three inches long is made along the inner border of the biceps, severing the skin and fasciæ. The muscle is retracted outwards and the median nerve, which at the middle of the arm crosses the artery from without inwards, located. The nerve is displaced to the more convenient side, and the needle passed from it, after separating the venæ comites and, above the middle of the arm, the basilic vein, which here lies beneath the deep fascia and close to the artery. The ulnar nerve lies to the inside. **At the bend of the elbow** (Fig. 558) the *biceps tendon* is the guide. A two inch incision is made along the inner edge of the biceps tendon extending down to the crease of the elbow. The median basilic vein is drawn downwards and inwards, the bicipital fascia incised, the venæ comites separated, and the ligature passed from within outwards to avoid the median nerve.

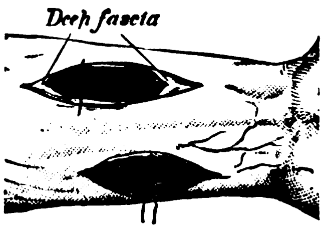

FIG. 137.—Ligature of the radial and ulnar arteries. (Moullin.)

The **ulnar artery** curves from its point of origin about one inch below the bend of the elbow, to the ulnar side of the forearm, thence passes downward to the radial side of the pisiform bone. The *line of the upper third* is from the middle of the front of the elbow joint to the junction of the upper and middle thirds of the ulna. The *line of the lower two-thirds* is from the apex of the internal condyle of the humerus to the radial side of the pisiform bone. The *muscular guide* is the outer border of the flexor carpi ulnaris. **Ligation at the wrist** (Fig. 137) is accomplished by making an incision an inch or more in length along the radial border of the flexor carpi ulnaris, which is drawn inwards after the deep fascia has been opened. The ligature is passed from within outwards to avoid the ulnar nerve, which lies to the ulnar side of the artery. **Ligation of the middle third** (Fig. 557) is performed by making a three inch incision in the line of the vessel, dividing the deep fascia, and separating the flexor carpi ulnaris from the flexor sublimis digitorum; this interspace is marked by a whitish or yellowish line, which is often indistinct and sometimes absent, but may always be distinguished by moving the wrist and the fingers.

The **radial artery** underlies a *line* drawn from midway between the tips of the condyles of the humerus, to the ulnar side of the styloid process of the radius. The *muscular guide* is the inner border of the supinator longus. For **ligation in the upper third** (Fig. 557) make a three inch incision along the line of the vessel, divide the fasciæ, retract the supinator longus outwards, and pass the needle from without inwards. The radial nerve lies to the radial side of the vessel. For **ligation above the wrist** (Fig. 137) an incision is made in the line of the vessel, the fasciæ divided, and the vessel found between the supinator longus and the flexor carpi radialis. In this situation the radial nerve lies on the dorsum of the forearm and is not encountered. A small superficial vein may overlie the artery, and branches of the external cutaneous nerve may be seen. **At the back of the wrist**, or in *la tabatière* (snuff box), which is bounded internally by the tendon of the extensor primi internodii, and externally by the extensor secundi internodii pollicis, the line of the artery is from the tip of the styloid process, to the posterior angle of the first interosseous space. An incision is made between the tendons, from the styloid process to the base of the first metacarpal bone. Beneath the skin will be found the superficial radial vein and a few branches of the radial nerve. The deep fascia is then opened and the artery exposed.

The **abdominal aorta** has been tied 15 times with 15 deaths, although one patient lived 10 days, one 39 days, and one 48 days. The operation is performed by opening the abdomen in the median line, retracting the intestines, incising the posterior parietal peritoneum, and tying the vessel.

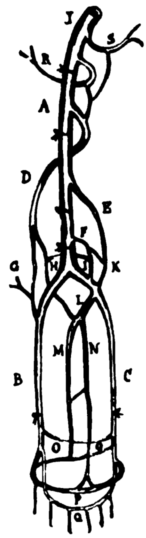

FIG. 138.—Diagram to show the collateral circulation after ligature of the axillary, brachial, radial, and ulnar arteries. A. Brachial; B. Radial; C. Ulnar; D. Superior profunda; E. Inferior profunda; F. Anastomotica magna; G. Radial recurrent; H. Interosseous recurrent; I. Anterior and K. Posterior ulnar recurrent; J. Axillary; L. Common interosseous; M. Posterior interosseous; N. Anterior interosseous; O O. Anterior and posterior carpal; P. Deep palmar arch; Q. Superficial palmar arch; R. Posterior circumflex; S. Subscapular. (Walsham.)

The **common iliac artery** extends from the aorta, opposite the left side of the body of the fourth lumbar vertebra, for two inches, to the upper end of the sacroiliac synchondrosis. The *line* of the artery is the upper two inches of a line drawn from a point half an inch below and to the left of the umbilicus, to midway between the anterior superior spine of the ilium and the symphysis pubis. The vessel may be tied by the transperitoneal or by the retroperitoneal route. The *transperitoneal route* is preferable. The abdomen is opened through the left rectus muscle by an incision whose center is a little below the umbilicus. The intestines are pushed aside, the posterior parietal peritoneum opened, and the needle passed from the patient's right to left, on both sides of the body, as the vein lies behind the artery on the right side, and behind and internal to it on the left. In the *retroperitoneal method* an incision is made from just above the internal abdominal ring, above and parallel to Poupart's ligament, curving upwards as the outer end of this structure is reached, to near the tip of the cartilage of the eleventh rib. The abdominal muscles and the transversalis fascia are divided, and the unopened peritoneum pushed upwards and inwards. The ureter crosses the artery, but usually adheres to the peritoneum and is carried out of harm's way with it. The deep *muscular guide* is the inner border of the psoas magnus muscle. The ligature is passed as in the previous operation.

The **internal iliac** may be tied extraperitoneally or transperitoneally through the incisions given for the common iliac.

The **gluteal artery** emerges from the pelvis through the upper part of the great sacrosciatic foramen, at the junction of the upper and middle thirds of a line drawn from the posterior superior spine of the ilium to the top of the great trochanter. An incision is made along this line, the fibers of the gluteus maximus separated, the deep fascia opened, and the artery exposed by separating the gluteus medius from the pyriformis. The **sciatic** and **internal pudic** arteries may be reached through an incision parallel with, but one and one-half inches lower than, that used for the gluteal artery. The fibers of the gluteus maximus are separated, and the vessels found emerging from the lower part of the great sacrosciatic foramen, at the lower border of the pyriformis and just below the great sciatic nerve.

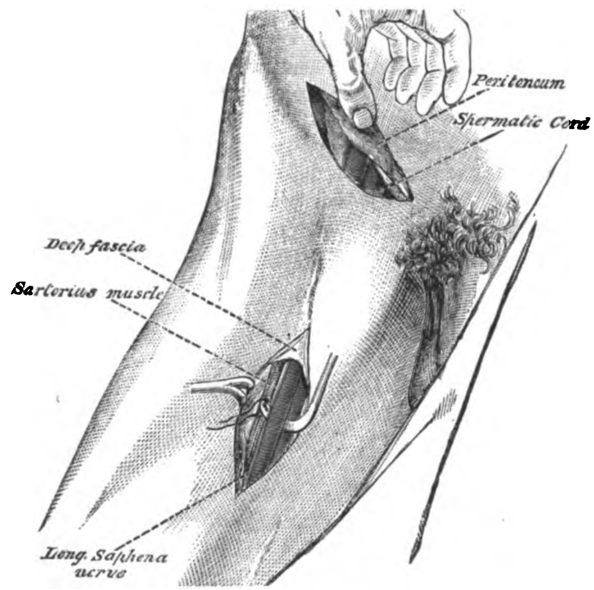

FIG. 139.—Ligature of external iliac and superficial femoral arteries. In this figure the incision for the femoral artery is placed too low. (Moullin.)

The **external iliac artery** underlies the lower two-thirds of a line drawn from one-half inch below and to the left of the umbilicus, to midway between the anterior superior spine of the ilium and the symphysis pubis. The artery may be tied by the *transperitoneal method* through an incision in the middle line or in the semilunar line. *The extraperitoneal method* (Fig. 139) is performed through an incision about four inches in length, extending from one-half inch above the middle of Poupart's ligament, to a point one inch above and one inch internal to the anterior superior iliac spine. After dividing the skin, superficial fascia, and external oblique, internal oblique, and transversalis muscles, the transversalis fascia is cautiously opened, and the peritoneum pushed upwards and inwards until the psoas muscle, along the inner border of which the vessel runs, has been exposed. The needle is passed from within outwards to avoid the vein. One should be careful not to injure the epigastric or the circumflex artery, as they are important aids in establishing the collateral circulation.

The *line* of the **femoral artery** is from midway between the anterior superior spine of the ilium and the symphysis pubis, to the inner condyle of the femur. The *muscular guide* is the sartorius, which lies external to the vessel in the upper third, in front in the middle third, and to the inner side in the lower third. The artery may be ligated just below Poupart's ligament, at the apex of Scarpa's triangle, or in Hunter's canal. **Ligation of the common femoral** just below Poupart's ligament is rarely performed, because its numerous branches may interfere with perfect occlusion, and the collateral circulation is much more free after ligation of the external iliac. An incision through the skin and superficial fascia is made in the line of the artery, from a little above Poupart's ligament downwards for two or three inches. The superficial veins and the lymphatic glands are drawn aside, the fascia lata divided, and the sheath opened. The needle is passed from within outwards to avoid the vein. The anterior crural nerve lies to the outer side. For **ligation of the superficial femoral** at the apex of Scarpa's triangle (Figs. 139, 580) an incision four inches in length, the center of which is four inches below Poupart's ligament, is made along the arterial line, dividing the skin and fasciæ. The sartorius is retracted outwards, and the needle passed from within outwards to avoid the vein, which in this situation lies to the inner side of and behind the artery. The internal cutaneous nerve lies in front of the vessel, and the long saphenous nerve lies to the outer side on a deeper plane. For **ligation in Hunter's canal** (Fig. 579), a four inch incision is made in the line of the artery in the middle third of the thigh. After dividing the fascia lata the sartorius is retracted inwards, the fibrous roof of Hunter's canal, running from the adductor longus to the vastus internus, incised, and the sheath of the vessel exposed. The long saphenous nerve lies upon the sheath and should be drawn out of the way. The needle is passed from without inwards to avoid the femoral vein, which lies behind and slightly to the outer side.

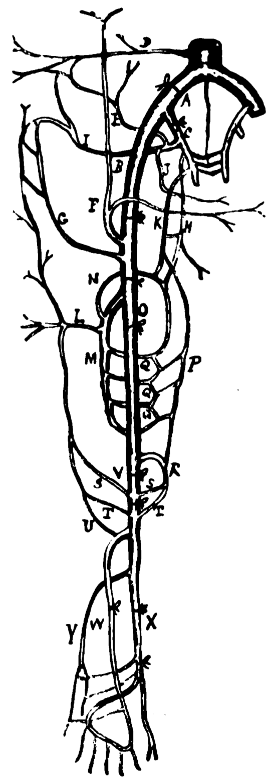

FIG. 140.—Diagram of the collateral circulation after ligature of the common iliac, external and internal iliac, femoral, popliteal, and arteries of the leg. A. Common iliac; B. External iliac; C. Internal iliac; D. Last lumbar; E. Ilio-lumbar; F. Epigastric; G. Circumflex iliac; H. Obturator; I. Gluteal; J. Lateral sacral; K. Sciatic; L. External circumflex; M. Profunda; N. Internal circumflex; O. Femoral; P. Comes ischiatici; Q Q Q. Perforating; R. Anastomotica magna; S S. Superior articular; T T. Inferior articular; U. Tibial recurrent; V. Popliteal; W. Anterior tibial; X. Posterior tibial; Y. Peroneal. (Walsham.)

The **popliteal artery** (Fig. 572) extends from the lower end of Hunter's canal, at the junction of the middle and lower thirds of the thigh to the lower border of the popliteus muscle. The *line* of the artery is from a point one inch internal to the upper angle of the popliteal space, passing midway between the condyles of the femur, to the apex of the lower angle of the space. The *muscular guide* in the upper third is the inner border of the semimembranosus; in the lower part the vessel lies midway between the heads of the gastrocnemius. The internal popliteal nerve is superficial to

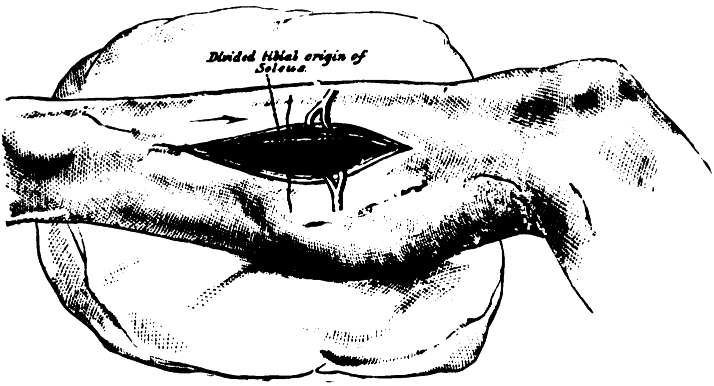

FIG. 141.—Ligature of posterior tibial artery. (Moullin.)

the artery, and the vein is external above, but crosses the vessels lower down, lying between the artery and the internal popliteal nerve. The external popliteal nerve lies well to the outer side. In ligation of the upper third an incision four inches in length is made along the outer border of the semimembranosus, which is retracted inwards, the internal popliteal nerve

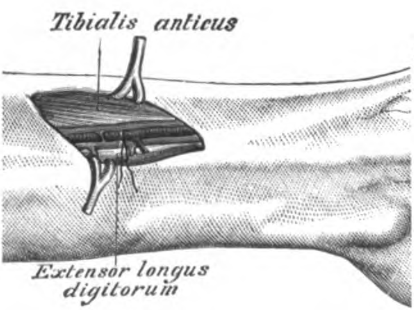

FIG. 142.—Ligature of the anterior tibial artery. (Moullin.)

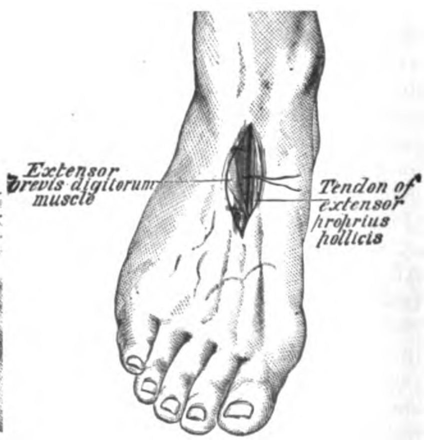

FIG. 143.—Ligature of dorsalis pedis artery. (Moullin.)

displaced outwards, and the needle passed from without inwards, as in this situation the vein is slightly external. The lower part of the vessel may be tied through an incision midway between the heads of the gastrocnemius, which are separated while guarding the external saphenous vein from harm.

The vein and nerve are drawn to the inner side, and the needle passed from within outwards.

The **posterior tibial artery** is marked by a *line* from the center of the popliteal space, to a point a finger's breadth behind the internal malleolus. **Ligation in the middle of the leg** (Figs. 141, 569) is performed with the leg flexed and lying on the outer side. An incision four inches long is made a finger's breadth behind the internal border of the tibia, dividing the skin and superficial and deep fasciæ, and avoiding the long saphenous vein and nerve. The gastrocnemius is drawn inwards, the soleus and the aponeurosis on its under surface severed and retracted backwards, and the vessel with the posterior tibial nerve to the outer side exposed on the tibialis posticus. After separating the venæ comites the needle is passed from without inwards. For **ligation behind the malleolus** make the incision one finger's breadth behind the malleolus, open the internal annular ligament between the tendons of the flexor longus digitorum and flexor proprius pollicis, and pass the needle from behind forwards, thus avoiding the nerve, which is posterior and external. The tendon sheaths should not be opened, and the annular ligament should be sutured after the vessel has been tied.

The *line* of the **anterior tibial** artery is from a point midway between the head of the fibula and the outer tuberosity of the tibia, to a point midway between the two malleoli. The *muscular guide* is the outer margin of the tibialis anticus. For **ligation in the upper third of the leg** make an incision in the line of the artery, incise the deep fascia, and separate the tibialis anticus from the extensor communis digitorum. The artery will be found in the intermuscular space upon the interosseous membrane, the anterior tibial nerve lying to the outer side. The needle should be passed from without inwards. **In the middle of the leg** (Figs. 142, 569) the same intermuscular space is opened, and the vessel found between the tibialis anticus and the extensor proprius pollicis; the nerve lies in front of the artery and slightly to the outer side; it should be retracted outwards and the needle passed from without inwards. **In the lower third of the leg** (Fig. 566) an incision is made in the line of the artery along the external border of the tendon of the tibialis anticus. After dividing the deep fascia, separate the tibialis anticus from the extensor proprius pollicis, retract the nerve, which lies in front and a little external, outwards, and pass the needle from without inwards.

The *line* of the **dorsalis pedis** is from the midpoint between the malleoli, to the upper end of the interosseous space between the first two metatarsal bones. The *muscular guide* is the outer margin of the tendon of the extensor proprius pollicis. An incision is made in the line of the vessel along the outer border of the extensor proprius pollicis, the deep fascia opened, the extensor proprius pollicis retracted inwards, and the extensor brevis digitorum outwards. Locate the nerve and pass the needle from it (Fig. 143).

The *line* of the **peroneal artery** is from the posterior border of the head of the fibula, to the point where the outer border of the tendo-Achillis is inserted into the os calcis. Make an incision along the arterial line, incise or draw inwards the soleus, which arises from the upper third of the bone only, divide the flexor longus pollicis close to the bone, and incise the aponeurotic structure covering the vessel, which is found close to the fibula. The needle may be passed in either direction and the venæ comites tied with the artery.

CHAPTER XVI.

LYMPHATIC SYSTEM.

Wounds of the thoracic duct during operations on the neck are probably more frequent than is generally believed, but owing to the fact that there may be two or more ducts, the accident may not be followed by serious consequences, and is overlooked. Of thirty-one recorded cases, two were fatal. The accident is recognized during operation by the escape of a white fluid which coagulates on standing. In many cases the leakage is not noticed until several days later, owing to the mixture of the lymph with blood, and to the small amount of food taken immediately after operation. The quantity of lymph lost varies; when the thoracic duct is not supplemented by a rich collateral circulation, it may be two or more quarts a day. In these cases there are great thirst, exhaustion, emaciation, hunger, and deficiency or suppression of urine, the general condition, owing to the dehydration, resembling cholera. Wounds or ruptures of the thoracic duct lower in its course may give rise to chylous ascites or chylothorax. The **treatment,** if the wound is recognized at the time of operation, consists of suture of the duct, ligation, forcipressure, or gauze tamponage. If not recognized until after operation, compression with gauze may be tried, and failing in this, if there is progressive emaciation, reopening of the wound and suture or ligature of the duct. In one case the end of the duct was implanted into the jugular vein (Deanesley).

Lymphangiectasis, or dilatation of lymphatics, may be congenital or acquired.

Congenital lymphangiectasis may occur as varicose lymph vessels more or less generalized over certain portions of the body, or as a localized lymphatic dilatation with marked proliferation of the connective tissue elements of the part, such as is seen in *macroglossia*, *macrocheilia*, and in *nevus lymphaticus*.

FIG. 144.—Elephantiasis of scrotum. (Nolan.)

Acquired lymphangiectasis is the result of obstruction from tumors pressing on the lymph vessels, wounds and cicatrices involving the lymph vessels, filaria, thrombolymphangitis, or chronic inflammation, neoplasms, or removal of lymph glands. Rupture of dilated lymph vessels is followed by *lymphorrhea*, causing *chyluria*, *chylous ascites*, *chylothorax*, *chylous diarrhea*, *chylous hydrocele*, etc. Obstructive lymphangiectasis is accompanied by a solid or *lymphatic edema* in which there is little or no pitting on pressure. This absence of pitting on pressure is due, not to the consistency of the lymph, which is fluid, but to the hyperplasia, especially of the connective-tissue cells, consequent upon the overnutrition. The skin and subcutaneous tissues are greatly thickened, the former presenting a coarse, corrugated surface, sometimes covered with *lymphatic warts*, which may ulcerate and give rise to *lymphatic fistulæ*. When the hyperplasia becomes enormous the condition is called *elephantiasis; elephantiasis Arabum*, or *true elephantiasis*, when due to the filaria sanguinis hominis; *pseudoelephantiasis*, when the result of other forms of obstruction. Elephantiasis Arabum is rarely seen outside of the tropics. The parts most frequently affected are the legs (*Barbadoes leg*), scrotum (Fig. 144), and vulva. The part becomes gigantic, the scrotum sometimes reaching the ground. The filaria sanguinis hominis passes its intermediate stage in the body of the mosquito, the ova entering the human body by means of contaminated water, or possibly directly from the bite of a mosquito. The worm finally lodges in the lymphatics, produces obstruction, and liberates a large number of embryos. The adult worm may be as long as three inches. The embryos are about $\frac{1}{80}$ in. in length, and are found in the blood during the night, or at least during the time that the patient selects for repose. Areas of lymphangiectasis are subject to attacks of inflammation, often associated with chill and fever (*elephantoid fever*), and sometimes eventuating in abscess.

The **treatment** of *lymphatic varix* is excision. *Lymphedema* should, when possible, be treated by removing the cause, e.g., a tumor. The excision of lymph glands, however, may augment the edema. In a few cases of true elephantiasis the parent filaria has been localized and removed. When the cause cannot be removed, and the trouble progresses despite elevation, massage, and the application of an elastic bandage, operative measures may be considered. Multiple punctures, and ligation of the artery of supply are not recommended. In lymphedema of the upper extremity due to carcinoma of the breast and axillary glands Handley has obtained much benefit by passing long silk threads through the subcutaneous tissues of the forearm and arm to the subcutaneous tissues of the chest, thus providing capillary drains for the lymph. Kondoleon has secured good results in several cases of lymphedema of the lower extremity by excising long strips of the deep fascia; this permits the subcutaneous lymph to pass to the deeper structures, which, according to Kondoleon, are normal and capable of absorbing the lymph. In the worst cases of elephantiasis wedge-shaped sections of the diseased tissues may be excised, or the entire part (scrotum, labium, upper or lower extremity) may be amputated.

Lymphangioma (see section on tumors).

Acute lymphangitis always follow infective processes within the area drained by the inflamed vessels. The walls of the lymphatics and generally the tissues surrounding the vessels take on the ordinary changes of inflammation, and lymph thrombosis may ensue. The process ends in resolution or in suppuration. In the former instance recovery may be only partial, obliteration or dilatation of the vessels ensuing.

The **symptoms** are those of sepsis. In *tubular lymphangitis*, in which the large lymph vessels alone are involved, red lines may be seen coursing from the infected area to the nearest glands. There may or may not be tenderness and edema. In *retiform lymphangitis* the capillary lymph vessels are affected and the redness is general; this condition is practically the same as erysipelas. In either instance suppuration may be encountered, either along the lymph vessels or in the lymphatic glands.

The **treatment** is primarily the disinfection of the wound from which the absorption of infection is taking place. The limb should be elevated and put at rest, and the lymph vessels covered with an ointment containing ichthyol, belladonna, and mercury. In the early stages cold, and later heat, may be of service. Suppuration demands incision and drainage. The constitutiona treatment is that of sepsis.

Chronic lymphangitis may follow an acute attack, or it may be chronic from the beginning, e.g., in syphilis, tuberculosis, and elephantiasis. The treatment is that of the cause; in some instances, particularly in the tuberculous variety, excision may be attempted.

Acute lymphadenitis is due to the same causes as acute lymphangitis, and occasionally follows cold or injury, inflammatory processes in contiguous structures, or infection from the blood stream. The lymph vessels may or may not participate in the inflammation. The glands enlarge as the result of the hyperemia and exudation, and the surrounding tissues are usually more or less involved in the process (*periadenitis*).

The **symptoms** are those of fever in all but the mildest cases. The glands are tender and palpably enlarged. In the severer cases the overlying skin becomes red, edematous, and adherent, and the glands are welded into one mass, which finally softens owing to the formation of pus.

The **treatment** in the early stages is that of acute lymphangitis. The source of infection is often of a trivial nature and frequently overlooked. A scratch on the foot is sufficient to produce a *femoral adenitis*, in which the glands about the saphenous opening are involved. In *inguinal adenitis*, in which the glands running parallel to Poupart's ligament are inflamed, and to which the term *bubo* is commonly applied, the penis, urethra, scrotum, lower part of the abdomen, anus, perineum, and buttock should be carefully examined. In *cervical adenitis* the scalp should be inspected for conditions like eczema or pediculosis, the ear for chronic inflammation or skin lesions, the lips for cracks or ulcers, the teeth for caries, the gums for pyorrhea, and the tongue and throat for lesions through which infection might gain access. When suppuration is threatened poultices may be applied, but pus should be evacuated as soon as it forms.

Chronic lymphadenitis follows the acute form, particularly when the source of irritation has not been removed; it also occurs as the result of chronic infection, particularly by the infectious granulomata, the most important of which are syphilis and tuberculosis.

The **diagnosis** of the cause of chronically enlarged glands involves a consideration of the chronic simple form, the tuberculous and syphilitic varieties, Hodgkin's disease, lymphatic leukemia, and primary and secondary new growths. In *chronic simple lymphadenitis* some source of continuous irritation in the area drained by the lymph glands may be discovered. Although the glands are enlarged and perhaps tender, they do not tend to mat together or to suppurate. Removal of the source of irritation results in cure. If recovery does not follow appropriate treatment, a strong suspicion of tuberculosis should be entertained. *Tuberculous lymphadenitis* progresses despite local treatment, and successively involves gland after gland. The glands show a strong tendency to adhere to each other and to the skin, and to undergo caseous degeneration. The condition is most common in children, in whom other signs of tuberculosis may be recognized. The family history is of some importance. The use of tuberculin for diagnosis is not generally employed (see diagnosis of tuberculosis). In the neck tuberculous glands usually make their appearance first in the submaxillary triangle. Calcified tuberculous lymph glands may be shown by the X-ray. *Syphilitic lymphadenitis* is diagnosticated by the history of a sore, by associated lesions of syphilis, by the Wasserman test, and by the results of treatment. The glands are hard, discrete, not adherent to each other or to the skin, do not tend to suppurate, and are neither painful nor tender. The enlargement in the primary stage is confined to the glands anatomically related to the sore; during the secondary period the the distribution is general, the epitrochlear and post-cervical glands always being involved; in the tertiary period the glands may become gummatous, the diagnosis then resting upon the history and the results of treatment. In *Hodgkin's disease* (*pseudoleukemia, general lymphadenosis*) the enlargement is usually first noticed at the root of the neck, and then spreads to other groups of glands, sometimes involving the lymphatic structures throughout the body and often the spleen. The glands increase rapidly in size, forming enormous masses in which the individual glands are readily made out, the mass resembling a bunch of large grapes; there are little or no pain, periadenitis, and rarely suppuration (Fig. 145). In some instances the disease remains localized for a considerable time. The nature of the condition is not quite clear, some believing it to be sarcomatous, some tuberculous,

FIG. 145.—Hodgkin's disease. (Longcope—Pennsylvania Hospital.)

and some a distinct morbid entity that can be recognized by microscopic study of an excised gland. Recurring attacks of intermittent fever are common. The blood shows no characteristic changes beyond those of a progressive anemia and occasionally eosinophilia. If a marked leukocytosis, or a relative lymphocytosis without an increase in the number of white cells, is found, the condition is called *lymphatic leukemia*. The disease is fatal in from a few months to several years. *Malignant disease* of the lymph glands is characterized by rapid growth, and by infiltration of the surrounding tissues, including skin, muscle, etc. There is considerable pain, and there may be softening, with later the discharge of a pultaceous material. If carcinomatous, it is always secondary to a primary growth elsewhere. Lymphosarcoma, melanotic sarcoma, and sarcoma of the tonsil, testis, and thyroid also cause secondary growths in the lymph glands. In the absence of a primary growth it is sarcomatous (*lymphosarcoma*). *Lymphadenoma and lymphoma* are terms loosely employed to designate chronically enlarged glands, either inflammatory or neoplastic in nature.

The **treatment** of chronic lymphadenitis when of a *simple* nature, consists in rest of the part, the removal of all forms of irritation, the local application of iodin, belladonna, mercury, or ichthyol, and the administration of tonics. In the presence of *syphilis* antisyphilitic treatment should be given. *Tuberculous adenitis* demands thorough removal of the diseased glands by operation, unless the general condition of the patient forbids such treatment. Recurrence takes place in probably half of the cases, and should be dealt with in the same manner as the primary focus. Fresh air, good food, and tonics are always essential. When thorough removal is impracticable, as much of the broken down gland tissue as possible should be removed with the curette. Recently encouraging results have been obtained with radio- and heliotherapy. *Hodgkin's disease* and lymphatic leukemia may be treated by the X-ray, the internal administration of arsenic, and injections of Coley's fluid. If the glandular enlargement is sufficiently localized, extirpation should be advised. *Malignant disease* of lymphatic glands requires thorough removal.

Status lymphaticus, or lymphatism, is a hyperplasia of the thymus, spleen, lymph tissues, and lymphatic glands of the entire body, including the lymphoid bone marrow. It may be associated with rickets, goiter, or hypoplasia of the heart and aorta. It may be found in adults but is most frequent in children. This condition is of interest to the surgeon, because every now and then it is responsible for sudden death during or some time subsequent to operation, often of the most trivial nature. The cause of death is not clear; in a few instances pressure of the enlarged thymus on the trachea seems to be responsible, but in most cases a lympho- or thymo-toxemia better fits the conditions found postmortem. The *diagnosis* of lymphatism should make one hesitate to perform an operation of election. The patients are usually anemic, the tonsils hypertrophied, the lymph glands generally enlarged, the thyroid more prominent, and the thymus increased in size (see hyperplasia of the thymus).

CHAPTER XVII.

NERVES.

Neuritis may be acute or chronic; limited to a single nerve or group of nerves, or widely distributed (*polyneuritis*, or *multiple neuritis*). It is caused by external influences, such as cold, injuries, and extension of inflammation from contiguous structures; or by toxic or infectious agents reaching the nerves through the blood, such as lead, arsenic, alcohol, diphtheria, gout, rheumatism, syphilis, beri-beri, etc.

The **symptoms** of the localized form, which alone is amenable to surgical treatment, are sharp pain and tenderness along the nerve, which is sometimes palpably swollen. In the early stages there may be hyperesthesia of the skin, and twitching or spasms of the muscles; later with the onset of degenerative changes there are paresthesia, such as numbness or formication, and possibly complete anesthesia, paresis or paralysis of the muscles, and various trophic lesions, such as edema, glossy skin, loss of the hair and nails, ankylosis of joints, ulcers, localized sweating, and atrophy of the muscles (which show the reaction of degeneration). Particularly in traumatic cases the inflammation may spread upwards to the spinal cord, and even to the corresponding nerve on the opposite side of the body. The duration of neuritis varies from days to months or years, and recovery may be complete or only partial.

The **treatment** is removal of the cause if possible, and during the early stages, complete immobilization, cold or heat, and nervous sedatives. Counter-irritation with a series of blisters is often of value. Any existing diathesis should be treated. In the later stages strychnin, massage, electricity, and active and passive motions for the prevention or alleviation of degenerative changes are indicated. When internal medication fails, the nerve may be pierced with needles, which are allowed to remain for a short time (*acupuncture*); injected with cocain, chloroform, alcohol, Schleich's solution, or osmic acid (p. 248); cut (*neurotomy*); resected (*neurectomy*); or avulsed if the nerve itself is of little importance; when the nerve is an important one, it may be stretched (*neurectasy*); or the sheath opened and the fibres separated by blunt dissection; and finally, in desperate cases, the sensory roots in the spinal canal or the skull may be divided or the ganglia excised.

Neuralgia is a paroxysmal stabbing or burning pain in a nerve or group of nerves, lasting from a few seconds to hours, and recurring at widely varying intervals. The nerve may be tender at a point where it leaves a bony canal or courses over a resistant structure (*points douloureux*) and pressure on these points may precipitate an attack. The muscles may twitch or be violently contracted during the paroxysm, and trophic changes may be found in the area over which the nerve presides.

The **causes** of neuralgia are those of neuritis, or those of reflex irritation, such as carious teeth, errors of refraction, worms, and diseases of the nose, throat, ovary, etc. Anemia, nervous temperament, and physical debility strongly predispose to, if not actually cause, the disease in many cases. Neuralgia is called *true* when no cause can be found, *secondary, or symptomatic*, when due to some general or local affection. The more thoroughly one studies the disease the more often will the source of irritation be discovered; thus sciatica may be due to a pelvic tumor, intercostal neuralgia to spondylitis or a tumor of the spinal cord, and neuralgia of the testicle to an incipient hernia.

The **treatment** of symptomatic neuralgia is that of the cause. In true neuralgia, the general health should be built up by fresh air, good food, and tonics. Nervous sedatives and hypnotics are used during the attack, which in some cases may be terminated by pressure over the nerve, or by freezing with chlorid of ethyl. Morphin is often absolutely necessary, but in chronic cases, as in neuritis, should be used with caution. The surgical treatment is that of neuritis. For the special forms of neuralgia the reader is referred to the section on special nerves and to the chapters on regional surgery.

Tumors of nerves include the *true neuromata* (rare), made up of medullated (*myelinic*) or non-medullated (*amyelinic*) nerve fibers, and the *false neuromata*, which are usually fibrous or myxomatous growths arising from the peri- or endo-neurium. Occasionally sarcoma develops in the same situation.

False neuromata may be single or multiple, and vary greatly in size. A *painful subcutaneous tubercle* is a small fibroma developing from the sheath of a nerve filament. When involving a large nerve, a false neuroma may be painless except when pressed upon. The function of the nerve is seldom disturbed.

The **treatment** of neuroma is removal. A false neuroma of a large nerve can usually be enucleated after splitting the neural sheath longitudinally and separating any nerve fibrils that may be spread over the growth. If removal cannot be effected without destroying the continuity of the nerve, this should be done and the ends sutured. The treatment of traumatic neuroma, a term often applied to the bulbous proximal end of a divided nerve, is excision (see amputations).

Neurofibromatosis ((*Recklinghausen's disease*) may be congenital, hereditary, or familial, and effects the male more often than the female. It is of long duration, and finally terminates in death, often owing to the development of sarcoma or phthisis. The varieties mentioned below may exist singly or in combination.

Multiple neurofibromata may be limited to a single nerve trunk, or to a nerve and its branches (*plexiform neuroma*), often one of the head or the neck, in which event the thickened, tortuous, elongated filaments can be felt beneath the skin; or there may be a widespread thickening (*generalized neurofibromatosis*) of many, indeed all, of the nerves of the body, with the development of multiple tumors springing from the connecting tissue of the nerves. The tumors may be tender or there may be no symptoms. Paralysis is uncommon, unless growths arise in the spinal canal.

Cutaneous neurofibromata (*molluscum fibrosum*) are soft, lobulated, or flap-like tumors which vary greatly in size, and may be scattered over the entire body, except the palms of the hands and the soles of the feet. They are supposed to originate in the sheaths of the dermal nerves.

Elephantine thickening of the entire cutaneous and subcutaneous tissue covering a part, e.g., the leg (*elephantiasis neuromatosa, pachydermatocele*), is really a diffusion of molluscum fibrosum. It differs from other forms of elephantiasis in that it may exist at birth (*congenital elephantiasis*) and be associated with multiple neuromata.

Brownish *pigmentation* of the skin, in patches or diffused, may appear in any of the forms of neurofibromatosis, the face, the neck, and the trunk being the regions most often discolored.

The **treatment** of plexiform neuroma is, in some cases, excision. Generalized neurofibromatosis is not amenable to surgical treatment, if one excepts amputation for an elephantiasis neuromatosa that, by its size and weight, interferes with locomotion.

Injuries of Nerves.—Contusion of a nerve causes violent pain, and if severe, signs of incomplete or complete section of the nerve (vide infra). It may be followed by neuritis and subsequent degeneration. The *treatment* is rest, and later massage and electricity. If the symptoms are those of complete section and the reaction of degeneration appears, the nerve should be exposed by an incision, when it may be discovered that the injury is a rupture instead of a contusion, in which event the nerve should be sutured. Usually the site of injury is marked by a thickened, indurated area, which should be resected, and the ends of the nerve sutured. If no change in the nerve can be found, the incision is closed.

Compression of a nerve may be caused by tumors, aneurysms, fractures, dislocations, cicatricial tissue, callus formation, tourniquets, splints, crutches, etc. *Acute compression,* such as that due to lying on the arm during sleep or other unconscious states, causes anesthesia and paralysis, or in the slighter forms a sensation of numbness or tingling. *Chronic compression,* gradually produced, causes at first increase in the function of the nerve, i.e., neuralgia, and twitching or spasms of the muscles, and later, anesthesia, paralysis, and trophic changes. The *treatment* is removal of the cause, massage, and electricity. After the liberation of a nerve from callus or cicatricial tissue (*neurolysis*) its sheath, if much thickened, should be split longitudinally, in order to relieve the fibers of the pressure thus exerted, and the nerve may be wrapped in muscle, fascia, Cargile membrane or, best, fat to prevent the reformation of adhesions.

Complete rupture or section of a peripheral nerve is followed by (1) immediate paralysis if it contains motor fibers; (2) immediate anesthesia if it contains sensory fibers; and (3) by trophic changes.

(1) *Paralysis* involves all the muscles supplied exclusively by the nerve. It may be recalled that certain muscles are supplied by more than one nerve, and that as most movements are the result of the action of several muscles, it is necessary, in order to determine the exact extent of the paralysis, to investigate the muscles themselves rather than the movements which they produce.

(2) *Anesthesia* of the skin is complete only in the area supplied exclusively by the nerve; in the parts which it supplies in common with other nerves, loss of sensation is incomplete or absent. Sherren divides the peripheral sensory nerve-fibers into three classes: (*a*) *Nerve-fibers of deep sensation* recognize deep pressure and the position and movements of the bones and joints. They accompany the motor nerves to the muscles and course through tendons, ligaments, and bones, hence deep sensation is rarely impaired, unless the nerve is divided above all its motor branches or unless the muscles and tendons are severed. (b) *Protopathic nerve-fibers* are important agents in the production of reflex movements. They appreciate pain, e.g., a pin prick, and great variations in temperature, but the sensations are badly localized,

radiate widely, and are accompanied by tingling. As the protopathic fibers of adjacent nerves overlap to a considerable extent, section of a single nerve results in a loss of their functions in a small and variable area. (c) *Epicritic nerve-fibers* perceive and accurately localize light touches, e.g., of a hair, trivial changes in temperature, and the contact of two points, e.g., of a compass, close together. These fibers do not overlap so much as the protopathic fibers, hence after section of a nerve their functions are destroyed over a well defined and larger area, which corresponds in outline to that given in an anatomical treatise as representing the distribution of the nerve.

(3) The *trophic changes* are at first hyperemia and elevation of the local temperature, owing to vasomotor paralysis; later the parts become cold and livid. If neuritis is absent, the *skin* becomes dry, rough, scaly, and edematous; if neuritis is present, thin, smooth, shiny, and often bathed with sweat. In the latter instance vesicular and pustular eruptions, painless ulcers and subcuticular abscesses, and chilblains may occur. The *nails* may become curved, brittle, and ridged transversely and longitudinally, sometimes being shed as the result of paronychia. The *hair* likewise becomes brittle and is lost. The *subcutaneous tissues* and the *bones* may atrophy, and the *joints*, especially those of the fingers, may be the seat of a plastic synovitis that eventuates in ankylosis. The *muscles* atrophy and are ultimately replaced by fibrous tissue, deformities often resulting from contraction of the unopposed normal muscles. The *electrical reactions* are altered. The nerve slowly fails to respond to the faradic and galvanic currents, all excitability disappearing after twelve days. The muscles cease to react to the faradic current in from three to eight days, but during the first few weeks excitability by the galvanic current is increased and the *reaction of degeneration* appears, i.e., the anodal closure is greater than the cathodal closure contracture, which is the reverse of normal. As the degenerative changes in the muscles advance, excitability by the galvanic current slowly diminishes, until finally, after a year or perhaps several years, all contractility is lost, and recovery cannot occur.

Secondary, or Wallerian degeneration, takes place in the proximal segment as far as the first node of Ranvier, and in the entire distal segment, the medullary substance undergoing segmentation, and with the axis-cylinders finally becoming absorbed. These changes are said to occur whether the nerve is sutured at once or not. If the nerve does not unite, the central end becomes bulbous, owing to the formation of fibrous tissue, in which coils of new axis-cylinders appear. Thus the end-bulb is really a neurofibroma, and sometimes, particularly after amputations, it becomes excessively painful (see amputations). The perpheral end also may become bulbous, but more commonly it shrinks.

Regeneration is thought, by some, to be due to the outgrowth of the undegenerated axis-cylinders of the proximal segment, which, when the ends of the nerve are approximated and occasionally when the ends are separated some distance, force their way downwards through the distal segment. Others believe the axis-cylinders are reformed by proliferation of the neurilemma cells, and that the distal segment regenerates even when not brought in contact with the proximal segment; certain it is that sensation sometimes returns so rapidly after secondary suture as to be explainable only by the union of the axis-cylinders from each segment. As a rule regeneration is not completed for at least several months. Restoration of function is first manifested by an improvement in the nutrition of the part.

Sensation always reappears before motion, which in many cases is never perfectly regained.

The **treatment** is immediate suture, or *neurorrhaphy*. The ends should be brought together by one or two sutures of chromicized catgut passing through the nerve, the sheath stitched with the same material, and, to prevent adhesions, the suture line covered with fat. In *secondary neurorrhaphy* i.e., weeks or months after the nerve has been divided, it will be necessary to resect a portion of each end to remove cicatricial tissue before bringing the ends together. The part should be dressed in the position in which there is the least tension on the sutures. In cases in which there is a wide gap between the ends of the nerve the defect may be remedied by (1) stretching each segment, (2) nerve grafting from lower animals, (3) neuroplasty (Fig. 146), (4) transplantation (Figs. 147 to 150), (5) resection of bone to shorten the limb, (6) *suture à distance* (Fig. 151), or by (7) tubulization, which consists of placing each end of the nerve in an excised segment of a vein, a segment of formalinized artery, or in a tube of decalcified bone or other material, to prevent the intervention of surrounding structures. When the ends of a nerve are brought directly in contact more or less function is restored in about 75 per cent. of the cases. Of 22 cases of nerve grafting 3 were "good" results and 3 "fair;" of 11 cases of neuroplasty 4 were complete or

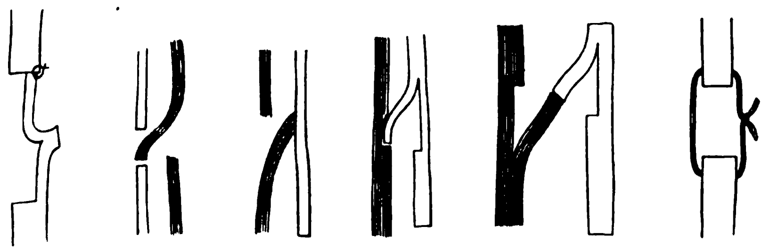

FIG. 146. Neuroplasty. FIGS. 147, 148, 149, 150. Nerve transplantation or anastomosis; paralyzed nerve shaded. FIG. 151. Suture à distance.

partial successes; of 10 cases of transplantation 5 were satisfactory; of 2 cases of *suture à distance* 2 were successful; and the only case of tubulization resulted negatively (Powers). After any case of neurorrhaphy, massage, electricity, and passive motions should be used as long as the paralysis continues.

Partial section of a mixed nerve, if not more than one-third is divided, may cause no symptoms. Paralysis, when present, is incomplete, and, although the muscles may fail to respond to faradism, they react promptly to the galvanic current and without showing the reaction of degeneration, i.e., polar reversal. Anesthesia involves principally the epicritic nerves, i.e., those which appreciate light touch. Trophic disturbances are slight or absent, unless a neuritis is inaugurated. Aside from removal of a foreign body, which might prevent union of the divided fibers or cause irritation, the treatment is expectant; and the prognosis is good.

LESIONS OF SPECIAL NERVES.

In affections of the cranial nerve trunks the loss of function is on the same side as the lesion; if the lesion be central, i.e., in the brain, the symptoms are referred to the opposite side of the body.

The **olfactory nerve** may be injured in fractures of the cribriform plate or in contusions of the forehead, resulting in transitory or permanent anosmia (loss of smell).

The **optic nerve** also may be involved in a fracture of the base of the skull, resulting in rupture or compression of the nerve. In the former event blindness is permanent, in the latter, particularly when due to blood, vision may be restored. The optic nerve may be compressed also by inflammations in the orbit, or by tumors, aneurysms, foreign bodies, or cicatricial tissue. *Optic neuritis* (*papillitis, choked disc*) is usually the result of increased intracranial pressure, such as occurs in tumor, abscess, etc., of the brain.

The **third nerve (motor oculi)** may be affected centrally in cerebral affections, or peripherally by trauma, tumors, etc. The nerve supplies the iris and all the muscles of the orbit except the superior oblique and the external rectus. Paralysis of the nerve causes ptosis, external squint with the eye turned a little downwards, mydriasis, loss of accommodation owing to paralysis of the ciliary muscle, and slight exophthalmos owing to the loss of tension exercised by the muscles.

The **fourth nerve (patheticus)** supplies the superior oblique, paralysis of which causes impaired movement of the eye downwards and outwards.

The **fifth or trigeminal nerve** supplies the face with sensation and the muscles of mastication with motion. It is rarely affected in head injuries, but is often the seat of neuralgia. *Trifacial or trigeminal neuralgia*, called also *tic douloureux* in contradistinction to *tic convulsif*, which is a spasm of the facial muscles, and which may or may not be associated with neuralgia of the fifth nerve, usually begins in the infraorbital or inferior dental branches. It is characterized by paroxysms of excruciating pain, often provoked by the slightest irritation, such as a breath of air or attempts at mastication. There may be lacrymation, an increase in the amount of saliva and nasal mucus, unilateral sweating of the head, and, as already mentioned, spasm of the facial muscles. There are two forms, the reflex or symptomatic, which may occur at any time of life, and true tic douloureux, which generally occurs after the fortieth year, and which is thought to be due to a senile sclerosis of the nerve or the blood vessels. *The treatment* is the removal of any reflex irritation, such as errors of refraction, diseases of the nose, teeth, ear, etc., and the combating of any existing constitutional affection, such as malaria, anemia, syphilis, gout, rheumatism, or other toxic or infectious condition. Of the many local measures which have been used may be mentioned cold, heat, menthol, belladonna, croton chloral, blisters, the cautery, freezing of tender points (*points douloureux*), and the galvanic current. Nerve sedatives and hypnotics must be used for the pain. Strychnin in increasing doses, until some physiological results have been obtained, has been highly recommended. When these measures fail *operative treatment* will be demanded. Facial neuralgia has been treated by ligation of the common carotid, resection of the superior cervical ganglion of the sympathetic, and by stretching the seventh nerve when associated with tic convulsif, but practically all surgeons prefer to attack the fifth nerve itself. Simple division of the nerve and nerve stretching are very transient in their effects and are not recommended. In order to effect a physiological section, which is claimed to be permanent, 5 or 10 m. of a 1.5 per cent. solution of osmic acid are injected into the branches of the nerve after they have been exposed by incision. Alcohol (80 per cent.), formalin, and other substances have been used in a similar way. The favorite treatment, however, is resection of the peripheral branches of the nerve, which may have to be repeated, owing to the regeneration of these filaments. Regeneration is especially likely to occur when the nerve occupies a bony canal, hence, after resection, some surgeons plug the canal with gold foil, dental paste, etc. Kanavel suggests covering the foramen with a flap of periosteum, or filling the canal with an osseous transplant. When the entire nerve is involved or recurrences are frequent, more formidable operations are required, even to resection of the Gasserian ganglion.

Resection of the supraorbital nerve may be performed through an incision about one inch long in the line of the eyebrow, after this has been removed by shaving. The nerve makes its exit through the supraorbital notch or foramen, at the junction of the inner and middle thirds of the upper margin of the orbit. As much of each end as possible is removed.

The **supratrochlear nerve** may be found at a point where a line drawn from the angle of the mouth to the inner canthus touches the upper margin of the orbit.

The **infraorbital nerve** emerges from the infraorbital foramen about one-third inch below the middle of the lower margin of the orbit. A curved incision is made below the lower margin of the orbit and the nerve isolated. The periosteum of the orbital floor is then elevated, the roof of the infraorbital canal opened, and the nerve divided as far back as possible and drawn out through the foramen. By this method even the main trunk of the superior maxillary may be reached and divided.

The **superior maxillary nerve** and Meckel's ganglion may be removed by the Carnochan-Chavasse operation. A T-shaped incision is made, the horizontal portion of which runs from canthus to canthus beneath the lower margin of the orbit, and the vertical, downwards from the center of this incision to, but not into, the mouth. The infraorbital nerve is isolated and secured with a piece of silk, and both the anterior and posterior walls of the antrum are opened by a gouge or chisel, care being taken not to injure the internal maxillary artery. The infraorbital canal is opened on the roof of the antrum, and the nerve divided on the cheek and pulled down through the antrum. It is then traced backwards to the foramen rotundum, where after slight traction it is divided. Meckel's ganglion is brought away with the nerve. The same procedure has been carried out through the orbit, and from the side of the face after resection of the zygoma and coronoid process of the lower jaw.

The **inferior dental nerve** may be resected by making an incision along the lower border of the jaw back to the angle. The masseter is scraped from the bone, which is then chiseled or trephined about one and one-fourth inches above the angle, so as to remove the outer half of the thickness of the bone and expose the nerve at its entrance into the inferior dental foramen. The nerve is lifted from its bed by a sharply curved hook, and as much of each end as possible removed by avulsion. The inferior dental may be resected also through the mouth. A gag is placed between the teeth of the opposite side, and an incision made along the anterior border of the ramus of the lower jaw to the last molar tooth. After separating the internal pterygoid muscle from the bone and locating the spine of Spix, at the base of which is the inferior dental foramen, a hook is passed around the nerve and as much of it as possible removed.

The **lingual nerve** may be exposed in the mouth by making an incision midway between the tongue and the gum of the last molar tooth, or externally by an incision in the submaxillary triangle.

The **auriculo-temporal nerve** may be exposed at the root of the zygoma by a vertical incision between the temporal artery and the pinna.

The **buccal nerve** may be exposed by a vertical incision through the mucous membrane and buccinator fibers, the center of the incision being at the middle of the anterior border of the vertical ramus of the inferior maxilla.

The **inferior maxillary nerve** may be divided at the foramen ovale after resection of the zygoma or coronoid process, or both. Another method is to deepen the sigmoid notch of the lower jaw three-fourths of an inch or more.

Myxter's operation is a resection of the second and third divisions of the fifth nerve at their exit from the skull, after temporary resection of the zygoma. In **Abbe's operation** the external carotid is ligated and a vertical incision made above the middle of the zygoma. The skull is then opened by gouge and rongeur, and the second and third divisions exposed extradurally and severed at the foramen rotundum and foramen ovale. A slip of gutta-percha tissue is placed over the foramina in order to prevent the junction of the divided nerves.

Removal of the Gasserian ganglion is indicated in cases in which the entire nerve is involved, or in which less dangerous operations have failed. In the *Hartley-Krause method* a horseshoe-shaped osteoplastic flap consisting of scalp and bone is made in the temporal region with the base at the zygoma. In raising this flap the middle meningeal artery is often injured. The dura mater is not opened, but is stripped from the middle fossa of the skull until the second and third divisions of the nerve are found; these are traced backward to the ganglion at the apex of the petrous portion of the temporal bone. The dural envelope (cavum of Meckel) of the ganglion is then opened, the ganglion separated from this envelope, the second and third divisions divided near their foramina, and the ganglion twisted out with forceps. *Cushing*, after cutting through the zygoma at each end, opens the skull lower down, so as to avoid injury to the middle meningeal artery. *Rose* reaches the ganglion through the pterygoid region after resecting the zygoma and the coronoid process of the lower jaw. In *Horsley's method* the dura is opened and the ganglion removed. In the *Spiller-Frazier operation* the sensory root of the ganglion alone is divided. The mortality of these operations is from 10 to 20 per cent., but the chance of permanent cure in those who survive is very great. Ulceration of the cornea may occur, and should be anticipated by suturing the eyelids together at the time of operation, and later, if there is the slightest irritation, by the wearing of a watch glass over the eye. The cavernous sinus and the sixth nerve have both been injured during operation.

Division of the **sixth nerve** causes internal squint as the result of paralysis of the external rectus.

The **seventh or facial nerve** may be paralyzed (Bell's palsy) within the cranium from tumor, abscess, hemorrhage, thrombosis, embolism, softening of the brain, etc.; in its passage through the Fallopian canal from fracture of the base of the skull and middle ear disease, causing compression or neuritis; and at its emergence from the styloid foramen by trauma, tumors, and neuritis from cold. When the nerve is affected in the cortex, corona radiata, or internal capsule, the lower half of the opposite side of the face is paralyzed, usually with hemiplegia, and the reactions of degeneration are absent. When the lesion is in the lower part of the pons, the face is paralyzed on the same side, and the arm and leg on the opposite side (*crossed paralysis*), owing to the fact that the motor fibers to the arm and leg decussate in the medulla. A lesion between the brain and the Fallopian canal is often accompanied by deafness, and the paralysis involves the entire face of the same side. Section of the facial nerve, where it is accompanied by the chorda tympani, i.e., between the geniculate ganglion and the lower part of the Fallopian canal, causes loss of taste over the anterior two-thirds of the corresponding half of the tongue.

The **treatment** is removal of the cause, whenever possible. Massage, electricity, and iodid of potassium are used in cases not suitable for surgical treatment. In cases of extracerebral origin in which electrical examination reveals the presence of fairly healthy muscles, the nerve may be severed at the stylomastoid foramen and the distal end sutured into the spinal accessory or hypoglossal nerve (Fig. 148). The extent of recovery is limited to associated movements in conjunction with the shoulder. The cases most suitable for operation are those in which the palsy has lasted for six months without any signs of recovery. The operation may be done also in severe cases of facial tic (clonic spasms of the facial muscles) which have resisted medical treatment and neurectasy (Ballance and Stewart).

The **eighth or auditory nerve** may be involved in tumors, meningitis, hemorrhage, or traumatism, often resulting in incurable deafness. It has been divided for uncontrollable tinnitus of peripheral origin.

Lesions of the glossopharyngeal nerve are rare; paralysis would affect taste, swallowing, and possibly speaking.

The **tenth or pneumogastric nerve** may be compressed by tumors or aneurysms, or injured in fracture of the base of the skull or in operations on the neck. Irritation may cause vomiting, inhibition of the heart, and spasm of the laryngeal muscles. Division of one pneumogastric may be followed by few or no symptoms, but division of both nerves causes death from paralysis of the laryngeal muscles. A lesion of the pneumogastric nerve in the lower part of the neck, or of the recurrent laryngeal branch, causes paralysis of the muscles of one side of the larynx, with resulting hoarseness and impaired phonation.

The **eleventh or spinal accessory nerve** is exposed to wounds and many forms of irritation. Section of the branch which joins the pneumogastric results in paralysis of the laryngeal muscles. The external branch is distributed to the sternomastoid and trapezius, which muscles may not be completely paralyzed after division of the nerve, as they receive filaments also from the cervical nerves. The nerve has been stretched or divided for spasmodic torticollis.

The **twelfth or hypoglossal nerve** when divided, causes paralysis of one side of the tongue, which, when protruded, is directed to the paralyzed side; deglutition also may be impaired.

The **phrenic nerve,** when irritated, causes hiccough, and when divided, paralysis of the diaphragm, which, if unilateral, is often scarcely noticeable, but if bilateral may cause instant death.

The **brachial plexus** may be injured (a) above or (b) below the clavicle.

(a) *Supraclavicular* injuries may be direct, e.g., from penetrating wounds, fracture of the clavicle or cervical spine, or pressure of a cervical rib; or indirect, the nerves being overstretched or ruptured as the result of traction, the direction and violence of the force determining the grade and extent of the paralysis, of which there are three common types.

(1) The *upper arm, or Duchenne-Erb type,* is the most frequent. It is due, not to the pressure of the clavicle, as has been thought, but to a forcing apart of the head and shoulder, the brunt of the strain falling upon the anterior primary division of the fifth cervical nerve, hence paralysis of the deltoid, supraspinatus, infraspinatus, biceps, brachialis anticus, supinator longus, and supinator brevis, which causes loss of abduction and outward rotation of the arm and loss of flexion and supination of the forearm. Sensation is not impaired. When the traction is less severe only the upper part of the fifth cervical may be ruptured, resulting in paralysis of the deltoid and spinati; as these cases follow a blow on the shoulder they are frequently diagnosticated as injury to the circumflex nerve (Sherren).

(2) The *lower arm, or Klumpke type,* is caused by upward traction on the arm, e.g., when a man saves himself from a fall from a height by clutching a projection of some sort. In these cases the first dorsal nerve is stretched or torn, and the intrinsic muscles of the hand and often the cervical sympathetic nerve are paralyzed. Anesthesia exists over the inner side of the arm and forearm, and occasionally along the ulnar border of the hand.

(3) The *whole plexus* type may be due to upward or downward traction, when of severe grade. All the muscles of the upper extremity, excluding the rhomboids and the serratus magnus, are paralyzed, usually with impairment of the functions of the cervical sympathetic nerve. Anesthesia exists over the whole limb, excepting the area along the inner side of the arm supplied by the intercosto-humeral nerve.

(b) *Infraclavicular* injuries, aside from penetrating wounds, are usually the result of direct pressure, e.g., from a crutch, from dislocation or fracture of the upper end of the humerus or attempts to reduce the deformity in these cases, especially by the heel-in-axilla method. The two common forms are the *whole plexus* type, which differs from that of the supraclavicular variety, in that the anesthesia is complete, and the *inner cord* type, which gives the symptoms of injury to the ulnar nerve, with paralysis of the muscles of the hand supplied by the median nerve. Lesions of the *outer cord* are accompanied by paralysis of the biceps, coracobrachialis, and the muscles innervated by the median, except those of the hand, and by anesthesia of the outer side of the forearm. Lesions of the *posterior cord* cause symptoms identical with those of the musculospiral and circumflex nerves.

Post-anesthetic paralysis of the brachial plexus is usually of the Duchenne-Erb type, the causative traction being exerted by the abducted arm hanging from the edge of the table. Those cases which follow elevation of the arm above the patient's head are due to pressure of the upper end of the humerus, and are of the infraclavicular variety.

Brachial birth paralysis usually involves the left arm and is usually due to forcible separation of the head from the shoulder, hence of the Duchenne-Erb type, although the lower arm type may follow a breech presentation with the arms extended, and in severe cases the whole plexus may be involved.

The **treatment** of brachial paralysis depending upon direct wounds, or pressure from callus, displaced bone, etc., is that of the same injuries affecting other nerves. Spontaneous recovery is the rule in post-anesthetic paralysis, crutch palsy, and lesions of similar intensity. Birth paralysis ultimately disappears in perhaps three-fourths of the cases, but in adults not more than 40 per cent. of the traction paralyses due to great violence recover without operation. In all cases, as soon as the tenderness due to the accident has subsided, massage, electricity, and passive motions should be ordered. If, in the course of several months, improvement does not follow this form of treatment, and especially if the muscles show the reaction of degeneration, operation should be advised. Kennedy, however, counsels delay in birth palsy for at least one year. An incision is made from the junction of the upper and middle thirds of the posterior border of the sternomastoid to the junction of the middle and outer thirds of the clavicle, and, if the lower branches of the plexus must be exposed, the clavicle divided temporarily. After severing the deep fascia an attempt is made to identify the individual parts of the plexus, often a most difficult undertaking, owing to the mass of cicatricial tissue in which they are imbedded. If the nerves have been divided they are sutured; if destroyed by scar tissue, resected and then united. If so much of a nerve must be excised that its ends cannot be brought together, the distal segment is anastomosed with a neighboring nerve. If operation on the nerves fails, muscular transplantation may be tried. In Duchenne-Erb paralysis Tubby has restored flexion of the forearm by transplanting a portion of the triceps to the biceps, and abduction of the arm by transplanting a portion of the pectoralis major and trapezius to the deltoid.

Neuritis of any of the nerves of the arm may spread to and involve the entire brachial plexus, and the plexus is occasionally the seat of intractable neuralgia, for which it has been exposed and stretched.

The **posterior thoracic nerve** may be injured or inflamed, causing paralysis of the serratus magnus, or winged scapula (q. v.).

The **circumflex nerve** winds around the neck of the humerus three-

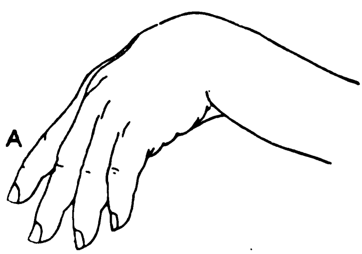

FIG. 152.—Wrist-drop after section of musculospiral nerve. (Gowers.)

FIG. 153.—Hand after section of median nerve. (Dagron.)

fourths of an inch above the middle of the deltoid. It is often involved in injuries about the shoulder, resulting in paralysis of the deltoid and teres minor, and transient anesthesia of the posterior fold of the axilla.

The **musculospiral nerve** may be injured in fractures of the humerus, especially where it lies close to the bone in the musculospiral groove. It is frequently compressed also in crutch palsy and by lying on the arm, and is peculiarly prone to be affected by lead poisoning. Division of the nerve near the plexus causes paralysis of the extensor muscles of the elbow, wrist (*wrist-drop*), fingers, and thumb, and, excepting the biceps, of the supinators of the forearm (Fig. 152). Extension of the terminal phalanges may still be accomplished by the interossei and lumbricales. Sensation is lost over the anterior and posterior aspects of the radial side of the elbow and forearm, the radial side of the posterior surface of the wrist and hand, and over the dorsal surface of the thumb, first, second, and half the third fingers (Fig. 155).

In cases of pressure palsy massage and electricity will be required, recovery usually ensuing in a variable length of time. When caught in callus or divided, operation will be necessary.

The **median nerve,** when divided above the bend of the elbow, causes paralysis of the pronators, flexor carpi radialis, palmaris longus, flexor longus pollicis, flexor sublimis, and the radial half of the flexor profundus digitorum, with the following, which alone are involved in an injury just above the wrist, abductor, opponens, and outer half of the flexor brevis pollicis, and the two radial lumbricales. There is loss of sensation in the skin of the radial side of the hand, the flexor surface of the thumb, and in the first, second, and half the third fingers, which are involved to a varying degree also on the dorsal surface (Fig. 155). There are loss of pronation, impaired radial flexion and abduction of the wrist, loss of the hand grasp on the radial side, and wasting of the thenar eminence (Fig. 153). Flexion of the proximal phalanges by means of the interossei is still possible.

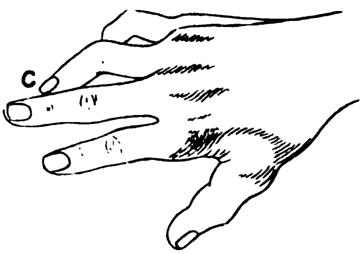

FIG. 154.—Hand after section of ulnar nerve. (Gowers.)

The **ulnar nerve** supplies the flexor carpi ulnaris, the ulnar half of the flexor profundus, the two ulnar lumbricales, all the interossei, the muscles of the little finger, the adductors of thumb, the ulnar half of the flexor brevis pollicis, and the skin of the anterior and posterior surfaces of the ulnar side of the hand, including the little finger and the ulnar half of the ring finger. After division of this nerve there are anesthesia in the area just mentioned (Fig. 155), impairment of ulnar flexion and adduction of the wrist, weakened hand grasp in the ring and little fingers, loss of adduction and abduction of the fingers, and extension of the proximal phalanges and flexion of the second and third phalanges of all the fingers (*claw hand*), with atrophy of the interossei, causing marked prominence of the interosseous spaces (Fig. 154). *Dislocation* of the ulnar nerve in front of the inner condyle may occur; it has been treated by suturing a flap of fibrous tissue over the nerve to the triceps tendon, after reduction has been effected.

The **lumbar plexus** may be affected by injuries, by tumors, and by disease of the vertebræ. It supplies sensation to the lower part of the abdomen, the anterior and lateral aspects of the thigh, and to portion of the inner side of the leg and foot. It supplies also the flexors and the adductors of the hip, the extensors of the leg, and the cremaster.

The **obturator nerve** may be injured during parturition, resulting in paralysis of the adductors of the thigh, the patient being unable to cross the legs. External rotation also is impaired.

The **anterior crural nerve,** when divided, results in paralysis of the extensors of the knee, and anesthesia over the front and sides of the thigh, and the inner side of the leg, foot, and big toe (Fig. 155).

The **sacral plexus** innervates the rotators and extensors of the hip, the flexors of the knee, all the muscles of the foot, and the skin of the buttock, posterior surface of the thigh, outer and posterior portion of the lower leg, and almost the entire foot. It may be compressed by pelvic tumors or inflammations, injured during child birth, or involved in a neuritis, which is often an extension from the sciatic nerve.

The **superior gluteal nerve** supplies the gluteus medius and minimus, hence its division results in loss of abduction and circumduction of the thigh.

The **small sciatic nerve** is not often injured. Its division results in paralysis of the gluteus maximus, and anesthesia of the posterior surface of the middle third of the thigh, and of the upper half of the calf of the leg.

The **great sciatic nerve,** when severed near the sciatic notch, causes

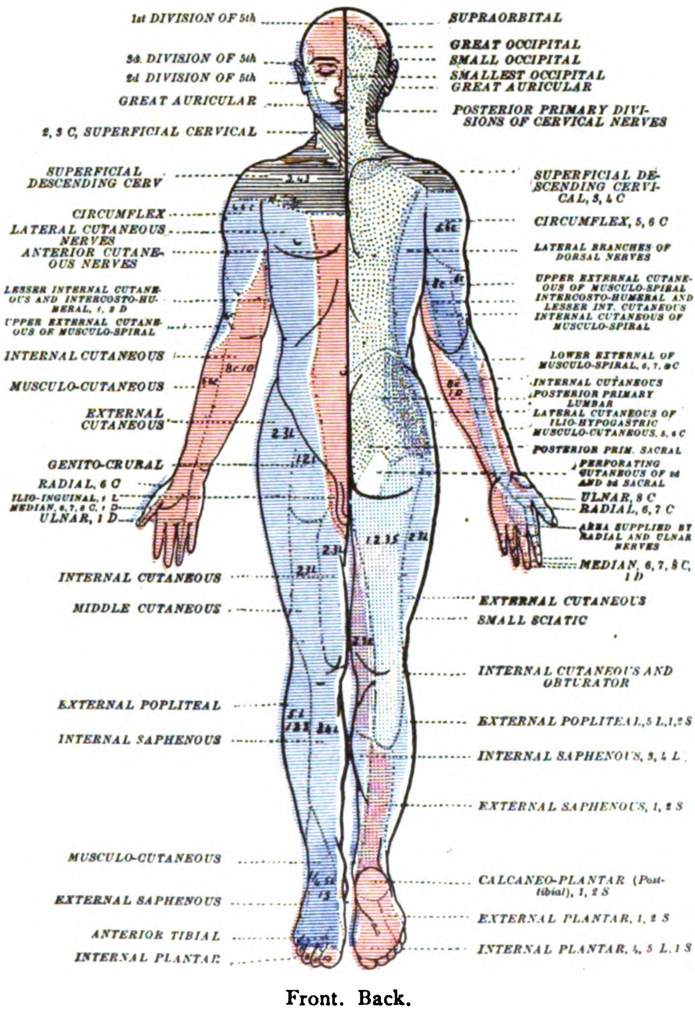

FIG. 155.—Diagram showing the areas of distribution of cutaneous nerves. (Morris.)

paralysis of the flexors of the leg (which are also extensors of the hip), and of all the muscles below the knee joint; the latter muscles alone are involved when the injury is below the middle of the thigh. Anesthesia exists in the outer half of the leg, and in the sole and the greater part of the dorsum of the foot. This nerve is frequently affected by a very painful form of neuralgia (*sciatica*), in intractable cases of which neurectasy may be required. This has been accomplished by flexing the extended lower extremity upon the abdomen, under an anesthetic. In the open operation the nerve is exposed midway between the great trochanter and the tuber ischii, by an incision three or four inches long, made in the middle of the thigh from the gluteal fold downwards. The lower border of the gluteus maximus is exposed, the ham-string muscles retracted inwards, and the nerve hooked up by the finger and stretched both centrally and peripherally, enough force being used to lift the lower extremity from the table.

The **external popliteal nerve** may be severed in cutting the tendon of the biceps subcutaneously, or compressed against the neck of the fibula by bandages or splints. Section of this nerve causes paralysis of the peroneal group of muscles, the tibialis anticus, the extensor longus hallucis, and the extensor longus and brevis digitorum, with anesthesia of the outer half of the anterior surface of the leg and the dorsum of the foot. The ankle cannot be flexed on the leg (*foot-drop*), and in old cases talipes equinus develops.

The **internal popliteal nerve,** when divided, causes paralysis of the muscles of the calf, extensors of the foot, flexors of the toes, and of the muscles of the sole of the foot. Talipes calcaneus develops after a time, and the toes become claw-like, owing to extension of the proximal and flexion of the second and third phalanges. There is anesthesia along the back of the leg and over the sole of the foot.

The **cervical sympathetic nerve** may be injured by wounds, or compression by tumors or aneurysms. Irritation of the nerve causes unilateral sweating of the head and face, dilatation of the pupil on the same side, widening of the palpebral fissure, slight exophthalmos, increased intra-ocular tension, contraction of the blood vessels of the head and neck, and tachycardia. Division of the nerve causes contraction of the pupil, ptosis and narrowing of the palpebral fissure, decrease of ocular tension with recession of the eyeball, dilatation of the vessels of the head and neck with increase in the flow of tears, nasal mucus, and sweat, and bradycardia. *Excision* of the cervical sympathetic ganglia, or Jonnesco's operation, has been performed for epilepsy, exophthalmic goiter, tic douloureux, and glaucoma. An incision is made along the anterior border of the sterno-mastoid, the carotid sheath with its contents retracted forwards, and the upper or, in some cases, the entire three ganglia excised. The value of the operation is not yet fixed.

CHAPTER XVIII.

MUSCLES, TENDONS, BURSÆ.

Contusion of muscles is followed by swelling, rigidity, and by late ecchymosis if some of the blood vessels have been injured. Pain and tenderness are made worse by active motion, but are unaffected by passive motion, unless the muscle is stretched by such procedure. *The treatment* is rest and relaxation of the muscles, by splints, posture, or strapping with adhesive plaster; the application of ichythyol or evaporating lotion; and later massage.

Wounds of muscles gap widely if they traverse the muscle fibers. A wound parallel with the fibers causes little or no separation. Suturing is readily carried out in longitudinal or oblique wounds, but is often difficult in transverse wounds, the stitches tearing out when approximation is attempted. In such cases mattress sutures may be employed; a number of sutures may be placed in each end of the muscle and tied, then the ends of the sutures in the upper segment tied to those in the lower segment; or the muscular wound may be covered with a free transplant of fascia, which can be employed also to bridge a gap when a portion of the muscle has been destroyed. Chromicized catgut is the best suture material. The muscles should be relaxed by suitable posture or splint, and massage and electricity employed when healing has been completed.

Strain of muscles is an overstretching of the fibres with possibly some tearing. *Glass arm* is a strain of the long head of the biceps; *lawn tennis arm*, of the pronator radii teres; *riders leg*, of the adductor muscles of the thigh. The symptoms and treatment are those of contusion of muscle.

Rupture of muscles and tendons usually occurs as the result of great violence to a contracted muscle, or as the result of a sudden, powerful, and strongly opposed contraction, but may follow even feeble efforts in muscles degenerated in consequence of senility or fevers. Rupture of the sheath or of the deep fascia may result in *hernia of the muscle*, a protrusion which is most marked during contraction, and which often disappears during relaxation of the muscle, when the opening in the aponeurosis may be felt through the skin. In recent cases rest and relaxation are required. Later if the hernia is large and causes inconvenience, the opening in the sheath may be sutured, or, if large, patched with a transplant of fascia lata. A muscle most frequently ruptures at the junction with its tendon, although the belly itself or the tendon may tear. In some cases the tendon is torn from its attachment, bringing with it a portion of the bone. At the time of rupture there is a sudden sharp pain, with, in some cases, an audible snap. This is followed by loss of function, tenderness, pain on motion, swelling, and ecchymosis. The gap may be felt in superficial muscles. Among the muscles and tendons most frequently ruptured are the sternomastoid (during labor), rectus abdominis, quadriceps, ligamentum patellæ, tendon of the adductor longus (from riding), plantaris (tennis leg, Chap. XXXI), biceps cubiti (long head), flexor muscles or tendons of the fingers, extensors of the fingers (mallet finger, Chap. XXXI).

The **treatment** in partial ruptures is rest and relaxation; in large or complete ruptures of important muscles the ends should be approximated as described above, and the part splinted. Massage, electricity, and passive motions are employed after union has taken place.

Dislocation of tendons is most frequent at the point where a tendon passes along a bony groove in order to change its direction, e.g., the long tendon of the biceps, and the tendons about the wrist and ankle. It is usually the result of injury, hence may be accompanied by a fracture of a bone or a dislocation of a joint, but it occurs also as the result of chronic affections of joints associated with displacement. There are pain and weakness, and in some cases the dislocated tendon can be felt, with the groove in which it normally lies. In dislocation of the long head of the biceps the head of the humerus passes slightly forwards (*subluxation*).

The **treatment** is reduction of the tendon, relaxation of the muscle, and the application of a splint, with pressure over the tendon to hold it in place. If this treatment fails in the course of six weeks or two months, the tendon may be exposed by incision and the edges of the torn sheath sutured with catgut. This operation is most frequently indicated in dislocation of the peroneus longus tendon from behind the external malleolus.

Myositis, or inflammation of muscles, may be acute or chronic.

Acute myositis may be due to injuries (*traumatic myositis*), infection from the surrounding parts, exposure to cold (*rheumatic myositis*), and to infectious fevers. The symptoms are pain, swelling, tenderness, and sometimes edema of the skin. When due to local infections or pyemia, suppuration follows. *Polymyositis* affects many muscles, is of obscure origin, and strongly resembles trichinosis, hence the term *pseudotrichinosis*. When there is an overproduction of fibrous tissue the muscle is shortened, thus in the sternomastoid torticollis may be produced, and in the forearm *Volkmann's contracture* (*ischemic myositis*, Chap. XXXI).

The **treatment** is rest, sedative applications, and constitutional treatment according to the general condition of the patient. Suppuration will require incisions. Massage and electricity are indicated to prevent muscular contractures, which, when present, may require tenotomy or, better, tendon lengthening; resection of bone to shorten the limb also has been performed in certain cases.

Chronic myositis results from the acute form, or from syphilis, tuberculosis, rheumatism, actinomycosis, or the lodgment of parasites (trichina, echinococcus). It may cause suppuration, or degeneration with fibrous overgrowth. In the latter event ossification may occur, particularly in the vicinity of bone, or where the parts are constantly irritated or strained, e.g., *rider's bone* due to ossification of the upper portion of the adductor tendons of the thigh, and localized ossification of the deltoid in soldiers. In *myositis ossificans progressiva* a large part of the muscular system may be calcified. The cause is not known. It is most frequent in young males, and is sometimes associated with shortening of the thumbs and great toes. The **treatment** is directed to the cause. In localized myositis ossificans the bony plates may be excised. In the progressive form treatment is of no value.

Tumors of muscle include fibroma, myxoma, lipoma, angioma, chondroma, osteoma, myoma, and most important of all, sarcoma; carcinoma is always secondary. A *desmoid* is a fibroma or fibrosarcoma of the rectus abdominis, usually occurring in women who have borne children. A tumor in a muscle is movable perpendicularly to but not in the axis of the muscle, and becomes fixed when the muscle is contracted. The *treatment* is excision.

Tenosynovitis, thecitis, or inflammation of a tendon sheath, may be acute or chronic. **Acute tenosynovitis** is caused by injury, strains, overuse, neighboring infections, gout, rheumatism, syphilis, gonorrhea, and the infectious fevers. The *symptoms* are swelling and tenderness, with pain and fine crepitus upon motion. Suppuration may occur when the sheath has been opened by a wound, or when the thecitis is secondary to neighboring infections. The symptoms are then intensified, the skin reddened, and constitutional symptoms of sepsis present. The *treatment* is immobilization on a splint, with the application of ichthyol or evaporating lotions. Pus formation demands incision and drainage, which, if carried out early, may prevent sloughing of the tendon. Massage and active and passive motions are useful in the later stages to prevent adhesions. Suppurative thecitis of the finger and palmar abscess are described in Chap. XXXI.

Chronic tenosynovitis may follow the acute form, in which case the sheath is distended with synovial fluid. There are weakness, swelling and fluctuation along the tendon sheath, and possibly crepitus. In most instances the condition is tuberculous. **Tuberculous tenosynovitis** may present the same signs, or the swelling may be doughy owing to the thick, pulpy granulation tissue which lines the sheath. Often there can be felt slipping beneath the fingers little rounded bodies (rice, riziform, or melon seed bodies), which are laminated masses of fibrin. The *treatment* of chronic tenosynovitis is attention to any existing constitutional disease, and locally the use of a splint, with compression or counterirritation. If this fails, the sheath may be opened, its contents evacuated, iodoform emulsion injected, and the wound closed; or an attempt may be made to remove the diseased sheath by dissection.

Ganglion is a tense sac connected with a tendon sheath, and filled with a transparent, whitish, jelly-like material. It may follow an injury or strain, and is then probably due to an encarcerated hernia of the synovial lining of the tendon sheath; in other instances it is due to a localized thecitis, a colloid degeneration of a synovial fringe, or perhaps, as some maintain, to a hyperplasia of the connective tissue followed by cystic degeneration. It is most common on the back of the wrist, but may occur elsewhere. It is painful and tender when increasing in size, but usually gives no trouble when it has ceased to grow, except possibly for some weakness of the affected tendon. It may be so hard as to resemble an exostosis. *Compound ganglion* is a tuberculous thecitis of the flexor tendons of the wrist, projecting above and below the annular ligament. The *treatment* is rupture of the ganglion by strong pressure with the thumbs, or by dealing it a sharp rap with a book; expression of the contents through a small puncture, and firm pressure for several days; the injection of iodin; or in recurring cases excision.

OPERATIONS ON TENDONS.

Tenotomy, or division of a tendon, may be *open* or *subcutaneous*. It is employed chiefly in cases of deformity, and occasionally to overcome muscular spasm, e.g., cutting of the tendo Achillis in fractures of the leg. The *subcutaneous method* should be used only in regions in which important structures are not close to the tendon. Under aseptic precautions a sharp pointed tenotome is pushed through the skin to the tendon, and is then replaced by a blunt pointed tenotome, which is passed over or under the tendon. The tendon is then made tense and is cut by a sawing motion. The little puncture is sealed by collodion. In the *open method* an incision is made over the tendon and the section carried out under the eye, so that there is little danger of wounding neighboring structures. The wound is then sutured. After either method the deformity is corrected, and the parts are immobilized with plaster-of-Paris or other form of splint.

Division of the sternocleidomastoid muscle. (See torticollis.)

The **tendo Achillis** is divided subcutaneously. With the foot on its outer side and the tendon relaxed, the tenotome is inserted about one inch above the os calcis, and the tendon divided after it has been made taut by flexion of the foot.

The **tibialis anticus** is divided about one inch above its insertion. The tenotome is introduced from the outside and the section made from below upwards.

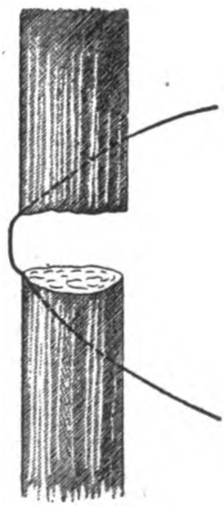
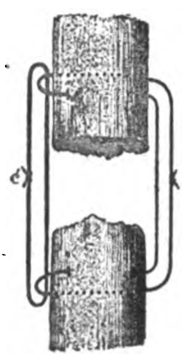
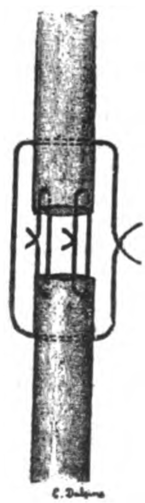
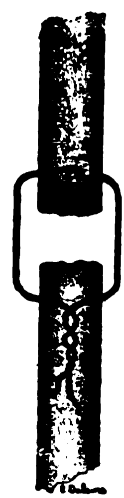

FIG. 156. FIG. 157. FIG. 158. FIG. 159.

FIGS. 156 to 159.—Tenorrhaphy. (Monod and Vanverts.)

The **peroneal tendons** are cut just above and behind the external malleolus, in which situation the synovial sheath is absent. The tenotome is introduced between the bone and the tendons, which are made tense and severed from below upwards.

The **tibialis posticus** is severed above the internal annular ligament and above the origin of the synovial sheath. The tenotome is inserted just above the base of the inner malleolus, between the tendon and the tibia, and hugs the bone closely. There is some danger of injury to the posterior tibial vessels.

The **plantar fascia** is divided subcutaneously just in front of the os calcis, by inserting a tenotome between the fascia and the skin from the inner side of the sole, and cutting towards the bone.

The **semimembranosus and the semitendinosus** may be divided subcutaneously just above the knee joint, but section of the **biceps femoris** is best done through an open incision, because of the proximity of the popliteal nerve.

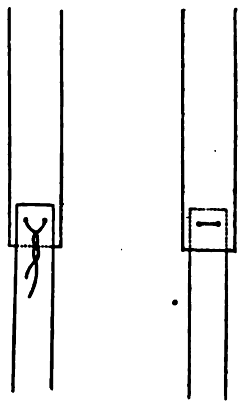

FIG. 160.—Tenorrhaphy. (Binnie.)

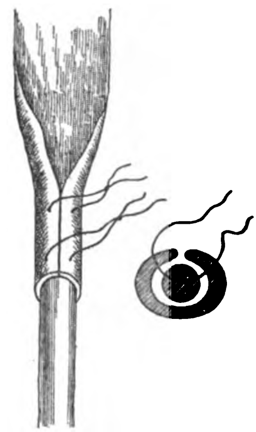

FIG. 161.—Tenorrhaphy. (Binnie.)

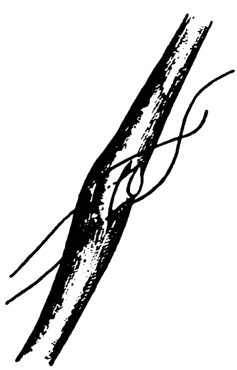

FIG. 162.

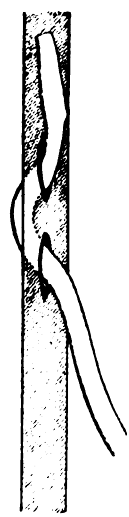

FIG. 163.

FIG. 164.

FIGS. 162 to 164.—Tenorrhaphy. (Vulpius.)

Tenorrhaphy (tendon suture) is best performed with chromicized catgut. The various methods are shown in Figs. 156 to 166; Figs. 165 and 166 show the methods for preventing the tearing out of sutures. To prevent adhesions the suture line should be enveloped with fat. After tenorrhaphy the part should be splinted. Gentle passive motion should be started at the end of two weeks, but forcible movements, if needed, should be postponed until the fourth week.

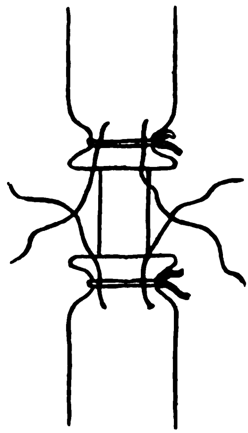

FIG. 165.—Tenorrhaphy. (Binnie.)

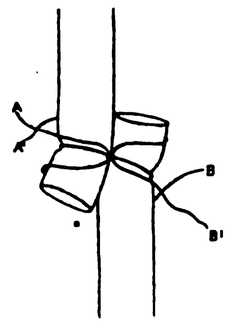

FIG. 166.—Tenorrhaphy. (Binnie.)

Tendon lengthening is occasionally employed in deformities due to shortened tendons, or in cases in which, after accidental division of a tendon, the approximation is difficult owing to retraction of the ends (Figs. 167 to 171) When the ends of a divided tendon cannot be sufficiently elongated to approx-

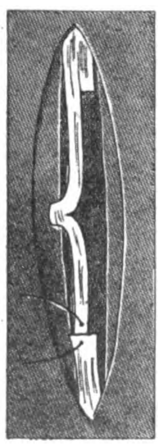

FIG. 167.

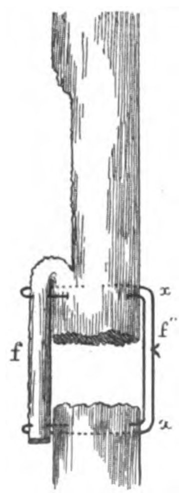

FIG. 168.

FIG. 169.

FIGS. 167 to 169.—Tendon lengthening. (Monod and Vanverts.)

imate them, the lower end may be sutured to a neighboring tendon with a similar function or to the periosteum; a graft may be made from adjacent fibrous tissue, from a neighboring tendon, from the tendon of an animal, or from silk, catgut (Fig. 172), or linen thread, or the osseous insertion may be transplanted (Fig. 173).

Tendon shortening is illustrated in Figs. 174 to 176.

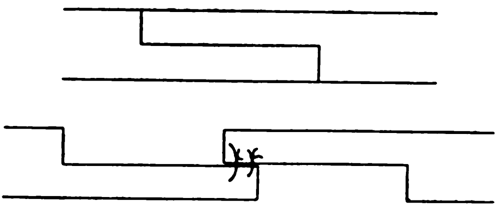

FIG. 170.—Tendon lengthening. (Binnie.)

FIG. 171.—Catgut graft. (Esmarch and Kowalzig.)

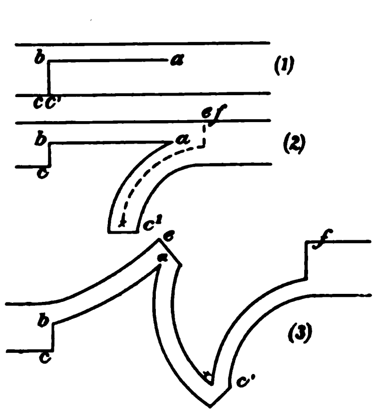

FIG. 172.—Tendon lengthening. (Binnie.)

FIG. 173.—Tendon lengthening by transplantation of osseous insertion. (Monod and Vanverts.)

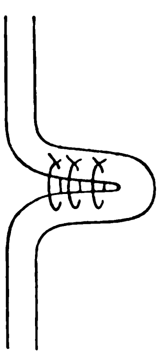

FIG. 174.

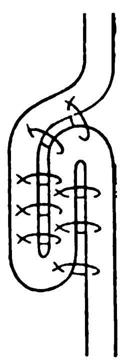

FIG. 175.

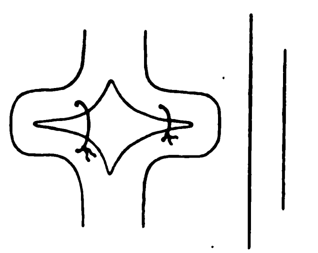

FIG. 176.

FIGS. 174 to 176.—Tendon shortening. (Binnie.)

Tendon transplantation has been employed for the relief of deformities due to paralyzed muscles. The tendon of the paralyzed muscle may be divided, and its distal end threaded through a split in an active tendon and

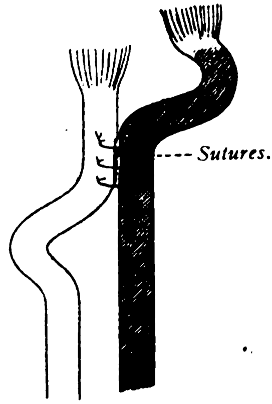

FIG. 177.

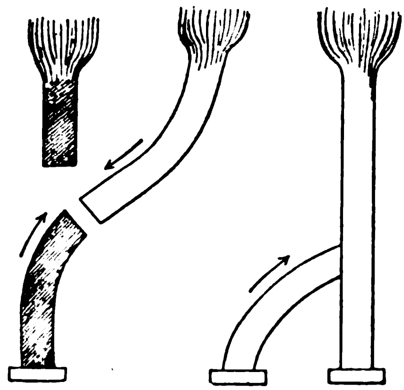

FIG. 178.

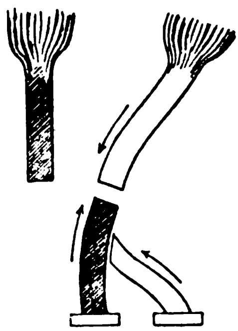

FIG. 179.

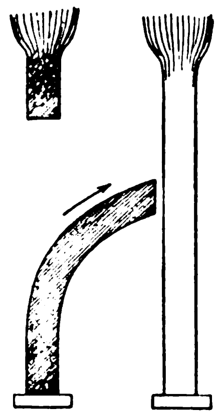

FIG. 180.

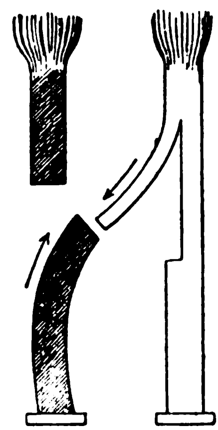

FIG. 181.

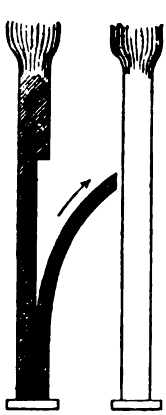

FIG. 182.

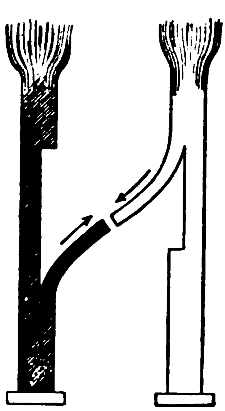

FIG. 183.

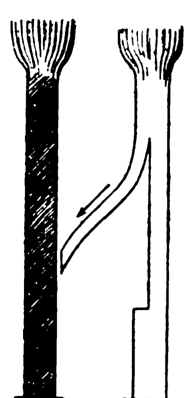

FIG. 184.

FIGS. 177 to 184.—Tendon transplantation. (Vulpius.)

there sutured (Figs. 162 to 164). Other methods are elucidated in Figs. 177 to 184; the paralyzed tendons are shaded. Free transplantation, as described under tendon lengthening, may be tried when a portion of a tendon has been destroyed.

Free transplantation of fascia, usually fascia lata from the upper and outer part of the thigh, has been employed to strengthen ligaments and joint capsules, to bridge gaps in muscles, to take the place of tendons, to close defects in the dura, pleura, diaphragm, bladder, air passages, and other hollow viscera, to reinforce the suture line in operations for hernia, to render joints movable (arthroplasty), to control bleeding from and to prevent the cutting of sutures in parenchymatous organs, to occlude the pylorus after gastroenterostomy, to support prolapsed organs, to cover the osseous stump after amputation, and to act as a substitute for suture material. For the building of a tendon or nerve sheath fascia is unsuited, as it may produce firm adhesions.

DISEASES OF BURSÆ.

Adventitious bursæ not uncommonly develop in situations habitually exposed to pressure, e.g., on the shoulder, under the scapula, and over the internal condyle in knock knee.

Wounds of bursæ differ from ordinary wounds in that the continuous escape of synovial fluid may interfere with healing and necessitate excision of the bursa or destruction of its lining membrane.

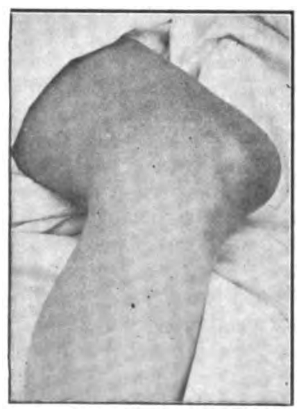

FIG. 185.—Prepatellar bursitis (housemaid's knee).

Acute bursitis is usually the result of traumatism. A painful and tender circumscribed swelling forms in the situation of a bursa, which fluctuates and is frequently the seat of a fine crepitus. Suppuration may occur as the result of infection through a wound or from the blood. The *treatment* is rest, the application of ichthyol or evaporating lotions, and later, compression to hasten absorption. If suppuration occurs incision and drainage are indicated.

Chronic bursitis may follow the acute form, or result from chronic irritation, syphilis, tuberculosis, gout, or rheumatism. The bursa is enlarged and fluctuates, owing to the effusion of serous fluid within. In old cases the walls may be so thickened as to simulate fibroma. In tuberculous cases the swelling may be doughy, owing to the thick layer of edematous granulations lining the cavity, or rice bodies may be detected. In late syphilis there may be a gummy degeneration, and in gout deposits of urate of soda (*tophi*).

The *treatment* in simple cases is rest, compression, and counterirritation with blisters or iodin. If the effusion persists it may be aspirated or the bursa excised. In tuberculous cases and in those with thick walls, excision should be performed. Constitutional treatment will be needed in the presence of syphilis, tuberculosis, gout, or rheumatism.

Among the bursæ which are more commonly diseased are the following: A *bursa over the metatarso-phalangeal joint* of the big toe is called a *bunion* (see hallux valgus), *the retrocalcaneal bursa*, when inflamed, *Albert's disease* (Chap. xxxi). The *prepatellar bursa* is often enlarged as the result of frequent kneeling, and is known as *housemaid's knee* (Fig. 185). The *infrapatellar bursa* lies between the ligamentum patellæ and the tuberosity of the tibia, and when inflamed causes a fluctuating swelling on each side of the tendon, which is more marked when the leg is extended. The symptoms may be somewhat similar to a dislocated semilunar cartilage, owing to the pinching of the ligamenta alaria, which are crowded back between the bones. Of the *popliteal bursæ* the one which lies between the gastrocnemius and the semimembranosus, and extends beneath the inner head of the gastrocnemius, is most frequently enlarged. It is hard and prominent when the leg is extended, and may exhibit transmitted pulsation; when the leg is flexed it is soft and may be difficult to detect. It is tedious to remove, and, as it frequently communicates with the joint, a ligature or suture will be required to close the synovial membrane at this point. *The iliopectineal (iliopsoas) bursa*, when enlarged, presents a swelling at the base of Scarpa's triangle, under or to the outer side of the femoral artery (Fig. 434). Sometimes the swelling is reducible, the fluid passing into the hip-joint or a neighboring bursa. Pressure of the bursa on the anterior crural nerve may cause pain running down the thigh, which is often slightly flexed, abducted, and rotated outward. The diagnosis from hip disease and femoral hernia is given under these headings. Psoas abscess is associated with disease of the spine. A neoplasm may closely simulate iliopsoas bursitis, and occasionally can be distinguished from it only by exploratory incision. *The bursa of the great trochanter*, when inflamed, causes abduction and eversion of the thigh, and a swelling which is most marked just behind the great trochanter. It is distinguished from coxalgia by the absence of restricted movements of the hip-joint. Enlargement of the *bursa over the tuber ischii* is known as *Weaver's bottom*, of the *olecranon bursa*, *miner's elbow*. *Subacromial* (*subdeltoid*) *bursitis* is described in Chap. XXXI.

CHAPTER XIX.

BONES.

INJURIES OF BONES.

A fracture has been defined as a sudden solution of the continuity of a bone, generally from external violence.

The Varieties.—Fractures are divided as follows: 1. *According to the cause*, into *traumatic* and *pathological* or *spontaneous* (resulting from trivial force to a diseased bone). Traumatic fractures are subdivided, according to the nature of the force, as explained on p. 268. 2. *According to the lines of fracture*, into *transverse*, *longitudinal*, *oblique*, *spiral*, *dentate*, *stellate*, *V-shaped*, and *T-shaped*. A *comminuted fracture* is one in which the bone is broken into three or more fragments, with intercommunication of the fracture lines. A *multiple fracture* is one in which there is more than one fracture in a bone, the lines of which do not communicate. Fractures of several different bones also are spoken of as multiple fractures. A *splintered fracture* is one in which a splinter of osseous tissue is broken from a bone. 3. *According to the degree of fracture*, into *complete*, which extends completely through a bone, and *incomplete*, in which the bone is not completely divided. A *green-stick fracture* (*infraction*) is an incomplete fracture resulting from the bending of a bone, the osseous tissue of the convex side separating and that of the concave side remaining intact. A *fissure fracture* is an incomplete fracture occurring as a crack, usually in the outer table of the skull. A *subperiosteal fracture*, which may or may not extend through the rest of the bone, leaves the periosteum intact. 4. *According to the position of the fragments*, into *impacted*, in which one fragment is forced into the other, and *depressed*, in which the bone is crushed in. Other terms used with reference to displacement are, transverse, rotary, angular, and longitudinal (either overlapping or separation). 5. *According to the presence or absence of a wound in the soft parts*, into *closed or simple*, in which there is no external wound in the soft parts, and *open or compound*, in which such a wound exists. A *complicated fracture* is one in which there is injury to an important vessel, nerve, joint, or viscus. 6. *According to the situation of the fracture*, into *intraarticular* or *extraarticular*, with reference to a joint, and *intra-* or *extracapsular*, with reference to the capsular ligament of a joint. *Epiphyseal separation* also may be put under this heading.

An intrauterine fracture occurs before birth, a *congenital fracture* at birth.

The causes of fracture are predisposing and exciting.

The predisposing causes are *physiological* and *pathological*. Among the former are age, sex, occupation, season of the year, and structure and position of the bone. Fractures are frequent in infancy because of the many tumbles which occur at this time, but owing to the elasticity of the bones, the breaks are often incomplete or of the green stick variety. In old age the brittleness of the bones is such that even a trivial injury may produce fracture. During adolescence and adult life fractures are more frequent in the male sex, owing to the greater exposure to injury. Occupations entailing daily exposure to injury predispose to fracture. In winter fractures are more frequent because of the presence of slippery ice under foot. The structure and position of certain bones render them more liable to fractures. *The pathological causes* are *atrophy of bone*, the causes of which are given on p. 316; *general disease of the osseous system*, such as osteomalacia, rickets, idiopathic fragilitas ossium, ostitis fibrosa, and ostitis deformans; and *localized disease of bone*, such as malignant disease, caries, necrosis, echinococcus, actinomycosis, syphilis, gout, rheumatism, scurvy, tuberculosis, and cysts.

The exciting causes are *external violence* and *muscular action*, e.g., fracture of the patella from contraction of the quadriceps. The former may be *direct* (the bone breaks directly beneath the point injured), in which case the fracture is usually transverse or comminuted, or *indirect* (the bone breaks at some distance from the point of violence). *Gunshot* and *punctured* fractures are special varieties of direct fractures. Indirect fractures may be designated according to the nature of the force as *bending* (e.g., fracture of the clavicle from a fall on the shoulder), *torsion* (e.g., fracture of the tibia from twisting of the leg), *compression*(e.g., certain fractures of the skull, and fracture of the tarsus from a fall on the foot), or *avulsion* fractures (e.g., fracture of the internal malleolus through the action of the internal lateral ligament when the foot is everted).

An *intrauterine fracture* is the result of violent uterine contractions, or of blows upon the abdomen. Multiple intrauterine fractures occur in syphilis. *Congenital fractures* result from uterine contractions, or more frequently from the manipulations of the obstetrician.

Epiphyseal separation, or diastasis, occurs before the age of twenty-two (see Fig. 186). The bones most frequently affected are the humerus, radius, femur, and tibia. As the end of a diaphysis is usually cup-shaped to receive the convex epiphysis, the deformity is often difficult to reduce. A pure epiphyseal separation is uncommon except in infants; in older children the line of cleavage usually involves at least a part of the end of the diaphysis. During the process of repair the epiphyseal cartilage may prematurely ossify and thus interfere with subsequent growth. Suppuration occasionally follows, and partial detachment or sprain of an epiphysis sometimes precedes tuberculous disease. Spontaneous separation is always the result of some disease of the epiphysis, such as rickets, scurvy, syphilis, tuberculosis, or acute infections.

The Symptoms.—Excepting certain cases of spontaneous fracture, there is a *history of injury*, at which time the patient may feel something give way, or hear a cracking sound. *Pain* is severe at the time of injury, but may be insignificant in pathological fractures. The location of acute tenderness is of great value in diagnosis. *Swelling* quickly supervenes, and within a day or two blebs, or bullæ, may form, the exuded serum from the deeper tissues passing beneath the epidermis. *Ecchymosis* occurs within a few hours or not for one or more days, according to the depth of the broken bone and the extent of the injury to the soft parts. *Loss of function* is caused by pain, or by loss of mechanical support; it may be absent in an incomplete or impacted fracture, or in a fracture of a bone whose function is supplemented by another bone, e.g., the fibula. *Muscular spasm* is a common symptom, particularly in the arm and thigh. *Deformity*, or change in the length or contour of a limb, is due to displacement of the fragments by the force of the injury, by the weight of the limb, or by muscular action. *Preternatural mobility* may be obtained by grasping the limb just above and below the fracture and making pressure in opposite directions, or by moving the limb as a whole. In fractures of the forearm or leg, the parallel bones may be alternately pressed together above and below the seat of fracture. A deceptive sense of abnor-

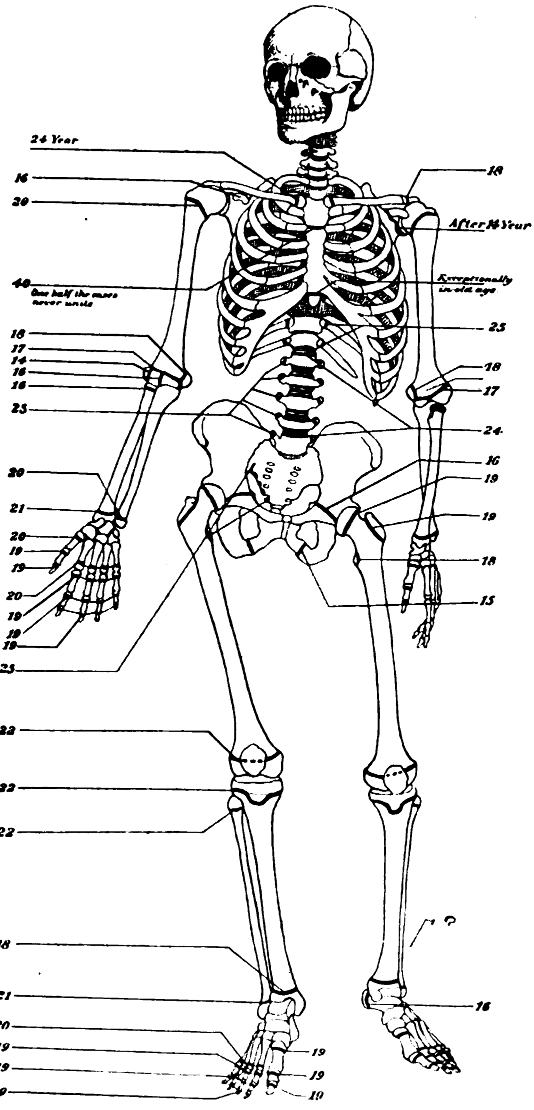

FIG. 186.—Time of bony union of the various epiphyseal junctions. (Brewer.)

mal mobilitiy may be present in elastic bones like the fibula and ribs, in bone diseases like rickets, in normal infants, and in the neighborhood of joints. Abnormal mobility may be absent in an impacted, an incomplete, or an intraarticular fracture. *Crepitus* is a grating sensation or sound obtained by rubbing the ends of the bone together. It may be absent in an incomplete or an impacted fracture, in one in which the fragments are greatly overlapped or widely separated, or in one in which soft tissues lie between the fragments. It is dry and harsh, and thus differs from the crackling of air or blood beneath the skin, or the creaking of inflamed synovial membranes, viz., those of joints, tendons, and bursæ. The crepitus of epiphyseal separation is soft or moist.

The **constitutional symptoms** are trivial or absent in simple uncomplicated cases. *Shock* is usually absent, except in severe or complicated fractures. *Fracture fever* is an aseptic fever due to the absorption of fibrin ferment, the temperature being elevated one or two degrees during the first two or three days or longer, according to the amount of blood extravasated.

The Diagnosis.—The injured limb should be compared with the sound limb by inspection, palpation, and measurement. An ancient deformity should not be mistaken for a recent one. A knowledge of the normal relations of bony prominences will aid in the quick recognition of deformity. If a stethoscope is placed over one end of the bone and the other end percussed, the sound may not reach the ear if a fracture exists. In many cases, owing to rigidity of the muscles, pain, and fright, a proper examination can be made only under an anesthetic. In doubtful cases an X-ray examination should be made. A more accurate idea of the amount and character of the displacement is obtained by taking two skiagraphs, one at right angles to the other or by making stereoscopic plates (see Fig. 2). Single exposures, especially in the region of the elbow, knee, ankle, and in oblique fractures of the long bones, may sometimes show apparently normal shadows, when a fracture really exists. Epiphyses cannot be recognized, of course, until sufficiently ossified to cast shadows. In interpreting skiagraphs the inexperienced may mistake an ununited epiphysis for a fragment of bone, and an epiphyseal juncture for a line of fracture.

The **complications** of fractures are: (1) Those occurring at the time of injury, which may be (a) general, i.e., shock, or (b) local, such as sprain, dislocation, and injuries to the vessels, nerves, muscles, or viscera; (2) those appearing during the time of treatment or later, which again may be (a) general, such as sepsis, tetanus, fat or clot embolism, hypostatic congestion of the lungs, delirium tremens, delirium nervosum, and suppression or retention of urine; or (b) local, such as excessive swelling from effusion of serum or extravasation of blood; inflammation, ulceration, sloughing, or gangrene, from swelling, pressure of splints or bandages, or from thrombosis; muscular spasm; necrosis of bone; stiffness or ankylosis of joints; atrophy of muscles, either from disuse, or from paralysis the result of nerve injury; excessive callus formation, usually the result of incomplete reduction; tumors of bone; stiffness of tendons from thecitis; contractures of muscles from myositis or neuritis; neuralgia; crutch paralysis; persistent edema, due to vasomotor paralysis or venous thrombosis; vicious union; non-union; delayed union; and fibrous or cartilaginous union.

Repair of fractures is analogous to the repair of other wounds, except that the reparative material ultimately becomes bone instead of scar tissue. Immediately following a fracture blood extravasates between and around the fragments, which are frequently united by a bridge of untorn periosteum. The surrounding blood vessels dilate, and serum and leukocytes escape into the tissues. The connective tissue cells proliferate (fibroblasts) and replace the blood clot, which, during the first week or ten days, is gradually absorbed and devoured by the leukocytes. At the same time there occurs a proliferation of the osteoblasts, which are found in the medulla and the deeper layers of the periosteum. This mass of actively multiplying cells is vascularized from neighboring vessels, becomes calcified, and is finally transformed into bone as the result of the activity of the osteoblasts. If the osteoblasts are slow in action, calcification is preceded by the formation of fibrous tissue by the fibroblasts, or in some instances bone fails to form and the fragments are united by fibrous tissue only. When the osteoblasts are more active, bony reproduction is preceded by the formation of cartilaginous tissue, which in some cases is as far as repair extends, the union being cartilaginous only. During the process of repair the ends of the bone become softened as the result of a rarefying ostitis, the roughened ends being smoothed by a process of absorption and covered with granulations, which are probably derived chiefly from the medulla. The compact bone itself is thought to take but little part in the process of repair. The mass of reparative material which forms between and around the fragments is called *callus*. The callus surrounding the fracture is called *ensheathing or external callus*, that in the medullary canal *internal or central callus*, and that between the ends of the bone *intermediate callus*. The ensheathing callus is finally absorbed, although it may persist and interfere with the motions of joints or tendons, unite the bone to a neighboring bone, or engulf an adjacent nerve. The central callus also may be absorbed, although this is not common. Ossification begins in the first week and is complete in from ten days (in the small bones of the face) to six or eight weeks (in the femur).

The **treatment** of simple fracture is (1) reduction, (2) retention, (3) restoration of function.

In transporting a patient with a broken limb it may be necessary to improvise splints from canes, umbrellas, etc. A fractured humerus may be fastened to the chest, a broken forearm may be supported by pushing a folded newspaper up the sleeve of a coat, the lower limb may be tied to its fellow or held between the rolled up ends of a blanket.

(1) *Reduction, or setting, of a fracture* should be performed as soon after the accident as possible. It is accomplished by manipulations to relax muscles or other soft structures while the ends of the bone are being maneuvered into place. Relaxation may be obtained by traction; by extension and counterextension; by posture, e.g., flexion of the leg in fracture of the tibia; by tenotomy, e.g., of the tendo Achillis in fractures near the ankle; and by general anesthesia, which always should be employed if reduction cannot otherwise be readily effected. In addition to muscular contraction the obstacles to reduction are interlocking of the fragments, separation of the fragments by soft parts or bone, entanglement of one fragment in the fascia or skin, and impaction. In the last instance reduction is contraindicated unless the deformity is excessive.

(2) *Retention* or *immobilization* is maintained by some form of splint, which may be of wood, metal, felt, leather, plaster-of-Paris, etc. Before the application of a splint abrasions should be covered with stearate of zinc, and blebs punctured without removing the epidermis. The splint should be thickly padded, particularly where prominent subcutaneous bony points will rest. As a general rule the joints above and below the fracture should be immobilized. The limb should not be bandaged beneath the dressing holding the splint in place, unless such bandage is of soft material loosely applied for the purpose of padding. Great care should be exercised not to

make the bandage too tight, for fear of sloughing or gangrene, or ischemic myositis. If the fingers or toes are left exposed, they will serve as an index to the general condition of the limb. If they become cold, blue, or numb, or if there is great pain in the limb, the bandages should be removed and the parts inspected.

The so-called fixed dressings (see section on bandages), such as starch, silicate of soda, and plaster-of-Paris, are frequently employed after the subsidence of swelling, although many surgeons apply them as a primary dressing. The dangers of the latter method, viz., sloughing or gangrene due to great swelling beneath the case, and undetected displacement of the fragments, are prevented by cutting the dressing immediately after its application if it encases the entire limb, or by applying the material as a large poultice would be applied and then allowing it to harden.

Plastic splints, such as cardboard, felt, leather, and gutta percha, are cut to the desired pattern, soaked in hot water to render them pliable, and allowed to harden while bandaged to the limb. Gooch's flexible wooden splints consist of thin strips of fir glued upon canvas; they are flexible transversely and rigid longitudinally.

(3) *Restoration of function* is obtained first by accurate reduction and the application of evaporating lotions or an ice bag to limit effusion, and during the subsequent treatment by massage and passive and active motions. In the early part of the treatment of a fracture the patient should be seen each day, and the dressings removed if such be indicated; later, in many instances, the dressing should be done every two or three days. The parts should be inspected, the skin kept in good condition by gentle friction with alcohol, and in suitable cases the muscles masséed and the neighboring joints moved, in order to prevent atrophy and stiffness. Lucas-Championnière advises *massage* from the very beginning in all fractures except those of the patella. In many instances in which there is no tendency towards recurrence of displacement the bone is not even splinted, and active motions are encouraged at an early period. There is no doubt of the value of massage and early mobilization of joints during the treatment of fractures, but in all cases the fragments themselves must be immobilized and kept so until the callus is sufficiently firm to obviate all danger of recurrence of displacement.

Some surgeons treat fractures of the lower extremity, as high as even the middle of the femur, by the *ambulatory method*. A large pad is placed beneath the sole of the foot and a plaster cast applied to above the seat of fracture, so that when the patient walks the weight of the body is supported by the limb above the fracture.

In cases in which successful reduction cannot be secured or maintained, *operative treatment* is indicated, providing aseptic details can be observed and the requisite skill is possessed by the operator; hence the more conservative plan of splint treatment should be employed by one who does not possess such qualifications. The fragments should be exposed by a suitable incision and the obstacle to reduction removed; this will often be found to be muscle, fascia, or other soft parts between the fragments. In bringing the fragments into alignment Lane uses, in addition to traction, strong long-handled forceps (Fig. 187) to grasp the ends of the bones. Martin has devised a method of traction that is efficient even in old cases with considerable shortening. He employs "a long, strong canvas strip pocketed in the middle and looped at the ends. The bones at the seat of fracture are freed, the pocket is slipped over the proximal end of the distal fragment, the ends of the canvas strip are carried in the long axis of the limb, and in the loops is fixed a cord to which are attached weights. By thumb pressure the bone is kept from angling out of the wound, and the weights, up to 100 pounds or more, are attached to the rope. In from three to five minutes the shortening is overcome." When

FIG. 187.—Lane's forceps.

the measures just mentioned fail it will be necessary to saw off a portion of each fragment before approximation can be accomplished, and in the forearm or leg an equal portion of the companion bone also must be removed. Unless there is no tendency for the bones to slip out of place the fragments

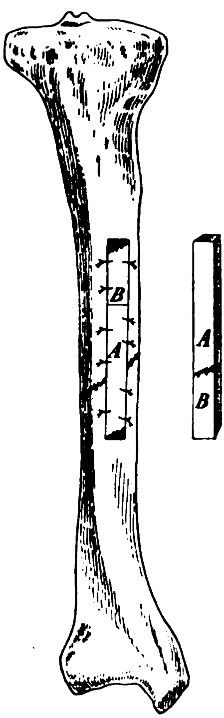

FIG. 188.

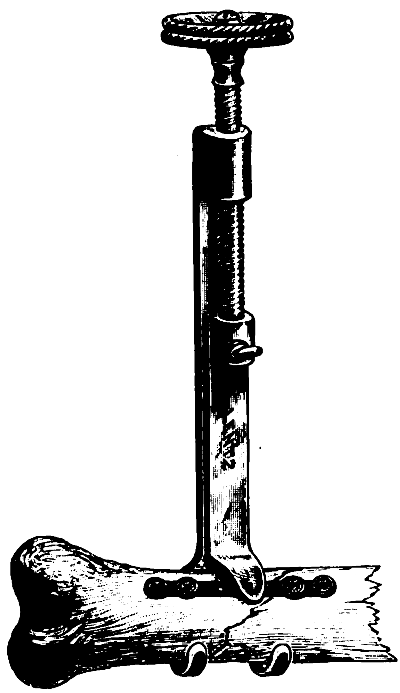

FIG. 189.

FIG. 188.—The small diagram to the right represents the grafts cut from the inner surface of the tibia. A, from the upper fragment; B, from the lower fragment. They are reinserted into the bone, as shown on the left, and held in place with catgut sutures traversing the periosteum.

FIG. 189.—Lane's plate, and Lowman's apparatus for holding the plate and the broken bone in position while the screws are forced into the bone.

must be held in position. Probably the best method for this purpose is transplantation of bone, the general principles of which are summarized at the end of this chapter. A graft can be cut from one of the fragments or from another bone (e.g., the crest of the tibia or a rib) and used as an intramedullary splint. This is driven into the medulla of the upper fragment, then pushed into the medulla of the lower fragment; if the latter maneuver is difficult, the medulla can be opened by raising a portion of the cortex on a hinge of periosteum. If the osseous splint is loose it may be held in place by nailing transversely, or, better, by passing catgut or kangaroo tendon through holes drilled in the fragments and the splint. Another method which is rapidly gaining in favor is to remove an oblong piece of the cortex from each fragment with a chisel or motor-driven saw, the cut surfaces being beveled, so that the grafts will not fall into the medullary cavity when replaced, and one graft being cut much longer than the other. The longer graft is made to bridge the line of fracture, and the cavity thus left is filled with the shorter graft (Fig. 188). Fixation may be secured also by silver wire passing around the bone or through holes bored in the bone, by kangaroo tendon or aluminium bronze wire, both of which are ultimately absorbed, by silver or steel plates which are fastened to each fragment with screws (Fig. 189), or by means of nails, screws, ivory pegs, metallic staples, bone ferrules, or intramedullary splints of metal, ivory, or bone. The last may be living, as mentioned above, or dead. Dead bone may be decalcified, which is unnecessary, or simply boiled and cleansed of medulla and soft parts. We have employed lamb and ox bone prepared in this way for ferrules and intramedullary splints. The special forms of apparatus consisting of long screws held by external clamps (Parkhill, Keetley, Freeman, Lambotte) are too complicated, and necessitate leaving the wound open, thus predisposing to infection. After the fragments have been fixed in place the incision in the soft parts should be closed, and the limb immobilized by plaster-of-Paris or a suitable splint. When non-absorbable foreign material has been used to fix the fragments, its removal is not infrequently demanded after union has occurred, owing to the formation of sinuses.

The treatment of compound fractures is that of the wound in the soft parts and of the broken bone itself. The constitutional symptoms are more severe than in simple fracture, there being a varying amount of shock according to the degree of injury, and later a higher rise in temperature, even when asepsis has been maintained. In some cases the fracture is non-comminuted, the injury to the soft parts slight, the opening in the skin small and comparatively clean; in such cases the wound may be disinfected with iodin and covered with a sterile dressing, the fracture reduced and immobilized, and the patient watched for evidences of sepsis. In others the injury is so extensive that amputation is required. The following remarks apply to cases of compound fracture of the extremities between these extremes. The dangers are hemorrhage and sepsis. Severe primary hemorrhage is controlled by the tourniquet, and measures taken to react the patient from shock. In the absence of shock the patient should be anesthetized and thorough disinfection carried out. The limb should be shaved, scrubbed with soap and water, and washed with bichlorid of mercury, 1 to 1,000, or disinfected with iodin. Devitalized tissues, tissues into which dirt has been ground, and completely detached fragments of bone should be removed, enlarging the wound in the skin as much as may be necessary. Pieces of bone firmly attached to the soft parts often retain their vitality and may be left in place. The fracture is fixed by wire or other means, the hemorrhage controlled in the usual way, and the injuries to the soft parts repaired, e.g., suturing of a torn nerve or muscle. The wound is again disinfected by irrigation with hot bichlorid of mercury solution, and drained by a large rubber tube, which if necessary may traverse the entire limb, emerging at a counteropening on the opposite side. The external wound is sutured as far as judgement dictates, and the limb splinted. If a plaster cast is applied, windows should be made over the wounds to permit subsequent dressings.

Fracture complicated with dislocation is treated by first reducing the dislocation by manipulations, aided, if need be, by a splint to give sufficient rigidity to the limb; or through an incision the articular end of the bone may be maneuvered into place by the fingers or by a hook. Some advise setting the fracture and, after union has been obtained, trying to reduce the dislocation.

Ununited fractures, delayed union, and non-union are due to imperfect immobilization; the presence of muscle or other soft tissue between the fragments; marked overlapping; wide separation; defective nutrition of the bone as the result of injury to its blood supply; general or local diseases of bones, such as are mentioned among the pathological causes of fracture (p. 268); or to constitutional diseases, such as syphilis, gout, rheumatism, scurvy, or other affections causing debility. Non-union may be distinguished from delayed union by the absence of pain and the presence of voluntary motion in the former. These conditions are most common in the patella, olecranon, and similar situations where strong muscular contraction tends to separate the fragments, and in the middle of the humerus and upper and lower thirds of the femur.

Absolute non-union, i.e., when there is absolutely no attempt at repair, is seldom seen apart from malignant disease of bone. In most instances the ends of the bone become rounded, the medullary canal closed, and the fragments joined by fibrous tissue (*fibrous union*). In a *pseudoarthrosis, or false joint*, the fragments are held together by a capsule of fibrous tissue, within which is developed a bursa the result of the friction of one bone on the other, and the ends of the broken fragments are covered with cartilage. Shipley

The treatment of delayed union is prolonged immobilization in plaster-of Paris, and attention to the general health. Some advise the induction of congestion or inflammation by rubbing the ends of the bone together, by scraping the ends with a long and strong needle pushed in through the skin, by the injection of a 10 per cent. solution of chlorid of zinc, or by applying a rubber band around the limb above the fracture. Bier injects fresh blood between the fragments; Dilger an emulsion of periosteum, the periosteum being obtained from the patient. The internal administration of thyroid extract and potassium iodid are thought to encourage callus formation. *Non-union* is treated by resection of the ends of the fragments, and fastening them together by one of the methods mentioned above (p. 273), the best of which for non-union is bone transplantation. Codivilla wires the fragments, and envelops the fracture with a strip of periosteum to the under surface of which is attached a thin slice of bone. When the ends are overlapped, and resection would prove a formidable operation owing to the situation of the bone, screws or pegs may be inserted into drill holes which traverse each fragment from side to side.

Vicious union, or union with great deformity, is due to imperfect reduction, recurrence of displacement, bending or overproduction of callus subsequent to the removal of splints, or to bone diseases, such as fragilitas ossium and osteomalacia. It may be treated, in the early stages while the callus is plastic, by pressing the bones into place, and later, if deformity or disability is marked, by osteotomy, by chiseling away projecting areas, or by resecting the callus and fastening the fragments with bone, wire, plates, etc.

Disunited fracture, or separation after the fragments have united, may occur from violence, and occasionally during the progress of an exhausting disease.

SPECIAL FRACTURES.

The **nasal bones** are usually broken in their lower third, the fracture being frequently compound through the skin or mucous membrane. The *cause* is direct violence, the degree and direction of which determine the amount and character of the displacement. The *nasal septum* is often injured, resulting in lateral displacement, which may later give rise to nasal obstruction. The *symptoms* are pain, swelling, crepitus, deformity, and epistaxis. Abnormal mobility may be fallacious in the lower third owing to the great mobility of the cartilages. The *complications* are emphysema, cerebral concussion, fracture of the neighboring facial bones or of the base of the anterior fossa of the skull, and later suppuration and necrosis of bone or cartilage.

The **treatment** should be prompt, as the bones early consolidate in deformity. In all cases the septum should be examined to determine whether or not it is broken. No apparatus is needed if there is no deformity or if the deformity does not recur after reduction. Reduction is accomplished by external pressure, and by lifting the fragments from within by means of a padded, narrow instrument, such as a grooved director, or by a rubber bag which is passed into the nose and distended with air. The septum may be straightened by a finger introduced into either nostril or by septum forceps. Either cocain or ether anesthesia may be necessary. In depressed fractures reduction may be maintained by packing the nostrils with gauze, or by passing a strong pin (*Mason's pin*) through the skin, beneath the fragments, and making external pressure by means of gauze, held in place by figure-of-8 turns of silk around the ends of the pin. Lateral displacement requires an external compress or molded splint, held in place by adhesive plaster, or an apparatus consisting of a metallic band around the forehead, with a support, provided with a pad and screw for making pressure, running down to one side of the nose. If the septum is deformed, it may be held in place by gauze packing, or by means of vulcanite or metallic tubes, which have perforations in the side for drainage, and which are made in various sizes. Roberts inserts one or more long pins into the septum in such a way as to press on the deviation as the stem of a flower is pressed upon when pinned to the lapel of a coat. In any case the nose should be sprayed several times daily with an antiseptic solution, and the patient cautioned about blowing or wiping the nose. The *prognosis* is usually good, although some deformity is very apt to remain in bad cases. Union is complete in from ten days to two weeks.

The **lachrymal bone** is rarely broken alone, and the treatment is directed principally to the neighboring bone. Obstruction of the lachrymal duct may be prevented by the passage of a probe.

The **malar bone** is fractured by direct violence, usually with injury to adjoining bones. Sometimes the whole bone is pressed into the bones on which it rests. The symptoms are deformity, conjunctival hemorrhage when the orbital surface is involved, and interference with the motions of the lower jaw when depression is sufficient to encroach upon the coronoid process. Crepitus and abnormal mobility may be absent. In favorable cases the deformity can be corrected by pressure beneath the bone within the mouth.

If this is unsuccessful, particularly in cases in which the movements of the ower jaw are impaired, the bone may be elevated through an external incision. No retentive apparatus is required, as displacement does not recur. The bone unites in two weeks.

The **zygoma** is fractured by direct force, or by indirect force when the malar is depressed. There is usually an indentation just behind its junction with the malar bone. The *treatment* consists in the application of pressure within the mouth or externally, in order to effect reposition. Failing in this, especially if the movements of the lower jaw are defective, a piece of silver wire may be passed through the skin and beneath the depressed fragment, in order to pull it into place. A retentive apparatus is seldom required. Union is complete in two or three weeks.

The **superior maxilla** is usually broken by direct blows, which in most instances break also contiguous bones. It may, however, be broken by indirect force through the chin. The fracture is almost always compound and comminuted, and often bilateral. There are pain, great swelling of the face, and interference with mastication; deformity, abnormal mobility, and crepitus are detected through the nose, mouth, or cheek. The *complications* are emphysema, violent hemorrhage from the internal maxillary or its branches, and injury to the lachrymal duct, infraorbital nerve, or the brain. Suppuration and necrosis may occur. The *treatment* is careful disinfection, and molding of the bone into position through the nose or mouth, or through an external wound if it be present. Loose teeth should be put back in place and fastened to their fellows by wire. In fractures involving the alveolus the lower jaw may be used as a splint by means of the Barton or the Gibson bandage, or an interdental splint may be employed. It may be necessary to insert a tube into the nose to maintain its patency. The nose and mouth should be washed several times a day with an antiseptic solution, and the wounds dressed daily. Liquid food is administered through a nasal tube, or by passing it into the mouth behind the last teeth. The bone unites in three or four weeks.

The **inferior maxilla** is generally broken by direct violence, but a fracture near the middle line may result from a force which presses the bodies together, and fracture of the condyle may follow a fall on the chin. The bone is most frequently broken just external to the symphysis, owing to the weakness occasioned at this point by the deep socket of the canine tooth and the mental foramen, just posterior to it. As a rule the fracture is compound internally, and not infrequently there are multiple breaks. The *symptoms* are pain, laceration of the gum at the point of fracture, bleeding from the mouth, swelling of the face, abnormal mobility, crepitus, and deformity as demonstrated by imperfect alignment of the teeth. When the bone is broken in front of the masseter, the posterior fragment is pulled upward by the masseter and temporal muscles, while the depressors of the jaw (geniohyoglossus, geniohyoid, anterior part of mylohyoid, digastric, and platysma) draw the anterior fragment downwards and backwards. In fractures of the neck of the condyle, the jaw is drawn toward the injured side by the pterygoids of the sound side, and the condyle is pulled forward and inward by the external pterygoid. Fracture of the coronoid is very rare, and displacement is usually slight, because the temporal muscle is attached farther down on the inner than on the outer side; if the fibres of attachment are torn the process is drawn upward by the temporal muscle. The *complications* are suppuration, and necrosis of bone, with the ills that they may produce, e.g., cervical adenitis, and digestive or pulmonary disorders from swallowing or inhaling foul discharges. Fracture of the base of the skull may be produced if the condyles are driven forcibly upwards.

The **treatment** consists in reduction by direct pressure, immobilization, and careful and frequent cleansing of the mouth. In cases in which there is little tendency to displacement, sufficient immobilization may be obtained by a molded chin piece (Fig. 195) of felt, cardboard, leather, or thick flannel impregnated with plaster-of-Paris, the chin cup being held in place by a Barton or a Gibson bandage. If the displacement tends to recur, and this is true in the large majority of cases, the adjoining teeth, if not loose, may be tied together with wire, or fastened by Angle's bands, which are thin pieces of metal that are clamped about several teeth in each jaw by means of a screw, the jaws being held together by wire or silk running from the clamps on the lower jaw to those on the upper jaw. Hammond's splint consists of a wire frame work which surrounds all the teeth of the lower jaw and which is fastened in place at several points by wire running between the teeth. In many instances accurate apposition can be obtained only by wiring the jaw itself, or by what is far better, an interdental splint. Interdental splints are made of vulcanite, hard rubber, or metal, from a plaster-of-Paris cast of the teeth; they can be made only by a skilled dentist. An impression of the teeth is first taken by a dental modeling compound, which is softened by heat and allowed to harden on the teeth. A plaster cast of the two jaws is made from this mold, the cast of the lower jaw severed at the point of fracture, the displacement in the cast corrected, and an interdental splint made from the plaster cast. Bars curving backwards over the cheeks are sometimes attached to support a bandage passing under the chin, so that the jaw will be held in place even when the mouth is open (Fig. 190). Moriarty fastens a metallic chin piece to these side bars by several vertical supports. Matas has constructed an adjustable metallic interdental splint, which may be applied by any medical man without special dental skill. The splint is a sort of clamp which holds the jaw between a mouth piece and a chin cup. It is made in three sizes, the smallest for children, the medium for youths, and the largest size for adults; the chin cup may be adjusted to various degrees of prognathism by a sliding joint (Fig. 191). If the teeth are loose, the gutter of the mouth piece may be filled with a dental modeling composition. In any case the mouth and teeth should be frequently cleansed and irrigated with a mild antiseptic solution. If inadvisable to open the mouth, the patient may be fed as described under fracture of the upper jaw. Fractures of the coronoid process and the condyle are treated by a Barton or a Gibson bandage.

Fig. 190.—Hard-rubber splint, with arms and bandage applied. (Moriarty.)

The **hyoid bone** may be fractured by constriction, such as occurs in throttling and hanging. The *symptoms* are pain, swelling, deformity, bleeding from the mouth, and interference with breathing, speaking, or swallowing. Abnormal mobility and crepitus are present in a few cases. The *treatment* consists in the correction of the deformity, if possible, by a finger in the mouth and the hand externally, and the application of a molded cardboard splint to the neck. The head, neck, and lower jaw may be immobilized, and the patient fed by rectum; talking is forbidden. The bone unites in four weeks. Edema of the glottis may demand intubation or tracheotomy.

The **laryngeal cartilages** may be fractured, particularly in old age owing to the deposition of lime salts. The symptoms are similar to those of fracture of the hyoid bone, except that dyspnea and interference with the voice are more marked and emphysema more common. The treatment is similar to that of fracture of the hyoid bone.

The **ribs** may be broken by direct violence, or by indirect violence, e.g., compression of the chest, in which case the rib breaks at its most convex part, or near the angle. In a few cases violent muscular action, such as occurs in coughing and straining, is responsible for the accident. In early life the ribs are very elastic and incomplete fracture is not uncommon. As a rule more

FIG. 191.—The Matas splint for fracture of the lower jaw. The splint consists of the following detachable parts: (*a*) a mouth piece of soft metal (block tin); (*b*) a clamp adjusted and tightened with a screw; (*c*) a chin plate (of perforated aluminum), which can be moved backward or forward by sliding on the lower limb of the clamp. This is fixed and held in place by a thumb-screw.

than one rib is broken, those suffering most frequently being from the fifth to the ninth, as the upper ribs are better protected and the lower ribs more movable. The fracture may be compound into the lung or through the skin. The *symptoms* are localized pain increased by movements of the chest or pressure over the sternum, grunting respirations, suppressed cough, emphysema if the lung is wounded, and rarely deformity or abnormal mobility. Crepitus is frequently absent; it is obtained by placing the hand or the ear over the point of greatest tenderness while the patient takes a full breath, or by alternately pressing on the bone on either side of the fracture. Hemoptysis indicates injury to the lung. The *complications* are injury to the heart, lung, diaphragm, liver, spleen, and colon, and hemothorax, pneumothorax, pleurisy, pneumonia, bronchitis, and empyema.

The **treatment** is immobilization of the affected side of the chest with adhesive plaster. In the male the chest should be shaved and a piece of lint placed over the nipple. Adhesive plaster strips, three inches wide and long enough to extend about three-fourths around the chest, are applied from below upwards during expiration, each strip overlapping the preceding one (Fig. 195). The dressing is changed once a week, and discarded at the end of three weeks, or later if there is much pain. If strapping increases the pain, it should not be employed, as the ends of the bone are probably driven inwards; these cases should be confined to bed with a compress between the shoulders. In the presence of marked displacement which is irreducible by external manipulations, the deformity may be corrected through an incision, and the fracture immobilized by suture. The patient should be guarded from draughts, and sedative expectorants employed if there be cough.

The **costal cartilages** may be broken, or separated from the ribs or sternum. The symptoms and treatment are those of fracture of the rib.

The **sternum** is usually fractured at or near the junction of the manubrium with the gladiolus, as the result of direct violence, although it may be broken by indirect force from excessive extension or flexion of the body, such as occurs in fractures of the spine, and by muscular action in the same way that the ribs may be broken. The upper fragment passes behind the lower

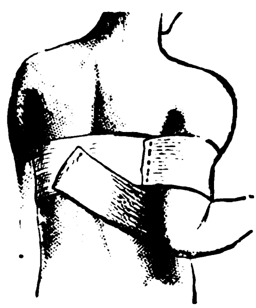

FIG. 192.—The Sayre dressing for fracture of the clavicle; posterior view.

FIG. 193.—The Sayre dressing for fracture of the clavicle; anterior view.

fragment, sometimes producing severe dyspnea and occasionally injury to the aorta. The *symptoms* are pain, deformity, abnormal mobility, crepitus, bending forward of the body, and in many cases dyspnea and cough. *Complications* are frequent, there usually being fractures of the ribs and spine, and often injuries to the thoracic viscera; aneurysm of the aorta, mediastinitis, and necrosis of the sternum are late complications.

The **treatment** is rest in bed, with a compress between the shoulders, and a broad strip of adhesive plaster carried across the chest over the fracture. Reduction may sometimes be accomplished by extending the spine and making pressure on the lower fragment while the patient breathes deeply. If this fails and there is dyspnea due to the depression, the displacement may be corrected and the fragments fixed in position through an external incision. Union is complete in five or six weeks.

The **clavicle,** with the possible exception of the radius, is broken more frequently than any other bone in the body, owing to its slenderness, its exposed position, and to its transmitting the force of blows or falls from the upper extremity to the trunk. Consequently the usual cause of fracture is indirect violence, although direct violence also is responsible for a certain munber of cases. The injury is most frequent in children, and is then often of the greenstick variety. The fracture may be located at the sternal end (unusual); just external to the middle, which is the usual situation, because it is here that the two curves of the clavicle meet, that the bone is most slender and that fewer muscles are attached; between the coracoclavicular ligaments, in which case there is little displacement; or at the acromial end, at which point, too, the displacement may be slight. The *symptoms* are those of fracture in general. The patient supports the elbow with the hand of the uninjured side, and bends the head toward the affected clavicle to relax the sternomastoid, which pulls on the inner fragment only. The shoulder with the outer fragment is displaced downwards, inwards, and forwards, owing to the weight of the extremity and the contraction of the subclavius and muscles of the axillary folds, viz., pectoralis major and minor, teres major, latissimus dorsi. The inner fragment ascends slightly, as the result of the action of the sternomastoid. The *complications* are injuries to the brachial plexus, subclavian vessels, pleura, and lung.

The **treatment** which gives the least deformity is the placing of the patient upon a firm mattress, with a pad between the scapulæ, a shot-bag on the affected shoulder, and the arm bound to the chest with upward pressure on the elbow. Union is usually firm in three or four weeks, when the patient may be allowed to get up with the arm in a sling. But patients do not often select this form of treatment. In an incomplete fracture with little deformity a sling for the forearm is all that is needed. Reduction is easy to accomplish by carrying the shoulder backwards, outwards, and upwards, but in ambulatory cases is very difficult to maintain. The Sayre dressing is one of the best for this purpose. Two strips of adhesive plaster three or four inches wide, and long enough to extend around the chest one and one-half times, are prepared. Lint powdered with zinc stearate is placed in the fold of the elbow and between the arm and the chest. A collar of lint as wide as the adhesive strip is placed about the arm just below the axilla, and over this is applied the end of one of the strips of plaster, so as to form a loop; the strip is now used to pull the arm backwards, and is fastened around the chest (Fig. 192). The hand of the affected side is placed on the opposite shoulder, and the second strip of plaster, with a hole for the point of the elbow, is run from the back of the sound shoulder, under the elbow of the affected side, over the sound shoulder, to the back (Fig. 193), thus drawing the elbow forwards and upwards, and, with the aid of the first strip, which acts as a fulcrum, forcing the shoulder backwards and outwards. A pad, held in place by a strip of adhesive plaster, may be placed just above the clavicle to press the fragment downwards. The Velpeau bandage is frequently employed, that of Desault is seldom used (see bandaging). A posterior figure-of-8 bandage, pulling the shoulders backwards, may be combined with an axillary

FIG. 194.—Fractures of the neck of the scapula. A, Through the glenoid fossa; B, through the anatomical neck; C, through the surgical neck. (Rose and Carless.)

pad, and a forearm sling which pulls the elbow inwards and upwards. The fragments may be wired when the fracture is compound or multiple, or when there is great deformity, pressure upon nerves or blood vessels, or a sharp fragment which threatens to perforate the skin. The *prognosis* is very good concerning the function of the arm, but after a complete fracture between the rhomboid ligament on the inside and the coracoclavicular ligament on the outside, deformity to a greater or lesser degree is sure to persist.

The **body of the scapula** is broken by direct violence. The *symptoms* are swelling, abnormal mobility, crepitus, and pain upon abduction of the arm or rotation of the scapula. Deformity is usually absent. The *treatment* is immobilization of the shoulder and arm by a bandage passing around the chest, and a sling for the forearm. Strapping the chest in a way somewhat similar to that used for the ribs also is useful.

The **surgical neck of the scapula**, when broken (Fig. 194), **causes** flattening of the shoulder, prominence of the acromion, lengthening of the arm (from acromion to external condyle), a swelling in the axilla, and crepitus on rotating or raising the arm. The deformity is reduced by pressing upwards on the elbow and on the axillary swelling, a pad placed in the axilla, and a Velpeau bandage applied. The dressing may be removed in five weeks.

The **anatomical neck of the scapula** or the glenoid cavity may in rare instances be broken, resulting in slight lengthening of the arm and a fullness of the axilla. Crepitus may be obtained by pushing up on the elbow or by rotating the arm. The *treatment* is that for fracture of the surgical neck.

The **acromion process** is broken by direct violence. The *symptoms* are pain, loss of abduction of the arm, flattening of the shoulder, and abnormal mobility and crepitus, obtained by pushing upwards on the elbow. The *treatment* consists in pushing the elbow upwards, thus supporting the acromion process with the head of the humerus. The position is maintained for four weeks by a Velpeau bandage or the third roller of Desault.

The **coracoid process** may be broken by direct violence or muscular action, but the accident is rare. Deformity is not noticed, but crepitus and abnormal mobility are often obtainable. A Velpeau bandage should be worn for four weeks.

The **humerus** may be broken through the upper extremity, the shaft, or the lower extremity.

The **upper extremity of the humerus** may be broken at the anatomical neck, at the surgical neck, or through the head of the bone or the tuberosities, or the upper epiphysis may be separated.

The **anatomical neck of the humerus** is broken by direct violence applied to the shoulder, particularly in the aged. The line of fracture may be wholly within the capsule of the joint (intracapsular fracture), but in many instances it extends beyond the capsule. Impaction is frequent, and even when the head of the bone is movable on the shaft it, as a rule, still remains attached to the capsule at some parts, so that necrosis is not as frequent as one might expect. The *symptoms* are pain, swelling, broadening of the neck of the bone, interference with the functions of the shoulder, slight shortening of the arm from acromion to external condyle, and in unimpacted cases abnormal mobility and crepitus; the last two symptoms are obtained by grasping the head of the bone, and gently rotating the humerus by manipulating the elbow with the other hand. These movements should never be violent, because of the danger of separating an impaction, or tearing away that portion of the capsule which remains attached to the head.

The **treatment** in impacted fracture is a sling for the limb, gentle massage from the beginning, and early passive motion. In other cases a pad should be placed in the axilla, a cap of cardboard or felt (Fig. 195) molded to the

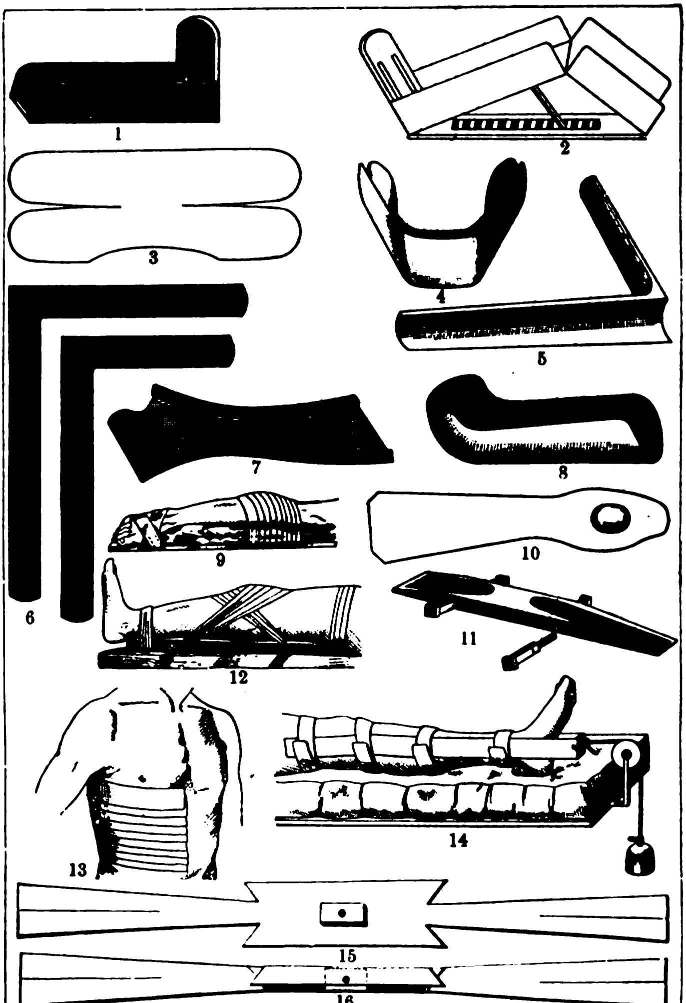

FIG. 195.—1. Fracture-box. 2. Double inclined plane fracture-box. 3. Jaw-cup (unfolded. 4. Jaw-cup (folded). 5. Anterior angular splint. 6. Internal angular splint. 7. Bond splint. 8. Shoulder-cap. 9. Dupuytren splint in Pott's fracture. 10. Agnew splint for fracture of the metacarpus. 11. Agnew splint for fracture of the patella. 12. Agnew splint applied. 13. Strapping the chest in fractured ribs. 14. Extension apparatus in fracture of the femur. 15, 16. Adhesive strips for extension apparatus. (DaCosta.)

shoulder, and the arm and forearm (flexed to a right angle) bandaged to the side. Union may not occur for five or six weeks or longer. The *prognosis* is good as far as union is concerned, but stiffness of the joint, atrophy of the muscles, and persistent pain are common sequelæ.

The **surgical neck of the humerus** is usually broken by direct violence, occasionally by indirect violence, rarely by muscular action. The *symptoms* are pain (which may be reflected along the large nerves from pressure), abnormal mobility, crepitus, shortening of the limb (one inch or more), a depression just below the shoulder, and abduction of the elbow from the side of the body. The upper end of the lower fragment passes into the axilla, owing to the inward traction of the muscles attached to the bicipital groove (pectoralis major, teres major, latissimus dorsi), and the upward pull of the deltoid, biceps, coracobrachialis, and triceps; the upper fragment may be abducted by the supraspinatus, but there is little or no rotary displacement, because the subscapularis in front and the teres minor and infraspinatus behind nearly or quite balance each other; if impaction be present the signs are obscure and the diagnosis difficult. The deformity resembles that of dislocation of the shoulder, but in the former the depression is lower (Fig. 196), the head of the bone is in place, and, when the arm is rotated, there is immobility of the head with crepitus. The X-ray should be used in doubtful cases. The *complications* are injuries of the axillary vessels or nerves, particularly the circumflex nerve, which passes around the bone at or near the line of fracture.

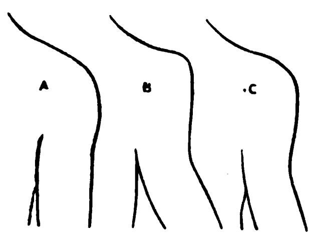

FIG. 196.—A, normal shoulder; B, dislocation of shoulder; C, fracture of surgical neck of humerus. (Rose and Carless.)

The **treatment** is that of fracture of the anatomical neck, or an internal angular splint and a shoulder cap (Fig. 195), the splinted arm being carried in a sling. Reduction is accomplished by extension, counterextension, and manipulation. Extension may be maintained during the course of treatment by attaching a weight to the elbow. Gentle passive motions are begun at the end of three weeks. The ***prognosis*** is good, but in the old and rheumatic stiffness and pain are frequent legacies.

The **head of the humerus** may be broken by direct violence, but the accident is rare, and seldom recognized without the aid of the X-rays. It is treated by immobilizing the shoulder.

The **greater tuberosity** may be broken by direct violence, or torn from the humerus by contraction of the attached muscles (supra- and infraspinatus, teres minor). The injury may complicate fracture through the neck or anterior dislocation of the shoulder. The *symptoms* are pain, swelling, crepitus, and loss of outward rotation of the arm. If completely detached, the fragment is drawn upwards and backwards by the supra- and infraspinatus muscles. The *treatment* is that of fracture of the anatomical neck, or, if there is much separation, incision with wiring or pegging the fragment in place. A theoretically correct but impracticable plan is to place the patient in bed and hold the arm abducted and rotated outward by means of sand bags.

The **lesser tuberosity** is said to have been fractured but three times.

Separation of the upper epiphysis of the humerus occurs before the twentieth year, as the result of direct violence, but the accident is not common. The *symptoms* resemble those of fracture of the surgical neck, except that the crepitus has a much softer quality. Displacement is often slight owing to the presence of an untorn periosteal bridge. The *treatment* is that of fracture of the surgical neck. Reduction is sometimes difficult, owing to the conical shape of the upper end of the shaft and the smallness of the upper fragment, but is of the greatest importance, because of the danger of arrest of growth in the limb. It is best accomplished by slight rotation, and by bringing the elbow forwards and upwards, as the untorn periosteal bridge is usually situated on the posterior surface of the bone.

The shaft of the humerus is frequently broken, usually by direct violence, but also by indirect force, and occasionally by muscular action. The *symptoms* are those of fracture in general. The displacement depends on the situation of the fracture. When the bone breaks above the insertion of the deltoid, the upper fragment is drawn inwards by the muscles attached to the bicipital groove (pectoralis major, teres major, latissimus dorsi), the lower fragment upwards and outwards by the deltoid (Fig. 197). When the fracture is below the insertion of the deltoid, the usual situation, the upper fragment is drawn outwards by the deltoid, and supraspinatus, forward by the coracobrachialis and anterior portion of the deltoid while the lower passes upwards and inwards (Fig. 198). The *complications* are injuries to the brachial vessels and the nerves, particularly the musculospiral, which lies close to the bone; non-union is more frequent here than in any other bone in the body, probably owing to the method of treatment, in which, as the result of imperfect fixation of the shoulder, movements at the seat of fracture are not entirely prevented.

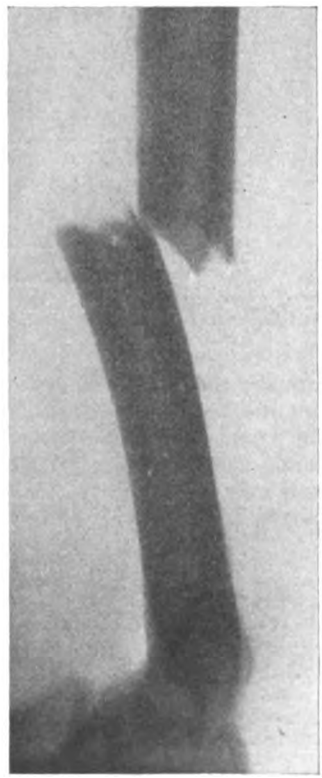

Fig. 197.—Skiagraph of fracture of the humerus above the insertion of the deltoid. (Pennsylvania Hospital.)

The **treatment** is reduction by extension and direct pressure, and the application of an internal angular splint (Fig. 195), extending from the axilla to the fingers, and a molded external splint. The forearm is carried in a sling. If desirable, weight may be attached to the elbow for extension. The dressings are removed in five or six weeks if the fracture is firm.

The lower extremity of the humerus may be broken above the condyles (*supracondyloid fracture*), above and between the condyles (*T- or Y-shaped fracture*), or through either condyle or epicondyle, or the lower epiphysis may be separated.

The examination of an injured elbow should be made with the greatest care, in order to exclude fracture and dislocation. General anesthesia is often necessary in fracture, to permit diagnosis and facilitate reduction, and the X-rays should be used in all doubtful cases. The injured elbow is compared with that of the opposite side while both are in a similar position. There are four landmarks whose position must be determined, viz., the two condyles, the olecranon, and the head of the radius. In the normal extended elbow the tip of the olecranon is a trifle below the intercondyloid line, but nearer the internal than the external condyle, while the three points are in a plane parallel to the back of the arm when the forearm is flexed to a right angle. The intercondyloid line is perpendicular to that of the axis of the arm. The head of the radius is immediately below the outer condyle, at the bottom of a dimple, which is easily seen when the arm is extended.

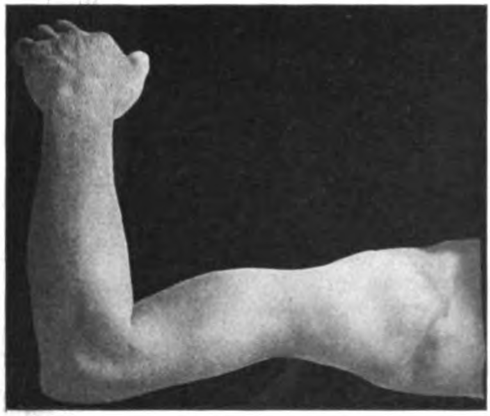

FIG. 198.—Fracture of the humerus below the insertion of the deltoid. (Pennsylvania Hospital.)

Normally the axis of the supinated and extended forearm is directed away from the body, forming an angle of about 15 degrees with that of the arm (Fig. 199). Deviations from this angle should be noted, as well as any lateral motion which is not present in the normal elbow. Measurements may be made from the tip of the acromion to the tip of the external condyle, from the tip of the external condyle to the styloid process of the radius, and from the tip of the olecranon to the tip of the styloid process of the ulna, as well as between the condyles and from either condyle to the olecranon.

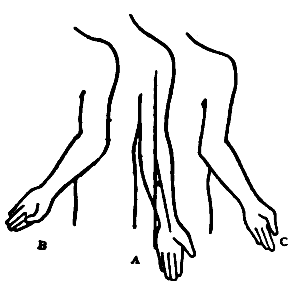

FIG. 199.—Outlines of upper extremity to show A, normal carrying angle; B, cubitus varus; C, cubitus valgus. (Rose and Carless.)

FIG. 200.—Supracondyloid fracture of humerus. (Gray.)

Supracondyloid fracture is caused by a fall on the hand when the elbow is flexed, or by direct violence. The *symptoms* are pain, swelling, loss of function, abnormal mobility, crepitus, and deformity. The lower fragment usually passes backwards and upwards, thus resembling a dislocation of both bones of the forearm backward (Fig. 200). In dislocation the relation of the olecranon to the condyles is altered, in fracture the relations are normal; in dislocation the forearm is shortened, in fracture the arm is shortened. In dislocation the lower end of the humerus causes a smooth projection at or below the crease of the elbow; in fracture the upper fragment presents a sharp projection above the crease. In dislocation reduction is difficult but permanent, in fracture reduction is easy, but difficult to maintain; there is no crepitus or abnormal mobility in dislocation, and the X-ray will show

FIG. 201.—Fastening figure-of-eight cravat over folded compression on opposite side of chest. Elbow region open to inspection. (Scudder.)

the bones out of place. As *complications* may be mentioned injuries to the brachial artery and median nerve.

The **treatment** is the application of an anterior angular splint (Fig. 195), and a posterior molded trough to the back of the elbow, after effecting reduction by drawing downwards and forwards on the forearm, and pressing backwards on the upper fragment. A Stromeyer splint is hinged and provided with a screw, so that the angle may be changed and thus some passive motion secured without removing the dressings. The *Jones position*, i.e., acute flexion of the elbow, is maintained by tying the wrist to the neck, or by means of a broad adhesive strap passed around the arm and forearm, which are supported by a figure-of-8 sling (Fig. 201). It is the best form of treatment for all fractures about the elbow, except those of the olecranon (separates the fragments), T-fractures of the lower end of the humerus (coronoid wedges fragments apart), fractures with great swelling (shuts off circulation), and fractures involving the groove of the ulnar nerve (nerve slips into line of fracture). The Jones position, indeed any kind of firm compression, should not be used, however, immediately after the accident, because of the danger of ischemic myositis (see prophylaxis of ischemic myositis, Chap. XXXI). Acute flexion reduces the fragments, and holds them in place between the coronoid process of the ulna and the trochlear surface of the olecranon in front, and the triceps posteriorly; it preserves the carrying function, and gives a useful elbow even in the presence of ankylosis; one must make sure that the compression at the elbow is not too great by feeling the radial pulse at the wrist. Some surgeons treat all fractures of the elbow in the extended position, by means of a long splint or a plaster cast. It is the best position in those cases in which the Jones method is contraindicated. It preserves the carrying angle, but if ankylosis occurs the limb is in the worst possible position. The right angle position rarely holds the fragments in place, but if ankylosis occurs the arm is still useful. Gentle passive motion may be commenced in three weeks, and the splints removed at the end of the fifth week. The *prognosis* of fractures about the elbow should be guarded, and the danger of limitation of motion explained to the patient. In most instances, however, a useful arm is obtained, although this may not be for a number of months.

Intercondyloid, T- or Y-shaped fracture, is a supracondyloid fracture with a fissure extending down between the condyles into the joint. It is caused by direct violence. There are widening of the elbow, shortening of the humerus, and the usual signs of fracture. The *treatment* is complete extension on a straight splint for three weeks, at which time passive motions should be commenced, the limb being placed on an internal angular splint for two weeks longer.

The **internal epicondyle** may be broken by direct violence, forced abduction of the extended elbow, or muscular action. There are crepitus and mobility. **Fracture of the external epicondyle** gives the same signs, and very rarely exists without other injury. The *treatment* is the Jones position.

The internal condyle of the humerus is broken by direct violence, the line of fracture running into the joint. The *symptoms* are pain, abnormal mobility, and crepitus; the fragment with the ulna passes upwards, thus destroying the carrying function of the arm. The *treatment* is the Jones position.

The **external condyle** may be broken by a fall on the hand, or by direct force. The line of fracture enters the joint and includes the capitellum, or a part of even the trochlear surface. The displacement is usually slight, but pain and swelling are generally marked. Crepitus and abnormal mobility are detected by grasping the condyle or by rotating the radius. The *treatment* is the Jones position or an internal angular splint.

Separation of the lower epiphysis of the humerus is not uncommon during childhood, at which time the entire epiphysis, consisting of several centers of ossification, is detached. The *symptoms* are practically identical with those of supracondyloid fracture, except that the crepitus is softer. The *treatment* is the Jones position. The possibility of interference with growth should not be forgotten.

The **ulna** may be broken through the olecranon, the coronoid process, the shaft, or the styloid process.

The **olecranon** is usually broken by direct violence, occasionally by muscular action. The *symptoms* are pain, swelling, abnormal mobility, and separation of the fragments owing to the action of the triceps. Crepitus is not obtained unless the fragments are approximated. If the periosteum or the tendinous fibers of the triceps covering the bone are untorn, separation may be unappreciable, even on flexion of the forearm, which ordinarily widens to a large extent the breach between the fragments. The *complications* are injury to the ulnar nerve and forward dislocation of the bones of the forearm.

The **treatment** is the application of a straight or nearly straight anterior splint, the upper fragment being pulled into position by means of adhesive strips. When union has become firm enough, possibly at the end of three weeks, the elbow should be flexed to a right angle, and placed on an internal angular splint for one or two weeks longer. The most satisfactory treatment in cases in which there is wide separation is wiring of the fragments through an incision. The *prognosis* should be guarded. Fibrous union often occurs, although such may not interfere with the usefulness of the elbow.

The **coronoid process** is rarely broken alone. The fracture may be associated with backward dislocation of the bones of the forearm, in which case reduction is associated with crepitus, is easily made, and hard to maintain. The fragment may be felt above its normal position, where it has been drawn by the brachialis anticus. There may be inability to flex the elbow. The *treatment* is the Jones position.

The **shaft of the ulna** is broken by direct violence. The *symptoms* are swelling, localized pain, abnormal mobility, and crepitus. There is little or no shortening unless the radius is broken, but the lower forearm is thickened owing to the action of the pronator quadratus, which draws the lower fragment into the interosseous space, while the upper fragment is drawn slightly forward by the brachialis anticus.

The **treatment** is an internal angular splint, which immobilizes the elbow and places the forearm midway between pronation and supination, in which position the bones are farthest apart and the danger of their union by callus is least. A posterior splint, reaching from the elbow to the wrist, also may be applied, while pieces of rubber tubing may be strapped over the interosseous space on each side of the forearm, in order to widen the interval between the bones. Union occurs in four weeks.

The **styloid process** is broken by direct violence, and is frequently detached in Colles' fracture. The loose fragment may be detected near the wrist.

The *treatment* is a Bond's splint (Fig. 195), with a pad over the styloid process.

The **radius** may be broken through the head, neck, shaft, or lower extremity.

The **head of the radius** is seldom broken alone, but the break may complicate dislocation of the elbow or fracture of the external condyle. There are crepitus and immobility of the head when the forearm is rotated. The *treatment* is the Jones position or an anterior angular splint. If the head escapes into the joint as a loose body, or unites with deformity, its excision may be called for to restore the movements of the elbow.

The **neck of the radius** is seldom broken. There are crepitus and immobility of the head on rotation of the forearm, and a prominence in front of the elbow, caused by the lower fragment, which is pulled upwards and forwards by the biceps. The forearm is pronated and voluntary rotation lost. The *treatment* is the Jones position or an anterior angular splint.

The **shaft of the radius** is usually broken by direct violence, and occasionally by a fall on the hand. The *symptoms* are loss of voluntary rotation in the forearm, localized pain, and immobility of the head and upper fragment with crepitus upon passive rotation of the forearm. The displacement varies with the site of fracture. When the fracture is *above the insertion of the pronator radii teres*, the upper fragment is flexed and supinated by the biceps and supinator brevis, while the lower fragment is pulled towards the ulna and pronated by the pronator quadratus and the pronator radii teres, hence the forearm is thickened below the seat of fracture. The *treatment* of these cases is full supination of the forearm on an anterior angular splint, in order to bring the lower fragment in contact with the upper, which, owing to its situation and small size, is not under control. Union takes place in three or four weeks. When the fracture is *below the insertion of the pronator radii teres*, the upper fragment passes inwards and forwards, owing to the action of the biceps, supinator brevis, and the pronator teres, which hold it also between pronation and supination. The lower fragment passes into the interosseous space and is pronated by the pronator quadratus; the supinator longus tilts the upper end inwards, but is not sufficiently powerful to overcome the pronation. The *treatment* is the same as that for fracture of the shaft of the ulna, the arm being placed midway between pronation and supination, because of the danger of union with the ulna by callus formation. The dressings may be removed in four weeks.

The **lower end of the radius** is broken with great frequency. **A Colles' fracture** is nearly transverse, and is situated within one inch of the articular

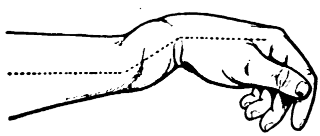

FIG. 202.—Colles' fracture showing silver fork deformity.

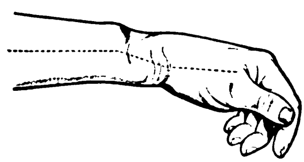

FIG. 203.—Fracture of lower end of radius with anterior displacement, showing gardener's spade deformity.

surface of the radius; it may, however, be oblique laterally or anteroposteriorly. *A Barton's fracture* involves the posterior lip of the lower end of the radius, the line of fracture entering the wrist joint. Colles' fracture is most frequent in old women, but may occur in either sex at any age. It is practically always the result of a fall upon the palm of the extended and pronated hand. Impaction, fracture of the lower end of the ulna or its styloid process, and tearing of the internal lateral ligament with subsequent dislocation of the lower end of the ulna, are not unusual *complications*. As a rule a strip of periosteum on the posterior surface remains untorn.

The **symptoms** are swelling, localized pain, and loss of function. Abnormal mobility and crepitus are frequently absent. The lower fragment passes upwards and backwards as the result of the direction of the violence, producing the silver fork deformity (Fig. 202); as most of the force is transmitted through the ball of the thumb, the displacement is also outwards, thus causing abduction of the hand and prominence of the styloid process of the ulna, which is found on a level with or lower than the radial styloid, which is normally the lower point. The lower fragment is also tilted, because the brunt of the force is received on the posterior lip of the articular surface, which looks downwards and backwards instead of downwards and forwards. The hand is pronated, and separated from the forearm by a deep depression on the flexor surface, caused by the posterior displacement of the lower fragment and the prominence of the lower end of the upper fragment. The distance between the styloid processes is lengthened and that between the external condyle and the radial styloid is shortened. In rare instances, as the result of falls on the back of the hand, the lower fragment is displaced forward instead of backward (Fig. 203).

The Treatment.—Reduction is accomplished by hyperextension, to free the fragments and relax the untorn dorsal periosteum, and direct pressure on the lower fragment, to force it in place, as the wrist is flexed and the hand adducted (towards the ulna). These movements may be quickly performed by locking the fingers beneath the wrist and using the thumbs to control the lower fragment. Great force is often required to reduce this fracture, and unless such can be effected quickly and at the first attempt, the patient should be anesthetized. Reduction is best maintained by means of the Bond splint (Fig. 195), fully padded beneath the hollow of the wrist, so that when placed on the splint the hand will be semi-flexed and adducted. A small pad is placed on the back of the forearm over the lower fragment, and another on the flexor surface over the lower end of the upper fragment. The fingers are not bandaged. The dressings are changed every two or three days, and while the fragments are held firmly in place with one hand, the fingers and wrist are gently moved, at even the second dressing. The splint may be permanently removed in three weeks. The Levis splint (Fig. 204) acts on the

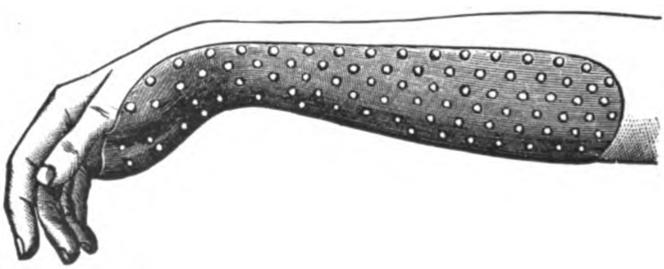

FIG. 204.—The Levis splint.

same principle as the Bond splint. Roberts uses a straight posterior splint. In simple Colles' fracture in the young and healthy the *prognosis* is good both regarding contour and function, but if there is comminution or much impaction, some deformity will result no matter what treatment is employed, while in cases with associated joint injury, or in the old and rheumatic, limitation of motion frequently follows the most careful treatment. If the bone has united in deformity and there is much impairment of function, reduction after osteotomy should be considered.

Separation of the lower epiphysis of the radius may occur before the twentieth year, the epiphysis passing backwards. It differs from Colles' fracture in that the dorsal swelling is less, the flexor or diaphyseal projection is greater, lateral deformity is rarely present, and crepitus is softer and more easily obtained. The *treatment* is that of Colles' fracture. The danger of interference with the growth of the radius should be borne in mind.

Fracture of both bones of the forearm (Fig. 205) may be due to direct or indirect violence; it is most frequent in the middle and lower thirds. As a rule the upper fragments are approximated and pronated, while the ends of the lower fragments also approach each other and may be found in front of or behind the upper fragments, hence the forearm is narrowed from side to side and thickened anteroposteriorly. There are also shortening, crepitus, preternatural mobility, pain, and swelling, and loss of active rotation.

The *treatment* of fractures below the insertion of the pronator teres is the same as that for fracture of the shaft of the ulna, the forearm being placed midway between pronation and supination, and the interosseous space preserved by means of pads. In fractures above this point the forearm should be put on an anterior angular splint, in full supination. If there is a persistent tendency to ulnar bowing of the forearm, i.e., convex towards the ulnar side, the elbow may be extended and a long straight splint or a plaster cast applied. Union is usually firm in four weeks.

The **carpal bones** are seldom broken, except in crushes in which the fracture is compound and associated with injuries to neighboring bones. Until the advent of the X-ray simple fractures of the carpal bones were usually treated as sprain, weak wrist, rheumatism, etc. Although any of the carpal bones may be involved in a simple fracture, the scaphoid is the one most frequently broken, often being associated with anterior dislocation of the semilunar bone; the proximal fragment passes forward with the semilunar. There is a "history of a fall on the extended hand; localized swelling of the radial half of the wrist joint; acute tenderness in the anatomical snuff-box when the hand is adducted; limitation of extension by muscular spasm, the overcoming of which by force causes unbearable pain. The possibility of the existence of a bipartite scaphoid should be considered in interpreting X-rays of simple fracture of the scaphoid" (Codman and Chase). Crepitus may be obtained in some instances of simple fracture of the carpus. The *treatment* in compound fractures is disinfection and the application of a straight palmar splint, or possibly resection of bone or amputation. In simple fractures deformity, if present, should be reduced by traction and direct pressure, and the wrist immobilized for three or four weeks by a palmar or dorsal splint. If pain and stiffness persist after fracture of the scaphoid, excision of the bone through a dorsal incision may give relief.

FIG. 205.—Fracture of both bones of the forearm. (Pennsylvania Hospital.)

The **metacarpal bones** may be broken by direct or indirect force. *Bennett's fracture* is a fracture of the upper end of the metacarpal bone of the thumb involving the articular surface. The *symptoms* are pain, swelling, crepitus, abnormal mobility, posterior angular deformity, and flattening of the knuckle of the affected bone. The *treatment* is reduction by traction and direct pressure, and the application of a straight palmar splint, well padded to fill up the hollow of the palm. It may be necessary to apply a dorsal pad over the deformity, and permanent extension to the finger by adhesive strips passing to the end of the splint. The dressing should be worn for three weeks.

The **phalanges** are generally broken by direct violence, which frequently renders the fracture compound. The *symptoms* are pain, swelling, mobility, crepitus, loss of function, and little or no deformity. The *treatment* is the application of a molded splint of cardboard or a straight wooden splint, which in fracture of the proximal phalanx should extend into the palm. In some cases it may be desirable to bandage adjacent fingers together on a splint, so as to provide lateral support. The splint may be discarded in three weeks.

Fractures of the pelvis are due to direct violence, as in a crushing accident, or to violence transmitted through the vertebral column or the femora.

Fractures of the false pelvis, i.e., of the spines, crests, or ala of the ilia, are not in themselves serious, as displacement is slight. The *complications* may, however, be highly dangerous; they are more often associated with comminuted fractures, and involve the abdominal viscera. The *symptoms* are pain, swelling, ecchymosis, mobility, crepitus, and but little or no deformity. The *treatment* is rest in bed, with the shoulders elevated and the thighs flexed to relax the muscles, and the application of a broad flannel binder around the pelvis. Rupture of the bowel will require laparotomy. Union occurs in four or five weeks.

Fractures of the true pelvis are always serious because of the danger of *complications*, such as rupture of the bladder or urethra, or injury to the bowel, uterus, or vagina. The fracture usually extends into the obturator foramen, either through the horizontal ramus of the pubes or the ascending ramus of the ischium. It may be associated with fracture through the opposite sacro-iliac joint, or there may be many lines of fracture in different parts of the pelvic ring. The *symptoms* are shock, pelvic pain, especially on coughing, straining, or moving the legs, swelling, ecchymosis, inability to sit or stand, and rarely deformity. Mobility and crepitus may be obtained by grasping the pelvis on each side and making alternate pressure, or by inserting the finger into the vagina or rectum while one side of the pelvis is moved on the other. It should be remembered that rough manipulations may drive sharp fragments into the viscera. Bleeding from the urethra, vagina, or rectum should be most carefully investigated.

The **treatment** is first to react the patient from shock, and carefully exclude visceral injuries, which, if present, are to be repaired as described under their respective headings. The fragments are reduced by external manipulation, or by combined external and internal manipulation, and the patient placed on a firm bed or a Bradford frame, with a broad binder encircling the pelvis. In some fractures of the pubic bone wiring may be indicated. Union occurs in about six weeks, but the patient should be kept in bed several weeks longer, then allowed to get about with a firm binder and crutches.

Fracture of the acetabulum may complicate dorsal dislocation of the femur, the posterior lip giving way; or the head of the femur, in falls on the trochanter, may fissure the acetabulum, or even perforate it and enter the pelvis, in which case the viscera may be damaged. In fracture of the posterior lip the head of the femur is easily reduced, with crepitus, but the deformity shows a strong tendency to recur. When the head of the bone has been driven into the pelvic cavity, a fracture of the neck of the femur may be simulated, but there is less mobility, and greater flattening of the trochanter, and the head of the bone may be palpated through the rectum. The *treatment* is reduction by traction and external manipulation, and the application of permanent extension as in fracture of the neck of the femur.

The **sacrum** is broken by direct violence. Comminution may be present, and injury to the sacral plexus is frequent, perhaps causing paralysis of the bladder and rectum. In a transverse fracture the lower fragment generally passes forwards, and may press upon or tear the rectum. Mobility and crepitus may be detected by placing one finger in the rectum and making external pressure. The *treatment* is reduction by pressure within the rectum, and the application of a pelvic binder, with a large pad over the upper part of the sacrum, so that external pressure will not be made on the lower fragment. Laceration of the rectum may require suture. In the presence of injury to the sacral plexus elevation and fixation of the depressed fragments through an external incision will be indicated. In these cases great care must be taken lest bed sores develop or lest infection of the bladder from catheterization result. The bone unites in four or five weeks.

The **coccyx** is normally mobile, but it may be broken by a fall or a kick. The symptoms are pain, more marked on walking, coughing, and defecation, and mobility, crepitus, and perhaps turning in of the fragment, appreciable on rectal examination. The *treatment* is rest in bed for four weeks; the bone cannot be splinted. **Coccygodynia** is a severe form of neuralgia following injuries to the coccyx. It may be due to non-union or vicious union, but occasionally occurs in cases in which there has been no fracture. The pain is similar to that occurring in fracture, and may be so harassing as to induce neurasthenia. If relief cannot be obtained by medical treatment, the coccyx may be excised through a straight incision in the middle line, care being taken not to injure the rectum.

Fractures of the upper extremity of the femur include intra- and extracapsular fractures of the neck, fractures of the great trochanter, fractures of the lesser trochanter, and separation of the upper epiphysis.

Intracapsular fracture of the neck of the femur is most frequent in elderly women, although it may occur in either sex or at any age. In old age the neck of the bone is more horizontal, and the bony tissue is atrophied and infiltrated with fat, hence slight indirect force, such as catching the toe in a piece of carpet, or suddenly throwing the weight of the body upon the lower extremity, is a frequent cause of this accident in the elderly. Impaction is unusual, and although some of the reflected fibers of the capsule or a portion of the periosteum may remain untorn, the head of the bone, as a rule, is entirely separated except for its attachment to the acetabulum by the ligamentum teres, through which it receives sufficient blood to maintain its vitality. Hence non-union or at best fibrous union is a frequent occurrence, particularly in the aged and debilitated.

The **symptoms** are pain, little or no swelling and ecchymosis (unless the patient has fallen on the trochanter after the neck has broken), loss of function, helpless eversion (the limb lying on its outer side as the result of gravity and the action of the external rotators; inversion is possible but very rare), crepitus if there is no impaction, lessened arc of rotation of the great trochanter (the radius extending to the line of fracture instead of to the acetabulum), inward displacement of the great trochanter (found by measuring the distance between the median line of the body and the outer surface of each trochanter), and slight shortening (one-half to one inch), which in a few days may increase to two or more inches, owing to muscular spasm, unlocking of impacted fragments, or laceration of untorn periosteal or fibrous tissue. Shortening may be determined by one of the following methods: 1. The limbs may be measured from the anterior superior spine of the ilium to the internal malleolus. The patient should be perfectly flat and straight upon a firm bed, so that a straight line drawn from the episternal notch to midway between the internal malleoli will intersect the umbilicus, the symphysis pubis, and the midpoint between the knees, and a line passing through each anterior superior spine of the ilium will be perpendicular to the axis of the body. The tip of the anterior superior spine and the tip of the internal malleolus are marked with a pencil, and in measuring the skin is not pressed upon lest it become displaced. A difference of a quarter of an inch is not unusual normally, and exceptionally it may be even much greater, so that in case of doubt the tibiæ may be measured to determine the presence or absence of symmetry. Normally a straight line from the anterior superior spine to the tip of the malleolus passes through the center of the patella. 2. *Nélaton's line* is one passing from the anterior superior spine of the ilium to the most prominent part of the tuberosity of the ischium. Normally when the lower limb lies in the axis of the body, midway between internal and external rotation, the top of the trochanter touches the middle of this line; in fracture it passes above the line. 3. *Bryant's triangle* (Fig. 206) consists of a line from the anterior superior spine to the top of the trochanter, and another from the anterior superior spine, drawn downwards perpendicularly to the axis of the body, to meet at a right angle one drawn upwards from the trochanter. Shortening of the last line as compared with the opposite side of the body, shows the amount of shortening of the limb. 4. Relaxation of the fascia lata, as determined by pressure above the great trochanter, also indicates shortening of the femur. In *children*, in whom this fracture is more common than was once supposed, there is usually the history of a severe fall rather than a trivial twist, and the fracture is often impacted or of the green-stick variety, so that the disability may be slight and the bony injury readily overlooked. Later, however, owing to the lack of proper treatment, the neck bends (coxa vara) and a permanent limp is produced, which, with the slight pain and limitation of motion, may be mistaken for hip disease. The symptoms of fracture of the femoral neck in children are slight eversion, limitation of abduction, and shortening; crepitus and abnormal mobility are usually absent. The diagnosis is confirmed by the X-ray. The *complications* in the old are mainly due to confinement to bed, e.g., bed sores and hypostatic pneumonia. Non-union, fibrous union, atrophy and absorption of the head, in the old, and coxa vara in the young, are among the sequelæ.

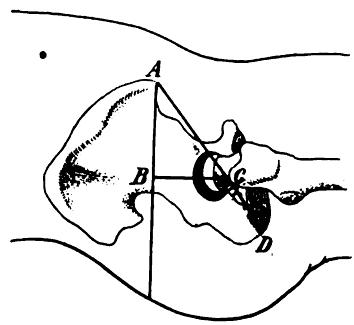

FIG. 206.—AD, Nélaton's line; ABC, Bryant's triangle; BC, test-line for fracture or shortening of neck of femur.

The **treatment** is seldom satisfactory. Aged patients rarely tolerate confinement to bed for the necessary length of time to obtain union, and, should there be evidences of impairment of the general health, the patient should be allowed to sit up and leave the bed at the earliest possible date, making no attempt to fix the fracture. The usual method of treatment is by ***Buck's extension apparatus***, with sand bags for lateral support. The patient is placed on a firm mattress, which is kept flat by boards placed between it and the frame of the bed. Impaction should never be broken up, except possibly in the young, hence one should never try to obtain crepitus and mobility, and should be careful in moving the patient. A hairy leg should be shaved, and the foot and ankle bandaged. A strip of adhesive plaster, about two inches wide, and long enough to run from the seat of the fracture to below the sole of the foot and back again, is prepared by fastening to its center a piece of board, with a hole in the middle, and a little longer than the width of the foot (Fig. 195). The plaster is applied to the sides of the lower extremity up to the seat of the fracture, and the bandage continued over the plaster. A piece of rope is knotted, then passed through the opening in the board and over a pulley at the end of the bed (Fig. 195). To this should be attached a weight of five pounds (a brick weighs about five pounds), unless there is great shortening and no impaction, in which case the weight should be sufficient to restore the normal length of the limb. The foot of the bed is raised five or six inches, to obtain counterextension by the weight of the body. The limb is slightly abducted, rotated inward to correspond with the other limb, and supported from the sides by sand bags, the outer reaching from the chest to below the foot, and the inner from the perineum to below the foot. A pad is placed beneath the popliteal space, and a bird's nest of cotton beneath the heel to relieve pressure. A cradle (Fig. 207) may be placed over the leg to support the bed clothing. The patient should be kept in bed six or eight weeks, and should bear very little weight on the extremity for three months from the time of injury, indeed crutches, or at least a cane, are usually necessary for many months, if not permanently.

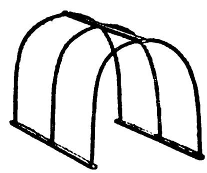

FIG. 207.—Cradle.

Senn encases the pelvis and the lower extremity in plaster-of-Paris, leaving an opening over the great trochanter, upon which lateral pressure is made by means of a screw apparatus which has been incorporated in the plaster.

The Thomas hip splint (Fig. 243) immobilizes the fracture by fixing the pelvis and the thigh, and allows the patient to be moved about without danger of disturbing the fragments. The splint is of iron, with bands encircling the chest, thigh, and calf. The method is an excellent one if the splint is at hand and the practitioner possesses the requisite skill to adjust it. In children Whitman advises the breaking up of impaction under anesthesia, and fixation of the limb at the limit of normal abduction, by means of a plaster-of-Paris spica. He believes this treatment may be applicable also to certain cases in adult life. If non-union occurs in young and healthy adults, the fragments may be fixed by driving a nail, screw, or bone peg through the trochanter into the head of the femur, after exposing these parts by incision. The *prognosis* is bad in the old. Death may occur from shock, exhaustion, or from pneumonia or other visceral disease. Complete recovery is rare, there usually being pain, weakness, and limping. In cases of non-union not suitable for operation, some relief may be obtained by means of a hip support.

The so-called **extracapsular fracture** of the neck of the femur is in reality extracapsular behind only, the line of fracture in front being covered by the caspule. The cause is direct violence to the trochanter, as a fall on the hip, hence impaction is common; if the violence be greater the trochanter is involved, sometimes with extensive comminution. The *symptoms* are much the same as those of intracapsular fracture, except that in the former there is greater pain, swelling, ecchymosis, and primary shortening, and later more thickening as the result of callus formation. The *treatment* is the same as that of intracapsular fracture. The *prognosis* is very much more favorable than in intracapsular fracture; bony union is the rule, although some shortening is inevitable.

Fracture of the great trochanter is the result of direct violence, the line of fracture running through the base of the trochanter to the lower part of the neck of the bone. The *symptoms* are very similar to those of extracapsular fracture. The lower fragment with the lesser trochanter passes upwards and backwards towards the sciatic notch, and may be palpated posteriorly. The *treatment* is that of extracapsular fracture.

Separation of the great trochanter without fracture of the shaft is very rare, and in youth is due to *separation of the epiphysis of the great trochanter*. The cause is direct violence. The *symptoms* are mobility of the trochanter and crepitus. The length of the limb and the motions of the hip joint are not affected. The *treatment*, if there is little or no displacement, is that of fracture of the neck. If the fragment is pulled upwards and backwards away from the shaft, the thigh may be flexed and rotated externally, while adhesive straps are applied to pull the trochanter downwards. Far better in such a case is fixation by wire, screws, or pegs, through an open incision.

Fracture of the lesser trochanter may occur in the young. Eight cases have been reported, one from direct violence, and the rest from avulsion the result of contraction of the psoas when the thighs were spread apart. The *symptoms* are external rotation of the thigh, pain and tenderness two or three inches below the groin in Scarpa's triangle, and ecchymosis along the inner surface of the thigh. Crepitus and abnormal mobility cannot be elicited, owing to the depth of the injury, and there is no shortening or deformity. The patient is able to raise the heel from the bed when lying down (as this is done by the rectus and the muscles on the anterior surface of the thigh), but not when sitting, as the rectus is then relaxed and the psoas must do the lifting (*Ludloff's sign*). This sign differentiates this injury from a fracture of the femoral neck, in which the leg cannot be raised when the patient is lying down. The diagnosis is confirmed by the X-ray. The *treatment* is fixation of the thigh in flexion and internal rotation, in order to relax the psoas.

Separation of the epiphysis of the head of the femur is uncommon, but may occur in early life. Growth of the limb may be impaired, or coxa vara may result. The *symptoms* are those of intracapsular fracture, although less marked and accompanied by soft crepitus. The *treatment* is that of intracapsular fracture.

The diagnosis of injuries about the hip should be made only after a comparative examination of both sides. The tape measure and the X-ray are the greatest aids. In contusion or sprain mensuration will reveal neither shortening of the limb nor flattening of the hip, although individual variations from the normal should be remembered. It should be recalled, however, that shortening may sometimes occur late after contusion, owing to atrophy and absorption of the head of the bone. Crepitus with shortening may be found in chronic osteoarthritis of the hip, but they antedate the accident and are probably associated with similar changes in other joints; moreover, the trochanter is more often prominent than flattened, and there is no relaxation of the fascia lata. An impacted fracture gives no crepitus, and presents a large arc of rotation of the great trochanter, but is accompanied by shortening which is not affected by extension. Dislocation occurs in young adults, never as the result of direct violence, but always from force applied to the knee,

FIG. 208.—Fracture of the shaft of the femur. (Pennsylvania Hospital.)

foot, or back when the thigh is flexed; there is no crepitus and the head of the bone may be felt in its new position. In dorsal dislocation the limb is adducted and inverted, while in forward dislocation there is abduction and outward rotation; in the obturator variety of the latter there is lengthening of the limb.

Fractures of the shaft of the femur are most frequent in the middle third. Fracture of the upper third is uncommon and usually due to indirect violence. Fracture of the lower third is usually due to direct violence. The

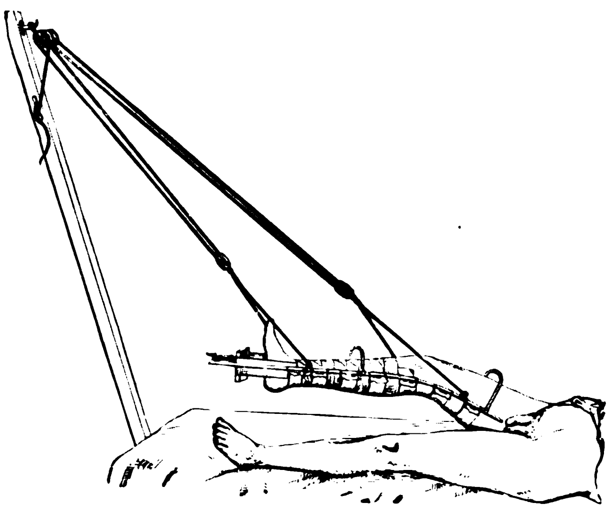

FIG. 209.—Hodgen's suspension splint. (Heath.)

middle of the bone may be broken in either way and occasionally from muscular action. The fractures are generally oblique and displacement is the rule, hence injury to the soft parts is of frequent occurrence, and occasionally the vessels or nerves are lacerated.

The **symptoms** are pain, swelling, muscular spasm, abnormal mobility, crepitus, deformity, and shortening. In the upper third the upper fragment is pulled forwards by the iliopsoas, and drawn outwards and rotated externally by the external rotators; the lower fragment is pulled upwards by the flexors and extensors of the leg, inward by the adductor muscles, and rolled outwards by the weight of the limb. In the middle third the displacement is much the same, although here any variety of deformity may be produced, according to the form and the direction of the violence. In the lower third the gastrocnemius draws the lower fragment backwards, and thus endangers the popliteal vessels.

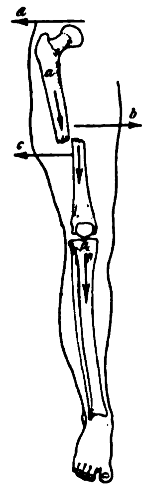

FIG. 210.—Bardenheuer's method of treating fractures of the femur. (*a*) Direction of traction by Buck's extension apparatus; (*b*) of traction on lower end of upper fragment, by band passing around the injured thigh and under the sound thigh; (*c*) of traction on upper end of lower fragment, by band passing around the thigh; (*d*) of traction by band to fix the pelvis. Each of these bands passes over a pulley at the side of the bed and is attached to a weight. The upper end of the distal fragment is forced outwards also by adducting the limb.

The **treatment** of fractures of the *upper third* is flexion of the thigh and traction to reduce the deformity, and the application of a double-inclined plane (Fig. 195) with extension in the axis of the thigh. A shot bag may be placed over the upper fragment if it is too short to be retained by an anterior splint. The principle of the double-inclined plane is utilized also in the Mc Intyre splint, the Nathan R. Smith anterior splint, and the Hodgen splint. The Nathan R. Smith splint is made of strong wire, bent to the desired shape; it is applied to the anterior surface of the limb and suspended by cord and pulley. The Hodgen splint consists of two long pieces of wire joined at each extremity and at the middle by a cross piece. The limb rests in a trough of flannel attached to the frame. A Buck's extension is applied, and attached to the foot piece, and further extension made by suspending the limb by cords, passing obliquely upwards to a vertical post at the foot of the bed (Fig. 209). All forms of treatment, however, are unsatisfactory, and if the displacement is marked and the patient young and healthy, operative fixation should be considered. In *fractures of the middle third* a Buck's extension is applied up to the seat of fracture, and enough weight attached to the cord to overcome the shortening. Lateral displacement is corrected by sand bags, lateral splints, or a molded splint. In the *lower third* horizontal traction as in the middle third may be tried, but if there is a marked tendency to displacement of the lower fragment backwards, the double-inclined plane should be used. Tenotomy of the tendo Achillis is useful in some cases. Bardenheuer treats fractures in all parts of the femur, and indeed fractures in other bones of the extremities, by lateral as well as longitudinal extension (Fig. 210). In order to make powerful traction Steinmann advises "nail extension." A steel nickel-plated nail or screw is driven through the skin into each condyle, obliquely downwards, and to the outer ends of these nails weight, even 40 or 50 pounds, is attached by means of wire or a special apparatus (Fig. 211). The nails are removed at the completion of the treatment. As the Steinmann procedure is attended by some danger of infection, it should be employed only when the other methods of extension fail. Fractures of the thigh unite in six or eight weeks.

In *children* Bryant's method may be used; the limb is splinted, flexed to a right angle with the body, and extension made from a cross bar above the bed (Fig. 212). The child may be fastened to a Bradford frame, which is simply an oblong of gas pipe to which canvas is attached, a space being left beneath the buttocks. Van Arsdale's triangular splint is made of thick cardboard, in the shape of two cards of spades joined at their apices (Fig. 213). When the splint has been folded, it forms a triangle, segment 2 being molded to the abdomen and segment 3 to the thigh. "The extreme flexed position of the thigh relaxes all the muscles and neutralizes any tendency to displacement; the child can sit on the floor or chair and creep about, and the genital and anal regions are well away from the dressings" (Gallant). The splint is worn for three weeks.

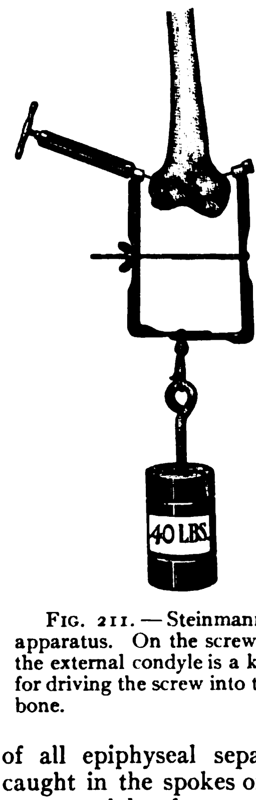

FIG. 211. — Steinmann's apparatus. On the screw in the external condyle is a key for driving the screw into the bone.

The *prognosis* in childhood is very good, but decreases with the advance of years, so that in adult life probably only one-half secure limbs which give them no trouble, and in old age perfect functional results are very rare. Excepting incomplete fractures, some shortening is inevitable.

Supracondylar fracture of the femur is identical with fracture of the lower third of the bone.

T- or Y-shaped fracture exists when a supracondylar fracture is complicated by a separation of the condyles one from the other. The lower end of the femur is broadened, one c ndyle may be moved on the other with crepitus, and the knee joint is filled with blood. The *treatment* is that of fracture of the lower third of the femur.

Fracture of either condyle is the result of direct force. The fragment is displaced upwards and the leg deviated towards the affected side; there are crepitus, broadening of the lower end of the femur, and distention of the joint, but no shortening. The treatment is a double-inclined plane.

Separation of the lower epiphysis occurs before the twenty-first year, is the most frequent of all epiphyseal separations, and is usually the result of the leg being caught in the spokes of a wheel. The *symptoms* are much like those of supracondylar fracture, except that the crepitus is moist, and the lower fragment is often displaced forwards owing to the action of the quadriceps on the tibia; the lower end of the diaphysis passes backwards, thus endangering the popliteal vessels. Suppuration may occur and the growth of the bone may be impaired. The *treatment* is reduction by traction while pressure is made on the fragments and the thigh gradually flexed. The limb is then put on a double-inclined plane.

Longitudinal fractures entering the knee joint may cause broadening of the bone, but are difficult to detect. The *treatment* is immobilization in a horizontal position for six or eight weeks. Occasionally a small piece of the articular surface of one of the condyles is chipped, but unless an

X-ray picture is taken, the diagnosis is rarely made until some time later, when a foreign body is detected in the joint.

Fracture of the patella is produced by direct violence, or much more frequently by muscular action. *Fractures by direct violence* are usually vertical or oblique, and not infrequently comminuted. As a rule the fibrous capsule of the patella is not separated to any great extent so that marked displacement is absent. The treatment of these cases is immobilization of the knee by a posterior splint for six weeks. Effusion into the joint is reduced by cold and compression and later by massage; in four weeks gentle passive motion is begun.

FIG. 212.—Bryant's vertical extension for fracture of femur in children.

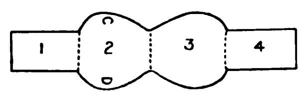

FIG. 213.—Segments 1, 2, 3, 4, each cut the length of child's thigh from groin to patella, and flanges C to D the same width. The width of sections 1 and 4 equal thickness of the middle of the thigh. Fold on dotted lines overlapping 1 and 4 after moistening. (Annals of Surgery.)

Fractures due to muscular action are transverse or slightly oblique, the fibrous capsule usually tearing so that marked separation takes place. The joint is therefore usually opened. When the knee is half flexed, the middle of the patella lies against the condyles of the femur, while the upper portion projects above; in this position sudden contraction of the quadriceps, as in an attempt to save oneself from a fall, may result in a transverse fracture. The *symptoms* are pain, effusion of blood into the knee joint, inability to extend the leg although walking backwards is possible, separation of the fragments, and if they can be brought together, crepitus. The separation is produced by the action of the quadriceps and also by the effusion in the knee joint.

The **treatment** is at first the application of a posterior splint, with cold and compression to reduce the swelling. If there is great distention of the joint, the effusion may be drawn off by a trocar and cannula. After the swelling has been controlled the fracture may be treated by the non-operative method or by operation.

The non-operative method is without risk to life and is generally followed by a useful joint, although it consumes more time than treatment by operation. It should be employed by the general practitioner who is not surrounded by facilities for perfect asepsis. Cases in which the fibrous capsule of the patella and the lateral fascial expansions are not torn through, i.e., cases in which there is but little or no separation, are best treated by the conservative plan no matter what the surroundings. The limb is placed on a posterior splint, the lower end of which is elevated to relax the quadriceps, and the fragments are approximated and held in place by two strips of adhesive plaster, one of which passes from below the joint on the outside, above the upper fragment, then down to the inner side of the lower part of the knee. The second strip in a similar way carries the lower fragment upwards. A third strip should be put across the line of fracture to prevent tilting of the fragments. Hopkins applies to the thigh a wickerwork of adhesive plaster, to which is attached an extension apparatus in order to relax the quadriceps and pull down the upper fragment. Agnew's splint (Fig. 195) is simply a posterior splint with rotating pins on the side for the attachment and tightening of the strips of adhesive plaster applied to hold the fragments in place. Massage may be used from the beginning. During the fifth or sixth week the splint may be removed, and the patient allowed to walk with a molded support to keep the knee stiff; passive motions are used at this time, but active movements are reserved until the end of two months; all support is removed at the end of six months.

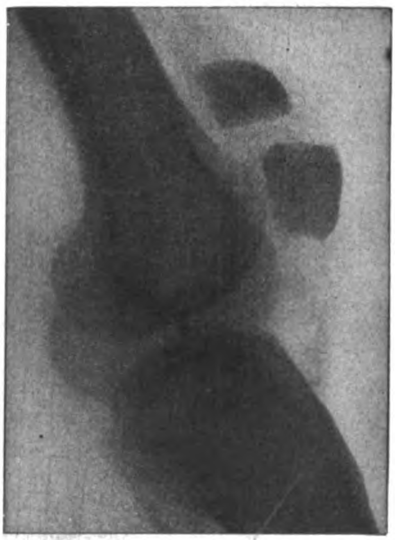

FIG. 214.—Skiagraph of fracture of patella. (Pennsylvania Hospital.)

The operative treatment of fracture of the patella is gaining in favor, and indeed with some surgeons is almost routine practice. It should never be employed unless facilities for aseptic work are available, as infection of the knee joint may result in its destruction, in amputation of the limb, or in death. Convalescence is more rapid after the operative treatment, and it offers the best chance for accurate apposition and bony union. Granting a healthy subject, it is particularly indicated in cases in which there is wide separation, in which soft tissues intervene between the fragments after their apposition, and in cases of compound fracture, refracture, or fibrous union in which the function of the limb is considerably impaired. In the laborer or in one whose occupation necessitates prolonged standing or much walking, operation offers the best chance for a strong patella. Operative treatment may be either *subcutaneous* or open. As an example of the former may be mentioned the antero-posterior suture of Barker. A special instrument somewhat like an aneurysm needle sharpened at the end is passed through a knife puncture just below the patella, then beneath the bone to and through the skin above the upper fragment, where it is threaded with silver wire and withdrawn to the point of entrance and unthreaded; it is then pushed upwards between the skin and the fragments to the opening above, threaded with the other end of the wire, and withdrawn. After rubbing the fragments together to dislodge blood or soft tissues, the ends of the wire are twisted, cut short, and pushed beneath the skin. In a somewhat similar manner Roberts passes a silk suture around the fragments laterally (circumferential suture). The subcutaneous possesses all the dangers of the open method without its advantages, viz., evacuation of the joint, removal of the fibrous or other tissue from between the fragments, and accurate apposition. The *open operation* is performed by exposing the fracture by a longitudinal or transverse incision, preferably the latter. The joint is irrigated with salt solution, the fragments brought together after removing any intervening soft structures, and two wire sutures passed obliquely through the fragments so as not to enter the joint. The wound is closed without drainage. When the fragments come together without much tension, it is preferable to omit the silver wire and simply suture the fibrous capsule of the patella and the lacerations in the lateral fascial expansion with strong chromicized catgut. Massage is begun as soon as the wound is healed, and the patient is allowed out of bed with a molded splint at the end of three or four weeks, when passive motions are commenced; all dressings are removed in two months, and at the end of three or four months recovery is complete.

The *prognosis* after non-operative treatment is good regarding the function of the leg, although fibrous union is the rule and some stiffness and weakness are generally present. After operation bony union may be secured, but pain and stiffness are by no means unusual. Of 373 cases of fracture of the patella, 48 suffered a refracture at the same point, in periods ranging from a few months to four years; the majority of these were treated by the conservative plan (Lauper).

The **tibia** may be fractured at the upper end, at any portion of the shaft, and at the lower end, and the tubercle, or the upper or lower epiphysis may be separated.

The **upper end of the tibia** is broken by direct violence. The *symptoms* are often masked by the swelling of the overlying soft parts. When the fracture is transverse there is but little displacement, when oblique the leg deviates from the axis of the limb. The fissure may enter the joint, which will then be greatly distended. Mobility and crepitus are present. The *treatment* is reduction by traction and pressure on the fragments, and immobilization on a double-inclined plane or in a plaster cast, for four or five weeks.

The **tubercle of the tibia** may be torn off by violent contraction of the quadriceps, in individuals under the age of twenty. The fragment is drawn upwards, and the injury may be mistaken for fracture of the patella, in which, however, there is no depression at the upper extremity of the tibia, the upper end of the lower fragment is serrated, and a finger pressed between the fragments touches the femur. If the separation is partial the diagnosis is made by pain, tenderness, localized swelling, and the X-ray. The *treatment* is a posterior splint; if there is much separation, the tubercle may be fastened in place by wiring or pegging.

Separation of the upper epiphysis of the tibia is an extremely rare injury which may occur before the sixteenth year and be productive of dwarfing of the leg. The *treatment* is that of fracture of the upper end of the tibia.

The **shaft of the tibia** is usually broken by direct violence, occasionally by indirect violence or torsion. Generally speaking the fracture is transverse when in the upper part of the bone, oblique or spiral when in the lower portion (Fig. 215). The *symptoms* are localized pain, irregularity of the crest of the tibia, crepitus, and mobility. In transverse fractures there may be no deformity, and even in oblique fractures the splinting action of the fibula may prevent much displacement; as a rule, however, the upper fragment is tilted forwards by the quadriceps, while the lower fragment is rotated inwards. The *treatment* is the application of a fracture box (Fig.

195), until the swelling has been controlled by evaporating lotions or the ice bag; the leg is then put up in a plaster-of-Paris cast, which is worn for five weeks. The cast should be split before it has hardened, so that it may be removed every few days for inspection and massage of the leg.

The **internal malleolus** is broken by direct force, or its tip may be torn off by the internal lateral ligament when the foot is strongly everted. The *symptoms* are pain, mobility, crepitus, effusion into the ankle joint, and possibly downward displacement of the fragment. The *treatment* is that of fracture of the shaft. Wiring or pegging should be considered if there is much displacement, as vicious union in this situation is followed by lameness.

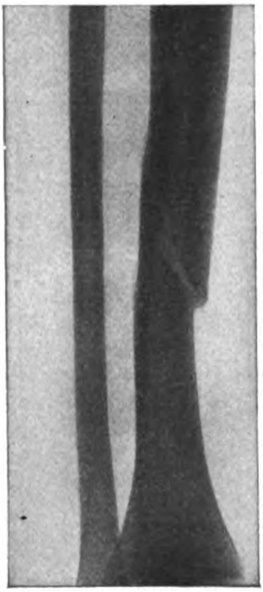

FIG. 215.—Skiagraph of torsion fracture of tibia. (Pennsylvania Hospital.)

Separation of the lower epiphysis of the tibia is very rare. The treatment is that of fracture of the shaft.

The **fibula** may be broken by direct or indirect force, or by muscular action (biceps).

The **upper end of the fibula,** when broken, causes localized pain, particularly on adduction of the leg. There may be no displacement, or the upper fragment may be drawn up by the biceps. Crepitus and mobility are present; the external popliteal nerve may be injured. The *treatment* is the application of a plaster cast for five weeks. If there is displacement the knee may be flexed to relax the biceps.

The **shaft of the fibula,** when broken, causes localized pain and tenderness. Deformity is not seen, but on pressing the tibia against the fibula, crepitus and abnormal mobility may be detected. As the bone is normally elastic, comparison with the other leg should be made before deciding that abnormal mobility is present. The *treatment* is a plaster cast for five weeks.

The **lower end of the fibula** may be broken by direct force, but the usual cause is a twist of the foot. **Pott's fracture** is caused by eversion and abduction of the foot, rarely by inversion and adduction. In a typical case there are three lesions, a fracture of the fibula about three inches above the tip of the malleolus, a fracture of the internal malleolus due to traction of the internal lateral ligament (or rupture of the ligament), and rupture of the tibiofibular ligament (or avulsion of that part of the tibia to which it is attached). The number of lesions and consequently the amount of deformity depend upon the degree of eversion and abduction. In the slighter forms the internal malleolus alone is broken or the internal lateral ligament ruptured. Continuation of the force presses the astragalus against the external malleolus and, with the tibiofibular ligament as a fulcrum, breaks the fibula above the ankle by indirect force, the upper end of the fragment passing towards the tibia. These injuries cause simply marked eversion of the foot. If the tibiofibular ligament also ruptures, or the tibia to which it is attached gives way, there is added displacement of the foot upwards and backwards; to this variety the term *fracture-dislocation* (Fig. 216) may be properly applied. If the outward dislocation is complete the injury is called *Dupuytren's fracture.*

Occasionally the fracture of the fibula is accompanied by a transverse fracture of the tibia immediately above the inner malleolus, in which case the projection of the lower end of the upper fragment of the tibia may be mistaken for the internal malleolus. In Pott's fracture by inversion the astragalus presses against and fractures the internal malleolus, and the fibula is broken above the ankle by the violent traction on the external lateral ligament, the tibiofibular joint acting as a fulcrum.

The **symptoms** in a typical case are eversion of the foot with displacement upwards and backwards. There is great swelling, the ankle joint being distended with blood. The internal malleolus is prominent, the ankle joint

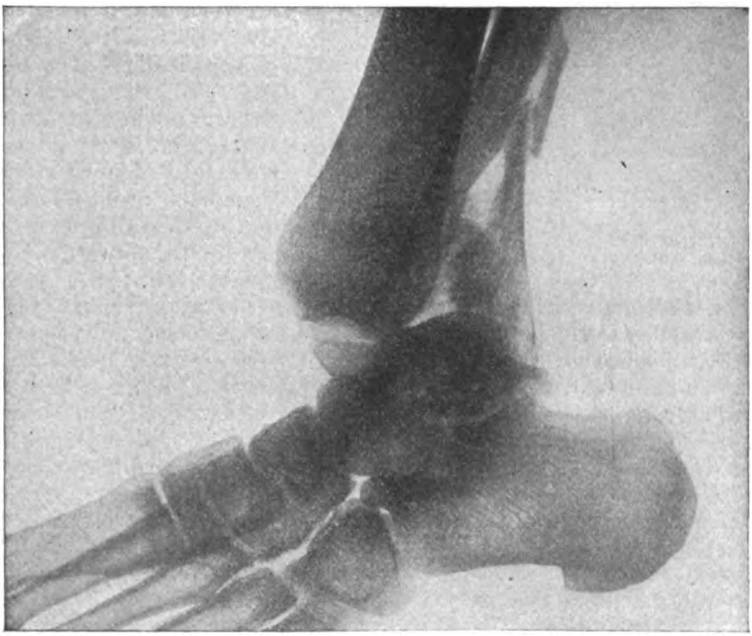

FIG. 216.—Skiagraph of fracture-dislocation of ankle. (Pennsylvania Hospital.)

widened, and the foot shortened, i.e., from the tibia to the toes. There are three points of great tenderness, corresponding with the three lesions mentioned above; the joint can be moved laterally and antero-posteriorly, and crepitus obtained.

The **treatment** is reduction by carrying the foot inwards, forwards, and downwards, and the application of a fracture box until the swelling has been controlled. The foot is fastened to the foot-piece of the box by a bandage, and pads so arranged as to maintain reduction. When the swelling has subsided, the leg may be put up in plaster, care being taken to maintain the foot at right angles to the leg and slightly adducted, and to continue extension on the foot until the plaster has hardened. The cast is permanently removed at the end of the fifth week. Dupuytren's splint is a straight board extending from the knee to five or six inches below the foot. The lower extremity is notched. The splint is applied to the inner surface of the limb, after being thickly padded down as far as a point corresponding to the internal malleolus, so that the foot may be inverted over the lower end of the pad by bandages, extending from the foot to the serrations in the end of the splint (Fig. 195). This splint is well suited to cases in which there is eversion and upward displacement, but does not correct backward displacement of the foot. If reduction cannot be effected or maintained, even after flexion of the knee or division of the tendo Achillis, fixation of the fragments by operation is indicated.

Fracture of the shafts of both bones of the leg (Fig. 217) may be due to direct violence, in which case the fracture may be transverse and at the same level in each bone; indirect violence frequently produces an oblique or a spiral fracture at about the junction of the middle and lower thirds of the tibia, the fibula yielding at a higher level. All the *symptoms* of fracture are in evidence. As a rule the lower fragments pass up behind the upper fragments, owing to the action of the calf muscles, and are rotated outwards by the weight of the foot.

FIG. 217.—Fracture of both bones of the leg. (Pennsylvania Hospital.)

The **treatment** is reduction by flexing the knee to relax the calf muscles, and traction on the foot while the bones are forced into place; division of the tendo Achillis is occasionally necessary. The limb may then be placed in a fracture box, and after the subsidence of swelling in a plaster-of-Paris cast. Some surgeons apply molded lateral splints, others the Nathan R. Smith anterior splint. Steinmann employs "nail extension" (p. 299), the nails being driven into the malleoli. The ambulatory treatment also may be used in this region. Splints may be removed in five or six weeks. Whatever treatment is employed, one should guard against rotation of the lower fragments and shortening; the former is absent if the inner surface of the great toe, the internal malleolus, and the inner edge of the patella are in the same plane.

The *prognosis of fractures of the leg* in the young is quite favorable; in adult life and more so in old age, pain, stiffness, and swelling may be present for many months. Next to the patella and humerus non-union is more frequent in this region than anywhere else. After a classical Pott's fracture some stiffness of the ankle and deformity are almost inevitable. Should the eversion persist there will be traumatic flat-foot, which will necessitate a support to the instep, or possibly in some cases osteotomy of the tibia and fibula.

Fracture of the astragalus is due to direct violence or to a fall on the sole of the foot. Many of the slighter forms are incorrectly diagnosticated as sprains of the ankle, as there are pain and great swelling. In the absence of deformity and crepitus a correct diagnosis can be made only with the X-ray. There are often associated lesions of neighboring bones. The *treatment* is a fracture box, and later a plaster-of-Paris cast for five weeks.

The **os calcis** is usually broken by a fall on the foot, and rarely from violent contraction of the calf muscles. The line of fracture may be in almost any direction; if in the anterior portion of the bone there may be no deformity, if through the sustentaculum tali there will be flattening of the foot, and if more posterior the fragment may be drawn up by the calf muscles. In the latter instances crepitus and mobility may be detected. The heel is often enlarged from side to side. The *treatment*, in the absence of deformity, is a fracture box, and later a removable plaster-of-Paris cast for four weeks. Widening of the heel may be corrected with lateral pads, flattening of the foot with an instep support. When the posterior fragment is drawn upwards, the tendo Achillis may be cut or the knee bent, and the foot fixed in plantar flexion by a slipper whose heel is connected with the thigh by a cord. Far more satisfactory, however, is wiring or pegging the fragment in place.

The **remaining bones of the tarsus** may be broken by direct violence, which is usually of such a nature as to cause an open wound and comminution of bone, hence excision of fragments with drainage, or in some cases amputation, is required.

The **metatarsal bones** may be broken by direct or indirect violence. The fracture is frequently compound. The usual symptoms of fracture are present. The treatment is a molded splint for four weeks.

Fractures of the phalanges of the foot are usually compound, and often require amputation. In other cases the toes should be fixed on a molded splint of cardboard, extending well up on the sole of the foot.

DISEASES OF BONES.

Inflammation of bone begins in the periosteum or the medulla, from which structures the osseous tissue receives its blood supply. The phenomena, viz., hyperemia, exudation, and changes in the perivascular tissues are much the same as in other structures, except that death of the bone is more likely to ensue, owing to the unyielding character of the canals in which the vessels run. Inflammation here as elsewhere terminates in resolution, new growth (*condensing ostitis, or osteosclerosis*), or death of the part. Death of bone is brought about by ulceration (*caries, inflammatory osteoporosis, or inflammatory rarefaction*), abscess formation, or gangrene (*necrosis*). Anatomically, inflammation of bone may be divided into periostitis, ostitis, and myelitis; clinically, however, periostitis is always linked with inflammation of the subjacent bone, myelitis with involvement of the surrounding osseous tissue, hence the terms osteoperiositis and osteomyelitis are more nearly correct.

Osteoperiositis (periostitis) may be acute or chronic, localized or diffuse. In the *acute form* the periosteum is red and swollen. This is followed by resolution (*simple periostitis*), by suppuration (*purulent periostitis*), or by permanent thickening owing to the deposition of new bone (*ossifying or osteo plastic periostitis*).

Periostitis serosa or albuminosa (Ollier and Poncet) is a variety of suppurative periostitis, probably due to organisms of low virulence. A serous or mucoid exudate, rich in albumen and containing staphylococci or streptococci forms beneath the periosteum. The course is subacute or chronic In old cases there is little tenderness and the condition may be mistaken for a cyst or, when on the skull, for a meningocele.

The **causes** of osteoperiostitis are contusions, wounds (including fracture), extension from neighboring tissues, and infection by way of the blood, such as rheumatism, gout, gonorrhea, syphilis, pyemia, tuberculosis, and acute infectious fevers. Periostitis may occur also at the point of attachment of muscles which are used to an abnormal extent, or as the result of pressure, e.g., periostitis of the os calcis in flat foot. *Marie's disease,* or pulmonary hypertrophic osteoarthropathy, is an enlargement of the bones of the forearms, hands, legs, and feet from ossifying osteoperiostitis, and occurs in association with chronic lung disease.

The **symptoms** are aching pain, worse at night and increased by pressure, palpable thickening of the periosteum in subcutaneous bones, and, in the event of suppuration, edema and redness of the skin and later softening of the swelling. After the abscess has been opened, denuded bone may be felt, which, as a rule, undergoes caries or necrosis to a variable extent, and is removed by the surgeon or separated by nature. In the presence of suppuration there will be constitutional symptoms of sepsis. In *chronic* periostitis, in the absence of suppuration, there may be no symptoms but a tender swelling of the bone. Ossifying periostitis may produce exostoses or osteophytes, particularly about a chronically inflamed joint.

The **treatment** of acute periostitis is rest, elevation, and heat locally. Constitutional treatment is directed towards any existing diathesis. Suppuration demands incision and drainage. *Chronic periostitis* is treated by iodin or by mercurial ointment locally, and potassium iodid internally, even in the absence of a syphilitic taint. The cause should, of course, be removed if possible. Removal of newly formed bone or osteophytes is occasionally indicated.

Acute osteomyelitis is also described by some authors under the following headings: acute infective osteomyelitis, acute septic osteomyelitis, acute diffuse infective periostitis, acute diaphysitis, acute panostitis, acute necrosis. Perhaps panostitis is the best term, as all the structures of the bone are sooner or later involved.

The **cause** is always infection by micro-organisms, among which are the staphylococcus, streptococcus, pneumococcus, gonococcus, typhoid bacillus and the bacillus coli communis. Bacteria may gain entrance through a wound, e.g., in compound fracture, amputation, osteotomy, etc.; or infection may extend from neighboring tissues, or come by way of the blood, e.g., in infectious fevers, notably measles and scarlet fever. Typhoid osteomyelitis is always subacute or chronic. When osteomyelitis occurs in a healthy individual without an open wound, the organisms are supposed to have entered the blood through the tonsils, or through the respiratory, intestinal, or genitourinary mucous membranes. In some of these cases chilling of the body, or a strain, sprain, or contusion, precedes the outbreak of symptoms. Children are peculiarly liable to this form of osteomyelitis, the process usually starting in the end of the diaphysis, rarely in the epiphysis (*acute epiphysitis*). The neighboring joint is apt to be involved if the epiphyseal line lies within the capsule (*acute infantile arthritis*). In the diaphyseal end of growing bone, or metaphysis as it is sometimes called, the vessels are arranged in terminal loops, which retard the blood stream and favor the deposition of organisms; moreover, this region is more exposed to injuries from wrenches or twists. The favorite sites for osteomyelitis are where the greatest growth in length takes place, viz., the lower end of the femur, the upper end of the tibia, the upper end of the humerus, and the lower end of the radius. Although it is possible for the mildest cases to terminate without suppuration, such an event is of rare occurrence. As a rule suppuration of the medulla occurs, and pus appears in the Haversian canals and finally lifts the periosteum from the bone, thence infiltrating the surrounding tissues. Necrosis of a portion or of even the entire shaft follows. Involvement of more than one bone is uncommon (*multiple osteomyelitis*), and occasionally the disease reappears in the same situation (*osteomyelitis recidiva*).

The **symptoms** are sudden in onset, generally beginning with a chill, which is followed by high fever. The limb is painful and tender, and soon becomes hot, swollen, and edematous. The superficial vessels are distended, and finally pus may make its way to the surface and give rise to fluctuation. If there is a wound the discharge will be copious and offensive and the bone tender. It may be possible to see the thick, red, and separated periosteum and the fungous suppurating medulla. The X-ray may show a subperiosteal exudate, but acute osteomyelitis ought to be recognized clinically long before there is sufficient destruction of bony tissue to show in a skiagraph. The constitutional symptoms are those of septicemia or pyemia, and these may predominate and mask the local phenomena, so that a diagnosis of typhoid fever or some similar condition may be made. The adjacent joint is often swollen, usually with sterile serum, sometimes with pus.

In the mildest cases of osteomyelitis the only symptoms are pain and slight fever. The so-called growing pains are supposed to be due to this cause.

The **diagnosis** may be difficult, but is most frequently not made because of an incomplete or careless examination. *Rheumatism* affects more than one joint, the tenderness is most marked in and not above or below the joint, the local phenomena are less marked, and the constitutional symptoms are less serious. *Gonorrheal rheumatism* is preceded by gonorrhea and does not give tenderness in the bone. *Typhoid fever* is slow in onset and does not present local bony symptoms in the early stages; the blood shows the Widal reaction, and a leukopenia instead of a high leukocytosis. *Tuberculous arthritis* starts in the epiphysis, not in the diaphysis; the onset is slow, and the local and constitutional symptoms much less severe. *Cellulitis* is always associated with a wound, the swelling does not involve the bone, and on incision, which is the proper treatment, the periosteum and bone are found unaffected. In *infantile scurvy* the bone is tender and enlarged, but many bones are apt to be involved, and there are other evidences of rickets, with marked anemia, swollen and bleeding gums, and perhaps normal temperature.

The **prognosis** is always grave. Death may occur from septic absorption before the local signs are well marked. Later dangers are exhaustion and amyloid disease. The neighboring articulation may be destroyed, resulting in either ankylosis or flail joint; growth of the limb may be checked from involvement of the epiphyseal cartilage; or it may be necessary to remove the limb because of septic symptoms, or because repair of the bone is impossible owing to destruction of the periosteum.

The **treatment** is immediate drainage. After making a longitudinal incision in the soft parts the periosteum is reflected, and the medulla opened with a trephine, gouge, or chisel (Fig. 219). Sufficient bone is removed to expose all the infected medulla, thus in some instances it is necessary to chisel a gutter in the bone almost from one end to the other. In children, excluding the rare cases in which the epiphysis as well as the diaphysis is diseased, care should be taken not to injure the epiphyseal line, because of the danger of interfering with the growth of the limb. The suppurating medulla is removed by gentle curettage, in order to do as little harm as possible to the endosteum, which may possibly have some influence in subsequent repair. The wound is irrigated with hot bichlorid of mercury solution and packed with gauze. The constitutional treatment is that of septicemia. Should drainage fail to mitigate the constitutional symptoms, amputation may be performed as a life saving measure. The *treatment* of the subsequent necrosis is given below.

Chronic osteomyelitis (**chronic ostitis**) follows the acute form or is chronic from the beginning. To the latter class belong the chronic bone inflammations caused by typhoid fever, syphilis, tuberculosis, actinomycosis, leprosy, and glanders. *Typhoidal osteomyelitis* usually appears during convalescence, the tibia and ribs being most frequently affected. The infection may be a pure one or mixed with pyogenic organisms. Like the gall-bladder and spleen, the medulla of bones may harbor typhoid bacilli for years before causing trouble. Workers in wool, jute, and mother-of-pearl may breathe in particles of these substances, which finally lodge in the medulla and cause sudden painful swellings at or near the end of the diaphysis; suppuration does not occur.

The **symptoms** of an osteomyelitis which is chronic from the start are pain, tenderness, swelling, and but slight constitutional disturbance. These cases may terminate in suppuration, or in hypertrophy of the bone (*osteosclerosis*, *condensing ostitis*); in the former the X-ray shadows are less dense, in the latter more dense than normal.

The **treatment** is rest, ichthyol or mercurial ointment locally, and iodid of potassium internally. If these measures fail or if pus forms, the bone should be opened and drained.

Necrosis, or gangrene of bone, is death of a portion of bone *en masse*. The dead portion (*sequestrum*) varies in size from a small superficial flake, such as follows suppurative periostitis, to a mass representing the entire shaft of the bone, such as not infrequently follows acute osteomyelitis.

The **causes** are acute and chronic inflammations of the periosteum, bone, and medulla. Removal of periosteum in the absence of inflammation does not induce necrosis. Injury to the nutrient artery or the lodgment of an embolus is rarely a cause of necrosis. Phosphorus and mercury may cause necrosis of the lower jaw, particularly in the presence of carious teeth, which permit infection of the bone whose nutrition is altered by the poison. *Quiet necrosis* is a rare condition following injury; it is unaccompanied by suppuration.

The *sequestrum* separates from the living bone by a line of ulceration or demarcation much the same as in gangrene of soft parts. The surrounding living bone usually undergoes a condensing ostitis and becomes much harder than normal. Small and superficial sequestra may be discharged spontaneously through a sinus, which inevitably exists in all but very small aseptic sequestra, in which complete absorption without suppuration is possible. If the necrotic mass is large or centrally located, spontaneous discharge is impossible, and suppurative inflammation may continue for years. The dense bone which surrounds the sequestrum in these cases is called the *involucrum*, and the sinus leading from the surface down to the cavity in which the sequestrum lies is called the *cloaca*.

The **symptoms** of necrosis are a discharging sinus or sinuses which have resulted from a preceding suppurative inflammation of the bone. The necrotic mass may be felt by the probe or demonstrated by the X-ray. In a skiagraph a sequestrum, because of its porosity, appears as a light shadow, surrounded by a clear area, representing the cavity in which it lies (Fig. 218).

The **treatment** in the early stages, that is, after providing ample drainage for the suppurative inflammation which has induced the necrosis, is frequent antiseptic irrigations and dressings until the sequestrum has separated, or at least until the destructive process has reached an end. This time varies, according to the age and general condition of the patient, the size and situation of the sequestrum, and the cause of the necrosis, from a few weeks to several months. In performing *sequestrotomy*, i.e., removal of the sequestrum, the bone is exposed by a suitable incision, the periosteum retracted, sufficient involucrum removed by gouge or chisel, the dead bone extracted with forceps (Fig. 219), and the cavity irrigated with an antiseptic solution and packed with iodoform gauze. If the sequestrum has not separated, the dead bone must be chiseled away. Dead bone is softer than normal, often whitish in appearance, and does not bleed when cut. If the cavity is small it rapidly fills with granulations, which are ultimately replaced by bone. If it is large, healing is very slow, hence the following methods to assist repair. The cavity has been filled with aseptic sponge, decalcified bone chips, gutta-percha, plaster-of-Paris, bismuth paste, lead, blood clot, mixture of paraffin and iodoform, etc., but owing to the presence of infection, such materials act simply as foreign bodies and are ultimately discharged. Recently, however, encouraging results have been obtained with *Moorhof's bone wax*, which consists of iodoform 20 parts, spermaceti 40 parts, and oil of sesame 40 parts. The cavity is rendered dry and sterile, and the mixture, heated to 50° C., poured into the cavity and allowed to solidify. The wax is ultimately absorbed and replaced by fibrous tissue or bone. *Neuber* fastens the flaps of skin to the walls of the cavity by nails or stitches, and thus secures healing with a trough-like depression lined with skin. *Skin grafting* has been used with a similar idea. *Nélaton* filled a cavity in the clavicle with a pedunculated flap of muscle; *Makkas*, one in the os calcis by the free transplantation of fat; *Makkas* says the fat is displaced later by fibrous tissue, which may ultimately ossify. *Tranplantation of bone* also has been successfully performed to fill osseous defects (see p. 321). When the periosteum has not been destroyed, it can confidently be expected to replace even the entire shaft of the bone. *Nichols* has recently investigated this subject and the following is from his paper: "The operation consists of an incision through the skin and ossified periosteum down to the necrotic shaft, reflexion of the periosteum, removal of the shaft, either entire or partial, folding of the plastic periosteum in such a way as to approximate the internal layers, suture of the edges by absorbable sutures, suture of the soft tissues, with provision for moderate drainage and complete immobilization." The shaft is sufficiently solid for use in from four to eight months. In regions such as the thigh or arm where there is no companion bone to act as a splint and maintain the length of the limb, one should wait until the periosteal shell of regenerating bone is sufficiently advanced to preserve the con-

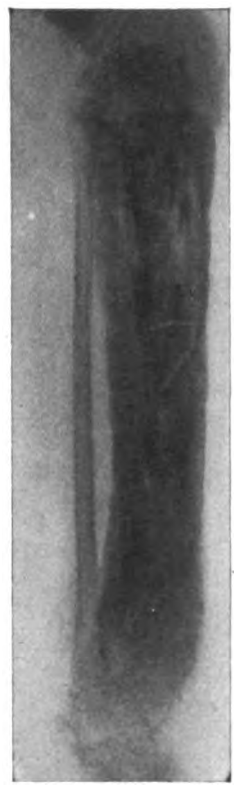

FIG. 218.—Skiagraph of chronic osteomyelitis showing involucrum and sequestrum. (Pennsylvania Hospital.)

tour of the limb and prevent shortening. This stage is reached when the periosteal shell as determined by the X-ray is equal in thickness to one-fourth of the diameter of the original shell. If delay is not advisable sequestrotomy may be performed and a magnesium splint, or a prop of bone obtained from another portion of the body, inserted. In a recent case of this character we maintained the length of the femur, until new bone had been formed, by means of a pece of sterilized ox bone.

Caries (*inflammatory osteoporosis*, *rarefying ostitis*, *ulceration of bone*) is molecular death of bone. The bone is soft and honey-combed, and crumbles

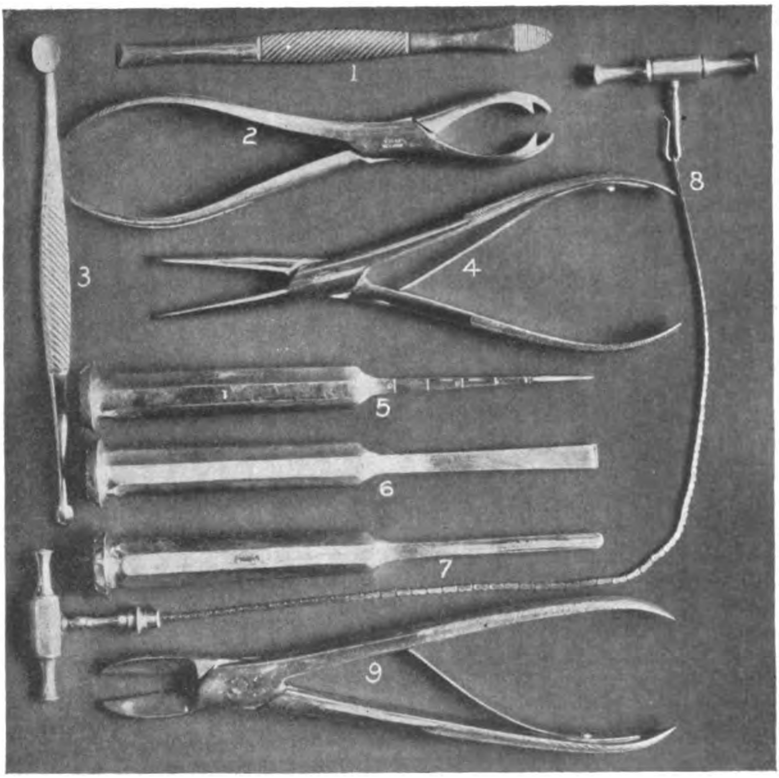

FIG. 219.—(1) Periosteal separator, (2) lion-jawed forceps, (3) curette, (4) sequestrum forceps, (5) Macewen's osteotome, (6) chisel, (7) gouge, (8) chain saw, (9) bone cutting forceps.

when pressed upon by a probe. Caries is the result of inflammation, particularly that form due to syphilis or tuberculosis. The ulceration which separates living bone from dead is a form of caries. The spaces in carious bone (*Howship's lacunæ*) are the result of suppuration, or absorption by large giant cells (*osteoclasts*). *Caries sicca* is caries without suppuration. In *caries fungosa* there is an excess of granulation tissue. *Caries necrotica* is the form in which small crumbling fragments are discharged. The *symptoms* of caries are those of necrosis, except that the probe detects rough and friable bone instead of a firm sequestrum.

The **treatment** is exposure of the bone, and removal of the diseased tissue with curette or gouge, the cavity being filled with iodoform gauze. The limits of the disease are reached when the bone becomes pink and firm and bleeds on cutting.

Tuberculosis of bone may be generalized in the course of acute miliary tuberculosis. Localized tuberculosis is most frequent in early life, and usually follows infection in some other portion of the body, notably the lungs and the lymph glands. In the long bones the disease usually begins in the metaphysis in children, in the epiphysis in adults; in the other bones it begins in the periosteum, or more frequently in the cancellous tissue. Tuberculosis of the phalanges is called *tuberculous dactylitis*, or *spina ventosa* (Fig. 220). Occasionally the disease begins in a joint and secondarily involves the bone. The pathology is much the same as that of tuberculosis elsewhere, the tuberculous mass undergoing caseation and liquefaction, and being surrounded by a zone of inflamed bone. The diseased bone may separate as a sequestrum, but as a rule it undergoes caries, which progressively invades the surrounding bone. When the process remains localized and undergoes suppuration, it forms an abscess (*Brodie's abscess*), which is lined by a pyogenic membrane and surrounded by a zone of condensing ostitis. Such abscesses are most frequent in the ends of long bones, particularly the tibia and femur. Traumatism, often slight in nature, frequently determines the site of the lesion.

The **symptoms** are boring pain, tenderness, and thickening of the bone. The X-ray will show the disease as soon as the process of disintegration is advanced far enough to lessen the density of the bone and long before the clinical period of softening. If allowed to progress, the disease invades the neighboring joint, or the pus finds its way to the soft parts about the bone and finally presents itself beneath the skin, sometimes a long distance from its point of origin. After the abscess breaks or is opened, infection with pyogenic organisms causes hectic fever, and in neglected cases this leads to exhaustion or amyloid disease.

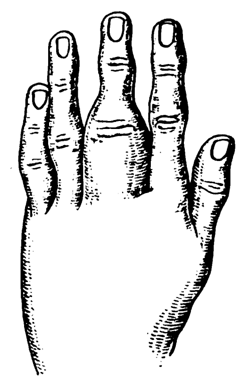

FIG. 220.—Spina ventosa, so called because of the flask-like inflation of the bone; it may be due to any of the causes of bone inflammation, but is usually syphilitic or tuberculous.

The **treatment** is removal of the diseased tissue by gouge, curette, excision, or in some cases even by amputation. Iodoform is used in the wounds, and the general health built up as much as possible (see tuberculosis). Spina ventosa, according to Pels-Leusden, should be treated by excision of the diaphysis with the periosteum, and transplanting to its place a segment of the tibial crest or a phalanx from a toe. In the early stages of osseous tuberculosis, before the formation of pus, or in the later stages if the site of the disease is inaccessible, the affected parts are immobilized by plaster-of-Paris or by other means, and a cure sometimes obtained. Passive hyperemia, radiotherapy, and heliotherapy are employed by some surgeons.

Syphilis of bone occurs in the secondary and tertiary periods, and like tuberculosis, the site is often determined by trauma. In the secondary stage osteocopic pains occur, apparently with no organic change in the bones. The periostitis of the second stage results in resolution, rarely in suppuration, and most frequently in ossification of the exudate, leaving a permanent node. In the tertiary stage the bone may become the seat of a condensing ostitis, or gummata may form in periosteum, bone, or medulla, the skull, sternum, and tibia being the favorite sites. With appropriate treatment, the gummatous material may be absorbed, but frequently degeneration occurs and the puruloid material ultimately evacuates itself through the skin. The bone is then carious and worm-eaten, and beyond this there may be a zone of sclerotic osseous tissue. Necrosis occurs in some cases (Fig. 221) owing to the constriction of the vessels by the surrounding sclerotic tissue; the sequestra in such cases may not separate for years. Should sepsis supervene, the soft parts become infiltrated with foul smelling pus, which in the skull may spread to the brain or its membranes. As in tuberculosis, amyloid disease may appear. Syphilitic dactylitis (Fig. 220) occurs in the late secondary stage as a periostitis, or in the tertiary stage as a gummatous osteomyelitis.

FIG. 221.—Syphilitic necrosis of the skull.

Congenital syphilis produces the same bone lesions as the acquired form. The site of the disease, however, is more often influenced by rapid growth than by traumatism, hence the frequency of *syphilitic epiphysitis, or osteochondritis* as it is sometimes called. The ends of the bones enlarge in these cases, and present some resemblance to rickets. The swellings, however, occur much earlier in life than rickets, are associated with other symptoms of syphilis, and are influenced by syphilitic treatment. Suppuration, separation of the epiphysis, and deformity may follow. *Periosteal nodes* occur, and when situated about the anterior fontanelle are called *Parrot's nodes*. *Craniotabes* is a thinning of the calvarium, which may crackle on pressure. Occasionally a bone is stimulated to overgrowth, and when there is a companion bone, as in the forearm or leg, marked curvature results.

The **treatment** is that of syphilis. Sinuses should be kept clean lest septic symptoms supervene. Necrotic or carious bone is treated as already indicated.

Rickets, or rachitis, is a constitutional disease due to malnutrition, and often associated with bad hygienic surroundings and improper diet. It usually occurs during the first three years of life. The so-called congenital rickets is generally achondroplasia or osteogenesis imperfecta.

The **symptoms** in the early stages are disorders of digestion, anemia, sweating about the head, swelling of the abdomen, and enlargement of the spleen. The important changes are those in the bones (Fig. 222), in which, although there is an active proliferation of the cellular elements, prompt calcification does not occur. The epiphyses are swollen and tender, and the shafts of the long bones softened. Later ossification occurs, frequently with deformity. The head becomes square and the frontal eminences prominent, the fontanelles and sutures close late, and craniotabes may occur. Eruption of the teeth is delayed, and they are often dwarfed, deformed, and the seat of early caries. The spine may become curved and the chest "chicken-breasted." The ribs are enlarged at their junctions with the costal cartilages (*rachitic rosary*), and there may be a marked groove extending from the axilla down towards the end of the sternum (*Harrison's sulcus*). The pelvis may be distorted and the limbs curved, e.g., bow-legs, knock-knee, etc. Growth of the entire body is often defective.

FIG. 222.—Skeleton of a child six years old, showing the osseous changes of rickets. (Donhauser, Pennsylvania Hospital.)

The **treatment** is correction of the diet, fresh air, sunshine, and attention to the bowels, together with cod-liver oil, syrup of the iodid of iron and hypophosphites. Deformities are prevented by keeping the patient in bed, and they are corrected, while the bones are soft, by daily manipulations and braces. After two or three years deformities usually require osteotomy or other form of operation.

Scurvy rickets (*acute rickets, infantile scurvy, Mœller-Barlow disease*) is a combination of rickets and scurvy, either of which may predominate. It is most frequent in the children of the well-to-do, and arises from malnutrition resulting from the administration of artificial foods. The symptoms of rickets may or may not be marked when the scorbutic features predominate. There may be spongy, bleeding gums, and bleeding from the mucous membranes, beneath the skin or periosteum, or into the muscles or joints. An epiphysis is sometimes separated from a diaphysis by hemorrhage, and the pain and swelling caused by this or by bleeding beneath the periosteum, particularly when associated with fever, may be mistaken for acute osteomyelitis (q.v.). Recovery occurs in 91 per cent. of the cases. The *treatment* is fresh milk, beef, or lime juice, and the juice of oranges, lemons, grapes, or apples. A painful limb should be kept quiet, and in some cases bandaged or splinted.

Achondroplasia (*chondrodystropia fetalis, micromelia*) is a rare congenital disease characterized by defective development of certain portions of the skeleton. Death at or soon after birth is the rule, although in a few instances adult life has been reached. The trunk is of normal length, but the bones of the limbs are short and bowed, and abnormally thickened at the points where the muscles are attached. All the fingers are of the same length, and a wide interval exists between the second and third fingers, giving rise to the "trident hand." The base of the nose is depressed and the vault of the cranium large, but the intelligence is in no way impaired. The pelvis is small, the belly prominent owing to lumbar lordosis, and the genitals normal. Rickets differs from this condition in that it is post-natal; the bones are soft, not hard; the trunk is affected; there is no pug nose; and the cranium is bossed. In cretinism the intelligence is defective, the hair scanty and coarse, and the patients improve after taking thyroid extract. Syphilitic pug nose is due to bone disease, not to premature union of the bones at the base of the skull as in achondroplasia. There is no treatment for achondroplasia.

Atrophy of bone may be congenital; or it may be due to inflammation; disease or injury of the epiphysis; disuse; pressure, e.g., from a tumor or aneurysm; or to disease or injury of the nervous system, e.g., tabes, section of nerves, syringomyelia, paresis and other forms of insanity. It is normal in old age, as is best seen in the cranium, lower jaw, and neck of the femur. Atrophied bone breaks easily, so that one should bear the above causes in mind during forcible manipulations, such as are employed in breaking joint adhesions, etc.

Fragilitas ossium, or osteopsathyrosis, is a condition in which there is an abnormal predisposition to fractures, even from slight force. There are two forms, the idiopathic and the symptomatic. **Idopathic fragilitas ossium** is congenital and often hereditary. In some cases (*osteogenesis imperfecta*) fractures occur before, during, or soon after birth, and the children are still-born or survive only a few months. In others the tendency to fractures is most marked between the second and twelfth years, and usually disappears with the advent of adult life. Union is prompt but often with considerable deformity. The cause and pathology are not known. The *symptomatic form* is due to any of the other conditions mentioned among the pathological causes of fracture (p. 268).

Osteomalacia, or mollities ossium, is a disease in which the bones become abnormally flexible owing to the absorption of calcareous material. It is rare in the male and peculiarly frequent in puerperal women. The cause is not known. The bones become distorted and break with greater ease than normally; in the latter instance non-union often occurs. Of great importance is deformity of the pelvis, because of the difficulties which may arise during labor. It is usually compressed laterally, the pubes passing forwards, thus giving it a triangular shape. The patient is weak and emaciated, and complains of pain in various parts of the skeleton. Death after many years is the usual result, although recovery occasionally occurs. The *treatment* is tonic and stimulating, with phosphates, cod-liver oil, and bone marrow. Braces may be needed, and means should be taken to prevent pregnancy. Removal of the ovaries sometimes results in cure.

Hypertrophy of bone may be congenital, or it may be due to increased use, e.g., where muscles are attached, or to increased nutrition the result of inflammation. Giant growth of the fingers or toes (*macrodactylia*), of an entire limb, or of the entire body, may be congenital or acquired; the cause is not known. Progressive hypertrophy of the bones of the skull is called *leontiasis ossium* (Fig. 223). It begins in early life, and terminates fatally after a number of years, sometimes from compression of the brain. No curative treatment is known.

Acromegaly is a skeletal overgrowth due to increased activity of the anterior lobe of the pituitary body (hyperpituitarism) sometimes induced by tumor or hypertrophy. All parts of the body are enlarged, particularly the forearms, hands, legs, feet, jaws, lips, tongue, nose, and orbital ridges (Fig. 224). The hands are spade-shaped, the fingers sausage-like, the jaw prominent (prognathism), the teeth separated, the face triangular with the base downwards (the face of Paget's disease is triangular with the base upwards, that of myxedema is moon-shaped), and the spine kyphotic, the attitude of the patient resembling that of the gorilla. The thyroid gland is often enlarged and arteriosclerosis is not uncommon. The principal symptoms are headache and malaise. Glycosuria is sometimes present. The disease is fatal, usually after many years. The *treatment* is symptomatic, unless evidences of tumor of the pituitary body be present, when its removal is indicated (see tumors of the pituitary body, Chap. XXI).

FIG. 223.—Leontiasis ossium. (Pennsylvania Hospital.)

Ostitis deformans, or Paget's disease, consists of enlargement or softening of the bones, usually after the age of forty. The cranium enlarges but the facial bones are not involved, the face being triangular with the base upwards. The patient diminishes in height owing to kyphosis and outward curvature of the lower extremities. The chest is sunken and the pelvis broadened. The patient complains of rheumatic pains and has an awkward gait. The disease is very slow in progress. Multiple sarcomata of the bones develop in some cases. The *treatment* is symptomatic, no remedies being known.

Ostitis fibrosa (von Recklinghausen) is classified by some writers with the inflammatory, by others with the non-inflammatory affections of bone. Its cause is unknown, some think that it is of infectious origin, others that it is of a syphilitic or parasyphilitic nature. There is extensive lacunar absorption of the osseous tissue with fibrous changes in the medulla, giving rise to a whitish or brownish-red tumor. This fibrous tissue usually melts down in places, thus forming multiple cysts (Fig. 225) containing serous or serosanguineous fluid (*ostitis fibrosa cystica*), but it may harden and ultimately ossify (*ostitis fibrosa osteoplastica*). The disease may appear at any time of life, and attack one or much more frequently a number of bones. The affected bone is enlarged, often curved, and sometimes the seat of spon-

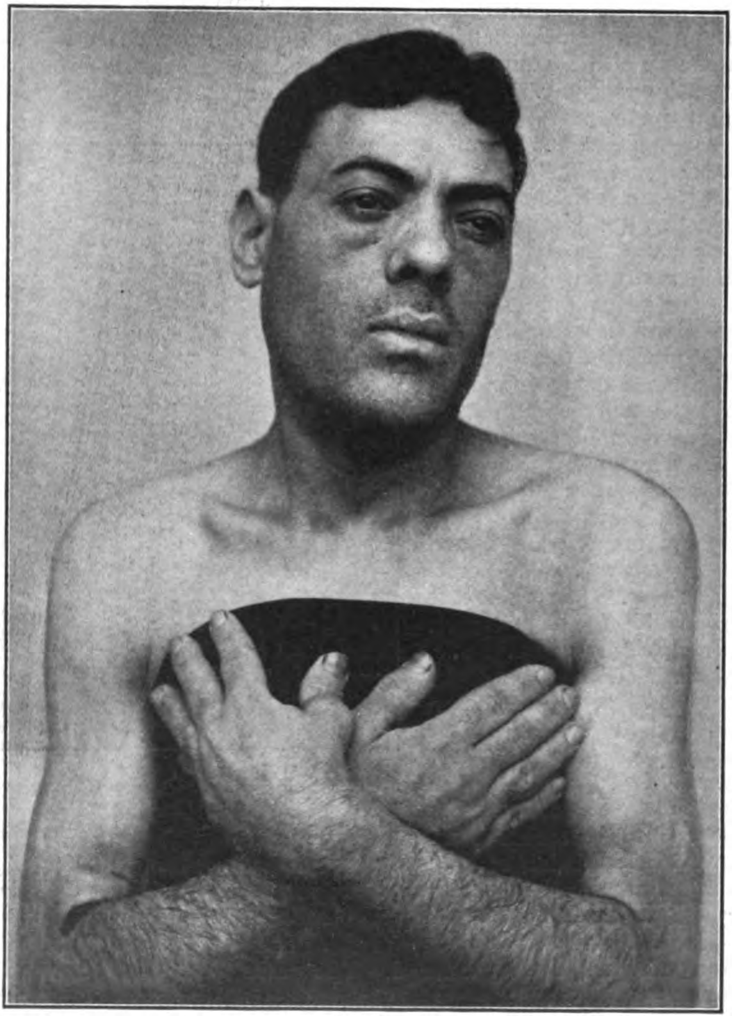

FIG. 224.—Acromegaly.

taneous fracture. The swelling may be mistaken, clinically and microscopically, for giant-celled sarcoma. Some authorities hold ostitis fibrosa responsible for leontiasis ossium, ostitis deformans, epulis, and certain cases of fragilitas ossium. When the disease is confined to one bone recovery may follow curettage or excision.

Tumors of bone may be benign or malignant. The benign tumors are osteoma, chondroma (p. 156), fibroma, lipoma, myxoma, and angioma.

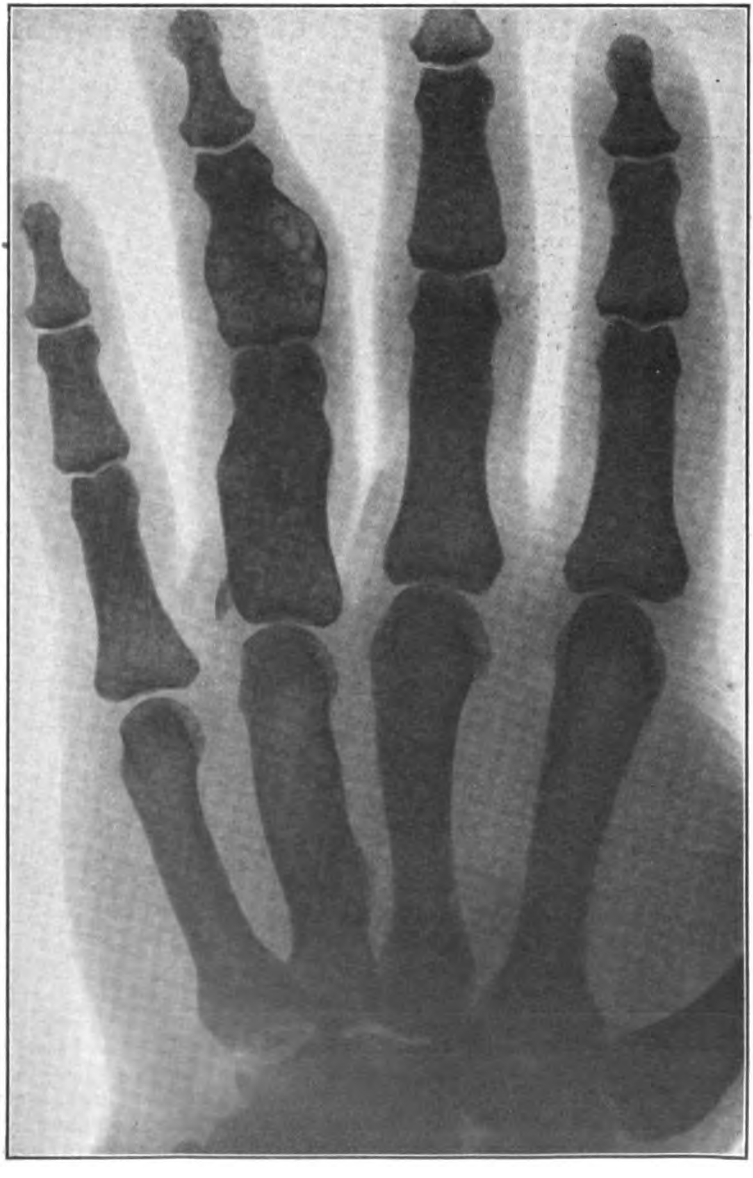

FIG. 225.—Ostitis fibrosa cystica.

The only primary malignant tumor of bone is sarcoma, although it may be invaded secondarily by carcinoma (especially from the bresat, thyroid, and prostate) and sarcoma. Metastatic osseous growths are sometimes the first sign of hypernephroma.

Periosteal sarcoma is of the spindle- or round-celled variety, grows rapidly, and causes early metastases, although it may undergo more or less complete ossification, as shown in Fig. 226. **Central sarcoma,** beginning in the osseous tissue or medulla, causes expansion of the bone, and is usually found near the end of a long bone, but rarely invades the joint. If of the

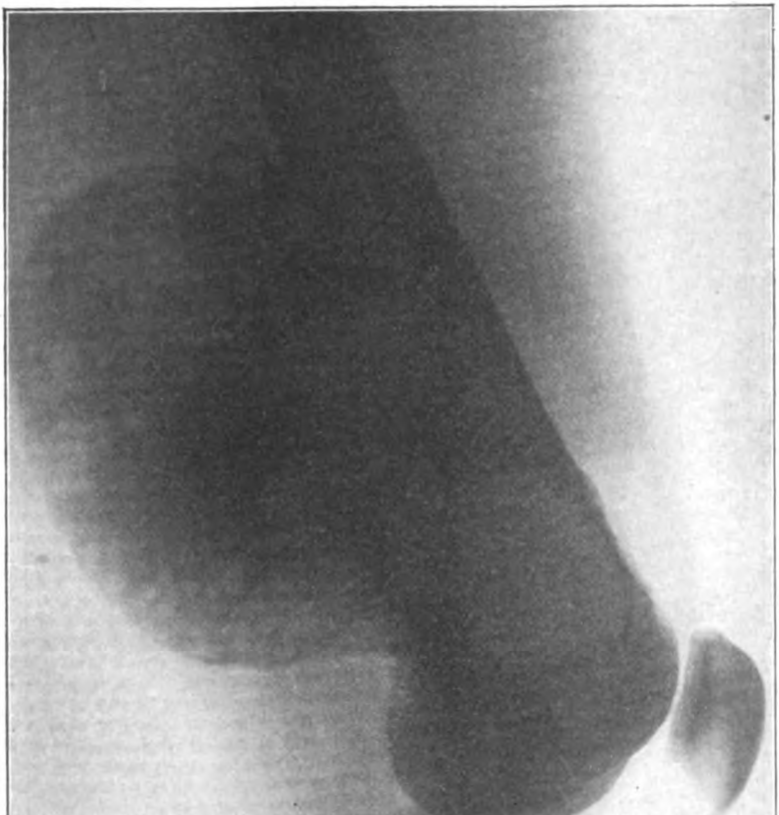

FIG. 226.—Sarcoma of the femur, showing radiating spicules of bone.

round- or spindle-celled variety the degree of malignancy is high, if giant-celled, or myeloid, it is comparatively benign. The overlying bone may become so thin as to crackle on pressure, and spontaneous fracture is not unusual. In all forms of sarcoma pulsation may occur owing to the great vascularity, and some degree of ossification is usually present; the superficial veins are distended and clearly evident beneath the whitened skin. Hemorrhagic infiltration and cystic degeneration are of frequent occurrence.

The **diagnosis** may be very difficult, owing to the resemblance to chronic osteoperiostitis, ostitis fibrosa, or syphilitic or tuberculous disease of bone. Sarcoma grows steadily, is irregular in contour and density, is apt to pulsate, causes distention of the superficial veins, and may give a crackling sensation on pressure owing to thinning of the bone. The X-ray shadow of the tumor is often sharply limited; it shows absorption of bone in the more malignant cases, spicules radiating at right angles to the bone in the more benign varieties (Fig. 226). In inflammatory bone diseases there is apt to be diffuse mottling, surrounded by a dense shadow corresponding to the zone of condensing ostitis; in syphilis and tuberculosis this dense shadow may extend over a large part of the diaphysis. In ostitis fibrosa the multiple cysts may show in the skiagram as numerous light areas. Often a positive diagnosis can be made only after exploratory incision.

The **treatment** in all but the myeloid form is early amputation through the next joint above. In the myeloid variety excision of the growth alone often results in cure, although in some instances amputation well above the growth is required. Osseous defects following operation may be filled by bone transplantation.

Primary multiple myelomata may arise simultaneously in the marrow of many bones, particularly those of the trunk (vertebræ, ribs, sternum); less frequently the skull and the femora are affected, and rarely almost the whole skeleton is invaded. The tumors consist of myelocytes, are sharply circumscribed, and usually dark red in color. The bones may become thin and bend, producing kyphosis, etc., or break. Occasionally the growth extends to the periosseous tissues, and sometimes metastases occur; myelocytes have been found in the blood of the liver and the spleen, the Bence-Jones body in the urine. The patients ultimately die of exhaustion; about 50 cases have been reported.

Cysts of bone are usually due to *degeneration* of sarcoma or myxoma. *Parasitic cysts* (echinococcus, cysticercus) and *dermoid cysts* are rare, cysts or *cyst-like cavities* may occur in ostitis fibrosa, periostitis serosa, osteomalacia, and ostitis deformans. Cysts of the jaw (*odontomata*) are described in the chapter on tumors.

Large solitary cysts of long bones (*osteodystrophia juvenalis cystica* of Mikulicz) are the only ones requiring special notice in this place. The cyst is usually found near the epiphyseal line of a long bone (femur, tibia, humerus, less frequently metacarpal or metatarsal bone) in an infant or adolescent, and often follows an injury. It is single, unilocular, benign, serous or serosanguineous, and surrounded by a zone of ostitis fibrosa. There may be pain and tenderness, but never signs of inflammation. The swelling is ovoid, regular, occasionally presents parchment crepitation or even fluctuation, and is sometimes discovered only after a spontaneous fracture. The X-ray shows an ovoid, regular, clear area, corresponding to the cyst. The *treatment* consists in opening the cyst, curettage, and gauze packing, or, as packing predisposes to infection, filling the cavity with fat, bone wax, or by one of the other methods described in the treatment of necrosis.

Transplantation of bone may be indicated to fill developemental defects (e.g., spina bifida, congenital saddle-nose, absence of radius or other bone), to replace bone destroyed by injury or disease (e.g., osteomyelitis, syphilis, tuberculosis, neoplasms), to immobilize broken bones or to induce ununited fractures to consolidate, and to secure rigidity of joints which are too mobile because of paralysis, or which are diseased, e.g., bone grafting for tuberculosis of the spine (Albee's operation). It has been stated that an osseous graft always perishes and is absorbed, being replaced by new bone derived from the periosteum; from the osteoblasts in the bone, the periosteum acting merely as a limiting membrane; or from the living bone with which the graft is brought in contact, the graft possessing not osteogenetic, but simply osteoconductive functions. In view of the fact that periosteum without bone, bone without periosteum, and isolated fragments of either or both may persist and grow, perhaps we may conclude that a bone graft does not always succumb, and that new osseous tissue can be formed from the osteoblasts of the deeper periosteum or from those of the bone itself. It seems, however, that a bone graft with its periosteum is twice as likely to survive as one without that membrane, probably because of the greater number of blood vessels in the periosteum. For a similar reason Ollier emphasized the importance of the mdeulla in preserving the life of a graft. McWilliams found that if a section of a bone is removed subperiosteally, the bone regenerates between the fragments; that without a periosteal or bony bridge there is very little attempt at repair; that small fragments of a bone shorn of periosteum are more apt to live than large ones, because the blood has easier access to the smaller fragments; and that periosteum alone when transferred to soft parts may create new bone. In performing bone transplantation strict asepsis, rigorous hemostatis, and gentle handling of the graft are essential. No attempt should be made to fill a septic cavity with a bone graft. Because of the cytolytic effect of the blood and the body fluids on alien cells autoplastic grafts, i.e., from the same individual, are the most successful. If a homoplastic graft, i.e., one from another individual, must be employed, a near relative, if possible, should be selected, and a Wassermann test made to exclude syphilis. Some surgeons have taken advantage of the opportunity offered to obtain bone from a freshly amputated limb which has neither been infected or the seat of a malignant neoplasm, e.g., a limb amputated for injury or dry gangrene, or from an individual immediately after death from an injury. Heteroplastic grafts, i.e., from the lower animals, generally become necrotic or are absorbed, although a few successful transplantations from the dog, the lamb, and the ape (which as man's nearest animal relative is to be preferred) have been reported. When sutures are needed to fix the graft in place, chromicized catgut or kangaroo tendon is the best material to employ, as wire, nails, and other non-absorbable substances predispose to suppuration and sinus formation. Whenever possible incisions should be made in such a way that the suture line in the skin shall not lie immediately over the graft. After transplantation the part must, according to the size and situation of the graft, be immobilized for from several weeks to several months.

The **methods** of bone transplantation may be divided into two groups, viz., transplantation by flaps and free transplantation.

Transplantation by flaps is illustrated by the various osteoplastic resections and amputations (see Figs. 570, 571, 575, and 575 to 578). A *periosteal flap* with a thin slice of bone attached can be raised from the bone on one side of an osseous defect, and turned over so as to bridge the defect (Ollier). *Flaps of muscle* have been employed to swing a piece of the iliac crest into the femur, a piece of the scapula into the humerus (Codivilla). *Flaps of skin* have been utilized in a similar way, thus we have transplanted a metatarsal bone to the tibia, and in a case in which the lower ends of the bones of the forearm had been destroyed, a fragment of the ulna to the radius. *Bone* may be grafted also one end at a time. Huntington closed a defect in the tibia by severing the fibula at its upper end and placing it in contact with the upper end of the tibia. After union had occurred the lower end of the fibula was transferred to the lower end of the tibia. Subsequent to this operation the fibula thickens in response to the demand made upon it. Morton, in a similar case, united the lower ends of the bones of a dog's leg to the upper end of the tibia, and five weeks later amputated the dog's leg and placed the bones in contact with the astragalus. A useful leg resulted.

In free transplantation the grafts are usually taken from the tibia, fibula, clavicle, scapula, rib, upper third of the ulna, or crest of the ilium. *Periosteum* with a thin slice of osseous tissue may be used to envelop the ends of a broken bone that have been joined by wire or other means (Codivilla). *Small bone chips* have been employed by Macewen to fill defects in the bones of the extremity, by Keen to close gaps in the skull. With rongeur forceps or chisel the excised fragment is broken into small pieces, which are placed in the cavity to be filled. The wound is closed without drainage. A *large section* may be cut from a bone with a chisel, or an electric saw, and transferred quickly, without washing in salt solution, to its new habitat, where it may be fixed with wire, nails, or preferably with chromatized catgut sutures. If a chisel is employed one must proceed cautiously and with light blows, so as not to splinter or fragment the graft. This form of grafting is employed in the Albee operation for tuberculosis of the spine, and is rapidly displacing other methods in the operative treatment of fractures (q.v.). Transplantation of joints is mentioned under ankylosis, implantation of dead bone and other foreign substances under necrosis and the operative treatment of fractures. In the sections on regional surgery also reference is made to bone transplantation, when the particular condition may be so treated.

Transplantation of cartilage is more apt to be successful when the cartilage is accompanied by its perichondrium. Pieces of the costal cartilages have been used to fill defects in the face, to establish new joints, to supply the place of absent phalanges. Transplantation of an articular cartilage with its attached bone (fibula) likewise has been performed. Whether or not a transplanted epiphysis can participate in the growth of a limb is a question that is still unanswered. Kuttner, however, one year and eight months after transplanting the fibula of an ape to the leg of a child, in whom the fibula was congenitally absent, found by X-ray examination that the epiphyseal line was fully preserved.

CHAPTER XX.

JOINTS.

INJURIES OF JOINTS.

Wounds of joints should always be regarded with apprehension. Extensive wounds are often associated with dislocation or compound fracture. A small penetrating wound may be recognized by the escape of synovial fluid, although this may not occur if the aperture is valvular. A probe should not be employed. The external parts should be disinfected, and the joint immobilized with a splint, in a position which will give the best function in the event of ankylosis. At the first symptoms of infection, viz., pain, swelling, fever, etc., the wound should be enlarged, the pus washed from the joint cavity with sterile salt solution, and drainage with gauze or tubes instituted. Resection or amputation may be necessary if severe constitutional symptoms continue. If the joint is wounded by an instrument which is known to be grossly infected, one should not wait for the appearance of septic symptoms, but open, disinfect, and drain the joint at once.

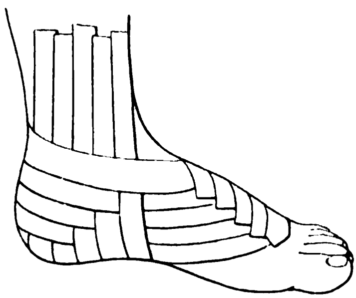

FIG. 227.—Strapping of the ankle.

A sprain has been defined as a self-reduced dislocation; as the result of a twist, some fibers of the ligaments are stretched or lacerated and the synovial membrane contused. The *symptoms* are severe pain, tenderness, swelling of the joint from effusion of blood and lymph, loss of function, and in some instances shock. Many cases of fractures about joints have in the past been diagnosticated as sprains. If the swelling is great, fracture can be excluded only by the X-ray.

The **treatment** during the first twenty-four hours is elastic compression, and cold in the form of an ice bag or evaporating lotion, thus limiting effusion. Compression is best made with a firm bandage over a layer of cotton. If the effusion is excessive aspiration should be considered. Later absorption should be promoted by heat and massage. The joint should be kept at rest until the pain and swelling have disappeared. Compression with a certain degree of fixation may be obtained by applying overlapping strips of adhesive plaster around the joint as shown in Fig. 227. Subsequent stiffness may be relieved by the hot air treatment and by frictions with stimulating liniments. The *prognosis* is good in uncomplicated cases; suppuration is rare, although tuberculosis may occur in those prone to this disease, and persistent pain and stiffness are common in the gouty and rheumatic and in the old. Absorption of the head of the femur may occur after sprain of the hip. Ankylosis is the chief danger.

DISLOCATIONS.

A dislocation, or luxation, is an abnormal displacement of the articular end of a bone. Dislocations may be congenital or acquired, and the latter may be traumatic or spontaneous (pathological).

Congenital dislocations are usually due to defective development, although it is possible that a few are due to violence to the mother's abdomen during pregnancy, or to a vicious position of the child in the uterus, the result of tumors, etc. Although various joints may be affected in this way, in 90 per cent. of the cases the hip is involved.

FIG. 228.—Bilateral congenital dislocation of hip. (Hopkins.)

Congenital dislocation of the hip is more frequent in females, both or more commonly one joint being involved. Damany states that the luxation rarely exists at the time of birth, but occurs during the first year of life, owing to an increased forward obliquity of the acetabulum and an exaggeration of the normal torsion of the femur, thus causing a progressive displacement of the head of the femur when the thighs are extended. However this may be, congenital dislocation of the hip is seldom recognized until the child begins to walk. The dislocation causes atrophy of the abandoned acetabulum, stretching or rupture of the round ligament, shortening and anteversion of the neck of the femur, flattening of the head of the bone from before backwards, and elongation with occasionally hour-glass constriction of the capsule of the joint. The limb is atrophied and the muscles altered in length. The head of the bone almost invariably passes onto the dorsum of the ilium, thus causing shortening with flexion and adduction of the thigh, compensatory obliquity of the pelvis, and anterior curvature of the lumbar spine (Fig. 228). In bilateral dislocation there is a peculiar waddling gait, in unilateral cases there is limping and associated scoliosis. In early cases the length of the limb may be restored by traction.

The **treatment,** when the condition is recognized before the child begins to walk and before marked changes in the soft structures occur, is continuous traction on the limb to bring the head of the bone down to the acetabulum, while the limb is fixed in abduction and pressure is made over the great trochanter. This treatment must be continued for six months or a year. At a later period, up to four or five years in bilateral cases and about seven years in unilateral cases, the *Lorenz bloodless method* may be tried. The author of this method claims 50 per cent. anatomic cures. Under anesthesia the shortened muscles are stretched by flexion, extension, and abduction of the thigh, during the last of which the adductor muscles are powerfully kneaded. The head of the bone is then drawn down to the level of the acetabulum by traction on the leg, and the thigh flexed on the abdomen, rotated internally, abducted, and finally rotated outwards while pressure is made on the trochanter. With the limb in flexion, abduction, and eversion, a plaster-of-Paris cast is applied to the pelvis and thigh as far as the knee. The child is allowed to walk with the limb in this position in order to deepen the acetabulum. At the end of three months the cast is removed, the flexion and abduction lessened, and another cast put on for three more months.

In children too old for the bloodless method Hoffa and Lorenz have each devised a *bloody method*. The former opens the joint by an incision similar to that of Langenbeck in resection of the hip, severs shortened fibers of muscle and fascia, enlarges the acetabulum with a gouge, reduces the dislocation fixes the limb in eversion and abduction for a few weeks, and finally straightens the limb. Lorenz opens the joint from in front, does not cut the muscles, but severs the ham strings if necessary. The rest of the operation is much the same as that of Hoffa.

Pathological dislocations occur from slight force or spontaneously, as the result of disease, such as tuberculosis, osteoarthritis, Charcot's disease, and unopposed action of muscles in paralysis. Those occurring in the

FIG. 229.—Dislocation of hip in typhoid fever, and large bed sore. (Pennsylvania Hospital.)

course of fevers (Fig. 229) are due to distention of the joint, and are most frequent at the hip, owing to habitual flexion of the thighs in bed.

Traumatic dislocations, like fractures, may be *simple* (*closed*), *compound* (*open*), *complete*, *incomplete* (*subluxation*), *or complicated* (associated with injury of the soft parts, vessels, nerves, or viscera). A *fractu e-dislocation* is one associated with a fracture entering the joint (Fig. 216).

The **causes** of traumatic dislocations are predisposing and exciting. The *predisposing causes* are powerful muscular development, thus dislocations are more frequent in males and in middle life; occupations which demand hard labor and exposure to injury; structure and situation of the joint., e.g., the shoulder, which is a ball and socket joint and exposed to many injuries; and diseases or previous injuries of joints which relax the ligaments or markedly alter the axis of the limb. The *exciting causes* are external violence (direct, or more commonly, indirect) and muscular action.

The **pathology** consists of a tearing of the ligaments and frequently of the soft structures around the joint, owing to the displacement of the articulating surfaces; effusion of blood into and about the joint; contusion of the synovial membrane and articular cartilages; and occasionally fracture, or compression or rupture of important nerves, vessels, or viscera. If the dislocation is reduced, the subsequent traumatic inflammation subsides with or without adhesions. If the torn ligaments are not fully repaired, there is a predisposition to the recurrence of the dislocation. In an unreduced dislocation the organization of the effused blood and exudate fills the normal articular cavity with fibrous tissue and fixes the head in its new situation, where, if persistent movements are made, it may form a *pseudoarthrosis*. The displaced head becomes more or less deformed, and wears a hollow in the bone on which it rests. The surrounding muscles atrophy, and are altered in length to accomodate themselves to the new position of the limb.

The **symptoms** are pain, swelling, ecchymosis, rigidity of the muscles, loss of function, and deformity, as evidenced by the alteration in the axis and length of the limb, by the disturbed relations of the bony prominences about the joint, and by feeling or seeing, with or without the X-ray, the empty articular cavity and the displaced bone in its new situation.

The **treatment** is (1) reduction, (2) retention, (3) restoration of function. (1) Reduction should be made at the earliest possible period by manipulation or extension, with or without anesthesia, according to the difficulties encountered. *Manipulation* consists in such movements of the limb as will cause the dislocated bone to reenter the joint by the path through the torn capsule which it has already traversed, hence it should be employed whenever possible, because but little additional injury is inflicted upon the tissues. *Extension*, or more commonly extension and counterextension, are used to draw the dislocated bone into place despite the resistance of muscles and other structures. Extension is made by the hands of the surgeon, by a broad band fastened about the extremity in a clove-hitch (Fig. 230) and passed around the waist or shoulders of the surgeon, or, much more rarely, by compound pulleys. *Counterextension* is obtained by the hands of an assistant, by a broad band, or by the knee or the foot of the surgeon. The application of great force, however, is very dangerous, and if sufficient relaxation cannot be obtained with ether, reduction through an incision should be employed. The bone usually goes back into place with an audible snap. (2) After reduction the joint is immobilized until the laceration in the capsule has healed. (3) During the first twenty-four hours compression with a bandage and the application of evaporating lotions or an ice bag serve to limit the swelling. Subsequently absorption is hastened by massage, heat, and liniments, and at the end of from ten days to two weeks passive motions are begun.

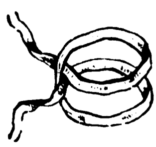

FIG. 230. Clove-hitch.

Compound dislocations are very grave injuries, which require disinfection of the surrounding soft parts, copious irrigation of the joint with hot salt solution, and as a rule free drainage. The supervention of sepsis may necessitate resection or amputation. The treatment of fracture near a dislocated joint has already been discussed.

Old unreduced dislocations are difficult to treat owing to the firm adhesions which anchor the bone in its new position. There is no fixed rule as to the time when reduction should no longer be attempted, as replacement may be effected sometimes after a number of months have elapsed. A general rule is to attempt reduction under anesthesia without the use of too great force, as such may seriously injure important vessels or nerves, or result in fracture; if reduction is not successful and the limb is incapacitated by pain or marked limitation of motion, the joint should be opened and the bone replaced, or in some cases the head of the bone excised. In joints in which bloodless reduction has not been successful, but in which there is fair motion and little or no pain, operation should not be undertaken, since persistent movements may result in a fairly useful pseudoarthrosis.

SPECIAL DISLOCATIONS.

The **lower jaw** may be dislocated upwards, the condyle entering the cranial cavity, or backwards; but these are extremely rare and the usual displacement is forwards, either one or much more commonly both sides being affected. The condyles pass forward over the eminentia articularis into the zygomatic fossa, as the result of blows on the chin, or contraction of the external pterygoids when the mouth is opened in yawning, vomiting, trying to take a big bite, etc.

The **symptoms** are an open mouth which cannot be closed, projection of the lower jaw forwards, drooling of saliva, and some interference with speech and swallowing. The condyles may be felt anteriorly and there is an abnormal depression in front of the tragus. In the unilateral variety the symptoms are less pronounced and the chin passes towards the sound side.

The **treatment** is pressure downwards and backwards on the last lower molar teeth with the thumbs, protected by bandages, while the chin is elevated with the fingers. The mouth should be kept shut by a Barton bandage for two weeks, after which the patient should be cautioned against opening the mouth too widely. In old cases excision of the condyle may be indicated.

The **sternal end of the clavicle** may be dislocated forward, backward, or upward.

Forward dislocation is caused by violence which pushes or pulls the shoulder backwards. The end of the bone is in front of the sternum, the acromion process nearer the middle line, and the clavicular head of the sternomastoid unduly prominent. Reduction is effected by pulling the shoulders backwards while the knee is placed between the scapulæ and pressure is made upon the displaced bone. A pad is fixed over the joint by adhesive plaster and the shoulders are pulled backwards by a posterior figure-of-8 bandage; recumbency is a great aid to the maintenance of reduction. The dressing should be worn for one month, and even then some degree of displacement is likely to remain.

Backward dislocation is rare, and is caused by direct violence, or by a forcing of the shoulder forwards and inwards. The head of the bone lies behind the sternum, a depression exists over the joint, the acromion is nearer the middle line, movements of the head and neck are painful or impossible, and occasionally there is dyspnea, dysphagia, or congestion of the head, from pressure upon the trachea, esophagus, or blood vessels. Reduction and treatment are the same as those for forward dislocation, except that pressure is not made on the head of the displaced bone. If reduction cannot be promptly made in cases with serious pressure symptoms, the head of the bone may be excised, or wired in place.

Upward dislocation is very rare, and is caused by violent depression of the shoulder. The head of the bone may be felt in its new situation, where it may press upon the esophagus or trachea. The shoulder falls downwards and inwards. The bone is replaced by pressing the elbow inwards over a pad in the axilla, while downward pressure is made on the head of the bone. The limb is bandaged to the side in this position for several weeks.

The **acromial end of the clavicle** may be dislocated downwards, but the usual displacement is upwards. The cause is violence to the shoulder. In dislocation upwards the outer end of the clavicle is prominent, the shoulder passes downwards and inwards, and its movements are limited. Dislocation downwards causes a depression over the joint and a prominence of the acromion. The shoulders should be pulled backwards, and pressure made upon the outer end of the clavicle or upon the acromion according to the displacement. A bandage or strap is then passed over the shoulder and under the elbow, and held in place by a band passing around the chest. Some deformity is very apt to persist, and in bad cases suturing of the bones with silver wire or kangaroo tendon should be considered.

Dislocation of the lower end of the scapula (see scapulum alatum).

Dislocation of the shoulder is the most frequent of all dislocations, owing to the exposed position and great mobility of the joint, and the disproportion between the head of the humerus and the depth of the glenoid cavity. The usual cause is a fall upon the outstretched hand or elbow, although direct violence or muscular action also may be responsible for this injury. As a rule the head of the bone is forced through the weakest portion of the capsule, i.e., the lower and inner part, into the axilla; it remains in this situation (*subglenoid*), or, as the result of muscular action or the direction of the force, passes backwards and downwards beneath the spine of the scapula (*subspinous*), forwards and upwards beneath the clavicle (*subclavicular*), or most commonly (three-fourths of all the cases) forwards and downwards beneath the coracoid process (*subcoracoid*). The subclavicular, subcoracoid, and subspinous dislocations may, however, be primary, i.e., the head of the bone may pass directly to its new situation without first entering the axilla. Two other forms, which are very rare, may be mentioned, viz., the *supracoracoid*, in which the head of the humerus passes above the coracoid and usually fractures it or the acromion process, and *luxatio erecta*, in which the head of the bone lies in the axilla, but the humerus projects upwards against the head of the patient.

The **symptoms** of all varieties of dislocation of the shoulder are (1) pain, swelling, rigidity, ecchymosis, and loss of function; (2) flattening of the shoulder and prominence of the acromion process (Fig. 231), so that a ruler can be made to touch the acromion process and the external condyle at the same time; (3) a hard swelling in the situation abnormally occupied by the head of the bone; (4) Dugas' sign, i.e., projection of the elbow from the side when the hand is on the opposite shoulder, and inability to place the hand on the opposite shoulder when the elbow is forced against the side (this may be absent in some subcoracoid dislocations); (5) increase in the vertical measurement around the axilla (Callaway's sign) with lowering of one of the axillary folds (Bryant's sign); and (6) displacement as shown by the X-ray. The variety of dislocation may be diagnosticated by the situation of the head of the bone; by the axis of the limb, the elbow projecting from the side in all instances, but decidedly backwards in the subcoracoid and subclavicular forms, slightly backwards in the subglenoid, and forwards in the subspinous; by the length of the limb, which is lessened in the subclavicular, increased very little if at all in the subcoracoid, slightly increased in the subspinous, and decidedly increased in the subglenoid; and by the X-ray. Rupture or compression of the axillary vessels or brachial plexus may occur. Subluxation of the shoulder is a condition in which the head of the bone passes forwards, owing to rupture or displacement of the long head of the biceps.

The **treatment** is reduction by manipulation or extension, employing ether if much difficulty is encountered. *Kocher's method* is useful in forward dislocations. The elbow is flexed to a right angle and pressed to the side. External rotation is then performed by carrying the forearm outwards until it is at a right angle with the body. If this does not cause reduction, the elbow is drawn forwards until the arm is at a right angle with the body, and internal rotation performed by placing the hand on the sound shoulder. External rotation relaxes the posterior untorn portion of the capsule, which lies across the glenoid cavity, and causes the opening in the capsule to gap. When the elbow is carried forward, the capsule above the rent is relaxed, and the lower margin of the opening acts as a taut band which directs the head of the bone into the glenoid cavity. The method should not be used if there is great resistance to external rotation, as in such instances the neck of the bone may be broken. In *Smith's method*, for anterior dislocation, the surgeon stands in front of the patient and, if the left humerus is dislocated, grasps the shoulder with his left hand, the fingers resting on the scapula and the thumb on the head of the bone. With the right hand the elbow is abducted to a right angle, extended, everted, and carried towards the sternum while pressure is made on the head of the bone. For the right shoulder the position of the surgeon's hands is reversed. In subspinous dislocation the surgeon stands behind the patient and in a similar manner abducts and extends the arm; external rota-

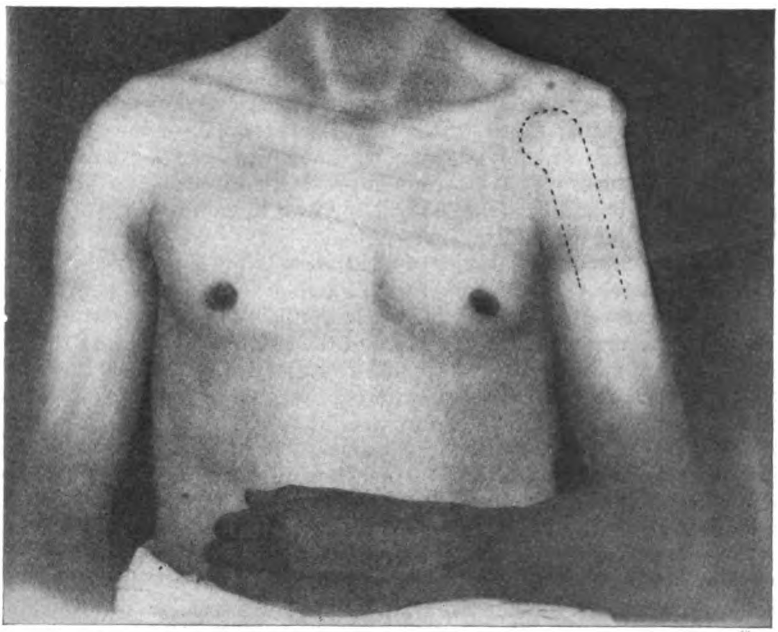

FIG. 231.—Subcoracoid dislocation of the shoulder. (Pennsylvania Hospital.)

tion is then performed, and the elbow carried towards the spine while the thumb presses the bone forwards into the glenoid cavity. *In reduction by extension* the patient lies down, and the arm is pulled directly outwards while counterextension is made by placing the unshoed foot against the chest close to the head of the bone. If this fails, the arm is carried downwards while the foot is used as a fulcrum to drive the head of the bone into place. Some surgeons make the extension downwards, others place the foot over the acromion and pull the arm above the head. *Cooper's method* consists in placing the knee in the axilla of a sitting patient and forcing the elbow to the side. In all methods of extension, and particularly in the vertical form, there is danger of injury to the axillary nerves or vessels. After reduction the joint should be immobilized for a week or ten days by a Velpeau bandage.

Recurrent dislocation of the shoulder is due to relaxation of the capsule as the result of nonunion of the laceration in it or stretching of the cicatrix. The shoulder may be strengthened by electricity, massage, and a support, or, after making an incision similar to that recommended for excision of the joint, the gap in the capsule may be sutured or the capsule reefed. We have employed Thomas's incision for capsulorrhaphy. The incision is made in the axilla, along the anterior border of the coraco-brachialis, which with the biceps and pectoralis major is retracted outwards, the axillary vessels and nerves, including the musculo-cutaneous nerve being drawn inwards. The anterior circumflex vessels are ligated and cut, and about half the width of the subscapularis divided, care being taken not to injure the circumflex nerve or the posterior circumflex vessels. The myeloplasty of Clairmont-Erlich consists in wrapping a strip of muscle, taken from the posterior border of the deltoid, around the inferior part of the capsule, and suturing the strip to the anterior margin of the deltoid.

Dislocations of the elbow are most frequent in children, and are caused by direct or indirect violence. In dislocation of both bones of the forearm the displacement may be backwards, forwards, or lateral.

FIG. 232.—Old backward dislocation of the elbow, reduced after opening the joint.

Dislocation of both bones backwards is the most frequent variety. The coronoid process lodges in the olecranon fossa, the forearm being flexed, midway between pronation and supination, and shortened. Occasionally the coronoid process is broken (mobility and crepitus). The lower end of the humerus displaces the artery and soft tissues forwards, and projects at or below the crease of the elbow; the upper ends of the bones of the forearm form a projection posteriorly, and the relations between the olecranon, head of the radius, and condyles are markedly altered (Fig. 232). For diagnosis see fractures about the elbow. The *treatment* is reduction by strong traction, and flexion of the forearm across the knee, which is placed in the bend of the elbow while the patient is in the sitting position (Cooper's method). The arm is placed in the Jones position for a week or ten days.

Dislocation of both bones forwards seldom occurs without fracture of the olecranon. The forearm is lengthened and flexed, and the normal prominence of the olecranon is absent. The *treatment* is pressure downwards on the bones of the forearm by the knee in the bend of the elbow, the forearm being drawn upon and flexed by one hand, while the other makes forward traction on the humerus. The arm is then dressed in the Jones position for a week or ten days.

Lateral dislocation of both bones, either outwards or inwards is infrequent and usually incomplete. In either instance the forearm is flexed and fixed, and the joint widened; the form of displacement is determined by studying the relations of the bony landmarks about the elbow. Reduction is made by traction on the forearm, the upper end of which is pushed inwards or outwards according to the form of dislocation. The arm should be placed in the Jones position for a week or ten days.

Dislocation of the ulna alone is rare, and can occur only in a backward direction; the forearm is flexed, fixed, and pronated, and the olecranon is unduly prominent. The treatment is the same as that for dislocation of both bones of the forearm backwards.

Dislocation of the radius alone may be forwards, backwards, or outwards.

Forward dislocation is the usual variety; it results from a fall on the hand when the forearm is pronated and extended, or from direct violence to the posterior part of the joint. The forearm is midway between pronation and supination, and cannot be flexed beyond a right angle, as the head of the bone strikes the lower end of the humerus. The head can be felt rotating beneath the skin, and a depression is noticed posteriorly beneath the external condyle. Reduction is the same as that for dislocation of both bones forwards. The arm should be kept in the Jones position for several weeks, as deformity is likely to recur owing to rupture of the orbicular ligament.

Backward dislocation is rare, and is caused by a fall on the hand, or a blow on the head of the bone from the front. The forearm is flexed, fixed, and pronated, and the head of the bone can be felt rotating behind the external condyle. Reduction is the same as that for both bones backwards, the arm being fixed in the Jones position for several weeks, although recurrence of the deformity is not as menacing to the function of the elbow as in the preceding dislocation.

Outward dislocation is very rare. The head of the bone may be felt external to the outer condyle; it is reduced by extension and direct pressure, and the forearm is dressed in flexion.

Dislocation of the radius forwards and ulna backwards is exceedingly rare, and causes great deformity and impairment of function.

Subluxation of the head of the radius occurs in children as the result of a forcible pull on the forearm. The head of the bone is displaced downward and a fold of the orbicular ligament becomes pinched in the joint. The forearm is flexed, pronated, and powerless, and pain and tenderness, increased by supination, exist over the head of the radius. The forearm should be forcibly supinated and then flexed, and the elbow immobilized for a few days.

Dislocation of the wrist is rare, but may follow a fall on the hand or direct violence. The displacement may be backwards or forwards; the deformity of the former resembles Colles' fracture, but the styloid processes of the ulna and radius project beneath the skin on the flexor side of the wrist, and their relations to each other are not disturbed. In forward dislocation the deformity is reversed. Reduction is effected by traction on the hand and pressure over the deformity, and the wrist is immobilized on a Bond's splint for two weeks.

Dislocation of the lower end of the ulna forwards, or more commonly backwards, occasionally occurs in twists of the forearm; the deformity is readily detected, and easily reduced by extension and pressure. The forearm and hand should be splinted for several weeks.

Dislocation of the carpal bones is uncommon apart from crushes. It is possible for the second row of bones to be dislocated backwards or forwards from the first, or for any one of the carpal bones to be individually dislocated. The most frequent injury is anterior dislocation of the semilunar, a sort of silver-fork deformity resulting, owing to the prominence of the os magnum, and the depression just above it caused by the forward displacement of the semilunar, which is felt under the flexor tendons of the wrist. The relations between the styloid processes and the radius are unaltered, although the distance from the radial styloid to the base of the first metacarpal is lessened. Reduction may be effected by hyperextension, then hyperflexion over the thumbs of an assistant, which press on the semilunar (Codman and Chase). Excision of any of the bones may be demanded in irreducible dislocations.

Dislocations of the metacarpal bones, i.e., at the carpo-metacarpal joint, are infrequent. The metacarpal bone of the thumb is the one most frequently displaced, the cause being powerful flexion or direct violence. The base of the bone forms a posterior prominence, which is easily reduced but hard to keep in place. An adhesive strap should be put over the joint, and the thumb fixed in abduction on a palmar splint for two weeks or longer.

Dislocations of the metacarpo-phalangeal joints, excepting that of the thumb, are infrequent. Forward dislocations are readily recognized and easily reduced. **Backward dislocation of the thumb** or of any of the fingers is often difficult to reduce, and the treatment of the former will serve as a guide for that of the latter. There are three forms of backward dislocation of the thumb. The *incomplete* some persons are able to produce at will by hyperextending the thumb until it forms an obtuse or even a right angle with the metacarpal bone. The *complete* is caused by forced extension, the first phalanx projecting backwards at a right angle, the terminal phalanx being flexed, and the head of the metacarpal bone forming a prominence anteriorly (Fig. 233). The anterior ligament is lacerated, and with the sesamoid bones is pulled up on the posterior surface of the head of the metacarpal bone, the long flexor tendon slipping to the inner or the outer side. The *complex form* may be caused by flexion of the thumb in attempts to reduce the complete form. The thumb is parallel with, but posterior to, the metacarpal bone.

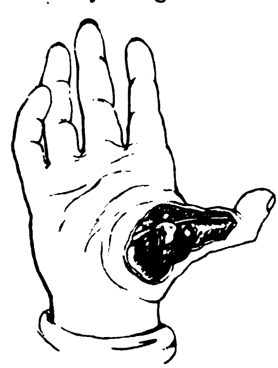

Fig. 233.—Complete backward dislocation of thumb. (Agnew.)

Reduction consists in increasing the extension, making strong traction, pushing the base of the thumb downwards, then pressing on the head of the metacarpal bone and flexing the thumb. If this is unsuccessful, as it often is, a palmar incision should be made over the head of the metacarpal bone and the ligament nicked between the sesamoid bones, when replacement will be easy. A splint should be used for at least three weeks.

Dislocations of the phalanges may be backwards, forwards, or lateral. Deformity is obvious and reduction usually easy. In difficult cases a firmer grasp on the finger can be secured by the Levis apparatus (Figs. 234, 235). The fingers should be splinted for one week.

Dislocations of the ribs, costal cartilages, sternum, and pelvis are very rare, and give the same signs and require the same treatment as fractures.

Dislocations of the hip are comparatively infrequent owing to the great strength of the joint. The cause is never direct violence, but always force transmitted from the feet or knees, or from the back when the hips are flexed. After the fortieth or fiftieth year dislocation is very rare owing to the fragility of the neck of the femur, which predisposes to fracture. The upper portion of the hip joint is formed by the rim of the acetabulum; the capsule is markedly strengthened in front by the iliofemoral or Y-ligament and to a lesser degree by the pubofemoral ligament, while posteriorly it is reinforced by the ischiofemoral ligament; hence the weakest portion of the joint is below, and

Fig. 234.

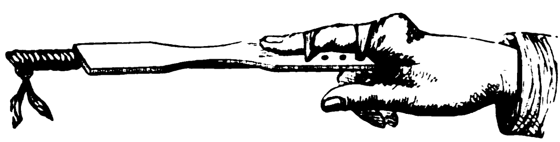

Fig. 235.

Figs. 234 and 235.—Levis apparatus for dislocations of the phalanges.

it is through this part of the capsule that the head of the bone usually passes when dislocated, thence passing forwards or backwards according to the presence of abduction or adduction at the time of the accident. The innominate bone is made of two planes, the ilio-ischiatic and the pubo-ischiatic, which meet and form a right angle at a line drawn from the anterior superior spine of the ilium, through the acetabulum, to the tuberosity of the ischium. When the head of the femur escapes through the lower portion of the capsule, it slides off this angle upon one or the other of these planes, according to the direction of the force; hence all dislocations of the hip are either inward (*forward*) upon the pubo-ischiatic plane or outward (*backward or dorsal*) upon the ilio-ischiatic plane. The head may lie upon any portion of either of these planes within a circle whose radius is the untorn portion of the capsule; consequently Allis, to whom belongs the credit for working out this problem, subdivides the inward dislocations into the (a) *high* (pubic and subspinous of other writers), (b) *middle* (thyroid of others), (c) *low* (perineal of others), and (d) *reversed;* and he divides the outward or dorsal into the (a) *high* (on dorsum of ilium), (b) *low* (sciatic, or dorsal below the tendon of others), and (c) *reversed* (everted dorsal, anterior oblique, and supraspinous of Bigelow). In three-fourths of the cases the dislocation is outwards, and in two-thirds of these it is high, i.e., upon the dorsum of the ilium; of the inward dislocations the middle (into the thyroid foramen) is the most frequent. Some writers state that the head of the bone may be pushed through the capsule, e.g., by force applied to the knee when the thigh is flexed and adducted, directly onto the dorsum of the ilium, but Allis explains all cases by leverage; thus outward dislocations are caused by flexion, adduction, and inward rotation of the thigh, which pry the head out of place by the fulcrum action of the iliofemoral ligament, which passes across the front of the neck of the bone; inward dislocations are caused by abduction, the head of the bone being forced out of the socket by the great trochanter impinging against the rim of the acetabulum, which acts as the fulcrum. The ligamentum teres is of course ruptured. If the tear in the capsule is close to the femur, its infolding may offer an obstacle to reduction. The Y-ligament is rarely ruptured; tearing of its outer branch permits the femur to rotate externally and results in reversed (everted dorsal) dislocations. If the entire ligament is ruptured, the head of the bone will be freely movable instead of fixed. The muscles about the joint are contused or lacerated to a greater or lesser degree. Rupture of the obturator internus allows the head of the bone to ascend and become high dorsal; if the muscle remains intact, the low dorsal (dorsal below the tendon) will likely ensue. It is possible, however, for the head to leave the joint above the tendon of this muscle, or leaving it lower down to ascend in front of the tendon. The sciatic nerve may be contused, compresssed, or lacerated, but the femoral vessels are very rarely injured.

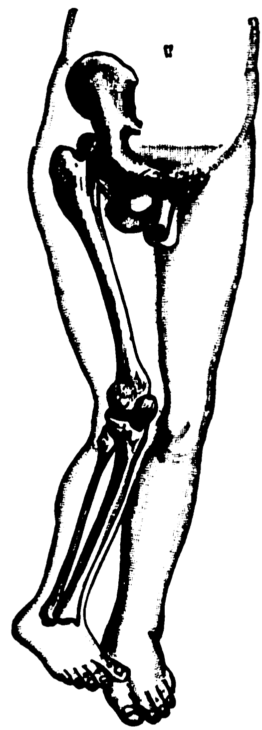

FIG. 236.—High dorsal dislocation of the hip. (Tillmanns.)

In **dorsal or outward dislocation** the thigh is flexed, adducted, rotated internally, and shortened, while the trochanter is above Nélaton's line and farther away from the median line of the body, so that the hip appears broadened. A depression exists over the front of the joint and the head of the bone can be felt posteriorly. The knee is flexed and the heel raised. Passive movement is possible only in the direction of deformity, and indeed the affected limb can be flexed to a right angle with the body without bending the knee. If both knees are flexed while the thighs are vertical, the patient lying down, the foot on the affected side touches the bed. In the high dorsal (Fig. 236) these signs are all marked, in the low dorsal they are less in evidence; e.g., in the former there is two or three inches shortening, the axis of the affected thigh passes through the lower third of the sound thigh, the foot passes over the sound ankle; in the latter the shortening is an inch or less, the axis of the femur passes through the sound knee, the foot crosses the great toe of the sound side. In the reversed dorsal the lower limb is rotated externally instead of internally, owing to tearing of the outer branch of the Y-ligament. For diagnosis from fractures see p. 297.

Reduction should be performed under ether with the patient lying on the back. *Bigelow's method* consists in flexion of the leg on the thigh and the thigh on the abdomen, adduction, inversion, strong traction upwards, and external circumduction, i.e., the knee is swept upwards towards the opposite shoulder, then towards the shoulder of the same side, and finally downwards with the limb in extension (Fig. 237). As there is some danger of hooking up the sciatic nerve by the head of femur in this method, *Allis* flexes the thigh, performs internal rotation by carrying the foot outwards, draws the thigh upwards to lift the head to the level of the acetabulum, and has an assistant push inwards on the head as the thigh is rotated externally and extended. In this method it is necessary to fix the pelvis firmly to the floor by straps or by the hands of an assistant. *Reduction by extension* is made by traction in the axis of the displaced thigh while pressure is made over the great trochanter. Extension by pulleys destined to rupture the Y-ligament is dangerous and should never be employed. After reduction the patient is confined to bed for two or three weeks with the legs tied together.

Inward or forward dislocations are characterized by flexion, abduction, and external rotation of the thigh. The hip is flattened, the trochanter being nearer the median line; the acetabular cavity is empty; and the head of the bone may be detected in its new position. The adductor muscles are prominent and the knees cannot be approximated. In the high thyroid dislocation, i.e., upon the pubes (Fig. 238), flexion is less marked, but eversion is greater and the limb is shortened about one inch; in the low thyroid (Fig. 239) flexion is greater and the limb is lengthened one or more inches. In the reversed thyroid external rotation may be so great that the toes point directly backwards.

FIG. 237.—Bigelow's method of reducing backward dislocation of hip.

In the **reduction** of inward dislocations *Bigelow* advised flexion of the leg and thigh as in the treatment of dorsal dislocation, then abduction, eversion, strong traction upwards, and internal circumduction, i.e., the knee is swept upwards towards the shoulder of the same side, then towards the opposite shoulder, and finally downwards with the limb in extension (Fig. 240). *Allis*, in order to avoid injury to the sciatic nerve, flexes and abducts the thigh, makes strong traction upwards, and adducts while an assistant pushes on the head of the femur. *Reduction by extension* alone is made by traction in the axis of the displaced thigh, the unshoed foot being placed in the groin for counterextension. After reduction the subsequent treatment is the same as in the dorsal variety.

The **knee** may be dislocated forward, backward, inward, or outward, and these may be complete or incomplete, the symptoms consequently varying in degree. The cause is violent force, either direct or indirect.

In **forward dislocation** the lower end of the femur passes backwards and compresses the popliteal vessels, and the tibia is displaced forward. The leg is shortened and extended, although it may be flexed; in the former case the patella is loose. **Backward dislocation** is more frequently due to disease of the knee joint than to injury. The leg is shortened and usually somewhat flexed, and compression of the popliteal vessels or nerves is generally absent. **Inward and outward dislocations** are usually incomplete. The leg is partly flexed and often rotated, but not shortened.

Reduction is accomplished by traction and direct pressure while the leg is extended and the thigh flexed. The knee should be immobilized on a splint for three weeks, and a support worn for some time longer.

Dislocations of the patella are due to muscular action or direct violence. An insidious outward dislocation may be caused by knock-knees or hydrarthrosis. The patella may be dislocated upwards, downwards, outwards, or inwards, or it may be rotated on its perpendicular or horizontal axis, or there may be a combination of any of these varieties.

FIG. 238.—High thyroid (pubic) dislocation. (Tillmanns.)

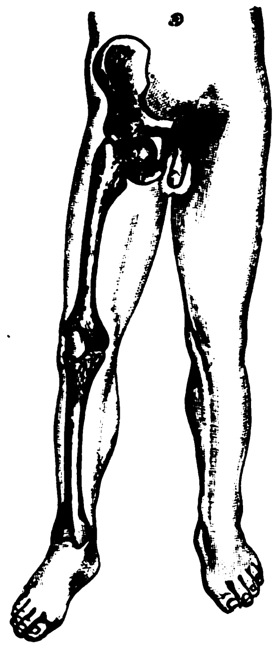

FIG. 239.—Low thyroid dislocation. (Tillmanns.)

Dislocation upwards or downwards is due to rupture of the ligamentum patellæ or the quadriceps tendon, and is to be treated as a rupture of a tendon.

Outward dislocation is the most frequent variety; it usually occurs when the limb is extended, as in flexion the patella is firmly held between the condyles of the femur. The patella lies upon the anterior or outer surface of the external condyle, according to whether the dislocation is incomplete or complete; in the former the outer edge projects forward, in the latter the inner border presents in front. The leg is extended, the knee broadened, and the intercondyloid notch perceptible. Reduction is made by pressure inwards on the outer margin of the patella while the thigh is flexed and the leg extended to relax the quadriceps. Incision is needed in some cases. The knee should be immobilized for several weeks.

Inward dislocation is rare; the signs and the treatment are the reverse of those of outward dislocation.

In rotation on the perpendicular axis (vertical or edgewise dislocation) either the outer or the inner border of the patella, usually the latter, lies between the condyles while the opposite border projects forward. In two cases the bone has been turned over, the articular surface looking forwards. *Reduction* may be effected by pressure while the knee is extended, but is often more difficult than at first sight appears, and incision may be necessary.

Rotation on the horizontal axis has been recorded in six instances, and the author has seen one case which has not been reported. In five of these the tendon of the quadriceps was torn and the upper border of the patella wedged between the femur and the tibia, in two the lower edge was forced into the joint, the articulating surface of the patella looking upwards. In five cases incision was necessary to free the patella.

FIG. 240.—Bigelow's method of reducing forward dislocation of hip.

Dislocation of the semilunar cartilages of the knee joint (*subluxation, internal derangement of the knee*) follows a twist of the partly flexed knee. The condyles fix the cartilages, which are torn from the tibia by rotation of the leg, the attachments of the cartilages to the tibia being relaxed when the knee is bent. The internal cartilage is the one usually affected. Any of its attachments or even the cartilage itself may be ruptured.

The **symptoms** are severe pain in the knee and effusion into the joint, which is locked in flexion, i.e., flexion may be increased but extension is impossible. Sometimes there is no locking, and these cases are often diagnosticated sprains. In the latter tenderness is more generalized, and extension may relieve rather than increase the pain. The displaced cartilage is occasionally felt, but more often palpation will reveal nothing but marked tenderness along the front of the upper surface of the tibia. Recurrences are frequent.

The **treatment** is reduction by increasing the flexion, rotating the leg, making firm pressure over the situation of the displaced cartilage, and extending the leg. Often spontaneous reduction occurs before the surgeon is called. The synovitis should be treated and the knee immobilized for five or six weeks. In order to prevent recurrence an elastic knee-cap should be worn for several months. If relapses are frequent, a brace may be applied which, while allowing flexion and extension, prevents rotation; or the joint may be opened by a curved incision along the upper edge of the tibia, and the cartilages stitched to the periosteum with catgut, or excised if they are ruptured or deformed.

The **fibula** may be dislocated at either end, either backwards or forwards. The injury is very rare. The leg is flattened from side to side and a depression is found over the end of the bone, which is felt in its displaced position. Reduction is effected by flexion of the knee and direct pressure, the leg being put up in plaster-of-Paris for several weeks. At the upper end displacement is likely to recur owing to the contraction of the biceps.

Dislocations of the ankle joint are often complicated by fracture. In the order of their frequency the displacements are outwards, inwards, backwards, forwards, and upwards.

Lateral dislocation is caused by a twisting or turning of the foot, and the resulting injury is a fracture-dislocation, known as Pott's fracture or Dupuytren's fracture (q.v.).

Dislocation backwards is caused by stumbling when jumping or running, or by direct violence; both malleoli are commonly broken. The heel is prominent, the dorsum of the foot shortened, and the relations between the malleoli and the tarsus altered. **Forward dislocation** may occur without fracture. The dorsum of the foot is lengthened, the heel inconspicuous, and the normal hollow in front of the tendo Achillis bulged by the tibia and fibula. Both these dislocations are reduced by strong traction, direct pressure, and rotation, while the knee is bent to relax the tendo Achillis, which in some instances it may be necessary to sever. The after treatment is that of fractures about the ankle.

Upward dislocation of the ankle is a rare injury in which the astragalus is thrust upward between the tibia and fibula as the result of a fall upon the feet. The ankle is widened and the foot flattened, the malleoli having descended towards the sole of the foot. Reduction is made by powerful traction and countertraction, the after treatment being that of fracture.

In dislocations of the astragalus the bone, as the result of falls or twists, is detached from the remaining tarsal bones as well as separated from the bones of the leg. The displacement may be complete or incomplete, the bone passing forwards or backwards, or rotating upon its perpendicular or horizontal axis; or these lesions may be combined.

In forward dislocation the astragalus forms a prominence in front of the ankle, the dorsum of the foot and the leg are shortened, and the malleoli are nearer the sole of the foot, which is either turned inwards or outwards. In **backward dislocation** the astragalus lies between the malleoli and the tendo Achillis. If either horizontal or vertical **rotary dislocation** alone occurs, the astragalus simply rotates without being displaced from between the bones of the leg and the bones of the foot; a positive diagnosis can seldom be made without the X-ray.

Reduction, if the bone is not completely displaced, is effected by traction on the foot and direct pressure on the astragalus while the knee is flexed to relax the calf muscles. If the dislocation is complete, reduction is rarely possible, and excision will be required.

Subastragaloid dislocation is a disrupture of the joints between the astragalus, and the os calcis and scaphoid, as the result of twisting. It is possible for the foot to pass forward, backward, inward, or outward, but in most instances the displacement is backwards and inwards, or backwards and outwards. If the displacement is *backwards and inwards*, the external malleolus is prominent, while the situation of the internal is occupied by a hollow. The foot is inverted and the astragalus conspicuous, thus resembling talipes equino-varus. If the dislocation is *backwards and outwards*, the deformity is the reverse of the preceding form and resembles talipes equino-valgus. In either of these varieties the foot is shortened on the dorsum and the heel elongated, while the tendo Achillis forms a curve which is concave in the direction of the displacement.

Reduction is accomplished by traction in an opposite direction to that of the deformity, the leg being flexed or the tendo Achillis cut to secure muscular relaxation. The foot and ankle are put up in plaster for several weeks.

Dislocations of the remaining tarsal bones are quite rare, and are treated by extension and direct pressure upon the displaced bone or bones.

Dislocations of the metatarsal bones are uncommon, and cause a backward or forward projection with shortening of one toe, if one bone is dislocated, or shortening of the entire foot, if all the bones are dislocated. Reduction is made by extension and pressure, a splint or a cast being worn for two or three weeks.

Dislocations of the toes are very rare, the metatarso-phalangeal joint of the great toe being affected most frequently. The symptoms and treatment are similar to those of like injuries of the hand.

DISEASES OF JOINTS.

Examination of a diseased joint should be preceded by obtaining the history of the patient and of the disease.

The **cause** of most joint affections is injury, infection, or nervous disturbances.

If the cause is a severe *injury* and the *onset* immediate the condition is probably a sprain, ruptured ligament, intraarticular fracture, or a dislocation. A trivial injury followed by immediate distention of a joint strongly suggests hemarthrosis due to hemophilia. A trivial injury followed, after an interval, by an insidious joint disease points to tuberculosis.

Infection gains entrance through a wound, extends from neighboring structures (most often bone), or comes by way of the blood, e.g., in pyemia, syphilis, gonorrhea, tuberculosis and acute fevers (variola, scarlet fever, enteric fever, measles, erysipelas, pneumonia, etc.). Gout and rheumatism may, at least for convenience, be placed under this heading, although some might consider "faulty metabolism" a more appropriate legend. "Rheumatism" is a common designation for many cases of infective arthritis, the source of infection being the tonsil, prostate, etc. (see diagnosis of sepsis).

The *nervous disorders* which may be responsible for joint disease are central (e. g., locomotor ataxia, syringomyelia), peripheral (e. g., neuritis, section of nerves), or emotional (e. g., hysteria).

As the nature of *hemophilia* is not known, it will not fit in any of these classes.

The **symptoms** of a *general* nature, when present, are those of sepsis or of the general diseases just mentioned.

The *local symptoms* that annoy the patient are *pain* and *interference with the function* of the joint. If these are intermittent the trouble may be due to a dislocated cartilage or a loose body; if remittent and chronic to osteoarthritis. Chronicity with slow but steady progress indicates tuberculosis. It should be recalled that pain may be referred to distant parts; thus hip joint disease may cause pain in the knee, disease of the vertebral joints pain in the areas supplied by the spinal nerves. A *number of joints* may be involved in general infections, e. g., in pyemia, rheumatism, gonorrhea, osteoarthritis, and in the acute infectious fevers.

In the **local examination** one should always compare the joint with that of the opposite side.

The *position* of the joint is generally one of flexion; in hysteria it may be rigidly extended.

The *skin* may be white in tuberculosis, ecchymotic after injuries, hyperemic in acute inflammation. Numbness immediately after trauma may be due to local shock; persistent anesthesia, to nerve injury or hysteria.

The amount of *swelling* may be accurately determined with a tape-measure, being careful to measure the corresponding joints on each side of the body at the same place and to have the joints in the same position. The situation, shape, and consistency of the swelling should be noted. It may involve the joint cavity alone (synovitis), or also the ends of the bones (arthritis), or it may be extraarticular, e. g., in bursitis, tenosynovitis, cellulitis.

Heat, redness, and *edema* are characteristic of acute inflammation, sometimes induced, however, by irritating applications.

Atrophy of neighboring muscles may occur in any case of long duration, even in hysteria, but is most marked in osteoarthritis depending upon injury or inflammation of the nerves and in tuberculosis.

Crepitus on pressure or motion may indicate, by its character (p. 6), blood clot, rice bodies, synovitis, or arthritis. Its exact situation must be ascertained, as it may originate in adjacent bursæ or tendon sheaths, a fact that can sometimes be elicited by moving the bursa, e. g., prepatellar bursa, or the tendons, e. g., those of the wrist, without moving the joint.

Alteration of the relations of the *bony landmarks* about a joint indicates fracture or dislocation, either of which may be the result of injury or disease.

Motions, both active and passive, are usually restricted or abolished, but occasionally the joint may be abnormally movable, e. g., in Charcot's disease. Caution must be exercised to fix adjacent parts lest their movement be wrongly interpreted as belonging to the joint under inspection, thus the scapula must be immobilized in examining the shoulder joint, the pelvis in examining the hip joint.

The *X-ray* may show distension of the joint cavity, lesions of the cartilages and bones, displacements, movable bodies, and similar conditions.

During the second stage of *general anesthesia* rigidity due to voluntary muscular contraction, e. g., in hysteria and in malingerers, ceases, but deep anesthesia is necessary to relax involuntary muscular spasm. Limitation of movements after complete anesthesia indicates ankylosis.

Aspiration is indicated when the nature of an effusion is doubtful.

Incision, for exploration, should be reserved for cases in which all other methods of diagnosis fail and in which the disability is marked.

Synovitis is inflammation of the synovial membrane alone, the remaining structures of the joint being unaffected. It may be acute or chronic, simple or suppurative.

Acute simple synovitis is caused by a closed injury (contusion, sprain), low grade infection, or nervous influences (p. 340). The synovial membrane is red and swollen, and the joint is distended with fluid consisting of synovia, inflammatory exudate, and sometimes blood, hence it is coagulable. Precipitated lymph may be absorbed, or become organized and result in adhesions.

The **symptoms** are pain, tenderness, increased heat, a fluctuating swelling, and in some cases hyperemia of the skin. The muscles fix the joint in the most comfortable position, usually some degree of flexion, in which position there is more room for the fluid. The effusion stretches the softer tissues entering into the formation of the joint and leaves it a little weakened and relaxed, at least temporarily. The constitutional symptoms vary with the cause of the synovitis and the size of the joint. Effusion is detected in the various joints as follows: The *shoulder* is increased in size, and swelling may be noticed along the bicipital groove and in the axilla. In subdeltoid bursitis axillary swelling is absent, and, although active motions are painful, gentle passive movements of the shoulder may be painless. In the *elbow* the swelling is on each side of the olecranon and tendon of the triceps. In the *wrist* swelling is most marked posteriorly. In the *hip* effusion is usually not detected, but reliance is placed upon the tenderness, limitations of movements, and upon the position of the thigh in flexion, abduction, and external rotation. In the *knee* swelling is detected upon each side of the patella and its ligament, and beneath the quadriceps. The patella is floated away from the condyles, and if tension is not too great it may be pushed backward by the finger and made to tap on the femur. In the *ankle* fullness may be seen in front, but is most in evidence on each side of each malleolus.

The **treatment** is immobilization and elevation of the joint, and in the first stage cold in the form of an ice bag or evaporating lotions; later absorption should be promoted by the use of heat, compression, and ointments containing ichthyol, belladonna, mercury, or iodin. If the effusion is large or unaffected by other forms of treatment, aspiration may be advisable. The position of the joint should be such as to give a useful limb even in the event of ankylosis. Thus the elbow is put on an internal angular splint, the hip and knee are fixed in extension, the wrist midway between flexion and extension, the ankle at a right angle, and the shoulder with the arm to the side. Traction by means of adhesive plaster, as for fracture, is of service when the hip or knee is involved. During the convalescing stage, liniments, massage, and elastic compression are useful. As soon as the inflammation has subsided gentle passive motions should be started, in order to prevent ankylosis.

Acute suppurative synovitis (*empyema of a joint*) may be a later stage of simple synovitis. More commonly it is suppurative from the onset, the cause being an open wound, neighboring inflammatory process, or a hematogenous infection (pyemia). The *symptoms* are those of simple synovitis, but more intense, and accompanied by marked general evidences of sepsis. The diagnosis may be confirmed by exploratory puncture. The treatment is that of acute suppurative arthritis, into which untreated suppurative synovitis merges.

Chronic simple synovitis follows the acute form or is chronic from the beginning. The synovial membrane is thickened and the joint contains an excess of fluid, which, when large in quantity, is called *hydrops articuli*. The *symptoms* are slight pain when the joint is moved, fluctuation owing to the presence of effusion, weakness with restriction of motion, atrophy of neighboring muscles, and in some cases crepitus on pressure or when the thickened layers of synovial membrane are rubbed together by motions of the joint. In some situations, e.g., the knee, hypertrophied synovial fringes may be palpated.

The **treatment** is immobilization, compression, and counterirritation with blisters, iodin, or occasionally the actual cautery; stimulating liniments and massage are useful, as well as an ointment containing equal parts of ichthyol, belladonna, mercury, and lanolin. Baking the joint by means of a hot-air apparatus usually gives at least temporary relief. Aspiration is occasionally employed. Arthrotomy is reserved for cases which resist all other forms of treatment. In these cases the joint is irrigated with salt solution and hypertrophied fringes removed; other undiagnosticated conditions, such as loose bodies, ruptured or inflamed semilunar cartilages, lipoma arborescens, tuberculous disease, etc., may be found and will require treatment. Constitutional treatment, of course, should be administered in the presence of any diathesis.

Chronic suppurative synovitis is usually a legacy of the acute form, or when originating insidiously, due to syphilis or tuberculosis, under which headings the treatment will be considered.

Arthritis (*panarthritis*) is inflammation of not only the synovial membrane, but also the cartilages, bones, and ligaments of an articulation, in a word all the structures of a joint. Clinically, arthritis is distinguished from synovitis by the tender, swollen articular ends of the bones, by the greater pain on active as compared with passive motion, and in the later stages, after the cartilages and bones have become eroded, by starting pains (p. 345), by cartilaginous or bony crepitus, and by the X-ray. Arthritis is classified like, and due to the same causes as, synovitis.

Acute and chronic **simple arthritis** are treated like acute and chronic simple synovitis. Joint inflammations occurring during or after acute infectious fevers commonly terminate without suppuration, the symptoms being much like those of rheumatic synovitis, one or several joints being involved. In some cases, notably in typhoid arthritis, there is little pain, although dislocation may occur. In doubtful cases aspiration of the joint, with, if need be, microscopic examination of the fluid, will reveal the presence or absence of pus.

Acute suppurative arthritis is always due to micro-organisms, which enter the joint through a wound, from neighboring tissues, or by way of the blood, e.g., in pyemia and acute infectious diseases. The entire joint and the periarticular structures participate in the inflammation, which destroys the cartilages, relaxes the ligaments (sometimes permitting luxation), and invades the neighboring bone and soft structures.

The **symptoms** are great pain and tenderness, and fixation of the joint, which is hot, swollen, and fluctuating. There are redness and edema of the skin and severe constitutional symptoms (septic intoxication or septicemia). The ends of the bones enlarge (ostitis), and finally, in progressing cases, ulcerate (caries), at which time starting pains (p. 345) may occur and osseous crepitus be obtained. If proper treatment is withheld and the patient survive, pus perforates the capsule, infiltrates the surrounding tissues, and finally breaks through the skin, the joint becoming abnormally movable and dislocated to a greater or lesser degree. The patient may die from toxemia during the acute stage, or succumb to chronic infection and exhaustion in the later stages. Should recovery ensue ankylosis is almost inevitable.

The **treatment** consists in freely opening the joint, irrigating with salt solution, establishing copious drainage, immobilizing the joint in a useful position, and treating constitutionally as for sepsis. Excision or amputation will be required if, after free drainage, septic symptoms threaten life. Murphy treats infective arthritis by aspirating the fluid and injecting 10 cc of a 2 per cent. dilution of formalin in glycerine. This procedure is repeated every few days if the effusion reappears. Others have great, and we think unwarranted, faith in vaccine therapy.

Chronic suppurative arthritis follows the acute form, or is due to one of the infective granulomata, notably syphilis or tuberculosis (vide infra).

Pneumococcal arthritis is due to pneumococcemia, although the organism is not always recoverable from the blood. The original infection is usually a lobar pneumonia, sometimes, however, a pneumococcal meningitis or peritonitis; rarely no primary focus can be found. In about two-thirds of the cases only one joint, usually the knee, is affected. The effusion may be serous, but is generally purulent. The diagnosis is made by bacteriologic examination of the aspirated joint fluid. The treatment is that of simple or suppurative arthritis, according to whether the fluid is serous or purulent.

Gonorrheal arthritis (*gonorrheal rheumatism*) is due to the gonococcus, which is carried by way of the blood from the urethra, or rarely from the conjunctiva in gonorrheal ophthalmia. As a rule it appears during the subsiding stages of an acute gonorrhea or in chronic cases. Men are said to be more frequently affected than women, but this is probably owing to the fact that the diagnosis is seldom made in the latter. One or several joints may be involved, generally the former, the knee, ankle, and wrist being most frequently affected. The inflammation may be acute or chronic, and varies in extent as well as in degree. Although the synovial membrane alone may be involved, the ligaments and periarticular structures are very apt to be thickened and infiltrated. Except in the mildest cases, the pain is severe and there is fever. Suppuration may occur, and ankylosis is very prone to follow even the milder cases. Endocarditis and like complications of general infection occasionally occur. In doubtful cases some of the fluid from the joint may be secured by aspiration for bacteriological examination. The complement-fixation test for gonorrhea, if it proves reliable, should be of the greatest value in many obscure articular inflammations.

The **treatment** is unsatisfactory, the disease being apt to persist or recur. The urethritis should be combated, and the joints immobilized and treated locally as in other forms of arthritis. As soon as the pain subsides, passive motions should be employed to prevent ankylosis. Among the internal remedies which have been used are the salicylates, iron, quinin, strychnin, and the iodids. If suppuration occurs, the joint should be opened, irrigated, and drained. Rogers and Torrey claim good results from the hypodermic injection of an antigonococcus serum, prepared by injecting cultures of the gonococcus into rabbits. From twenty to sixty minims are administered every day or every other day until the pain and disability subside. Vaccines made from the gonococcus also have been employed.

Syphilitic gummatous arthritis occurs in the tertiary period. The onset is insidious; the disease begins in one portion of the joint, and is associated with but little pain. If unchecked it finally reaches the surface, when the characteristic gummy material will be exposed. The symmetrical form of synovitis occurring in the secondary period has already been mentioned. There is also a form of gummatous synovitis resembling tuberculosis, and a form of chondroarthritis analogous to osteoarthritis. The history, the evidences of syphilis elsewhere, the Wassermann reaction, and the response to appropriate treatment, are important factors in making the diagnosis. The *treatment* is that of syphilis; excision or amputation may sometimes be required.

Tuberculous arthritis (*white swelling, pulpy degeneration*) is much more common in children, the joint generally being invaded from an adjacent epiphysis; in adults the primary focus is probably in the synovial membrane as often as it is in the neighboring bone. The tubercle bacillus is transported by the blood to the joint, in which an area of lessened resistance has often been created by some slight injury, the patient possessing a hereditary predisposition to the disease.

The **pathological anatomy** is as follows: When beginning in the synovial membrane, whitish or pinkish pulpy granulations are formed and eventually fill the joint, giving a characteristic doughy feel. In other cases the membrane is covered with small tubercles and the joint is filled with fluid. The tubercles caseate and liquefy, forming tuberculous pus. The ligaments become softened and finally destroyed; the cartilages are eroded and eventually the bones; and the surrounding soft tissues are edematous. When the disease begins in the bone, the changes are those of tuberculous ostitis, the joint being affected secondarily. In any case the tuberculous pus generally finds its way to the exterior by one or more sinuses.

The **symptoms** are very slow in onset. At first there is slight pain, causing some limitation of motion and, in the lower extremities, limping. Later, swelling is noticed and the muscles rigidly hold the joint in a semiflexed position. In a well developed case the joint is *spindle-shaped*, due not only to the swelling, but also to the atrophy of the neighboring muscles, and the *skin is white*, owing to obliteration of the subjacent vessels, and is adherent to the parts beneath. A peculiar *doughy* or elastic sensation is imparted to the fingers on palpation, but fluctuation is detected only when a cold abscess approaches the surface, or in the rare cases in which the effusion predominates. *Rice bodies* are sometimes found in the latter variety. *Night cries* (*starting pains*) indicate erosion of cartilage or bone; when the patient falls asleep the rigid muscles relax, permitting some alteration in the relation of the joint surfaces, and producing severe pain which causes the patient to wake with a start. Partial or even complete *luxation* may be induced by tonic contractions of the muscles upon the disorganized joint. The local temperature of the joint is raised, and later, when sinuses form, hectic fever develops owing to mixed infection.

The **diagnosis** may be difficult in the early stages, in deep seated joints, and in cases with a large effusion, which resembles chronic synovitis. The examination of aspirated fluid and the X-ray are often of great value, and some recommend the tuberculin test. Doubtful cases should be regarded as tuberculous.

With proper treatment the **prognosis** is good regarding life, metastases being uncommon. Ankylosis generally follows, and indeed is nature's method of cure. In late cases, i.e., those with sinuses, the patient may develop amyloid disease or die of exhaustion.

The **treatment** is constitutional (see tuberculosis) and local. The local treatment may be conservative or radical. *Conservative treatment*, which is indicated in the early stages, includes immobilization, often for months, by splint, plaster-of-Paris, or extension apparatus; baking with the hot-air machine; Bier's passive hyperemia; aspiration of the joint fluid and injection of 10 per cent. iodoform emulsion (two to five drams according to the age of the patient) or other antiseptic (see tuberculosis) at intervals of a week or longer; phototherapy (Finsen light); radiotherapy (radium, X-rays); and heliotherapy (see tuberculosis). Compression, counterirritation, and external applications of various lotions and ointments are useless. As soon as detected, abscesses should be tapped with a large trocar and cannula, irrigated with salt solution, and injected with iodoform emulsion. If sinuses exist injections of Beck's bismuth paste may be tried before proposing operation (see section on sinus). If the disease continues to progress, or if the general condition of the patient is such as to forbid prolonged treatment, *radical measures* are demanded. The joint should be opened and the tuberculous tissue removed by erasion (arthrectomy) or excision, according to its extent. Amputation is indicated in cases too far advanced for excision, or in cases in which excision has failed.

Tuberculosis of Special Joints.—In the **shoulder joint** the disease is more frequent in adults than in children, but is not common in either. It usually begins in the head of the humerus and rarely attacks the glenoid cavity. Abscesses, which are rather unusual, point on either side of the deltoid or in the axilla. In caries sicca, which occurs more often here than in any other joint, instead of doughy swelling, there is shrinkage due to muscular atrophy and destruction of the head of the humerus. Immobilization should be persisted in for a number of months. If sinuses form, however, excision of the head of the humerus will usually be required.

The **elbow** is affected more often than either the shoulder or the wrist, because the nutrient arteries of the humerus, radius, and ulna run towards the elbow, thus favoring the deposition of bacterial emboli in this region. The disease is most frequent during adolescence, beginning, in the order of their frequency, in the synovial membrane, or in the epiphysis of the humerus, ulna, or radius. The characteristic spindle-shaped swelling is well marked. Abscesses point on either side of the olecranon, or occasionally follow the ulnar nerve and present on the inner side of the arm. Immobilization at a right angle, with the forearm midway between pronation and supination, is the correct treatment in the early stages, but if the bones are much involved, either erasion, or in adults excision, is the quickest and best treatment.

Tuberculosis of the wrist is comparatively infrequent, but may be met with at all ages. It may begin in the synovial membrane, or be secondary to disease in the carpal bones, lower end of the radius, or neighboring tendon sheaths. If, after several months of conservative treatment, the disease is not checked, erasion or excision is usually advisable, and if the disease is very extensive, amputation will offer the only hope of relief.

Tuberculosis of the sacroiliac joint is of infrequent occurrence, and is most commonly seen in adults. It may be synovial in origin but more often arises in adjacent bones. There is pain in the back, in the joint, or down the thigh, which is increased on standing, walking, or rocking the pelvis with the hands. The patient limps and puts most of his weight on the sound leg, the body being bent forward and away from the affected side, thus causing apparent lengthening of the limb corresponding to the diseased joint. There may be swelling and tenderness directly over the articulation, and in the later stages abscesses discharge in this situation, in the lumbar region, in the iliac fossa, in the groin, or even alongside the rectum.

The *diagnosis* may be difficult in the early stages. *Lumbago* follows exposure to cold, affects both sides, and is transient in character. *Sciatica* causes a very severe shooting pain, tenderness of the nerve, no apparent lengthening of the limb, and no increase in pain when the iliac bones are pressed together or pulled apart. *Hip disease* causes rigidity of adjacent muscles and limitation of hip movements, which, if the pelvis is supported, are not present in sacroiliac disease. If there is an iliac abscess in sacroiliac disease, the thigh may be flexed, but the hip can be freely moved. In *disease of the spine* there are pain, tenderness, rigidity, and perhaps deformity in the affected segment. The *prognosis*, owing to the deep situation of the joint, is often unfavorable.

The *treatment* is rest in bed with a felt or plaster-of-Paris case for the pelvis. If abscesses form, the joint should be opened, and the diseased tissue removed as thoroughly as possible, with gouge, chisel, or curette.

Hip joint disease (*morbus coxæ*, *coxitis*, *coxalgia*) without qualification means tuberculosis of the hip, although any other form of joint disease may occur in this articulation. The disease may originate in any of the structures of the joint, but the primary lesion is most often in the femoral epiphysis. It is very much more frequent in children than in adults.

The **symptoms** in the beginning are slight lameness and stiffness of the hip. Pain is present in the hip or along the inner side of the knee (both joints being supplied by the obturator nerve), and is increased by movements of the joint. Very likely a history of tuberculous disease in the immediate ancestors, and a history of a slight injury, will be obtained. Examination reveals limitation of the movements of the hip and slight flexion, due to rigidity of the muscles which guard the joint. With the child in the recumbent posture the lumbar spine will curve forwards if the knee on the affected side is pressed down to the table (Fig. 241). Slight fullness about the joint or muscular atrophy may be observed at this time. With the progress of the disease flexion increases and is associated with abduction and eversion of the thigh, a position which relaxes the ligaments, increases the capacity of the joint, and thus secures the greatest comfort. If the patient stands or walks, most of the weight is borne on the sound leg, causing lowering of the pelvis on the diseased side with apparent lengthening of the limb (Fig. 242–B), and a compensatory lateral curve of the lumbar spine, convex towards the affected

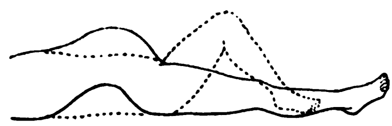

FIG. 241.—Lordosis of lumbar spine, disappearing, as indicated by the dotted line, when the thigh is flexed.

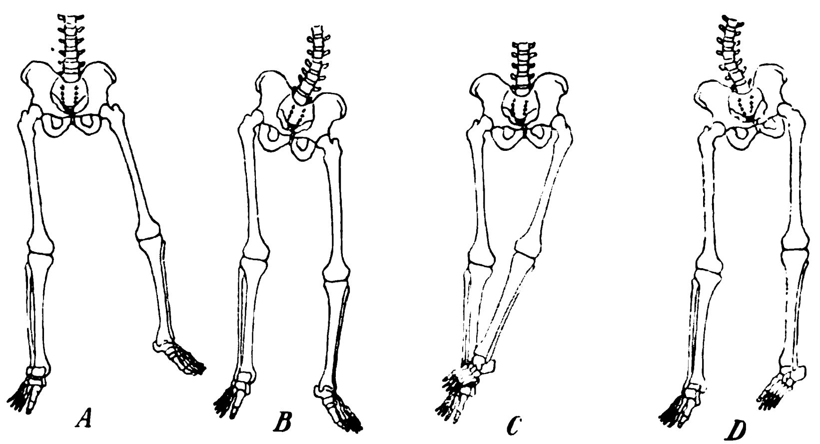

FIG. 242.—A. Abducted thigh. B. Apparent lengthening when limbs are parallel. C. Adducted thigh. D. Apparent shortening when limbs are parallel. Note the effect on the pelvis and the lumbar spine.

side. Flexion may be obscured by compensatory lordosis, abduction by tilting of the pelvis and lateral curving of the lumbar spine, but eversion is never masked. At this stage muscular rigidity is well marked, the pelvis moving upon any attempt to move the thigh; if the lumbar spine is made to approach the table by flexing the sound thigh on the abdomen, the thigh on the diseased side will rise according to the amount of flexion present. The gluteal crease is obliterated (due to muscular atrophy and flexion) or, if present, is on a lower level than its fellow, and some fullness may be detected in the upper part of Scarpa's triangle. Pain increases, is rendered more severe by any jarring motion to the knee or foot, and is apt to wake the patient suddenly from sleep (*night cries, starting pains*). Abscesses may now form and point in the buttock, above or below Poupart's ligament, on the inner side of the thigh, or most frequently at the front of the great trochanter; hectic fever is thus established, and anemia and emaciation become more marked. The ligaments are softened and weakened, the limb flexed, adducted, and inverted, the pelvis elevated on the diseased side, and the lumbar spine convex towards the sound side. Hence the limb appears shortened (Fig. 242–D); later, owing to erosion of bone or in some cases to dislocation backwards, real shortening becomes evident. Ankylosis and recovery are possible at any period; death occurs from tuberculosis elsewhere, or in the late stages from septicemia, exhaustion, or amyloid disease.

The **diagnosis** may be very difficult in the early stages. The patient should always be stripped and both sides carefully examined. Pain in the knee, especially in a child, always indicates a careful examination of the hip. Spinal disease, sacroiliac disease, infantile paralysis, and other conditions not immediately connected with the joint are not associated with restricted motions of the hip. In inflammation of the iliopsoas bursa there may be pain on extending the hip, but after flexion the thigh may be rotated without discomfort. In gluteal bursitis there may be limp and restriction of motion, but not the characteristic deformity of hip disease; in some cases fluctuation or crepitus may be obtained over the bursa. In flexion of the thigh due to intra-abdominal disease, the movements of the hip are free. Any form of joint disease may occur in the hip, and if the synovial cavity is distended there will be flexion, abduction, and eversion. Chronic inflammation of the hip in childhood should, however, always be regarded as tuberculous unless proved otherwise. The X-ray is of value in differentiating from *dislocation* and in determining the presence and extent of bone disease. The *prognosis* is favorable if the diagnosis is made early and the proper treatment instituted. In the later stages recovery will always be associated with shortening and ankylosis.

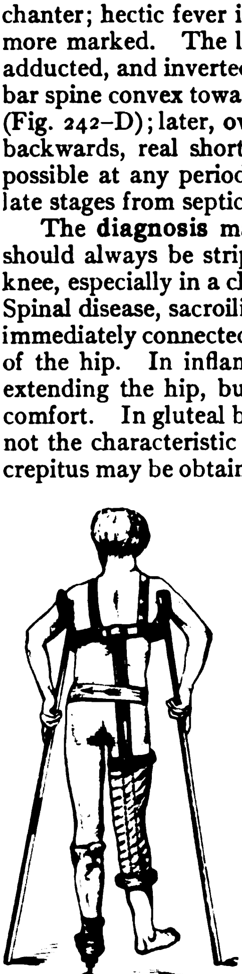
FIG. 243.—Thomas hip splint. Patten on sound limb.

The **treatment** in the early stages is rest in bed, and traction by Buck's extension apparatus to overcome muscular spasm and prevent deformity. If flexion is marked, extension should be at first in the axis of deformity, and as the muscular spasm diminishes, it may be gradually lowered to a horizontal position. Young children who are difficult to keep still should be strapped to a Bradford frame. The proper weight for traction will vary between one and six pounds or more, according to the age and the effects of the extension. The constitutional treatment is that of tuberculosis (q.v.). When the deformity has been corrected and pain has subsided, a brace may be applied and the patient allowed to get about on crutches. Of the many mechanical appliances which have been used, the Thomas hip-splint (Fig. 243) or one of its modifications is the most useful. A patten or thick soled shoe is worn on the foot of the sound side, and the patient walks with crutches, the affected limb hanging some distance away from the ground, thus acting as an extension weight. In the presence of deformity the brace may be bent to accomodate itself to the altered position of the limb. Some surgeons apply plaster-of-Paris to the limb and pelvis. Traction splints are those which may be lengthened by a sliding rod or movable foot piece, counterextension being supplied by perineal bands. A brace should be worn for six months after all symptoms have disappeared. Intraarticular injections of iodoform or other antiseptics are occasionally used. Abscesses should be tapped with trocar and cannula and injected with iodoform emulsion. Sinuses may be injected with Beck's paste, but if they persist or recur they should be explored, and necrotic or carious bone removed by erasion. Formal resection of the hip results in immediate shortening, and in children interferes with the growth of the femur, so that it should not be performed unless the disease progresses despite other means of treatment. If excision fails, or if there is an extensive osteomyelitis of the femur, amputation will be required.

The **knee,** with the possible exception of the hip, is more frequently attacked by tuberculosis than any other joint. The term *white swelling* when used alone means tuberculosis of the knee. In children the disease usually begins in the lower end of the femur, in adults in the synovial membrane. The symptoms are those of joint tuberculosis in general. Flexion is present, and in the later stages backward dislocation of the tibia often occurs. The *treatment* is immobilization with plaster-of-Paris or a traction knee splint (Fig. 244). Other conservative methods also may be employed. If the progress of the disease is not checked by these measures, or if the case is seen in a late stage, erasion or excision will be indicated. Amputation should be reserved for cases in which the disease is very extensive, or in which excision has failed.

FIG. 244.—Thomas knee splint. The metal plate is several inches below the foot. A patten is worn on the sound foot, and the apparatus is suspended by the strap over the opposite shoulder.

Ankle joint disease begins most frequently in the synovial membrane, next in the astragalus; it may, however, commence in the tibia or fibula, or be secondary to disease of the tarsus or tendon sheaths. The usual symptoms of joint tuberculosis are present; the foot is extended, as in this position the narrowest part of the articulating surface of the astragalus is between the tibia and fibula. Antero-posterior movements are markedly limited, but inversion and eversion of the foot may be made if the subastragaloid and mid-tarsal joints are free of disease. The *treatment* is immobilization in plaster-of-Paris with the foot at a right angle to the leg. Other forms of conserative treatment also are of service. In the presence of sinuses or disorganization of the joint erasion or excision should be performed. The disease is apt to invade other tarsal bones besides the astragalus and to extend into the surrounding soft tissues; in these cases amputation will be the operation of choice.

Rheumatic arthritis, when *acute*, is characterized by fever, acid and sour smelling sweats, concentrated highly acid urine, and by the successive involvement of a number of joints; and it is often complicated by sore throat, pericarditis, endocarditis, or pleurisy. The history of previous attacks is often obtained. There is nothing characteristic in the local symptoms to distinguish it from infective arthritis, indeed, many believe it to be infective in origin, and even incision and irrigation of the joints have been recommended. For a full consideration of this subject the reader is referred to a book on practice of medicine, it being necessary in this place only to caution against a too ready diagnosis of rheumatism without a careful investigation, particularly if but one joint is involved.

In the *chronic* variety the history, the involvement of several joints, the presence of cardiac lesions, and the detection of rheumatic nodules on tendons or fascia, or about joints, will usually lead to a correct diagnosis. The synovial membranes and the ligaments are thickened and sometimes the cartilages eroded; grating, or crepitus, may be felt on moving the joint, and ankylosis occasionally occurs.

Gouty arthritis is characterized by sudden severe pain, which often comes on during the night and attacks the smaller joints, particularly that between the great toe and its metatarsal bone. The articulation is swollen, the skin red, shiny, and edematous, and there is moderate fever. A history of previous attacks may be elicited, and other evidences of gout, e.g., *tophi* (chalky deposits in or around the joint), dyspepsia, and atheroma may be present. For the treatment the reader is referred to a book on internal medicine.

Osteoarthritis (*rheumatoid arthritis, arthritis deformans, rheumatic gout, malum senile*) is a chronic disease of joints associated with great deformity. The cause is not known. Some believe it to be of nervous origin because of the accompanying trophic lesions, others that it is due to microorganisms because, in about half the cases, it is preceded by some infectious disease. It is more common in women, and is sometimes associated with disease of the uterus or ovaries. Traumatism is often a factor in monarticular cases; the disease is not very uncommon in the old after a Colles' fracture, or after a fracture of the neck of the femur. It may occur at any period of life, but is most frequent after middle age. The cartilages become eroded and the ends of the bones exposed, the synovial membrane and the ligaments are markedly thickened, and exostoses, or osteophytes, form about the joint, leading to ankylosis and great deformity. Partial dislocation may occur.

FIG. 245.—Osteoarthritis of elbow; note osteophytes and enormous lips on the ends of the bones. (Moullin.)

The disease begins in several ways: 1. *Heberden's nodes* are little hard knobs developing on the dorsal surfaces of the second and third phalanges, subsequently to recurring attacks of inflammation in the interphalangeal joints, which finally become ankylosed. They are most common in neurotic women between the ages of thirty and forty, and are incurable. 2. *General progressive osteoarthritis* begins as an acute process somewhat resembling rheumatism, or more commonly in a chronic manner. In the latter variety the joints of the hands usually swell and become tender, and with the subsidence of inflammation they creak, becoming more and more deformed with each succeeding attack. Gradually other joints are involved, until in the worst cases practically every articulation in the body may be affected. The muscles atrophy and by their contractures further increase the deformity. The progress of the disease is very slow, and although no remedy is known, it may be spontaneously arrested at any stage. 3. The *monarticular form* is the only one which concerns the surgeon. It occurs chiefly in old men subsequently to injury. In the hip it is known as *morbus coxæ senilis*, in the spine as *spondylitis deformans; spondylosis rhizomelique*, or ankylosis of the spine, hips, and shoulders is a form of osteoarthritis. In the early stage there are pain, stiffness, and perhaps a little swelling and creaking in the joint. Later motion is less free, bony crepitus becomes evident, neighboring muscles atrophy, osteophytes form, and finally ankylosis occurs. Occasionally, however, the joint becomes loose and the bones displaced. The *diagnosis* is made by the chronic nature of the affection, the absence of suppuration, the deformity (lipping of the ends of the bones and osteophytes—Fig. 245) crepitus, the frequent history of injury, and the advanced age of the patient. The *prognosis* is unfavorable.

The *treatment* is unsatisfactory. The general health should be improved, colds and draughts avoided, and perhaps iodid of sodium or arsenic administered. In view of the possible bacterial origin of the disease, the whole body should be reviewed for sources of infection, not forgetting the nose, accessory sinuses, ear, teeth, tonsils, rectum, colon, and genitourinary organs. When the joints are swollen and tender they should be treated like synovitis. During the quiescent period, the hot-air apparatus, stimulating liniments, massage, and passive motions are useful, as they hinder the development of ankylosis. When the disease is limited to one joint, e.g., the temporomaxillary, shoulder, elbow, or knee, excision or arthroplasty may be performed if the function of the articulation is seriously disturbed.

Neuropathic arthritis resembles osteoarthritis, and is the result of disease or injury of the central or peripheral nervous system. That form occurring in locomotor ataxia is called *Charcot's disease*. The joints of the lower extremity, particularly the knee, are most frequently affected. As the result of a slight injury, or often without such history, the joint rapidly and painlessly swells, and in even a few hours may be dislocated, or so freely movable that it can be bent in any direction. The disease may, however, run a chronic course and end in ankylosis. A somewhat similar joint affection occurs in syringomyelia, but the joints involved are usually those of the upper extremity, and suppuration is more frequent than in Charcot's disease. Every painless osteoarthritis should rouse a strong suspicion of syringomyelia or tabes dorsalis.

The **treatment** of neuropathic arthritis includes that of the causative disease. In some forms massage and passive motions are indicated, but in Charcot's disease, if there is a tendency towards ankylosis, it should be encouraged. As this is seldom the case some form of support will usually be required. Resection has been performed, but is not generally regarded with favor. If suppuration or extensive disorganization occurs, amputation is the best treatment.

Neuralgia of joints usually depends upon some local or constitutional cause, although cases occur in which neither of these can be found. After injury loose bodies, adhesions, or small areas of inflammation may be responsible. It may be due to disease of the central or peripheral nervous system, or be reflex from disease or injury of nerve fibers coming from the same trunk that supplies the joint, and it may be associated with gout, rheumatism, syphilis, malaria, neurasthenia, or hysteria. Like neuralgia elsewhere, the pain is paroxysmal. The *treatment* is that of the causative lesion, if such can be found; other cases are treated as neuralgia elsewhere.

Hysterical joint (*neuromimesis*) is characterized by pain and tenderness, hyperesthesia or anesthesia of the overlying skin, rigidity of the joint, muscular atrophy from disuse, and absence of local heat and swelling, unless these be present from the use of irritating applications. The condition is most frequent in the knee and hip, usually of young women. Some cases follow injury, others arise spontaneously. The *diagnosis* is made by carefully excluding all organic disease, and by finding associated symptoms of hysteria. The joint may be fixed in a position contrary to that usually assumed in disease, and be freely movable under light anesthesia or when the patient's attention is diverted. The position of the limb may vary, sometimes quite suddenly. The *treatment* is that of hysteria. Electricity, massage, and passive motions are useful, but may do harm by concentrating the patient's attention upon the joint.

Hemarthrosis (effusion of blood into a joint), apart from injury, may be due to a number of causes (see spontaneous hemorrhage). In hemophilia, following a slight injury or sometimes spontaneously, a joint becomes distended with blood, which may gradually be absorbed, leaving the joint again normal, or become organized and lead to adhesions and obliteration of the joint. The history is the most important factor in diagnosis. The *treatment* is immobilization and compression. Massage and passive motion may be used with caution in the later stages. Under no circumstances should the joint be aspirated or opened, as such treatment might be followed by uncontrollable hemorrhage.

Loose bodies in joints (*joint mice*) consist of fibrin, fatty tissue, fibrous tissue, cartilage, or bone. Those made of fibrin are usually small and numerous, and are best seen in tuberculosis of joints, bursæ, or tendon sheaths (*rice bodies*). Occasionally they are due to other causes, e.g., a small foreign body, blood clot, or detached synovial villus, around which the fibrin collects. Such loose bodies frequently become fibrous. Bodies which are at first pedunculated and afterwards become loose by rupture of the pedicle, may be fatty (in lipoma arborescens), fibrous, cartilaginous, or bony, according to the tissue from which they spring; they may be also neoplasms, or result from hypertrophy of synovial villi, desiccation of cartilage, or detachment of osteophytes in chronic arthritis. The most frequent cause, however, is injury, a portion of bone, or more frequently cartilage, being detached from the articular surface, usually the internal condyle of the knee, which is the joint generally affected. Though even completely detached, these bodies may continue to grow, being nourished by the synovial fluid.

The **symptoms** are severe pain and temporary locking of the joint, followed by subacute synovitis, and caused by the loose body lodging between the ends of the bones or in a synovial recess. These attacks recur from time to time, and owing to repeated distention, the ligaments may become relaxed and the joint weakened. Loose bodies may sometimes be palpated, but are very elusive, hence the name joint mice. If bony in nature they may be detected by the X-ray. The symptoms closely resemble those of a dislocated semilunar cartilage, but in loose bodies the locking of the joint is usually of brief duration, and there is no marked tenderness over the site of the semilunar cartilage.

The **treatment** is removal by a small incision directly over the loose body, which should be held, whenever possible, by the fingers of the other hand, or, better, transfixed by a needle before the patient is anesthetized, otherwise the body may elude even the most careful search after the joint is opened. Some surgeons employ a local anesthetic, thus enabling the patient to bring the loose body to the surface, in case it escapes the operator. The joint should be explored for other loose bodies, closed with sutures, and immobilized for a week or two.

Ankylosis is rigidity or immobility of a joint. It may be true or false.

In *true*, or *intraarticular ankylosis*, the joint surfaces are united by fibrous tissue, cartilage, or bone. *Fibrous ankylosis* is usually incomplete, unless the entire joint is obliterated by short bands of strong fibrous tissue; the latter may be differentiated from bony ankylosis by the X-ray, by pain on attempts to move the joint, and by subsequent signs of inflammation, if these attempts have been very forcible. *Cartilaginous* or *bony ankylosis* is complete (no motion), except in some cases of ossification of the periarticular structures, and in some cases caused by the interlocking of osteophytes in osteoarthritis. The *causes* of true ankylosis are the various forms of synovitis and arthritis. It may be caused also by an unreduced dislocation or fracture, or by disease, e.g., caries, which alters the shape of the ends of the bones so that they no longer fit each other (*ankylosis of deformity*). Simple immobilization of the large joints without inflammation does not lead to ankylosis, although if prolonged it may cause stiffness owing to the atrophy of the periarticular structures. The *effects* of ankylosis vary with its degree, the angle of fixation (a straight knee and an elbow bent to a right angle are much more useful than a bent knee and a straight elbow), the joint affected (e.g., in the shoulder ankylosis is compensated for by movements of the clavicle and scapula), and the amount of atrophy of the bones and soft parts; in children there may be stunting of the growth of a limb.

The **treatment** is prophylactic and curative. The prophylactic treatment consists in limiting effusions or inflammatory exudates, which by organization cause ankylosis; and in preventing the union of synovial surfaces by early passive movements. If ankylosis is inevitable the joint should be placed in a position which will be of most service to the patient. In *incomplete ankylosis* due to limited synovial adhesions, *daily attempts to move the joint*, without causing intolerable pain, will stretch or break the adhesions and result in cure. If the adhesions are more extensive, the joint may be forcibly moved while the patient is under a general anesthetic. This treatment causes a recurrence of the inflammation, and the joint must be immobilized until it has subsided, when massage and passive motions are begun. In long standing cases *forcibly breaking adhesions* under an anesthetic occasionally results in fracture of atrophied bone, fat embolism, or tearing of shortened blood vessels, nerves, skin, or other soft tissues. It should not be attempted after the subsidence of a tuberculous arthritis for fear of recurrence. Other cases of ankylosis which should be left alone are those occurring in patients (the old, feeble, etc.) whose general condition forbids operation or painful manipulations, particularly when the joint is in a useful position. Electricity and massage are beneficial in maintaining nutrition and preventing atrophy of muscles. If the adhesions are very extensive, forcibly breaking them under an anesthetic will be followed by so much inflammatory reaction that they will reform before passive motions can be started. In these cases as well as in *complete ankylosis*, recovery can be secured only by operation, which always should be undertaken if the joint be fixed at a vicious angle. *Osteotomy* has been employed, chiefly in ankylosis of the hip and knee, to straighten a limb that is fixed at an inconvenient angle. In ankylosis of the hip the femur is cut through the neck or immediately below the trochanter, after making an incision from just below the anterior superior spine vertically downwards for three or more inches. *Adams' subcutaneous osteotomy* of the neck of the femur is performed by introducing a knife midway between the trochanter and the anterior superior spine of the ilium, and pushing it inwards until it reaches the neck of the bone. An Adams' saw (Fig. 246) is then introduced and the neck of the bone divided. The limb is straightened and the bone reunites. In ankylosis of the knee the bone is divided above the joint in much the same way as for genu valgum. *Excision* may be performed, e.g., at the elbow, to obtain a movable joint, or, e.g., at the knee when it is bent, to place the limb although still rigid in a more useful position. *Arthrolysis* is exposure of the joint by an incision suitable for resection, and division or removal of all

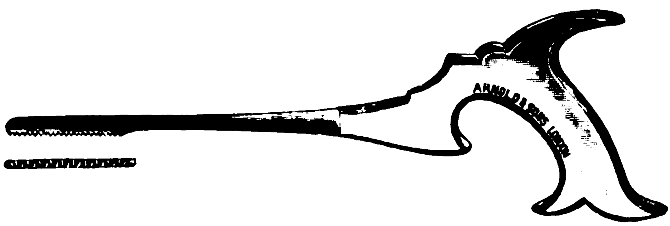

FIG. 246.—Adams' osteotomy saw.

adhesions, bony prominences, etc., which interfere with movement. After operations of this character the joint may be filled with sterile olive oil or liquid vaseline to prevent the reformation of adhesions. Nonabsorbable foreign bodies, such as silver, zinc, celluloid, rubber, etc., have been placed between the ends of the bones to maintain mobility, but are almost uniformly unsuccessful, in that the foreign substance is usually discharged and the ankylosis recurs. Absorbable substances, e.g., magnesium, Cargile membrane, chromicized pig's bladder, decalcified bone, are objectionable because they are absorbed, thus permitting the osseous surfaces again to come in contact. Fortunately nonforeign and nonabsorbable material (cartilage, muscle, fascia) can always be obtained from the patient. At the present time the best prospects for a new and movable joint (nearthrosis) seem to be offered by *arthroplasty*, which, thanks to the activity of Huguier, Murphy, and others, has been developed to an advanced degree of perfection. The operation proceeds as in arthrolysis, but the ends of the bones are removed or pared down, and new articular surfaces fashioned after the pattern of a normal joint (Figs. 247, 248). A pedunculated flap of fat and fascia from the neighborhood of the joint, or a free transplant of the same material from a distance (e.g., from the fascia lata to the elbow) is then fixed with catgut sutures between the bony surfaces. Lexer has resected the knee and successfully transplanted to its place the knee-joint of a recently amputated limb. Buchmann transplanted the first metatarso-phalangeal joint to the elbow and obtained a good result. Weglowski secured a movable elbow by the interposition of the outer surfaces of the sixth and seventh costal cartilages.

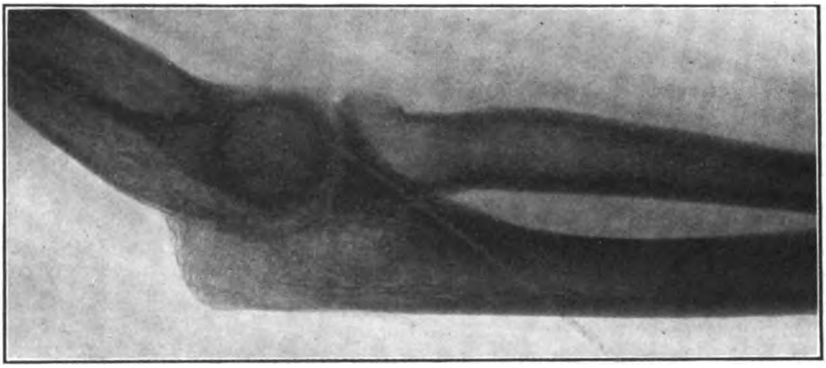

Fig. 247.—Complete ankylosis of the elbow.

Fig. 248.—Same as Fig. 247, after arthroplasty, with the interposition of a free transplant of fascia lata.

False ankylosis is caused by extraarticular lesions, such as cicatrices, shortening of muscles, adhesions of tendons, and contraction of fascia; it may be bony as the result of ossification of periarticular inflammatotry fibrous tissue or of muscles (myositis ossificans). False ankylosis is treated according to the cause; it may require excision of a cicatrix; tenotomy or tenoplasty; myotomy or myoplasty; removal of areas of ossification, etc. It should be recalled that any of these operations may be needed to assist also in the cure of a true ankylosis.

Arthrodesis is just the opposite of arthrolysis, i.e., the surgeon attempts to sécure ankylosis in a flail joint, such as may follow paralysis. The joint is opened, either arthectomy or excision performed, and the bones fastened together with wire or nails. In performing arthrodesis of the ankle Lexer advises boring a hole up through the os calcis, astragalus, and lower end of the tibia, and driving into this hole an autoplastic bone graft.

In **erasion, or arthrectomy,** the joint is opened by an incision suitable for resection, and the diseased tissues (usually tuberculous) alone removed by scissors and forceps, or by curette. When applicable, erasion is to be preferred to resection, since it causes neither immediate shortening nor subsequent interference with the growth of the limb.

EXCISION OF JOINTS.

Excision, or resection, of a joint, i.e., of the articulating ends of the bones with the cartilages and synovial membrane, is performed to remove an articulation destroyed by injury or disease (usually tuberculosis), thus avoiding amputation, or to render a limb more useful, e.g., in irreducible luxations or other forms of ankylosis. There is, of course, immediate shortening of the limb, and in youth, if an entire epiphysis is removed, interference with sub sequent growth, hence resection of joints, especially those of the lower extremity, in which the greatest growth takes place and in which shortening causes the greatest inconvenience, should be avoided whenever possible. There are two general methods of excision. The *subperiosteal*, or conservative, in which the periosteum, joint capsule, and attached ligaments and ten dons are saved, is the ideal operation, as bone may be reformed from the periosteum, and movements of the joint preserved by the muscular attachments. It is rarely applicable, however, because these structures are usually involved, and in certain joints, notably the elbow, new bone might interfere with free motion. In the *radical* method the periosteum is sacrificed. The incisions should be so made as to enter the joint by the shortest way with a minimum amount of injury to the surrounding tissues. Drainage with gauze or a rubber tube is almost invariably required.

The **shoulder joint** may be excised through an anterior oblique incision, three or four inches in length, extending from the coracoid process downward and outward along the anterior border of the deltoid muscle, the patient being supine, close to the edge of the table, and the shoulders raised. The pectorodeltoid groove is opened, the cephalic vein and the pectoral muscles retracted inward and the deltoid outward, thus uncovering the biceps tendon, to the outer side of which the capsule of the joint is incised. After depressing the elbow and rotating the humerus inward, the supra- and infra-spinatus and teres minor are separated from the greater tuberosity, and the subscapularis from the lesser tuberosity after rotating the bone outward. Flexing the elbow relaxes the tendon of the biceps, which is then displaced inward, and the head of the bone delivered through the wound and divided with a saw. If the glenoid cavity is involved, the diseased bone is removed with a curette, or as a sequestrum. The arm is bound to the chest over an axillary pad, to prevent displacement of the end of the humerus under the coracoid. Passive motions are begun as soon as the stitches have been removed.

The **elbow joint** (Fig. 558) may be resected through a posterior median incision (Langenbeck), about four inches in length, with the tip of the olecranon process at its middle, the arm lying across the patient's body. The periosteum and the inner half of the triceps tendon are separated from the ulna and olecranon and pushed inwards with the ulnar nerve, then the internal lateral ligament and the common origin of the flexor muscles separated from the inner condyle. The periosteum, outer half of the triceps tendon, anconeus, external lateral ligament, extensors of the forearm, and supinator brevis are next scraped from the bone on the outer side, and, after flexing the forearm, the ends of the bones delivered through the wound and removed with a saw. The forearm is placed on an internal angular splint for a week or ten days, after which daily passive motions are made.

Of all excisions that of the **wrist joint** is the least satisfactory. The operation is difficult and tedious, and so much of the bony structures usually have to be removed that the hand is often useless afterwards. The simplest method is that of Langenbeck. A straight dorsal incision is made from the middle of the metacarpal bone of the index finger to the middle of, and three-fourths of an inch above, the lower extremity of the radius. The incision passes along the radial side of the tendon of the extensor indicis. The tendons of the index finger are retracted to the ulnar side and the lower border of the annular ligament divided. The fibrous sheaths of the extensor tendons, the insertion of the supinator longus, the annular and capsular ligaments, and the periosteum are separated from the end of the radius, and the tendons, ligaments, and periosteum from the ulna. Flexing the hand opens the radio-carpal joint and facilitates excision of the first row of carpal bones. It may be necessary to remove those of the second row and even the bases of the metacarpal bones. The lower ends of the radius and ulna are next delivered and divided with a saw. If the tendons of the extensor radialis longior and brevior are in the way, they may be divided and later sutured. A straight splint is applied with the forearm midway between pronation and supination. The fingers should be flexed and extended daily, beginning on the second or third day, but the wrist should remain fixed until healing is complete; indeed in some cases a flail joint results and a permanent support is needed.

The **hip joint** may be entered from three aspects, anteriorly through the straight incision of Barker, laterally through a curved (White) or straight (Langenbeck) incision, and posteriorly through the angular incision of Kocher. With the anterior incision no muscular structures are divided and very little damage is done to the surrounding tissues, but the joint is poorly exposed at the bottom of a deep wound which is not well situated for subsequent drainage. The lateral and posterior incisions necessitate the cutting of muscles and inflict greater damage on the tissues, but they render the joint more accessible and facilitate drainage. The *anterior incision* extends from one-half inch below the anterior superior spine of the ilium downward and slightly inward for three or four inches. The joint is exposed by retracting the tensor vaginæ femoris and glutei outwards, the sartorius and rectus inwards. Branches of the circumflex artery are encountered and ligated. The joint capsule, cotyloid ligament, and periosteum of the femur are incised in the line of the wound, and as air enters the joint, the articulating surfaces of the bones may be separated and the ligamentum teres cut. The periosteum with the attached muscles is then separated from the greater tuberosity, and the bone cut with an Adams' or a chain saw, or with a chisel. The line of division may be above or below the greater trochanter. The acetabulum is curetted, and if drainage be necessary, a counteropening made posteriorly.

Langenbeck's external incision extends from a point three inches above the upper border of the great trochanter down over that prominence for four or five inches in the long axis of the femur, the patient lying upon the sound side with the thigh flexed at an angle of forty-five degrees. The skin and fascia are divided and the fibers of the gluteus maximus separated, thus exposing the gluteus medius and pyriformis, which are separated with retractors. The capsule of the joint and periosteum over the greater trochanter are then incised in the line of the wound, an additional transverse incision being made if necessary, and the periosteum and muscles elevated. After cutting the cotyloid and round ligaments, the thigh is adducted and rotated outward, thus forcing the head of the bone through the wound. The bone is usually divided below the great trochanter, as its removal, if the periosteum and muscles are intact, does not interfere with subsequent motion; if permitted to remain it interferes with drainage and may become diseased. A Buck's extension is applied to the leg, which is supported laterally by sand bags. The cavity becomes filled with fibrous tissue which permits limited motion.

In the **knee joint** (Fig. 572) fixation and not motion is desired after resection. An anterior semilunar incision is made from the posterior and upper border of one condyle to the other, the convexity closely approaching the insertion of the ligamentum patellæ. After flexing the leg to a right angle, the superficial tissues, ligamentum patellæ, and the anterior, lateral, capsular, and crucial ligaments are divided in turn. Carefully protecting the popliteal structures, the condyles of the femur are freed, then cut in a plane at right angles to the long axis of the bone. The head of the tibia is similarly exposed by retraction of the tissues, pushed forward, and the articulating surface shaved off. The patella and all of the infected synovial membrane and bursæ are then removed, and a rubber tube placed behind the bones, to emerge at each angle of the wound. The bones may be fixed together with a bone graft, wire, nails, by suturing the ligaments, or merely by a fixed dressing (see Fig. 54). The splint or plaster cast should be worn for at least eight weeks.

The **ankle joint** is seldom resected, as a modern artificial leg gives a more useful limb than the ankylosed and fixed joint usually following excision. In the Langenbeck operation a hook-shaped incision is first made around the lower end of the fibula; starting three inches above the tip it follows the posterior border, curves around the external malleolus, and passes upward on the anterior border for one inch. The periosteum and overlying tissues are separated from the bone, which is divided at the upper end of the wound and drawn outward, when the ligaments attached to the lower end are cut. A second incision, one and one-half inches in length, curves around the internal malleolus, and this is joined by a vertical cut, two inches long, made in the median line of the tibia (anchor-shaped incision). The bone is freed and removed as on the outer side. A part or the whole of the astragalus may be removed through either wound, preferably the inner. Another method is to make a transverse incision across the front of the joint connecting both malleoli. The tendons and anterior tibial nerve are sutured at the completion of the operation. A fenestrated plaster cast is applied with the foot at a right angle with the leg.

CHAPTER XXI.

HEAD.

THE SCALP.

Contusions of the scalp require special mention only because of the danger of associated injury to the brain, for the symptoms of which a careful examination should always be made. They cause an effusion of blood into the tissues which may amount to a hematoma. In new-born children the effusion due to pressure around the presenting part is called *caput succedaneum*. **Hematoma** may be (1) subcutaneous, (2) subaponeurotic, (3) subpericranial. (1) *Subcutaneous hematoma*, i.e., in the cellular tissue between the skin and the aponeurosis of the occipitofrontalis, is the result of a direct injury, and is small, sharply localized, movable, and often associated with ecchymosis. (2) *Subaponeurotic hematoma*, i.e., in the loose tissue between the occipitofrontalis and the pericranium, may be caused by a glancing blow which slides the scalp beyond its normal range of movability, or by a direct injury, in which event the bleeding usually proceeds from a fracture of the skull. It appears as a large fluctuating swelling, often reaching from the eyes to the occiput. (3) *Subpericranial hematoma* (*cephalhematoma*) is due to tearing of the vessels running from the pericranium to the bone, as the result of slipping of the pericranium on the skull during birth, or as the result of a glancing blow in childhood. It probably never occurs in adults, in whom the pericranium is much less vascular, because growth is finished, and in whom the scalp is much less movable. The swelling covers a part or the whole of one bone, usually the parietal, but does not extend beyond the margins of the bone, owing to the attachments of the pericranium at the sutures. It is not associated with ecchymosis, and is immovable, soft in the center, and, owing to a deposition of fibrin, hard at the margin, hence may be mistaken for a fracture of the skull. The margin, however, is regular, pits on pressure (sometimes with moist crepitation), and is above the contour of the head. In late cases deception is still more easy, as the edges may ossify and slope upwards so gradually that one cannot be sure whether they are above the normal contour of the skull or not. In one of our cases there was parchment crepitation on palpating the elevated periosteum. Here must be mentioned also the possibility of mistaking a cephalhematoma for a spurious meningocele (*vide infra*). A skiagram may, of course, demonstrate a fracture, but if it is negative and one is still in doubt, particularly if there are symptoms of intracranial mischief, the parts should be incised and carefully explored. The *treatment* of contusions and hematomata of the scalp is that of similar lesions in other parts of the body.

Wounds of the scalp always require a careful examination for fracture of the skull or, in the absence of this, for signs of concussion or intracranial hemorrhage. It should be recalled also that laceration of the scalp may have been the result of a fall caused by a serious constitutional disease or the taking of a poison. If the wound is too small for exploration and there are any suspicious symptoms, it should be enlarged. A slit in the pericranium may feel like a fracture, but all doubt is dispelled by careful inspection. A suture will not be taken for a fracture if one recalls the situation of the suture and observes that it does not bleed. In the temporal region a wound of the fascia may resemble a fracture, but the supposed cerebral tissue (temporal muscle) will harden when the patient shuts his jaw. A superficial scalp wound, even if infected, is rarely a serious matter; if, however, the loose subaponeurotic tissue has been opened and infected, suppuration may spread to the attachments of this structure, i.e., to the eyebrows, zygoma, and superior curved line of the occipital bone. A flap of scalp, even of the largest size, retains its vitality owing to the fact that the vessels run in the scalp and do not come from the subjacent structures. The *treatment* is that of wounds elsewhere.

Traumatic or spurious meningocele is a collection of cerebrospinal fluid beneath the scalp following a fracture, usually in a child. It pulsates, has an impulse on coughing, and may be reducible. The *treatment* is the same as that of meningocele.

Abscess of the scalp may be due to infection from the exterior or to disease of the cranial bones. Suppuration is limited in the same way as extravasation in hematoma. In the subaponeurotic form the abscess is bounded only by the attachments of the aponeurosis of the occipito frontalis. In these cases the constitutional symptoms are severe and the infection may spread to the intracranial structures. Incision should be made above the zygoma on each side, above the superior curved line of the occipital bone behind, and, if necessary, above the brows in front.

Tumors (using the term in its broadest sense) springing from the scalp or the subjacent structures are pulsating or non-pulsating. The *pulsating tumors* include ordinary aneurysm, arteriovenous aneurysm, arterial varix, angioma, circoid aneurysm, sarcoma (of bone or meninges), meningocele (true and spurious), encephalocele, hydrencephalocele, hernia cerebri, and other tumors if situated over an open fontanelle. Among the *non-pulsating tumors* are papilloma (wart), horns, moles, epithelioma, fibroma (when diffuse and involving a large part of the scalp it is known as pachydermatocele), sarcoma, sebaceous cyst, dermoid cyst, subaponeurotic lipoma, gumma, syphilitic nodes, exostosis, and pneumatocele. The *congenital tumors* are hematoma, angioma, meningocele, encephalocele, hydrencephalocele, and dermoid cyst. The last is usually situated at the outer canthus of the eye or root of the nose, and sometimes communicates with the interior of the skull through a congenital opening in the bone, hence may be mistaken for a meningocele. Most of these affections have already been described, the rest will be described below.

Craniocerebral Topography and Cerebral Localization.—Fig. 249 shows Broca's points marked on the skull. The *longitudinal fissure*, containing the longitudinal sinus, underlies a line drawn from the glabella to the inion and passing along the sagittal suture. The *fissure of Bichat* separates the cerebrum from the cerebellum, contains the lateral sinus, and is indicated by a line drawn from the inion to the external auditory meatus. The *fissure* *of Sylvius* runs from a point one and a quarter inches behind the external angular process of the frontal bone and the same distance above the zygoma to a point three-fourths of an inch below the most prominent part of the parietal eminence. The main fissure corresponds to the first three-fourths of an inch of this line, and the horizontal limb to the remaining portion, the ascending limb passing upwards, parallel to the coronal suture, for one inch from the junction of the main fissure and the horizontal limb. The *fissure of Rolando* extends from one-half inch behind the midpoint between the glabella and the inion, downward and forwards for three and three-eighths inches, at

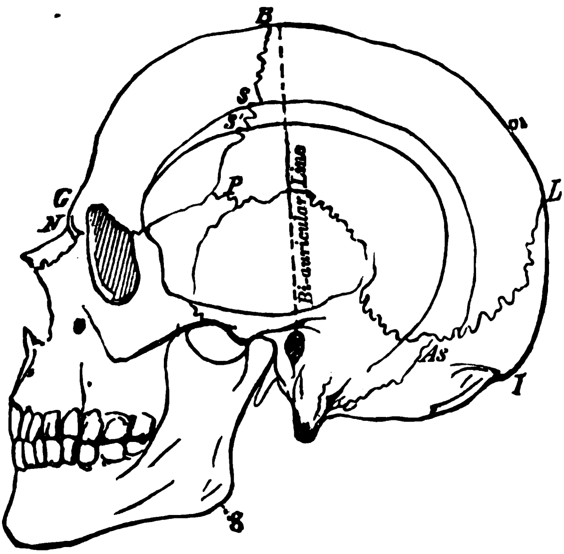

FIG. 249.—Skull showing the points named by Broca. *As*, asterion (junction of the occipital, parietal, and temporal bones); Basion, middle of anterior wall of foramen magnum; *B*, bregma (junction of the sagittal and coronal sutures); *G*, ophryon (on a level with the superior border of the eyebrows, and corresponding nearly to the glabella, the smooth swelling between the eyebrows); *g*, gonion (angle of the lower jaw); *I*, inion (external occipital protuberance); *L*, lambda (junction of sagittal and lambdoidal sutures); *N*, nasion (junction of the nasal and frontal); *Ob*, obelion (the sagittal suture between the parietal foramina); *P*, pterion (point of junction of great wing of sphenoid and the frontal, parietal, and squamous bones. This may be H-shaped or K-shaped, or "retourné," in which the frontal and temporal just touch); S, stephanion (or, better, the superior stephanion, intersection of ridge for temporal fascia and coronal suture); *S'*, inferior stephanion (intersection of ridge for temporal muscle and coronal suture). (American Text-book of Surgery.)

an angle of 67½ degrees. This angle may be found by taking a square piece of paper and folding one corner back on the line A C (Fig. 250), i.e., from the middle of the side D B to the corner A. The side E A is then placed in the middle line of the head, and the line A C corresponds to the fissure of Rolando, the angle E A C being 67½ degrees. Horsley's cyrtometer (Fig. 251) is an instrument for marking out the fissure of Rolando. The *precentral* or *vertical sulcus* (Fig. 252) lies just behind and parallel to the coronal suture, or one convolution (roughly one finger's breadth) in front of the fissure of Rolando.

The *intraparietal sulcus* begins one convolution behind the junction of the middle and lower thirds of the fissure of Rolando, passes upward midway between the Rolandic fissure and the parietal eminence, then curves backwards between the longitudinal fissure and the parietal eminence into the occipital lobe. The *supramarginal convolution* lies behind the intraparietal fissure and curves over the extremity of the fissure of Sylvius, uniting posteriorly with the *angular convolution*, which arches over the extremity of the superior temporal fissure (Fig. 254).

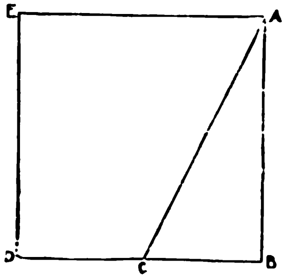

FIG. 250.

Kronlein's method (Fig. 253) of craniocerebral topography is as follows: A horizontal line, A B, is drawn through the lower margin of the orbit and upper margin of the external auditory meatus. Above and parallel with this is a second line, C D, on a level with the upper margin of the orbit. Three vertical lines are now drawn, the first passing through the middle of the zygoma, E F, the second, G H, through the condyle of the lower jaw, and the third, T J, through the posterior margin of the mastoid process. A line drawn from K to J corresponds between L and J to the fissure of Rolando. The line K M, which bisects the angle J K N, corresponds to the horizontal limb of the fissure of Sylvius. If this line is continued backwards to the middle line of the head (O) it indicates approximately the situation of the

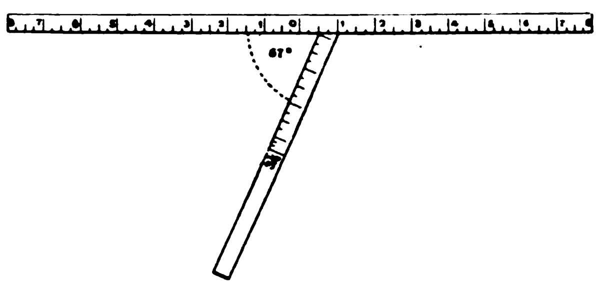

FIG. 251.—Horsley's cyrtometer.

parietooccipital fissure. K and N are the points to trephine for the anterior and posterior branches of the middle meningeal artery.

It should be recalled that the cerebral centers exhibit exaltation or abolition of function according to the degree of disease or injury; thus there may be mania or coma, spasm or paralysis, hyperesthesia or anesthesia, if the intellectual, motor, or sensory centers respectively are involved.

The motor area (Figs. 254, 255) occupies the ascending frontal convolution (which lies just in front of the fissure of Rolando) and extends to the mesial surface of the brain. On the cortex the leg center occupies the upper third, the arm center the middle third, the face center the lower third; on the median surface from before backward are the centers for the head, trunk, and leg. The motor area presides over the muscles of the opposite side of the body. A lesion in a motor center causes localized convulsions followed by paralysis (monoplegia); paralysis without preceding spasm occurs in subcortical lesions. Lesions of the internal capsule cause hemiplegia without convulsions; of

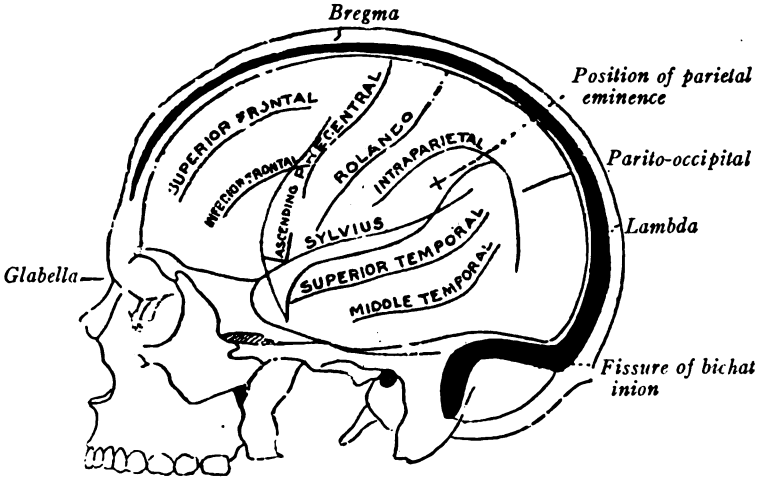

FIG. 252.—Diagram showing relations to the skull of the middle meningeal artery (in red) the superior longitudinal and lateral sinuses (in blue), and the principal fissures.

the pons, paralysis of the face on the same side and of the limbs on the opposite side (crossed paralysis). Spastic paralysis indicates a lesion of the conducting tract rather than the motor centers. The centers for general *sensation*, arranged in like order, lie in the post-central or ascending parietal convolution, just behind the fissure of Rolando. The center for *vision* is in the cuneus, which lies in the occipital lobe between the parieto-occipital and calcarine fissures (Fig. 255); unilateral destruction of this area results in *hemianopsia*, or blindness of the corresponding half of each retina. The *auditory* center is in the middle and posterior parts of the first temporosphenoidal gyrus, while *smell* and *taste* are located in the uncus, which is the anterior extremity of the hippocampal convolution; these centers are bilateral, hence both sides must be damaged to cause total abolition of hearing, smell, or taste. The center for *speech* is the posterior half of the third left frontal convolution (*Broca's convolution*), in right handed people; in the left handed it is on the right side. Destruction of this center causes *motor aphasia*, or loss of speech. It is usually associated with *agraphia*, or inability to write, which points to a lesion near the hand center or a lesion of the second frontal convolution. *Sensory* or *amnesic aphasia* includes many complicated symptoms, the most important of which are *word deafness*, indicating a lesion in the posterior half of the first or second temporal convolution, and word blindness (*alexia*), in which the angular and supramarginal gyri are at fault.

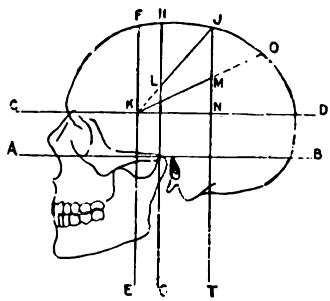

FIG. 253.—Kronlein's method of craniocerebral topography.

Apraxia, or loss of memory of the use, color, odor, taste, etc., of objects, also points to a lesion in the supramarginal and angular gyri. The *stereognostic center* is in the superior parietal lobule; a lesion in this region causes *astereognosis*, or loss of power to recognize the size and shape of objects.

FIG. 254.—(Walsham.) The cortical areas of the convexity of the left cerebrum. F1, F2, F3. Frontal convolutions. F3. Center for speech. T1, T2, T3. Temporosphenoidal convolutions. T1, center for hearing. A. Angular convolution, the area of clear vision connected with the yellow spot. F. S. Sylvian fissure. O. Occipital lobe. P F. Intraparietal fissure. P O F. Parietooccipital fissure. Recent observations tend to show that in man the sensorimotor areas do not extend much behind the fissure of Rolando, but lie mainly in front of it. (Sherrington.)

FIG. 255.—(Walsham.) Median surface of left cerebrum. G F. Gyrus fornicatus; perhaps connected with general sensation, its impairment causes hemianesthesia. C. Cuneus. C M F. Callosomarginal fissure. Q. Quadrate lobule. C F. Calcarine fissure. U. Uncinate lobule.

Reason, intelligence, and will are supposed to reside in the superior and middle frontal convolutions, particularly those of the left side. Affections of the cerebellum, especially of the middle lobe, cause vertigo and ataxia; lesions of the lateral lobe cause the patient to fall towards the affected side. Those portions of the brain in which lesions do not cause localizing symptoms are called silent or latent regions, viz., the anterior portion of the frontal lobes, the temporosphenoidal lobes except in part on the left side, a large part of the parietal and occipital lobes, and a portion of the cerebellum.

The **technic of cerebral surgery** includes the instructions laid down under general technic (q.v.). As a prophylactic measure against meningitis hexamethylenamine, which, according to Crowe, passes rapidly into the cerebrospinal fluid and gives it a certain amount of antiseptic power, may be

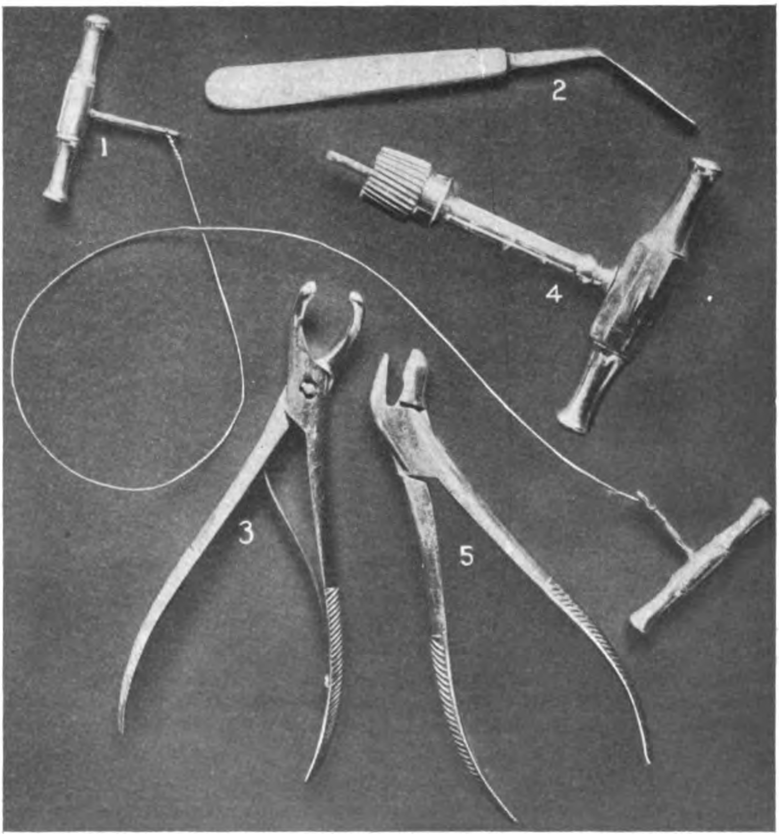

FIG. 256.—(1) Gigli wire saw; (2) Horsley's dural separator; (3) rongeur forceps; (4) trephine; (5), Keen's rongeur forceps.

given, gr. x. t. i. d., before and after operation. A special assistant should be assigned to make blood-pressure records at frequent intervals; if the blood pressure falls below 100 the operation should, if possible, be interrupted, and completed at a later period. The head is shaved and carefully examined for scars, etc. It is disinfected with soap and water, alcohol, and bichlorid of mercury, 1 to 4,000, the day before operation, and again at the time of operation. In emergency cases disinfection can be carried out only immediately before operation. Ether increases the bleeding, but is safer than chloroform for anesthesia. The fissures may be marked out with an aniline pencil or with iodin, but as it will be necessary to reflect the soft parts, the center-pin of a trephine should be forced through the scalp, in order to mark the bone, in three places, viz., at each end of the fissure of Rolando, and at the point which will occupy the center of the trephine opening. The head should be raised on a sand pillow in order to give it firm support and lessen bleeding. Unless the operation can be performed by enlarging an existing wound, a horseshoe-shaped flap, with the base downwards to preserve the blood supply and including the periosteum, is reflected from the skull. The skull may be opened with a trephine, gouge, chisel, Gigli's wire saw, or with a special drill and saw attached to a dental engine or electric motor, and any of these openings may be enlarged with rongeur forceps, after separating the dura from the skull with a Horsley's dural separator, with which the inner surface of the skull may also be explored. The trephine (Fig. 256) is a hollow cylinder with a saw-edge. It is provided with a center-pin, which projects be-

FIG. 257.

FIG. 258.

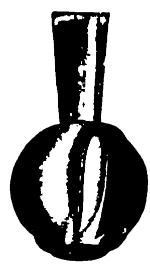

FIG. 259.

FIGS. 257 to 259.—Hudson's burrs. These burrs are driven by a hand-brace, and cut rapidly through the skull, but bind as soon as they reach the dura, thus preserving that membrane from injury. The smallest burr is used first, then the opening widened with the larger burrs.

yond the saw-edge, and holds the instrument in place until a groove in the skull has been made. The pin is then withdrawn, and the section completed by twisting the trephine from left to right and from right to left. When the diploë has been reached, there will be more bleeding and lessened resistance. The inner table is recognized by its density; at this time one should proceed with caution and frequently test the depth of the groove with the flat end of a probe. If one segment of the circle is cut through before the remainder, the trephine is tilted so as to avoid injury to the dura. The trephine should be conical, or provided with guards, so that it cannot plunge suddenly into the brain. A trephine three-fourths of an inch in diameter is the best size for most purposes. Very large trephines are difficult to manage, owing to the amount of bone to be cut and the curvature of the skull. By *osteoplastic resection* is meant the turning back of a trap-door, consisting of scalp and bone, which is replaced at the completion of the operation The flap is outlined by an incision extending down to the bone, but the scalp is not separated from the skull. A groove is then made in the bone, in the line of incision, with chisel or saw, and the section completed with an osteotome. Elevators are placed beneath the flap, which is pried upwards, and turned back by fracturing the bone at its base. By making a small opening on each side of the base and at each corner of a ∇-shaped flap, with a trephine, or, better, with a Hudson burr (Figs. 257, 258, and 259), the intervening bone may be severed with forceps (Fig. 260), or with the Gigli wire saw, which is passed from one opening to the other beneath the bone and over a grooved director, the bone being divided from within outwards, on a bevel, thus preventing the bone from pressing on the brain when it is replaced. Stellwagen has invented an ingenious instrument for quickly making a trap-door in the skull. Osteoplastic resection is used chiefly for exploratory purposes or for the removal of tumors, in other words, when it is desirable to expose a large extent of the cortex.

The dura is opened about one-fourth inch away from the bone, so that subsequent suturing will be facilitated. It is lifted from the brain with rat-tooth forceps, nicked with a knife, and the flap completed with scissors. No antiseptic should be used after the dura is opened. Irrigation with salt solution also is contraindicated. It should be noted whether the membranes

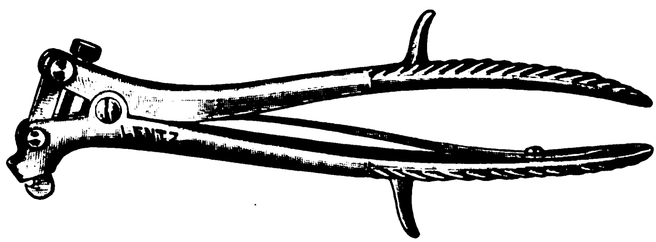

FIG. 260.—Hudson's modification of the De Vilbiss forceps.

are edematous, and whether the brain pulsates or bulges. Bulging and absence of pulsation indicate a marked increase in intracranial pressure (tumor, abscess, cyst, etc.). Lividity, a yellowish color, or an increase in density as determined by the finger, point to a tumor. The exposed centers may be stimulated with Keen's double brain-electrode in order to corroborate the findings of craniocerebral topography. The current should be no more powerful than that required to move the muscles of the thumb. If further exploration is desirable, the brain may be punctured with a needle or grooved director, or even incised. In removing diseased brain tissue anteroposterior incisions do less harm to the centers than those placed in a vertical direction.

Hemorrhage from the scalp is controlled temporarily with hemostatic forceps, permanently with ligatures or sutures. Bleeding from the bone is checked by gauze pressure, by crushing the edge of the bone with forceps, or best by Horsley's wax (beeswax 7, almond oil 1, salicylic acid 1). Blood vessels in the dura and brain may be tied with fine suture-ligatures of silk or catgut, general oozing may be controlled with hot compresses or by applying small sections of tissue removed from the temporal muscle (Cushing). Bleeding from a sinus may readily be controlled by gauze packing, which should be left in place several days; other procedures for the same purpose are to catch the wound with forceps, which remain for several days, to apply a lateral ligature, to suture the opening, and to ligate the entire sinus. The indications for drainage are the same here as elsewhere.

The dura should be sutured with catgut, the scalp with silkworm gut, and a copious dressing applied. The head should be slightly elevated, and the patient kept absolutely quiet.

Excepting osteoplastic resection, the bone is ordinarily not replaced, the defect in the skull being remedied in time by dense fibrous tissue. Bone, either in chips or in the form of a button, may, however, be replaced, if during the operation it is kept in salt solution at a temperature of 105 degrees. Osseous defects in the skull have been filled with decalcified bone chips, with plates of celluloid, tin, etc., and with a portion of the outer table of the neighboring skull, transferred to the opening by means of a flap of scalp. In children, in whom, owing to the thin cranium and scalp, the last mentioned proceeding is difficult, the defect may be filled with a transplant of periosteum and bone from the inner surface of the tibia, or a piece of the body of the scapula, which possesses the advantage of having periosteum on both sides. Suggestions for the closure of defects in the dura will be found under hernia cerebri. Attempts have been made to prevent adhesions between the brain and overlying structures by interposing rubber tissue, egg membrane, celloidin, gold and silver foil, etc., and by the free transplantation of fat.

INJURIES TO THE CRANIUM AND ITS CONTENTS.

Concussion of the brain is due to a shaking or jarring of the brain by direct (e.g., a blow on the head) or indirect force (e.g., a fall on the buttocks). In the mildest form no anatomical changes take place, but in the severe variety there are lacerations of the brain tissue and blood vessels. If the bleeding from these lacerations is sufficiently great to exert pressure on the brain, or if edema supervenes, the condition is one of compression rather than concussion.

The **symptoms** vary from temporary giddiness or stunning, to collapse and death. In a well marked case there is unconsciousness which is rarely complete, in that the patient may be partly roused by shouting, pricking the soles of the feet, etc. The muscles are relaxed, the skin cold and pale, the temperature subnormal, the respirations slow and shallow, the pulse weak and rapid. The pupils are equal, react to light, and are usually dilated. The reflexes are sluggish or, in the severest cases, abolished. The sphincters are relaxed, so that involuntary evacuations from the bowel may occur, but retention of urine is more common than its expulsion owing to relaxation of the bladder muscle. Transient paralyses may exist. This is the stage of collapse, which may last from minutes to hours; it ends either in death or in the stage of reaction, which may be inaugurated by a convulsion, or more commonly by slight movements of the extremities and vomiting. The symptoms mentioned above gradually disappear, the temperature rises, perhaps to 100° F. or a little above, and there is headache, drowsiness, or irritability, which may last a number of days.

The **prognosis** should always be guarded, although in most cases complete and permanent recovery follows. The early dangers are compression from hemorrhage or edema, and inflammation of the brain or meninges. Among the sequelæ may be mentioned cerebral irritability, inveterate headache, vertigo, loss of memory, change in character, insanity, epilepsy, diabetes, neurasthenia, and possibly tumor or abscess. Frequently the patient's memory is defective for the events immediately preceding the accident.

The **treatment** during the stage of collapse is the application of external heat and the administration of stimulants as in shock. Alcohol, however, should not be given, because of its exciting effect on the brain, and care should be taken not to overstimulate. When reaction has been obtained, the patient should be kept in bed in a quiet room, an ice bag placed on the head, the bowels opened with a purge, and the catheter used if there is retention of urine. The diet should be fluid, and sedatives used if necessary. If unconsciousness is prolonged, a suspicion of greater injury than concussion should always be entertained. After severe concussion the patient should avoid mental exertion for a number of weeks or months.

Cerebral irritability may come on in a few hours or days after severe concussion of the brain. The patient lies curled up on his side, is restless, irritable, or delirious, and perhaps has involuntary evacuations from the bladder and bowels; the eyes are closed, the pupils contracted but react to light, the temperature slightly elevated, the pulse weak and slow. The condition lasts a few days or several weeks, and ends in complete recovery or in permanent impairment of the mental faculties. The treatment is the same as that for the second stage of concussion.

Compression of the brain may be caused by depressed fracture, foreign body, intracranial hemorrhage, hydrocephalus, inflammatory products (including abscess and edema), and by cysts and tumors (including gumma and tuberculous deposits). It may be *localized* to a single center or group of centers, e.g. in depressed fracture, or *generalized*, e.g., in hydrocephalus; or, e.g., in intracranial hemorrhage, it may begin as the former and, as the pressure increases, gradually merge into the latter.

The **pathological changes** are, first, a displacement of the cerebrospinal fluid, then compression of the blood-vessels, the veins collapsing primarily, owing to their thin walls and the low intravenous blood pressure, and finally capillary anemia, with loss of function in the anemic parts. As the cranial cavity is divided into three compartments by the falx and the tentorium, pressure in one of these compartments may become very great before causing generalized compression. When subtentorial pressure is increased and the blood supply to the medulla decreased, the vasomotor center at once becomes more active and the blood pressure rises; thus there may be oscillations in the blood pressure and consequently irregularity of the medullary circulation, with irregular action of the respiratory center (Cheyne-Stokes respiration) and intermittent pulse. Finally intracranial exceeds the limit which intravascular pressure may attain and death ensues.

The **symptoms** are immediate in depressed fracture, foreign bodies, and apoplexy. The onset is delayed in middle meningeal hemorrhage and in inflammatory exudates, and is very gradual in tumors, cysts, and chronic hydrocephalus. In traumatic cases the symptoms may be preceded by or mixed with those of concussion. *Local compression* causes irritation or paralysis of the center affected, according to the degree of pressure. The symptoms of *generalized compression*, and this is usually what is meant when one speaks of cerebral compression, are, when the condition develops gradually, likewise (1) those of irritation and, as the pressure becomes more marked, those of paralysis of (2) the cortical and finally (3) the bulbar centers. (1) During the first stage there may be headache, vertigo, restlessness, delirium, convulsions, vomiting, tinnitus, contracted pupils, and choked disc. The pulse is slow and full, the blood pressure elevated, and the respirations more rapid and deeper, from stimulation of the vagus, vasomotor, and respiratory centers. The temperature varies with the cause of compression, thus trauma, hemorrhage, and shock lower it, while inflammatory conditions and lesions of the pons and medulla elevate it. Lumbar puncture in this and the succeeding stages may reveal increased tension of the cerebrospinal fluid, which may contain blood (in traumatic cases), pus (in meningitis), or other evidences of the causative lesion (see lumbar puncture). (2) In the second stage, or the stage of fully developed compression, the excitement gives place to stupor and finally to complete unconsciousness, i.e., the patient cannot be roused by shouting, pricking the soles of the feet, etc. The face is more or less cyanotic and the veins of the eyelids distended. As the medullary centers resist longer than the cortex the pulse remains full and slow and the blood pressure high. The respiratory center is the first of the medullary centers to show signs of weakening, hence the breathing becomes slow and stertorous. The stertor is due to paralysis of the soft plate, the flapping of the checks to paralysis of the facial muscles. (3) In the final stage the respirations are rapid, irregular, and of the Cheyne-Stokes variety; the pupils are dilated, perhaps unequal, and do not respond to light; and there are retention of urine from paralysis of the bladder, and involuntary fecal evacuations from relaxation of the sphincter ani. Localized paralyses may be detected on one side of the body in the early stages, but in the final stage all the muscles are equally relaxed. The temperature usually rises and in fatal cases may reach 106° or 108° F. The blood pressure falls (paralysis of the vasomotor center) and the pulse becomes rapid and often intermittent (paralysis of the vagus center), death ultimately occurring, however, from respiratory failure, as the heart continues to beat for some minutes after breathing ceases.

The **diagnosis** may be very difficult in cases in which no history can be obtained. Most cases of unconsciousness are due to toxemia (e.g., from nephritis, diabetes, infective maladies, terminal infection in noninfective diseases, ingested poisons, including alcohol), cardiac disease, syncope, apnea (e.g., from foreign bodies in the air passages, coal gas, smoke, drowning, embolism of the pulmonary artery), disease or injury of the brain (e.g., cerebral concussion, compression, or embolism; epilepsy, catalepsy, hysteria), shock (some of the causes of which may be overlooked, e.g., internal hemorrhage, lightning stroke, shock from artificial electric currents), sunstroke, freezing, or malingering. The surgeon's chief concern in these cases is to determine whether the condition demands operation or the services of his medical colleague. If the patient is cyanosed the first condition to be thought of, because of the necessity for instantaneous action, is apnea, particularly from a foreign body in the air passages, and especially if the individual has suddenly fallen unconscious while eating. If pallor is marked and there is no external wound the first consideration should be internal hemorrhage. After apnea and hemorrhage one should think first of poisoning, evidences of which may be found in the odor of the breath, on the lips, in the mouth (e.g., from corrosives), or in the gastric contents; a farewell letter or an empty bottle may be discovered in the patient's pocket. Aside from the investigations just suggested, and in addition to careful scrutiny of the scalp for injuries, including incision of a contusion for the purpose of inspecting the skull, many mistakes may be avoided, in doubtful cases, by examining the urine and the eye grounds, by lumbar puncture, and by making a skiagram of the head. The forms of unconsciousness most frequently confused with compression of the brain are mentioned below.

The symptoms of *concussion* should be compared with those of compression. Errors are most likely to arise in the first stage of compression, and in cases in which concussion precedes and merges with compression, e.g., intracranial hemorrhage.

In *acute alcoholism* the patient is not absolutely unconscious; the pupils are dilated, equal, and react to light; the pulse is frequent; and there are no paralyses. Dilated varices on the face, injected eyes, and the odor of alcohol, are of lesser importance, since an alcoholic may have a fracture of the skull, and an injured man may have been given whisky. A drunken individual improves after washing out the stomach and as the effects of the alcohol pass away. In doubtful cases any contusion of the scalp should be investigated by incision, and the patient watched for symptoms of compression.

In *opium poisoning* the respirations are very slow, the pupils small, and paralyses absent. It should be recalled that in pontine hemorrhage the pupils are contracted, but there are crossed paralysis and a high temperature.

In *uremia* the coma follows convulsions, the temperature is subnormal, the face and feet are edematous, the pupils are normal or dilated, albuminuric retinitis is sometimes present, albumin and casts are found in the urine, and paralyses, except in rare cases, are absent. A chronic nephritic is, because of the associated arteriosclerosis, predisposed to apoplexy, and uremic coma may be accompanied by compression of the brain due to edema.

In *apoplexy* all the symptoms of compression are present, and the diagnosis can be made only by the history and the absence of local evidences of injury. The X-ray may be of service in excluding fracture of the skull, lumbar puncture in excluding subdural hemorrhage.

Diabetic coma follows somnolence, the respirations are rapid, the pulse weak, and there are sugar and perhaps acetone and diacetic acid in the urine, a sweet odor to the breath, and no paralyses.

The **treatment** of cerebral compression, which is removal of the compressing agent whenever possible, is given in more detail in discussing the causative conditions mentioned above. Irrespective of the cause, however, it may be advisable to trephine simply for the relief of pressure.

Fractures of the skull are divided into those of the vault and those of the base. They are produced in four ways. (1) *Bending*, or *impression* fractures (confined always exclusively to the vault), are due to violence restricted to a small area of the skull, e.g., a blow from a hammer, the bone bending inward until it breaks. As with a stick that is broken by bending, the fracture begins and is more extensive on the surface made convex by the bending, i.e., the inner table. (2) *Bursting*, or *compression* fractures, may involve the vault, the base, or both. As the skull is elastic, when the head is squeezed between two objects the axis between the poles of compression is shortened, the equator lengthened, and the meridians of longitude separated, the greatest gap occurring at the equator, hence the line of fracture runs parallel with the direction of the compressing force. The same changes may occur when the head strikes a broad, hard object, as in a fall on the pavement, or when a broad, hard object strikes the head. Since the skull is not spherical and varies greatly in thickness and structure in its different parts, the fracture does not occur at the mathematical equator, but at the most inelastic point in the expanding portion of the skull. When this point is on the opposite side to that which has been struck, the fracture is sometimes, although incorrectly, called "fracture by *contre coup.*" Fracture by *contre coup* does not exist. (3) *Splitting*, or *wedge* action, is exemplified when an instrument like a chisel is driven into the skull, the bone splitting like a piece of wood. (4) *Explosive* action occurs in some gunshot wounds, waves of force being transmitted from the bullet to the cranial contents, the skull suffering extensive comminution.

In the *repair* of fractures of the skull very little callus is thrown out, possibly because of the perfect immobilization. Completely detached fragments may, in the absence of sepsis, survive and unite with each other and with the uninjured bone. Defects in the cranium following injury or operation are ultimately filled in with firm fibrous tissue, which, if the opening is small, may undergo complete ossification, the new bone forming from the dura and from the pericranium at the margins of the opening. Large gaps, however, are seldom entirely closed by bone. Suggestions for the operative closure of such openings are made in the section on the technic of cerebral surgery.

Fractures of the vault are caused by direct or indirect violence; in the latter instance the bone yields from compression of the skull. Like fractures elsewhere those of the skull may be *simple* or *compound*, *complete* or *partial*. The best example of incomplete fracture is that of the outer table in the region of the frontal sinus, the inner table being uninjured. Fracture of the inner table alone is rare. In children the skull may be indented without fracture of either table. The usual injury is a *fissured fracture;* if several fissures radiate from one point the injury is called a *stellate fracture*. *Depressed fractures* are generally comminuted. The depression may slope evenly from the sound bone (*saucer* or *pond-shaped fracture*), or the fragment or fragments may be completely detached and depressed below the inner table (*gutter fracture*). *Punctured fractures* are, as a rule, comminuted and depressed, but the area involved is small. In all complete fractures the inner table is usually more involved than the outer, owing to its lack of support and greater brittleness, and owing to the diffusion of the force, as pointed out above.

Symptoms in a simple fissure-fracture, apart from local bruising, may be absent, and the condition can be recognized with certainty only by the X-ray, or after exploratory incision, which should be done if there are evidences of compression or severe concussion. Occasionally a cracked-pot sound is obtained, and in rare instances a spurious meningocele forms. In simple depressed fracture the indentation may be masked by swelling. An old scar or a hematoma may feel like a depression (see hematoma of the scalp). In compound cases the fracture may be seen and felt, and if the dura is injured there will be an escape of cerebrospinal fluid and possibly of brain tissue. The possibility of mistaking a suture, a slit in the pericranium, or a tear in the temporal fascia for a fracture should be recalled (see wounds of the scalp). Fracture of the inner table alone is diagnosticated only by the X-ray or after trephining for the associated brain symptoms. The general cerebral symptoms may be those of concussion or compression. The localizing cerebral signs depend on the region involved (p. 362). In any fracture accompanied by subdural hemorrhage lumbar puncture shows bloody cerebrospinal fluid. The *prognosis* is that of the complicating injury of the brain. The immediate dangers are shock, laceration of the brain, and compression from bone or blood. The intermediate danger is septic inflammation; and the remote dangers those of concussion (q.v.). Of all cases of fractured skull that recover about one-half develop, in some degree, remote ill effects, and probably 20 per cent. of these are seriously affected.

Treatment is required for (1) disinfection, (2) depression, or (3) compression. 1. All compound fractures must be disinfected; when the injury is even a fissure, it will often be necessary to remove the line of fracture by gouge or rongeur, owing to the presence of hair or dirt which has been driven into the crack. 2. If depression exists, whether the fracture is simple or compound and whether there are symptoms of intracranial trouble or not, the bone should be pried into place by an elevator. If an opening sufficiently large for the elevator does not exist, it will be necessary to trephine, the center-pin being placed upon the sound bone near the fracture. If there is much comminution, it may be better to remove the fragments. In simple depressed fractures in children the same rule should apply as in adults, although some authors advise expectant treatment in these cases. The reason for trephining in depression without symptoms is to prevent subsequent cerebral troubles, e.g., epilepsy, insanity. Punctured fractures require trephining both for depression and disinfection. 3. All fractures, whether simple or compound, with symptoms of compression require trephining. The only cases which are treated expectantly are those of simple fracture without depression or symptoms, and those in which the injury is very extensive.

Fractures of the base of the skull are caused by direct violence, as stabs or gunshot wounds through the orbit, nose, mouth, ear, or occiput, in which case the fracture may be depressed; a similar injury results from a blow on the chin which drives the condyles of the jaw into the middle fossa, or from a fall on the head, feet, or buttocks, which drives the vertebral column upwards into the posterior fossa. Direct fractures are caused also by blows at the level of the base of the skull, which split the base as a chisel does a piece of wood. Indirect fractures are caused by extension of a fracture of the vault (*irradiation*), or by a squeeze of the head, the resulting fracture running parallel with the direction of the compressing force (*bursting fracture*), modified, however, by the lines of least resistance in the base of the skull. Most fractures of the base are compound, communicating with the air through the orbit, nose, pharynx, or ear. Fracture of the middle fossa is the most frequent; fracture of the posterior the most fatal, because of the vital centers therein contained. The dangers, both immediate and remote, are those of fracture of the vault, except that here the important structures at the base and the cranial nerves are much more likely to be implicated.

The **symptoms** are usually those of severe concussion or compression, although both may be absent. The temperature is at first subnormal from shock, then rises to 100° or 101° F., and subsequently falls to normal or subnormal. A continuous rise indicates extensive injury to the brain or meninges. Fractures involving the *anterior fossa* may cause prolonged epistaxis followed by a flow of cerebrospinal fluid from the nose, and subconjunctival hemorrhage, which is recognized by its occurrence after several hours or days and by the fact that it comes from behind forwards, i.e., no white sclerotic can be seen posterior to it. If the bleeding is profuse the eye may be pushed forward. Escape of brain tissue from the nose or orbit is rare. The first, second, or third cranial nerves may be injured. In fractures of the *middle fossa* blood and cerebrospinal fluid, rarely brain tissue, may escape from the ears and occasionally from the nose or mouth. It should be recalled that bleeding from the ear may be caused by injury to the bone or cartilage, or by rupture of the tympanum, without fracture of the base, and that a serous fluid may come from the mastoid cells and inner ear. Cerebrospinal fluid may be recognized by its watery character, by the increase in flow on straining or coughing, and by chemical examination (see spinal puncture). Ecchymosis may be seen in the temporoparietal region. The cranial nerves most likely to be injured are the sixth, seventh, and eighth. In the *posterior fossa* the blood infiltrates the muscles at the back of the neck, but is prevented from reaching the skin by the cervical fascia, except along the course of the posterior auricular artery, thus causing a crescentic line of ecchymosis behind the ear (*Battle's sign*). Escape of blood from the mouth and injury to the cranial nerves are rare. Optic neuritis occasionally occurs a week or more after fracture of the posterior fossa. Bloody cerebrospinal fluid may be obtained by lumbar puncture, even three or four weeks after the injury. The X-ray often reveals the fracture.

The **treatment** is first that of shock as indicated under concussion of the brain. The patient should be put in a dark and quiet room, the nose, pharynx, or ear disinfected (Chap. IV), according to the situation of the fracture, and in case of the ear the canal plugged with sterile cotton and a bandage applied over an external dressing. Ice should be applied to the head, a purgative administered, and the patient kept on a fluid diet. In a punctured wound of the orbit involving the base of the skull, it will be necessary to enlarge the wound in order to disinfect thoroughly; in some of these cases it may be advisable to trephine above the orbit to remove depressed fragments and disinfect. Symptoms of compression indicate bilateral subtemporal decompression (Cushing), i.e., removal of a portion of bone under each temporal muscle, with incision of the dura; hexamethylenamine is then given for its antiseptic effect on the cerebrospinal fluid. The mortality is in the neighborhood of 75 per cent.

Intracranial hemorrhage may be spontaneous (e.g., apoplexy) or traumatic. *Spontaneous* hemorrhage belongs to the physician rather than to the surgeon, although in certain cases of ingravescent apoplexy the common carotid artery has been tied, and in ordinary apoplexy the removal of a section of the skull has been suggested in order to relieve compression. *Traumatic* hemorrhage may be extradural (between the dura and the bone), subdural (between the dura and the brain), or cerebral (within the brain).

Extradural hemorrhage may be due to a wounded sinus, but is most commonly caused by rupture of the middle meningeal artery or one of its branches. Fracture is usually but not invariably present. Rarely the bleeding is on the opposite side to that which has been struck (*contre coup*), and occasionally the hemorrhage does not occur for days or weeks after the injury (*traumatic apoplexy*), a matter of considerable importance from a medicolegal standpoint.

The **symptoms** are divided into three periods, the first or the second of which, however, may be absent. (1) *Temporary unconsciousness* from concussion, during which the pulse is feeble and consequently the bleeding slight; (2) a period of *consciousness* that varies according to the size of the vessel injured from a very brief period to a number of hours, during which the pulse grows stronger and the hemorrhage increases; hence (3) *secondary unconsciousness* due to compression, which comes on gradually as the clot increases in size. The patient becomes stupid and finally comatose; paralysis, perhaps preceded by twitching, develops in one center, usually the head or arm, and slowly creeps to adjacent centers until the whole opposite side of the body is involved; the pupil of the affected side becomes dilated and immobile owing to the extension of the clot to the base of the brain; and choked disc develops on each side, being more marked, however, on the side corresponding to the hemorrhage. The pulse is more frequent than in other forms of compression owing to the loss of blood; the temperature, particularly on the paralyzed side, rises; and in case of fracture blood finds its way externally. Lumbar puncture reveals the cerebrospinal fluid clear of blood. Owing to the period of consciousness mentioned above subdural hemorrhage has been confused with the cerebral form of fat embolism (q.v.).

The **treatment** is trephining one and one-fourth inches behind the external angular process of the frontal bone, on a level with the upper margin of the orbit, thus exposing the middle meningeal and its anterior branch; if the clot is not found, a second opening should be made at the same level just beneath the parietal eminence, i.e., over the posterior branch (Figs. 252 and 253). The side to be trephined is that opposite the paralysis, and not necessarily the side on which injury to the scalp or skull is evident. The clot is removed with the finger and the artery secured by a suture-ligature. If the artery has been ruptured where it lies in an osseous canal, such may be plugged with wax, gauze, or sterile wood, or gently crushed with forceps. The only means of diagnosticating hemorrhage from a sinus are the situation of the injury, and possibly the slower onset of symptoms owing to the low pressure of the blood in the sinus. The means of controlling hemorrhage from a sinus have already been indicated (see technic of cerebral surgery). The mortality of extradural hemorrhage without operation is 90 per cent., with operation 33⅓ per cent.

Subdural hemorrhage arises from injuries to the inner wall of the venous sinuses, from rupture of the middle meningeal artery if the dura has been opened, and most frequently from wounds of the middle cerebral or its branches.

The **symptoms** are those of concussion, rapidly merging into compression owing to the widely diffused clot. In rare instances the clot may be limited and give localizing symptoms. Lumbar puncture discloses bloody cerebrospinal fluid.

The **treatment,** if the clot can be localized, is trephining over the region indicated by the symptoms, removal of the coagulated blood, hemostasis by ligature or packing, and drainage. In other cases bitemporal decompression may be performed. As a rule, however, the injury is widespread and but little can be accomplished by operation.

Cerebral hemorrhage due to trauma is accompanied by injuries so diffuse that death quickly follows, and operation is indicated only in the presence of localizing symptoms. See also wounds of the brain.

Wounds of the internal carotid artery within the skull are quickly fatal if the wound is large, but if small, recovery sometimes occurs with the development of an aneurysmal varix between the artery and the cavernous sinus. The treatment is ligation of the common carotid in the neck.

Intracranial hemorrhage in the new-born may occur during difficult labor and after the application of forceps, from overriding of the cranial bones, particularly the parietal, in which case the veins emptying into the superior longitudinal sinus are torn.

The **symptoms** are irregular respirations or asphyxia, a bulging, feebly pulsating anterior fontanelle, unequal pupils, and usually convulsions; lumbar puncture reveals bloody cerebrospinal fluid. The few cases that survive develop idiocy, epilepsy, or some form of birth palsy (*Little's disease*), e.g., spastic hemiplegia, or, if both leg centers are involved, spastic paraplegia.

The **treatment** is removal of the clots, after making an osteoplastic flap in one or both parietal regions, according to whether the bleeding is unilateral or bilateral.

Edema of the brain, local or generalized, may be associated with any other form of cerebral compression, augmenting its symptoms. It may follow concussion, contusion, or laceration of the brain, in which event the symptoms are practically identical with those of hemorrhage; absence of blood in the fluid obtained by spinal puncture would favor the diagnosis of edema. Cerebral edema may occur also in mitral stenosis and in lesions, e.g., tumors, interfering with the return flow of blood from the head. It sometimes arises in chronic nephritis, causing unilateral convulsions or paralysis, which symptoms have been misinterpreted and the patient operated upon for tumor or abscess of the brain. The *treatment* is that of the causative lesion. Regardless of the cause decompression may be considered in any case in which life is threatened, even in uremia.

Wounds of the brain may be non-penetrating, i.e., those which do not communicate with the exterior, or penetrating, i.e., those associated with an external wound.

Non-penetrating wounds are caused by falls and blows, and may or may not be associated with simple fracture of the skull. They vary in degree from a limited contusion to extensive lacerations or pulpification. The amount of hemorrhage depends upon the situation and extent of the injury. If the patient recovers, the effused blood may be absorbed and the site of the laceration be marked by a depressed cicatrix, or the extravasated blood may become organized as a brownish adherent layer or form a cyst. In other cases inflammatory phenomena supervene and cause softening of the brain tissue, which, if not extensive or involving important centers, may result in complete recovery. In more serious cases the inflammation spreads to the meninges, and compression of the brain ensues as the result of edema or exudation. It is generally thought that cerebral tissue once destroyed is never regenerated; if the functions of such tissue reappear, it is supposed to be due to compensatory action of neighboring centers.

The **symptoms** are those of severe concussion, indeed if a patient does not react promptly from concussion, contusion or laceration of the brain, or hemorrhage is probably present. Death may be instantaneous if the vital centers are involved. Symptoms of compression, if present from the beginning, indicate depressed fracture, or extensive hemorrhage from the brain tissue; compression coming on later is due to bleeding from the meningeal vessels or sinuses, or to a spreading edema or inflammatory exudate. The localizing symptoms depend upon the portion of brain injured. The remote effects are those of concussion.

The **treatment** depends upon the symptoms. If concussion is present it should be treated; if signs of compression arise the skull should be trephined according to the localizing symptoms, and depressed bone elevated, hemorrhage checked, or drainage instituted, according to the cause of compression.

Penetrating wounds of the brain are caused by blows, falls, stabs, and gunshot wounds and, excepting rare cases, e.g., a puncture through an open fontanelle or foramen, are accompanied by fracture of the skull.

The **symptoms** are those of compound fracture of the skull with those of non-penetrating wounds of the brain. In punctures such as a stab wound, in which important centers are not injured, there may be no symptoms referable to the brain, as the injury is not of such a nature as to produce concussion. The general facts regarding gunshot wounds are given in Chap. X. In all open wounds of the brain there is danger of septic meningitis, fungus cerebri, and cerebral abscess. If proper disinfection can be carried out and sterility maintained, the subsequent course is the same as in non-penetrating wounds.

The **treatment** is that of shock, and exploration, by enlarging the scalp wound if necessary. Depressed fragments of bone should be removed, the opening in the skull, if small, enlarged with rongeur forceps, hemorrhage controlled, accessible foreign bodies removed, drainage by gauze or rubber tube instituted, the dura sutured as far as possible, and the patient watched for symptoms of meningitis or abscess. Gunshot fractures of the skull, even with clean perforations, require trephining for the removal of depressed portions of the inner table. Tangential wounds make a gutter in the external table and may not penetrate, but the inner table is usually fragmented, and

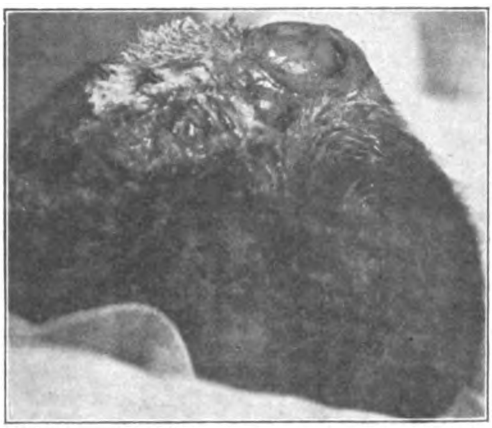

FIG. 261.—Fungus cerebri following an operation for brain tumor. (Pennsylvania Hospital.)

the fragments are driven into the brain. The best means for locating a bullet is the X-ray. If a probe is employed, it should be very light, e.g., the Fluhrer aluminum probe, and allowed to follow the tract by gravity, the head being placed in a position rendering this possible. If the bullet cannot be found by a careful but gentle search, or, if a formidable operation would be necessary to remove it, even if localized by the X-ray, it should be allowed to remain unless causing distinct symptoms.

Hernia cerebri is a protrusion of the brain tissue beneath the scalp, through a traumatic defect in the skull, as the result of increased intracranial pressure, e.g., after an operation for an irremovable tumor. When there is a defect in the scalp the condition is called *prolapse of the brain*. It pulsates, has an impulse on coughing, and may be partly reducible, causing symptoms of compression of the brain. According to the cause of increased intracranial pressure, it increases or decreases in size. If uncovered by scalp, septic meningitis is likely to occur; and if of large size, gangrene frequently results. Prolapse of the brain should not be confused with *fungus cerebri* (Fig. 261), which is simply exuberant and edematous granulations from the neuroglia, as the result of wounds of the brain. Since the latter occurs only when there is an opening leading down to the brain, care should be taken after operation to suture the dura whenever possible; when a portion of the dura has been destroyed, the defect may be closed with a flap of pericranium, sutured in place with the osteogenetic surface outwards, or with a piece of the fascia lata, fatty side in. The treatment of hernia and prolapsus cerebri is, if possible, the removal of the cause of the increased intracranial pressure. The size of the hernia may be reduced by creating a hernia on the opposite side, i.e., by a decompressive operation. Repeated lumbar punctures are of little value. The protruding brain should be protected, and, if uncovered, dressed with sterile gauze to prevent septic contamination. Pressure may be dangerous, and amputation should be employed only when sloughing has occurred. The prognosis is unfavorable. Fungus cerebri is treated by slicing off the granulations, or by cauterizing them with silver nitrate. The condition is not serious.

DISEASES OF THE CRANIUM AND ITS CONTENTS.

For **diseases of the cranial bones** see chapter on diseases of bone.

A meningocele is a sac of cerebral membranes containing cerebrospinal fluid and protuding through a congenital opening in the skull. It occurs most frequently in the middle line, midway between the foramen magnum and the posterior fontanelle, but may be found also at the root of the nose, at any of the fontanelles, or at the base of the skull. It is round, translucent, pedunculated, and reducible: and it has an impulse on coughing, fluctuates, and rarely pulsates. In meningocele, as well as in encephalocele and hydrencephalocele, the bony defect may be detected by palpation and the X-ray. Spurious meningocele is described on p. 360. The *treatment* is excision of the sac and closure of the opening in the membranes.

Encephalocele is a meningocele containing a portion of the brain. The signs are the same as those of meningocele, except that the tumor is opaque, pulsates but does not fluctuate, and causes symptoms of pressure when reduced. Occasionally the brain tissue retracts within the skull and the tumor becomes a meningocele, which in rare instances may undergo spontaneous cure owing to the closure of the opening. The *treatment* is excision of the sac and brain tissue, providing no important center is involved.

Hydrencephalocele is the same as encephalocele, except that the herniated brain tissue contains a cavity which communicates with the ventricles. The swelling is large, lobulated, somewhat translucent, and rarely pedunculated or reducible; and it fluctuates, pulsates, and has a slight impulse on coughing. If the tumor contains motor centers there may be paralysis. Hydrencephalocele is not amenable to treatment and is always fatal.

Pneumatocele is a collection of air between the pericranium and the skull, the result of a spontaneous or pathological perforation of the frontal sinus or mastoid cells. Of thirty-three cases reported, twenty-three were occipital and ten frontal. The tumor is elastic, tympanitic, pseudo-fluctuant, and often partly reducible. The *treatment* is puncture and compression; or better incision, and plugging of the opening in the bone with antiseptic wax.

Hydrocephalus is an excess of fluid in the ventricles (*internal hydrocephalus*) or in the subarachnoid space (*external hydrocephalus*). The term external hydrocephalus has been loosely applied to edema of the piaarachnoid, porencephaly, and fluid collections following meningitis, but should be restricted in its signification to the rare cases in which, owing to atrophy or lack of development of the brain, there exists a large space between the cerebral cortex and and the skull; in these cases surgical treatment is not indicated.

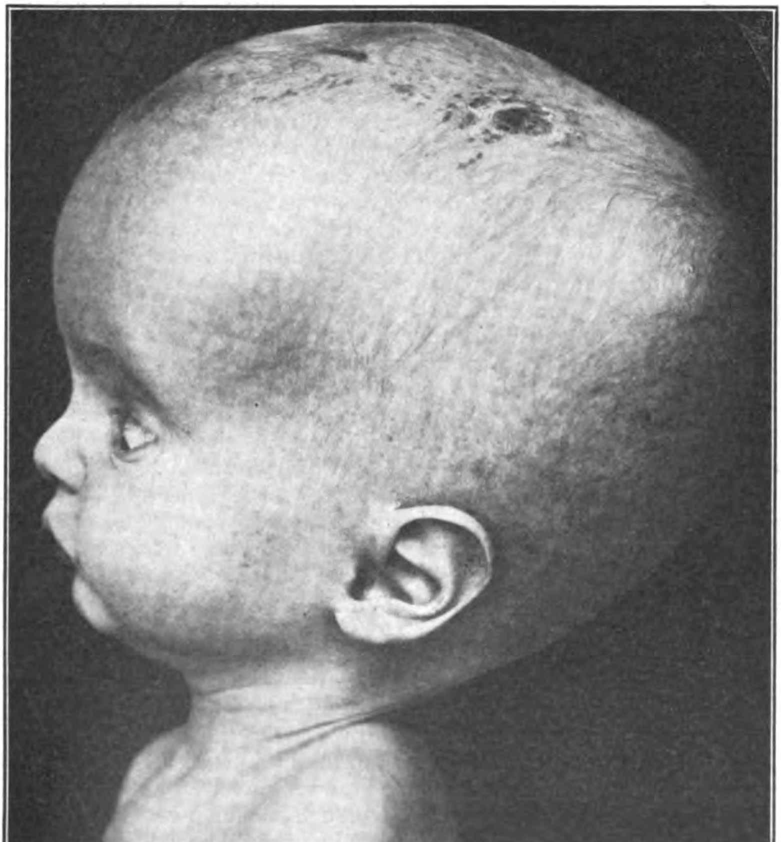

FIG. 262.—Hydrocephalus. The circumference of the head was twice that of the chest. Note pressure sore on the scalp.

Internal hydrocephalus may be congenital or acquired. The *congenital* (*chronic, idiopathic*) *form* is of unknown origin. Syphilis or alcoholism in the parents has been held responsible for a few cases. The cranium becomes very much enlarged (Fig. 262), the superficial veins are distended, the face looks small, the sutures and fontanelles are wide and bulging, and the child is defective mentally. Convulsions, optic atrophy, and paralyses may occur, and death usually takes place early. Sometimes a cracked pot sound may be obtained on percussion, sometimes fluctuation may be felt, and occasionally the head is translucent. The X-rays reveal the thinned bone and cerebral cortex, the wide sutures and fontanelles, and the dilated lateral ventricles. The *acquired form* may be acute (e.g., from meningitis, breaking of an abscess into the ventricle) or chronic, e.g., from adhesions or tumor closing the aqueduct of Sylvius or the foramen of Majendie, or a tumor pressing upon the veins of Galen or the straight sinus. It sometimes follows operation for spina bifida. The symptoms are those of compression of the brain, with, in the acute variety, those of infection. The contour of the head is not altered in acute cases, or in those developing after ossification of the sutures.

The **treatment** of acute hydrocephalus is that of meningitis. Chronic hydrocephalus depending upon tumor should be treated by removal of the tumor. If this is impossible, relief from pressure may be obtained by making a large opening in the skull. Congenital hydrocephalus cannot be cured. Elastic pressure, the injection of Morton's fluid (see spina bifida), tapping the ventricles, and spinal puncture are practically useless. The lateral ventricle may be punctured either at one side of a large anterior fontanelle, or by making a small trephine opening one and one-fourth inches above and behind the external auditory meatus, and pushing the needle inwards two and one-fourth inches, towards a point two and one-half inches above the opposite meatus (Keen). The most encouraging results have been obtained by means of horse hair or catgut strands, one end of which is introduced into the lateral ventricle and the other placed beneath the dura or beneath the skin, thus providing permanent drainage of the ventricular fluid to a situation where it may be absorbed. Payr drains the ventricle into the internal jugular by means of a transplanted vein or artery. Cushing drains the spinal theca into the retroperitoneal tissues by a cannula passed through the fifth lumbar vertebra. Cotteril in one case secured improvement by opening the foramen of Majendie. Stiles ligates the common carotids, one several weeks after the other, in an effort to restore the normal balance between the secretion and the absorption of cerebrospinal fluid.

Microcephalus, or abnormal smallness of the cranium, is due to defective development, and is usually associated with idiocy. The patient should be referred to a school for the feeble minded. Linear craniotomy is useless and will not be described.

Intracranial inflammation may involve the dura (*pachymeningitis*), the arachnoid and pia (*leptomeningitis*), or the brain (*encephalitis*). In most instances both the membranes and the brain are involved and the condition is called meningitis or encephalitis, although meningo-encephalitis would perhaps be the best term. Under this heading should be included also infective sinus thrombosis.

Pachymeningitis externa, i.e., inflammation of the outer layer of the dura, is due to injury, syphilis, or to diseases of the cranial bones, particularly of the osseous tissue surrounding the middle ear. In the simple form the membrane is thickened, perhaps causing a persistent localized headache. In the suppurative variety pus collects between the dura and the bone, and the symptoms and treatment are identical with those of extradural abscess.

Pachymeningitis interna may be due to extension from the outer layer of the dura or from the pia and arachnoid. *Pachymeningitis interna hemorrhagica* (*hematoma of the dura mater*) is caused by the rupture of vessels in a vascular layer which forms on the inner surface of the dura. The condition is generally bilateral, and is found most frequently in the insane, alcoholic, syphilitic, and in the aged, although it may be associated with infectious fevers and diseases of the blood. The symptoms are those of cerebral irritation and slowly progressing compression, perhaps with localizing phenomena. The *treatment* is trephining on both sides and removal of the subdural clot.

Leptomeningitis, or inflammation of the pia-arachnoid, may be acute or chronic, localized or diffused.

Acute leptomeningitis may be primary, e.g., in wounds (pyogenic organisms) and in epidemic cerebrospinal meningitis (diplococcus intracellularis meningitidis), but it is most frequently secondary to infective diseases of the scalp, cranium, and face, e.g., erysipelas, carbuncle, caries, necrosis, and middle ear disease, or to pyemia, pneumonia, typhoid, influenza, diphtheria, gonorrhea, anthrax, actinomycosis, tuberculosis, or sun-stroke. It occurs too as a terminal infection in many chronic maladies, including chronic alcoholism (pyogenic organisms). Thus a great variety of bacteria may be responsible for the condition. The inflammation is essentially the same as in other parts of the body. The subarachnoid space becomes distended with a cloudy or purulent fluid, and the brain becomes edematous and covered with lymph and frequently shows small hemorrhages. Extension to the meninges of the cord is very apt to follow. Should recovery occur, the patient is liable to suffer from the changes which occur in the brain tissue, or from adhesions which shut off the ventricles (hydrocephalus) or which form at the cortex or base of the brain (epilepsy, paralyses of the cranial nerves, etc.).

The **symptoms** in traumatic cases usually come on within two or three days, although there is a subacute form in which the onset may be delayed for a number of days or even weeks, probably the result of a late infection by way of the blood or lymph vessels. The symptoms are those of (1) sepsis, viz., chills, irregular fever, and the changes associated with fever; (2) those of irritation of the brain, which occur in the early stages, viz., severe headache, vomiting, stiff neck, rigidity of other muscles (producing in the leg Kernig's sign), delirium, photophobia, contracted pupils, hyperesthesia, and convulsions; and (3) those due to pressure, which occur during the terminal stage, viz., coma, dilated unequal pupils, optic neuritis, strabismus, paralyses in other parts of the body, slow pulse, and stertorous respirations. Upon lumbar puncture the cerebrospinal fluid spurts out; it contains many polymorphonuclear leukocytes in septic cases, many lymphocytes in tuberculous cases, the causative bacteria, and no dextrose.

The **treatment** is to place the patient in a quiet darkened room, put ice to the head, administer laxatives and hexamethylenamine, and apply wet cups to the mastoid (to drain the mastoid vein) and back of the neck. Sedatives, such as bromid of potassium, are used in the early stages, stimulants in the final stage. Mercury and potassium iodid are often employed. In epidemic cerebrospinal meningitis Flexner's serum has proved of value. Lumbar puncture may be used to remove pressure temporarily; the ventricles also have been tapped for the same indication. Trephining for drainage is indicated if the process is localized, and has been employed in even the diffuse form, with, however, very little encouragement, the opening being made in the occipital bone towards the base of the brain so as to drain the cisterna magna.

Chronic leptomeningitis may follow trauma and is not infrequently seen in syphilitics and alcoholics. The membranes are thickened and are adherent to the brain, causing persistent localized headache, tenderness, and sometimes epilepsy. The *treatment* is the administration of sedatives and potassium iodid, or if these fail trephining.

Infective thrombosis of the venous sinuses may be due to primary infection in compound fractures of the skull or in the acute infective fevers, but is usually secondary to infections of the ear, nose, pharynx, face, orbit, or scalp, the primary inflammation spreading by contiguity, or by setting up a phlebitis which extends inwards to the sinuses. In two-thirds of the cases the cause is disease of the middle ear, and the lateral sinus is the one affected. Meningitis and brain abscess are not infrequent complications.

The **symptoms** are due to (1) the infective process and (2) to the thrombosis. 1. The infective symptoms are those of septicemia or more frequently pyemia; some cases resemble typhoid fever, in others pulmonary symptoms are prominent owing to infection of the lungs with emboli. If the infection spreads to the meninges, there will be irritation or compression of the brain, as indicated under meningitis. 2. The symptoms due to the thrombosis vary with the sinus affected. Thrombosis of the *lateral sinus* causes pain, tenderness, and edema along the line of the sinus, over the mastoid, and along the jugular if the latter is invaded. There will be a history of suppurative middle ear disease, with perhaps an offensive discharge which has ceased with the onset of the symptoms of sinus thrombosis. The pneumogastric, glossopharyngeal, and spinal accessory nerves may be paralyzed by pressure in the jugular foramen. Thrombosis of the *superior longitudinal sinus* causes pain, tenderness, and edema along the sinus and over the forehead, epistaxis, and possibly convulsions from irritation of the motor area. Thrombosis of the *cavernous sinus* causes exophthalmos, edema of the orbit and eyelids, choked disc, and paralysis of the third, fourth, ophthalmic branch of the fifth, and sixth cranial nerves. Thrombosis of the *petrosal sinus* gives no localizing symptoms.

The **treatment** of thrombosis of the lateral sinus due to middle ear disease is to clean out the mastoid (p. 411), and then expose the sinus by gouging or chiseling away the bone at the posterior part of the opening. Any pus in the groove of the sinus is washed away, and an attempt is made to confirm the diagnosis by palpating the sinus and by introducing a hollow needle. If no blood flows through the needle thrombosis is present, if blood flows through the needle it should be withdrawn until the point is just within the sinus, to make sure there is no mural thrombus. After the diagnosis has been confirmed, the internal jugular vein should be tied below any existing thrombus to prevent septic dissemination. The sinus is then opened, and the clot removed by curetting until free bleeding is obtained, which is easily controlled by forcing gauze between the sinus and the bone. If the jugular is involved it should be excised above the ligature which has been placed on it, and irrigation practised from the opening in the skull through to that in the neck. Both wounds should be packed with sterile gauze. Death is practically certain without operation, while the mortality after operation is about 50 per cent. Inflammation of the longitudinal sinus should be dealt with in a similar way, but the remaining sinuses of the head are practically inaccessible, although attempts have been made to drain the cavernous sinus through an opening in the temporal fossa, somewhat like that used to expose the Gasserian ganglion.

Intracranial abscesses may lie between the dura and the skull (*extradural*), between the dura and the brain (*subdural*), or in the brain substance (*cerebral or cerebellar*). The causes are those already indicated under intracranial inflammation, 50 per cent. being due to chronic suppurative otitis media.

Extradural abscess causes fever with or without chills, edema of the scalp over the abscess (*Pott's puffy tumor*), a discharging sinus if due to bone disease or compound fracture, localized headache and tenderness, and pressure symptoms, e.g., spasm or paralysis if over the motor area, optic neuritis or dilated pupil if near the base, etc. Coma finally occurs, owing to the growth of the abscess, or to the extension of the inflammation to the meninges and the brain. The X-ray may localize the abscess, especially if it is due to disease of the bone. The *treatment* is drainage by enlarging a sinus, if such exists, or by trephining. If due to middle ear disease, the mastoid is opened and the abscess usually found by following a sinus.

Subdural abscess and abscess of the brain cannot be differentiated. Excepting those due to tuberculosis and pyemia, the abscess is usually single. In traumatic cases it is generally under that portion of the scalp which has been struck, but it may be on the opposite side of the brain just like contusions and lacerations. Abscesses due to middle ear disease are most common in the temporosphenoidal lobe and next in the cerebellum, nine-tenths being within a circle whose center is one and one-fourth inches above and behind the external auditory meatus, and whose radius is one and one-fourth inches. The abscess may be just beneath the membranes, or it may lie some distance below the surface of the brain, the infection having traveled along the blood or lymph vessels.

The **symptoms** may be either acute or chronic, and are due to the absorption of septic products and to compression of the brain. In *acute* cases, the best example of which is seen a few days after a compound fracture of the skull, there are severe headache, fever, perhaps chills, and the rapid development of pressure symptoms, in a word the symptoms of meningo-encephalitis, from which the condition cannot be distinguished unless there are localizing symptoms. In the course of a chronic abscess the same group of symptoms may suddenly arise, owing to the bursting of the abscess into the lateral ventricle or on the surface of the brain. *Chronic abscess* seldom begins within one week of an injury, and it may not appear for months or even years. In a typical case the signs of septic absorption are slight or absent, thus there may be an initial rise in the temperature, but it soon falls to normal or subnormal, although the local temperature over the abscess remains elevated. The symptoms of compression come on slowly in the course of weeks or months. They are persistent headache, often most marked (and associated with tenderness) over the abscess; cerebral vomiting, which is distinguished by its explosive character, the absence of nausea, the presence of a clean tongue, and by the fact that it has no relation to the ingestion of food; slow, full pulse; mental hebetude merging into coma, with Cheyne-Stokes respiration in the final stages; optic neuritis, which if bilateral is more marked on the affected side; dilated fixed pupil on the diseased side; ptosis or strabismus; convulsions or paralyses of the face, arm, or leg; interference with the special senses; and vertigo, ataxia, etc., according to the portion of brain involved (see cerebral localization). Localizing symptoms in abscess of the temporosphenoidal lobe are often absent. Sometimes the abscess can be demonstrated by X-ray examination.

The **diagnosis** of chronic abscess from *acute meningitis* is made by noting that the latter commences a few days after injury, that it is associated with fever, delirium, contracted pupils, photophobia, and stiff neck, and that the whole course is very actue. Lumbar puncture (q.v.) is of diagnostic value. *Mastoid disease* alone may cause cerebral symptoms, but opening the mastoid will cause these symptoms to subside. *Thrombosis of the lateral sinus* is associated with chills, fever, and sweats, and there are local evidences of thrombosis. *Tumor of the brain* comes on more slowly than abscess, but presents earlier localizing symptoms. *Uremia* may cause symptoms very much like those of abscess.

The **treatment** is trephining, according to the localizing symptoms, and drainage. The dura may be opened by a crucial incision, which will be all that is needed if the abscess is subdural. If it lies beneath the cortex the livid and edematous brain will bulge into the opening and there will be absence of pulsation. The exact site of the abscess should be determined by a grooved director or trocar and cannula, when a pair of hemostatic forceps may be pushed along the exploring instrument into the abscess, opened, and withdrawn. The cavity is drained by means of a double rubber tube, around the projecting portion of which gauze may be packed to protect the meningeal cavity. Curetting and irrigation are contraindicated. In abscess due to middle ear disease the mastoid should first be opened and any sinus followed, thus perhaps evacuating an extradural or even a subdural collection of pus. If the abscess is in the temporosphenoidal lobe, the incision in the soft parts may be extended upwards, and the skull opened about three-fourths of an inch above the posterior root of the zygoma, on a line with the posterior border of the bony auditory meatus. Barker advises trephining one and one-fourth inches above and behind the external auditory meatus. For abscess of the cerebellum the trephine opening is made below the lateral sinus, midway between the inion and the mastoid, although it may sometimes be reached by deepening and enlarging the opening which has been made in the mastoid.

Intracranial tumors may spring from the interior of the skull or from any of the intracranial tissues, or they may be metastatic, the primary tumor existing in some other portion of the body. In this region the term tumor is used in a broad sense, and includes not only neoplasms, but cysts and growths due to parasites and the infectious granulomata. Speaking in round numbers 33⅓ per cent. are sarcomata (including endothelioma, psammoma, and glioma), 25 per cent. tuberculous, 10 per cent. cysts (usually resulting from old blood clots; dermoids, hydatids, and cysticerci are very rare), 5 per cent. secondary carcinomata, and 3 per cent. gummata. Benign tumors of the connective tissue type are exceptional; adenoma is occasionally found in the pituitary body. About two-thirds of all tumors are situated in the cerebrum, one-third in the cerebellum. They are more frequent in males than in femlaes.

The **symptoms** are those (1) of general and (2) of local compression. (1) The *general symptoms* are constant severe headache, which may be localized to the site of disease, and associated with tenderness if the tumor be superficial; cerebral vomiting (p. 383); generalized convulsions; in 80 per cent. of the cases optic neuritis, which is usually double and more marked on the affected side (unilateral choked disc indicates a tumor near the back of the orbit on the same side); limitation of the visual field for blue, or blue blindness (Cushing); vertigo, particularly in cerebellar tumors; inequality of the pupils; and stupor or other mental symptoms, finally merging into coma, with slow pulse and Cheyne-Stokes respirations. The temperature is normal or subnormal unless there is a complicating meningitis. (2) The *localizing symptoms* are, according to the location of the tumor, interference with the special senses, spasm or paralysis of any of the eye muscles or of muscles in other portions of the body, anesthesia (rare unless the internal capsule is involved), etc. (see cerebral localization). Localizing symptoms are absent if the tumor lies in a silent region. Tumors in the cerebello-pontine angle may cause irritation or paralysis of the third, fifth, sixth, seventh, and eighth nerves. The symptoms of pituitary tumors are given below.

The **diagnosis** from *abscess* is given under abscess (vide supra). *Chronic uremia*, and occasionally *lead poisoning*, may cause headache, vomiting, convulsions, and optic neuritis, so that a careful examination should be made for these conditions. Optic neuritis may occur also in other forms of toxemia, e.g., from arsenic, alcohol, diabetes, acute infectious fevers, as well as in anemia, cerebal syphilis, sinus thrombosis and all forms of compression of the brain. Occasionally no cause for it can be found, and sometimes it is hereditary. Many cases of tumor, particularly in the silent regions of the brain, are wrongly, or perhaps we should say, incompletely diagnosticated as hysteria, neurasthenia, migraine, or essential epilepsy, these conditions really being secondary to the cerebral growth. The situation of a tumor is determined by the localizing symptoms and occasionally by the X-ray. A cortical tumor often causes tenderness over the growth and a local rise in the temperature, and is not associated with anesthesia. Multiple tumors, of which the most frequent are the tuberculous, metastatic, and gummata, may be suspected if widely separated centers are involved. The size of the tumor may be indicated by the number of centers involved and the degree of compression. The nature of the tumor can rarely be foretold. Those which most frequently follow injury are sarcomatous. Tuberculous masses are apt to occur before the twentieth year, and to be associated with tuberculosis elsewhere; the patient may react to one of the tuberculin tests, and tubercles on the choroid are occasionally seen with the ophthalmoscope. The history of syphilis or of a primary malignant tumor in some other portion of the body may aid in arriving at a correct diagnosis, as may also the Wassermann test. Lumbar puncture may be of service, but only a small quantity of fluid should be withdrawn, as several fatalities have followed the escape of a large amount, probably owing to jamming of the brain stem in the foramen magnum.

The **prognosis** is exceedingly gloomy. Excepting the gummata, death is inevitable without operation, and almost 95 per cent. are inoperable. In 25 per cent. of those subjected to exploration the tumor is not found, and the operative mortality is about 33⅓ per cent. for cerebral tumors and 60 per cent. for cerebellar tumors. Of those which survive the removal of a malignant growth, practically all will be the victims of recurrence. The damage to the nervous centers caused by the tumor, even if it has been safely removed, is usually permanent.

The **treatment,** at first, is usually the administration of potassium iodid, with the hope that the growth may be syphilitic. If no improvement is noticed within six weeks, operation should be undertaken. If the Wassermann reaction is absent, one may dispense with this preliminary treatment. The skull over the area indicated by the symptoms is opened by an osteoplastic flap at least three or four inches in diameter. If the patient's condition is poor, the flap may be replaced and the operation completed after several days (*operation in two stages*). The dura is opened as indicated in the chapter on technic, and the tumor enucleated with the finger or handle of a knife, after incising the brain tissue if the tumor be subcortical. If the tumor cannot be removed, the dura should be allowed to gap, and the scalp sutured after stripping the bone from the inner side of the osteoplastic flap, so that at least relief from pressure may be obtained. When the growth cannot be localized or is known to be irremovable *decompression* may be deliberately undertaken to relieve headache and vomiting, prevent blindness, and prolong life. In such cases, if the tumor be cerebral, the bone and dura beneath the right temporal muscle (the speech center is on the left side) should be removed, through a straight longitudinal incision. Cerebellar decompression is made by removing the bone and dura, on each side, from the superior curved line of the occipital bone to the foramen magnum, after reflecting the soft tissues as a flap.

Tumors of the pituitary body (hypophysis cerebri), in addition to the general symptoms of brain tumor, may cause bitemporal hemianopsia (primary atrophy of the nasal half of each optic disc) from pressure on the optic chiasm, and, as shown by the X-ray, excavation of the sella turcica. As with tumors of the thyroid gland the function of the hypophysis may be increased or decreased. Hyperpituitarism (increased activity of the anterior lobe) causes gigantism in youth, acromegaly (q.v.) in adults. Hypopituitarism (decreased activity of the posterior lobe) causes dystrophia adiposogenitalis, i.e., small stature, infantile genitalia (with impotence in men, amenorrhea in women), hypotrichosis, obesity, drowsiness, insensitivity, slow pulse and respirations, low blood pressure, subnormal temperature, and high tolerance for carbohydrates, i.e., it is difficult or impossible to produce glycosuria by giving large quantities of sugar. Little is known of the effects of decreased activity of the anterior lobe and increased activity of the posterior lobe. The tumor may be removed from the front, after osteoplastic resection of the lower portion of the frontal bone, ligation of the longitudinal sinus, and elevation of the frontal lobes; from the side, as in the operation for resection of the Gasserian ganglion; through the body of the sphenoid, after reflecting the nose to one side and removing the turbinate bodies and vomer; or by one of the several modifications of these operations. Care is taken not to excise the entire gland, as complete ablation results in cachexia hypophyseopriva and death.

Epilepsy, from an etiologic and therapeutic standpoint, may be divided into two forms, the idiopathic and the symptomatic. When no cause can be determined the disease is called *idiopathic*, or *essential*, and surgical treatment is not indicated. It is true, however, that operations, e.g., decompression (Kocher), ligation of the longitudinal sinus (Delangéniere), carotid, or vertebral artery, and removal of the cervical sympathetic ganglia, have been recommended for this disease, but such are generally regarded in the same light as an accident, a severe shock, or in fact an operation in any portion of the body, which is occasionally followed by a temporary improvement in the convulsions. *Secondary*, or *symptomatic epilepsy*, may be divided into four varieties. (1) Syphilitic and (2) toxic epilepsy (e.g., due to plumbism, nephritis, diabetes, alcoholism) must be treated medically. (3) Peripheral sources of irritation, such as phimosis, carious teeth, ovarian disease, etc., should be removed with the hope that the disease may be reflex. (4) Those cases depending upon a definite lesion of the brain or its coverings, e.g., injury to the scalp, skull, or brain, or tumor, abscess, hemorrhage, localized meningitis, foreign bodies, adhesions of the membranes, cicatrices in the brain, degenerative changes in the cortex, etc., are usually *focal*, or *Jacksonian*, in type, i.e., the spasm affects one group of muscles only and is not associated with unconsciousness, or it begins in one group of muscles and terminates in a generalized convulsion with unconsciousness. Such cases always demand exploration and removal of the source of irritation. Occasionally simple excision of a scar in the scalp, particularly if it be tender, the seat of an aura, or if pressure upon it produces a fit, will result in cure, even when the convulsions are not focal in character. If on exploration no lesion can be found, the center which initiates the convulsion may be accurately localized by electricity and excised. The resulting paralysis may involve neighboring centers from edema, but such is only temporary, and even the parts supplied by the excised center often resume their functions. The means for preventing adhesions after operations of this character have already been mentioned. When indicated, operation should be performed early, as in late cases the convulsions may continue from the development of an epileptic habit, even after the cause has been removed. Apart from this, recurrences may be due to the redevelopment of adhesions or cicatrices, so that recovery is seldom permanent, although, as indicated above, temporary improvement may follow any operation.

Inveterate headache, particularly when localized and severe, may be due to one of the causes mentioned above under focal epilepsy. If unrelieved after a thorough trial of medicinal measures, trephining and exploration is indicated.

Insanity and arrest of development, when of traumatic origin, may occasionally be benefited by removal of any existing lesion if such, e.g., a depression in the skull, can be localized.

CHAPTER XXII.

SPINE.

Spinal Localization.—The first bony prominence which can be felt beneath the occiput is the forked spine of the axis. The next prominent spine is the seventh cervical, although frequently the sixth cervical or the first dorsal is equally prominent, and in the infant the first dorsal is regularly more prominent. Generally the third lumbar spine is a little more prominent than its neighbors. A line passing through the inner extremities of the spines of the scapulæ crosses the third dorsal spine; through the inferior extremities of the scapulæ, the seventh dorsal; through the highest points of the iliac crests, the fourth lumbar; through the posterior superior spines of the ilia, the first

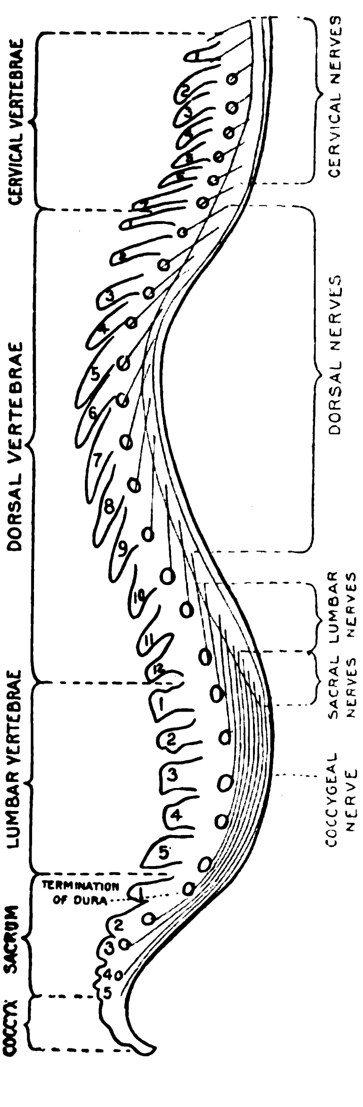

FIG. 263.—Relations of the cord, the membranes, and the nerves with the spinous processes (after Marion). The spinal cord extends to the level of the spinous process of the first lumbar vertebra in men, to the second in women, to the third in infants. The cervical cord terminates at the sixth interspinous space, the dorsal cord at the ninth dorsal spine, the lumbar cord at the twelfth dorsal spine.

The dura terminates at the first sacral spine.

The level of the spinal segments is determined as follows: In the cervical region, add one to the number of a given spinous process, thus the third cervical segment lies opposite the second cervical spine; in the superior dorsal region, add two; from the sixth to the eleventh, add three; the inferior part of the eleventh dorsal spine, the subjacent interspace, and the twelfth spine correspond to the last three lumbar segments; the subjacent interspace and the first lumbar spine correspond to the sacral segments.

In the cervical region, the nerves emerge above the corresponding vertebræ (the seventh nerve emerges above the seventh cervical vertebra); in the dorsal and lumbar regions, they emerge below the corresponding vertebræ. In the cervical and lumbar regions, the foramina are on a level with the spine of the vertebra which limits them above; in the dorsal region, they are on a level with the spine of the vertebra next above that which limits them superiorly.

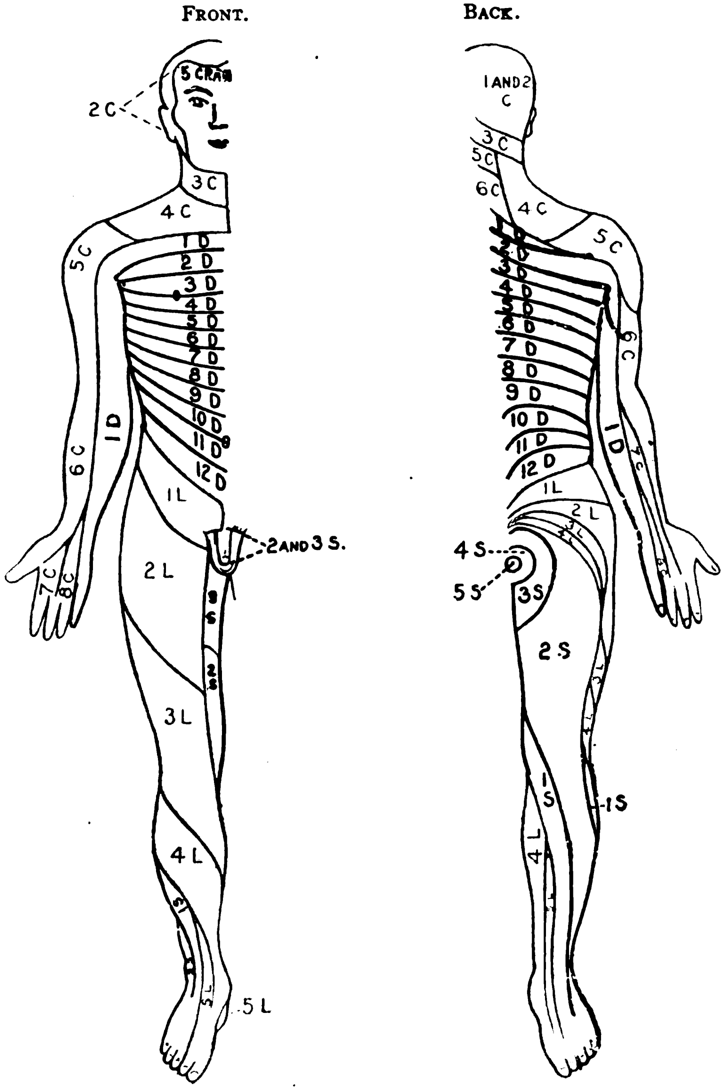

FIG. 264.—Sensory distribution of the spinal segments, combined principally from the diagrams of Bolk. The zones corresponding to the distribution of the cervical and lumbar segments are marked in red. Every cutaneous area is supplied not by one, but by three segments, so that an injury to one sensory root might be followed by but little sensory disturbance. It is therefore necessary to localize a lesion at the level of the highest nerve root corresponding with the highest cutaneous zone attacked.

sacral spine. The bodies of the vertebræ may be palpated as far as the fifth cervical and occasionally lower, through the mouth; the anterior surface of the sacrum and coccyx through the rectum. That section of the cord from which spring the fibers forming a single spinal nerve is called a segment; it corresponds to the nerve to which it gives origin, but does not lie opposite the vertebra of like name and number, owing to the fact that the cord is much shorter than the spinal canal (Fig. 263). A lesion involving all the contents of the spinal canal at a given level destroys not only the segment at that level, but also the nerves which run alongside of it, thus a fracture at the level of the twelfth dorsal vertebra might destroy not only the cord at that level, but also the spinal nerves as high as the twelfth dorsal. A lesion in the cord is localized by the sensory, motor, and trophic symptoms, and by the alterations in the reflexes. These symptoms correspond to an exaltation (hyperesthesia, spasms, increased reflexes) or an abolition of the functions of the spinal segments (anesthesia, paralysis, loss of reflexes), according to the nature and degree of the lesion. Total destruction of one segment causes: *anesthesia* of the skin supplied by that segment and all lower segments, with frequently a narrow band of hyperesthesia immediately above, from irritation of the nerve roots at that level; *paralysis* of the muscles supplied by the destroyed segment and all lower segments; *trophic changes* in the parts supplied by the destroyed segment, and as a rule in the parts supplied by the lower segments owing to descending degeneration (in the absence of descending degeneration trophic changes in the parts supplied by the lower segments need not occur); and absence of the superficial and deep *reflexes*, which may, however, reappear if the cord below the lesion remains intact. Priapism from vasomotor paralysis may occur in lesions of any part of the cord; it occurs also from irritation of the erection center in the sacral cord. Diabetes likewise may occur after a total transverse lesion of any portion of the cord. Complete unilateral lesions cause paralysis upon the same side and anesthesia upon the opposite side (*Brown-Séquard paralysis*).

A study of Fig. 264 will aid in the localization of a cord lesion according to the sensory symptoms. Practically all muscles are innervated not by one but by several segments. In the following table the muscles and reflexes are listed with the highest segment concerning them, since it is in that segment a lesion must be localized if the muscle is completely paralyzed.

Segment.	Muscles.	Reflex.
C. 1	Rectus capitis anticus major (C. 1–4). Rectus capitis anticus minor. Rectus capitis posticus major and minor. Geniohyoid (C. 1–2). Superior and inferior oblique (C. 1–2). Complexus (C. 1–3).	
C. 2	Longus colli (C. 2–8). Sternomastoid. Subhyoids (C. 2–3). Splenius.	

SEGMENT.	MUSCLES.	REFLEX.
C. 3	Levator angulæ scapulæ (C. 3–5). Trapezius (C. 3–4). Diaphragm (C. 3–5). Total lesions at or above this level are usually immediately fatal, as respiration can be maintained only by the sternomastoids and superior part of the trapezii.	
C. 4	Scaleni (C. 4–D. 1). Teres minor (C. 4–5).) Rhomboid (C. 4–5).	Pupillary (C. 4–D. 1).
C. 5	Supra- and infraspinatus (C. 5–6). Deltoid (C. 5–7). Serratus magnus (C. 5–8). Subclavius (C. 5–6). Brachialis anticus (C. 5–6). Supinator longus and brevis (C. 5–7). Biceps. In total lesions just below this level the diaphragm is not paralyzed but coughing is impossible so that a bronchitis quickly proves fatal; the upper extremities assume a characteristic position, abduction and external rotation of the arm with flexion and supination of the forearm, owing to the unapposed action of the muscles just enumerated.	Scapular (C. 5–D. 1). Supinator longus. Biceps.
C. 6	Pectoralis major (C. 6–D. 2). Pronator radii teres. Extensors of wrist (C. 6–8). Triceps (C. 6–7). Teres major (C. 6–7). Latissimus dorsi (C. 6–8). Subscapularis (C. 6–7).	Triceps Posterior wrist.
C. 7	Pectoralis minor (C. 7–D. 2). Coraco-brachialis and anconeus (C. 7–8) Superficial flexors of fingers. Pronators of wrist. Extensors of fingers. Muscles of thenar and hypothenar eminences (C. 7–D. 1). In a total lesion just below this segment the flexors of the wrist and intrinsic muscles of the hand are the only muscles of the upper extremity paralyzed.	Anterior wrist.
C. 8	Flexors of wrist. Interossei and lumbricales (C. 8–D. 1).	Palmar.
D. 1	Intercostals (D. 1–12). Erector spinæ (D. 1–L. 5). Below this level the arms escape paralysis.	

SEGMENT.	MUSCLES.	REFLEX.
D. 2–12	Rectus abdominis and external oblique (D. 5–12). Internal oblique and transversalis (D. 7–L. 1.) Paralysis of these muscles interferes with coughing, defecation and all straining movements. Severe meteorism may develop and interfere with respiration.	Epigastric (D. 4–7). Abdominal (D. 9–12).
L. 1	Quadratus lumborum (L. 1–2). Cremaster. Psoas magnus (L. 1–3).	Cremasteric (L. 1–2).
L. 2	Iliacus. Quadriceps (L. 2–4). Pectineus. Sartorius (L. 2–3). Adductors of thigh (L. 2–4). In lesions below this level the lower limbs are not completely paralyzed.	
L. 3	Internal rotators of thigh. Adductors of thigh (L. 3–4).	Patellar.
L. 4	Flexors of knee (L. 4–5). Extensors of ankle (tibialis anticus, etc). Gluteus medius and minimus (L. 4–5). Flexors of ankle (calf muscles) (L. 4–S. 2). Extensors of toes (L. 4–S. 1).	Gluteal.
L. 5	External rotators of thigh. Gluteus maximus (L. 5–S. 1). Peronei (L. 5–S. 3). Flexors of toes (L. 5–S. 2).	
S. 1–2	Small muscles of foot.	Ankle clonus. Plantar.
S. 3–5	Levator and sphincter ani (S. 3–4). Bladder (S. 3–4). Perineal muscles (S. 4–5). In all total lesions of the spinal cord and of the cauda equina the bladder and rectum are paralyzed, causing retention and later dribbling of overflow in the former, and incontinence in the latter.	Anal. Vesical. Erection of penis.

Laminectomy, or removal of the laminæ of the vertebræ, may be performed for exploration, wounds or compression of the cord, section of the sensory roots, or for diseases of the bones. A straight incision is made over the spinous processes; the laminæ exposed by separating the muscles from the bone with a rougine; the bleeding controlled by gauze sponges, held beneath the retractors which separate the wound; the spinous processes removed with rongeur forceps; the laminæ excised with bone-cutting forceps, chisel, or saw; the contents of the spinal canal examined; the dura opened, if necessary, by a longitudinal incision, using the same precautions as in opening the dura of the brain; the cord examined, being very careful not to exert undue compression; the dura sutured with fine catgut, without drainage whenever possible; and the muscles approximated with catgut and the skin with silkworm gut, superficial drainage being employed for twenty-four hours, or longer if there is infection. Osteoplastic resection, with the base of the flap above or on one side, is more laborious and no more useful. One need not fear to make a large exposure, as such does not permanently weaken the spine. Braces or casts are seldom required after operation. The dangers of infection are no greater than in the skull, chest, or abdomen, and the escape of cerebrospinal fluid seems to do no harm.

Resection of the posterior roots of the spinal cord is commonly called Foerster's operation, although it was first suggested by Dana. The operation has been performed for intractable pain of various sorts, including the gastric crisis of tabes, and for athetosis, spastic paraplegia, and other forms of spasticity, the idea being to break the reflex arc of the affected muscles. Laminectomy is performed, the dura opened, and the roots isolated separately and divided. The location of the pain or the spasticity determines the roots to be sacrificed. In order not to induce complete anesthesia and flaccidity in the affected region, not more than two of the three sensory roots presiding over a given area should be severed. For spastic paraplegia Foerster advises division, on both sides, of the second, third, and fifth lumbar, and the second sacral. The seventh to the tenth dorsal roots on both sides have been divided for gastric crises in locomotor ataxia. Other combinations can be worked out from Fig. 264 and the table on p. 390. The operation has given satisfactory results in some cases; in others it has not secured the desired result. In at least one case a Brown-Séquard paralysis followed.

Spinal puncture (subarachnoid) may be made anywhere between the lower end of the cord and the lower end of the dural sac (Fig. 263), but the favorite spot is just below the fourth lumbar vertebra. The back is bent forward, the left index finger placed on the selected spinous process, the needle (three or four inches long, 1 to 2 mm. in diameter, and containing a stylet) entered just below and to the outside of the finger and pushed slightly inwards and upwards for from ½ to 3 inches, according to the age of the patient and the thickness of the tissues, the stylet withdrawn, and the fluid collected in a sterile test tube.

Spinal puncture has been employed for *anesthetic* (see anesthesia), therapeutic, and diagnostic purposes. The *therapeutic* indications are to relieve pressure, e.g., in cerebrospinal meningitis and compression of the brain, and to inject medicaments, e.g., antitoxins, salvarsanized serum, etc. For *diagnostic* purposes not more than 5 cc. of the fluid, in a child, 10 cc., in an adult, should be withdrawn, as a few cases of collapse after the withdrawal of a large quantity have been reported. Normal cerebrospinal fluid is clear, colorless, alkaline, has a specific gravity of from 1002 to 1010, and contains chlorids, a trace of protein, 0.1 per cent. of glucose (or destrose), and very few leukocytes and endothelial cells (from 1 to 10 per c.mm.). It escapes, when the patient is recumbent, under a pressure of from 5 to 7.5 mm. of mercury. The specific gravity is increased in meningitis, the pressure in meningitis and all forms of compression of the brain (except when the fluid accumulates above a closed foramen of Majendi or aqueduct of Sylvius, or when the communication between the subarachnoid spaces of the brain and cord is obstructed), the protein in meningitis, hydrocephalus, acute infectious diseases, subarachnoid hemorrhage, and in syphilitic and parasyphilitic affections of the cerebrospinal tract. Noguchi's globulin test is positive in meningitis and cerebrospinal syphilis. Glucose disappears early in meningitis, "due to autolysis controlled by leukocytic ferments, the glucose being converted into lactic acid" (Kopetsky). The Wassermann test of the fluid is positive in nervous syphilis. Microscopic examination for cells (cytodiagnosis) may reveal a large number of polynuclear leukocytes (suppurative meningitis), lymphocytes (tuberculous and epidemic cerebrospinal meningitis—moderate lymphocytosis may occur in superficial tumors and syphilis of the brain or cord, in alcoholic meningitis, in uremia), or erythrocytes (fracture of the skull or spine, subdural hemorrhage, hemorrhagic meningitis). In the last instance the fluid should be collected in two tubes, and only that in the second one examined. Bacteriologic examination may discover the organism responsible for a meningitis (q.v.), for poliomyelitis, or for sleeping sickness (trypanosoma Gambiense).

INJURIES OF THE SPINE.

Sprains of the spine are caused by falls, twists, and violent shocks when, as in a railway accident, the muscles are not on guard. The pathology is that of sprains elsewhere. The symptoms are pain, tenderness, and rigidity. Fracture without displacement and without nervous symptoms might give identical symptoms, and the author has seen several cases in which a correct diagnosis could be made only by an X-ray examination. In a *strain* of the back, such as is produced by heavy lifting, the lesion is in the muscles, not in the joints. Sprains are rarely serious, although they are occasionally followed by bleeding into the spinal canal, extension of the inflammation to the meninges, traumatic neuroses, or, in those so predisposed, by spinal caries. The *treatment* is local applications as in sprains in other parts of the body, and rest in bed in the severer cases.

Concussion of the spinal cord is caused by blows or falls which shake or jar the cord. Theoretically at least, no anatomical change is produced. When minute hemorrhages or like lesions occur, the term *contusion* is applicable. Concussion is becoming rarer with improved methods of investigation, and some have doubted even its existence. The author, however, has seen two cases of gunshot wound, close to but not involving the dorsal cord, in which there were typical symptoms of a total transverse lesion, but in which autopsy revealed no anatomical changes in the cord. The *symptoms* are those of shock, and usually a limited, incomplete, and transient interference with sensation and motion, although, as noticed above, they may be those of a total lesion. After any injury to the cord the reflexes may be absent, at least for a time. The *prognosis* in the mildest cases is good, the symptoms disappearing within a few hours or days. If the symptoms are severe and persist, the condition is probably one of contusion or compression rather than concussion. Neurasthenia, hysteria, or organic cord disease may follow even the slightest cases. The *treatment* is reaction from shock and rest in bed. If compression is suspected, laminectomy may be indicated.

Traumatic neuroses may occur after any injury or severe mental shock, but are most frequently the result of sprains of the spine or concussion of the cord due to railway accidents, hence the term "railway spine"; when following an injury to the head the condition has been termed "railway brain."

The *symptoms*, which may closely follow the accident, or be delayed for hours or even days, are those of neurasthenia (*traumatic neurasthenia*), hysteria (*traumatic hysteria*), or hystero-neurasthenia, and are identical with those occurring in non-traumatic cases, for which the reader is referred to a text-book on medicine. Other nervous affections, such as neurotic diabetes, paralysis agitans, chorea, exophthalmic goiter, tabes, myelitis, and similar inflammatory and degenerative processes, may follow accidents such as have been described above. The *diagnosis* of traumatic neuroses requires great care, first to rule out organic disease, secondly to detect malingerers who feign disease in order to secure damages. The prognosis is generally favorable. The *treatment* is that of non-traumatic neurasthenia and hysteria.

Compression of the spinal cord develops suddenly in fractures, dislocations, foreign bodies, and intramedullary hemorrhage; more slowly in extramedullary hemorrhage (within twenty-four or forty-eight hours), inflammatory exudate, e.g., in acute spinal meningitis (in the course of several days), and pachymeningitis (a week or longer); and very gradually in tumors, cysts, aneurysms, callus formation, cicatrices, etc. The *symptoms* and the means of determining the level of the lesion have already been considered under spinal localization. The *treatment* varies with the nature and cause of compression, and will be given when the individual forms are discussed.

Fracture of the spine is caused by direct, or much more frequently by indirect violence. In the former the break is situated at the point struck and the arches are particularly liable to suffer, a spicule of bone often being driven into the cord. In the latter the injury is usually due to hyperflexion of the spine, such as occurs when a man dives into shallow water, falls from a height on the feet or buttocks, or is doubled up by the caving in of an embankment, the vertebral column generally breaking at the junction of a freely movable with a comparatively fixed portion, i.e., in the cervico-dorsal (most frequent) or dorso-lumbar region; the bodies of the vertebræ, with or without the arches, are broken, and the upper segment usually displaced forwards (*fracture-dislocation*), thus contusing or compressing the cord. The muscles, ligaments, and membranes may be torn, and blood may collect between the bone and the membranes, or between the membranes and the cord.

The **symptoms** are (1) *shock* of varying degree; (2) *local evidences of fracture*, such as pain, swelling, tenderness, usually deformity, and possibly crepitus; and (3) *interference with the functions of the cord*, due to concussion, contusion, or compression, i.e., more or less complete paralysis and anesthesia below the injury, with decrease or abolition of the reflexes, and trophic changes (see spinal localization). Without displacement, cord symptoms may be absent, and in some cases the diagnosis can be made only by the X-ray. Paralysis coming on after a short interval may be due to edema of the cord, extramedullary hemorrhage, inflammatory exudate, or secondary displacement of bone. The symptoms of complete transverse destruction of the cord have already been given. Incomplete destruction may be diagnosticated when there is incomplete paralysis, partial anesthesia, and retention of the reflexes in the parts supplied by the cord below the injury; not infrequently, however, the symptoms will be identical, sometimes for several days or longer, with those of a total transverse lesion. The *prognosis* in all cases with total paralysis and complete anesthesia is distinctly unfavorable, both regarding life and return of function. The higher the lesion the worse the prognosis. Death occurs immediately from shock or interference with respiration (in the upper cervical region); during the first week from suffocation with mucus (in the lower cervical region) or from meningitis; or after weeks or months from exhaustion and sepsis the result of extensive bed sores, cystitis, or pyonephrosis. With even a completely divided cord, however, life may be prolonged for years if the injury is in the dorsal or lumbar region.

The **treatment** is first reaction from shock. Whether or not operation has been decided upon, the patient should be placed on an air or water bed and most carefully nursed to prevent bed sores. The bladder should be catheterized every eight hours, or more often, with the most rigid aseptic precautions to prevent cystitis. Massage and electricity should be employed to maintain the nutrition of the paralyzed parts. Attempts to effect reduction by extension and pressure, without operative exposure of the parts, are too dangerous to be recommended. Excepting fractures in the cervical region, sand bags, plaster casts, etc., are seldom required to immobilize the parts. There is no general agreement as to the indications and time for operation. Many neurologists and a few surgeons doubt the value of laminectomy in any case. This condition of affairs is due to the difficulty of differentiating concussion from compression, and to the teaching that the tissues of the cord are incapable of regeneration; the latter is true with regard to the brain, however, but does not deter surgeons from operating early and radically in fractures of the skull. The authhor's views, which are not those generally adopted, are as follows: Fractures of the spine should be treated like fractures of the skull, i.e., for (1) disinfection; (2) depression, and (3) compression. 1. All compound fractures must be disinfected. 2. Obvious depression of the laminæ will often be associated with symptoms of compression, but even in the absence of such symptoms, the depressed bone should be removed, because of the danger of injury to the cord by displacement of the fragments during subsequent treatment, and because of the danger of pressure from callus on the cord or nerve roots at a later period. 3. All fractures, whether simple or compound, with symptoms of compression require laminectomy as soon as shock has subsided, unless in the meantime the symptoms have distinctly ameliorated. The more severe the symptoms the more imperative the operation. It is true that at this period one cannot always be sure whether the symptoms are those of concussion, contusion, or compression, but pure concussion is rare, and contusion with its subsequent edema can only be benefited by the drainage of operation. The compressing agent (bone, blood clot, foreign body) should be removed before the onset of secondary degeneration. Removal of the posterior arches may be all that is required, or compression may be caused likewise by the body of a vertebra (Fig. 265), in which case reduction may be attempted by extension and direct pressure, or failing in this, the projecting edge of bone should be bitten away with rongeur forceps, taking care not to contuse the cord. If the dura is distended or bluish and no pulsation can be detected, a subdural clot exists,

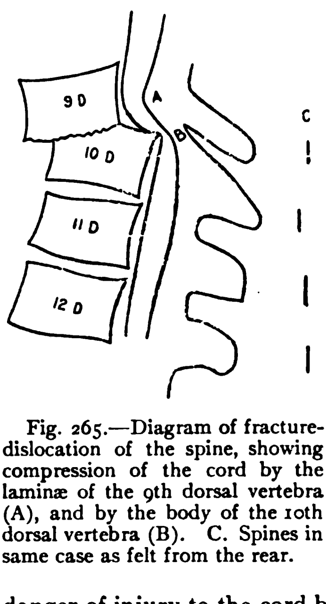

Fig. 265.—Diagram of fracture-dislocation of the spine, showing compression of the cord by the laminæ of the 9th dorsal vertebra (A), and by the body of the 10th dorsal vertebra (B). C. Spines in same case as felt from the rear.

and such should be removed. If the spinal sheath seems empty, the dura should likewise be opened and the divided cord, for such will probably be found, sutured with catgut (see also wounds of the cord). Operation is not indicated in simple fractures without obvious depression or cord symptoms, or in simple fractures with cord symptoms which are improving.

Dislocations of the vertebræ without fracture are extremely rare and confined almost exclusively to the cervical region, usually the lower half. The upper vertebra is called the dislocated one, contrary to the custom when speaking of dislocations elsewhere. The usual cause is hyperflexion, both articular processes of the upper vertebra passing in front of those of the lower vertebra, i.e., a *complete bilateral anterior dislocation* (Fig. 266). *Bilateral posterior dislocation* may be caused by hyperextension, *unilateral dislocation* by forcible approximation of the head and shoulder combined with rotation. *Incomplete dislocation* also may occur (Fig. 267). The ligaments and intervertebral discs are torn, and in complete bilateral cases the cord is almost always compressed, usually causing, in the upper cervical region, immediate death. In many incomplete or unilateral cases, the cord may escape pressure by bone, although it may still be compressed by blood clot, and the nerve roots may be stretched or torn, causing neuralgia, etc. In forward dislocations the head is displaced forwards and bent towards the chest. In backward dislocations the head is displaced backwards and the face turned upwards. In unilateral dislocations the head is bent towards the sound shoulder. The deformity may be felt externally or through the pharynx, and demonstrated with the X-ray; in any case there is likely to be difficulty in swallowing.

The **treatment** of unilateral and incomplete dislocations is reduction, under an anesthetic, by traction and approximation of the head towards the

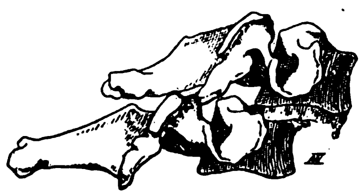

FIG. 266.—Complete dislocation. (Marion.)

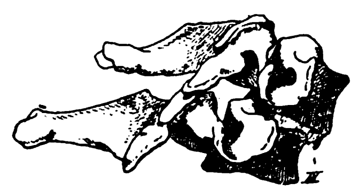

FIG. 267.—Incomplete dislocation. (Marion.)

sound shoulder to unlock the processes, then rotation of the head, the ear on the sound side moving forwards. In long standing cases reduction cannot be effected, but operation may be undertaken to relieve pressure on the spinal nerves. Bilateral dislocations may be reduced by bending the head towards the right shoulder and rotating the head (the right ear being carried forward), thus converting the dislocation into a unilateral one, which may be reduced by reversing the movements just described. These manipulations are so dangerous, that it is probably best to relieve pressure by at once removing the laminæ of the dislocated vertebra, and then reducing the bones under the guidance of the finger and eye. If sufficient traction cannot be exerted to unlock the processes, as little as possible of the upper margin of the upper articular processes of the lower vertebra should be removed to permit reduction. Removal of the whole process would, of course, permit recurrence which, however, might be prevented by fixing the spinous processes with a transplant from the spine of the scapula. The dura may be opened to remove coagulated blood.

Wounds of the spinal cord are usually the result of stabs or gunshot injuries. There may be complete paralysis below, or if half of the cord is divided, loss of motion on the same side and anesthesia on the opposite side, or again the injury may be limited to the nerve roots. Although it is generally taught that regeneration of the cord never occurs, the author has had a case in which a severed spinal cord was sutured and in which partial return of function followed. The *treatment* is laminectomy, removal of foreign bodies and comminuted bone, and suture of the wound of the cord and of the severed spinal nerves with catgut. The dura should be closed whenever possible. Probes should never be employed to explore the wound. In the cervical region it may be necessary to tie the vertebral artery.

Intraspinal hemorrhage may be extradural, subdural, or intramedullary. It is usually the result of injury, but may be due to other causes, e.g., acute infectious fevers, convulsions, rupture of aneurysms, etc.

In extra- and subdural hemorrhage (*hematorrhachis*) the *symptoms* are pain in the back and irritation of the nerve roots (pain, hyperesthesia, and spasms in the parts supplied by the affected nerves), followed by symptoms of compression, the paralysis and anesthesia coming on suddenly, or perhaps slowly from below upwards as the blood increases in amount. Complete recovery may occur in traumatic cases. The *treatment*, excepting the milder forms, is, in the early stages when the blood is still fluid, spinal puncture, and at a later period laminectomy and removal of the clot.

Intramedullary hemorrhage (*hematomyelia*) is most frequent in the lower cervical region. The *symptoms* are sudden paralysis and anesthesia of the parts below, and intense pain in the back. The lesion may be unilateral (paralysis on one side, anesthesia on the other), or if the bleeding is slight, signs of irritation may be present, but are not so common as in extramedullary hemorrhage. The usual treatment is that of concussion.

DISEASES OF THE SPINE.

Spina bifida (*rachischisis*), or failure of the spinal laminæ to unite, is present in about one in every 1,000 children born. Sometimes there is a small congenital gap in the spine, the cord and membranes remaining in the canal (*spina bifida occulta*); the skin is frequently indented over this defect and the dimple filled with hair. These cases need no treatment unless there are symptoms of pressure on the cord, when the removal of such compression, which may be due to hypertrophy of the skin and subjacent soft parts, would be indicated. In 2 per cent. of the cases the cleft is wide, the skin is absent, and the cord protrudes through the opening, its central canal communicating with the surface of the body (*myelocele*). This condition is not compatible with existence. In 10 per cent. the membranes alone escape through the opening (*meningocele*), but in the vast majority (about 75 per cent.) there is also a portion of the cord in the protuberance (*meningomyelocele*), and very rarely the tumor is the result of a dilatation of the central canal of the cord (*syringomyelocele*). The last variety is often situated laterally. More than one vertebra is usually fissured, and cases have been reported in which all the vertebræ were involved. Rarely the body of the vertebra is implicated (*anterior spina bifida*). One-half of all cases occur in the lumbar region, and more than one-third in the lumbosacral or sacral portion of the spine.

Diagnosis.—The swelling is congenital, almost always central, and partly reducible, pressure causing the fontanelles to bulge and sometimes producing convulsions or other nervous symptoms. Palpation and the X-ray reveal the cleft, and there is bulging on crying or coughing. Translucency may be detected, with the cord or nerves represented as shadows. There may be other developmental defects, such as hare-lip and talipes (Fig. 268), and as the result of compression or abnormalities of the nervous elements, anesthesia, paralysis, or trophic changes may be found below the cloven spine.

The **prognosis** is bad, although spontaneous recovery may occur in rare instances when the opening is small and the skin thick and healthy. Death is due to marasmus, to the sequelæ of paralyses, or to meningitis following rupture or inflammation of the sac.

The **treatment,** if operation is not decided on, is protection of the sac by collodion or a suitable cap, in order to prevent rupture. Morton's fluid (iodin gr. 10, potassium iodid gr. 30, glycerin 1 oz.) may be injected in the dose of 2 dr., repeated in ten days if necessary, care being taken during the injection to obliterate the neck of the sac as much as possible by compression. This plan has so often been followed by sloughing and rupture of the sac, by convulsions and meningitis, and by paralysis and hydrocephalus (mortality 40 per cent.), that most surgeons prefer excision (mortality 25 per cent.). The lumbar region in infants is so difficult to keep clean that operation should be postponed as long as possible. If the skin is thin, or threatens to ulcerate, or if the tumor is enlarging, operation becomes imperative. An elliptical incision is made about the tumor, and the sac opened laterally by a small transverse cut, in order to avoid the cord, which may be adherent in the middle line, and the nerves which run at right angles to it. If no nervous tissues are present, the sac is removed and the opening sutured with catgut. If nervous structures are present, they are separated from the sac; if intimately adherent, that portion of the sac in which they are incorporated may be reduced with them into the spinal canal. The muscles on each side are then loosened, sutured together, and the skin closed. The bony defect has been closed by drawing the remnants of the laminæ, if present, over the gap; by swinging a flap of bone, attached by its periosteum, from the outer table of the ilium; by a bone graft, such as the scapula of the rabbit; and by foreign substances, such as a plate of celluloid; procedures of this character are rarely necessary. Recurrences sometimes occur and hydrocephalus may follow.

FIG. 268.—Spina bifida and club foot. (Kirmisson.)

Congenital sacrococcygeal tumors occur on the dorsal or ventral surface. *Lipomata* may communicate with the interior of the spinal canal, *dermoids* with the rectum, bladder, or spinal meninges. *Cystic tumors* containing a myxomatous material and developing between the rectum and sacrum originate in the remains of the postanal gut, or neurenteric canal (the canal which connects the neural and enteric tracts in early fetal life). *Teratomata* (Fig. 269), *sarcomata,* and *spina bifida* constitute the remaining congenital tumors in this region. The *treatment* is removal; it may be necessary to excise a portion of the sacrum or split the posterior wall of the rectum.

Sacrococcygeal fistulæ are the result of imperfect coalescence of the skin, or persistence of the postanal gut. The simplest form is the postanal dimple. Others may communicate with the rectum or spinal canal. The *treatment* is excision unless the condition gives no trouble.

Spinal curvatures include scoliosis, kyphosis, and lordosis.

Scoliosis, or lateral curvature, rarely involves the spine in one curve (*total scoliosis*); as a rule there are two or more lateral curves with their convexities in opposite directions (Fig. 270). Lateral deformities of the spine due to caries, fracture, tumors, etc., are not placed under this heading. The *causes* are *rickets; asymmetry,* the result of shortness of one leg, empyema, torticollis, etc.; *faulty postures,* the result of habit (e.g., standing on one leg), occupation (e.g., constantly working a lever with one hand or foot), or disease (e.g., sacroiliac disease); and *central nervous diseases,* producing unilateral atrophy or spasms of the muscles, The most common form is the *scoliosis of adolescence,* due to relaxed muscles and ligaments which do not develop as rapidly as the spine. One of the causes mentioned above may be a contributing factor. The patients are usually anemic girls, easily fatigued, and frequently assuming attitudes of rest, e.g., standing with the weight resting on one leg or lounging in a faulty position.

Symptoms and Pathological Anatomy.—In the usual variety the lumbar spine becomes convex towards the left, and later a compensatory dorsal curve with the convexity to the right develops; there may or may not be an associated kyphosis. The vertebral column not only deviates laterally,

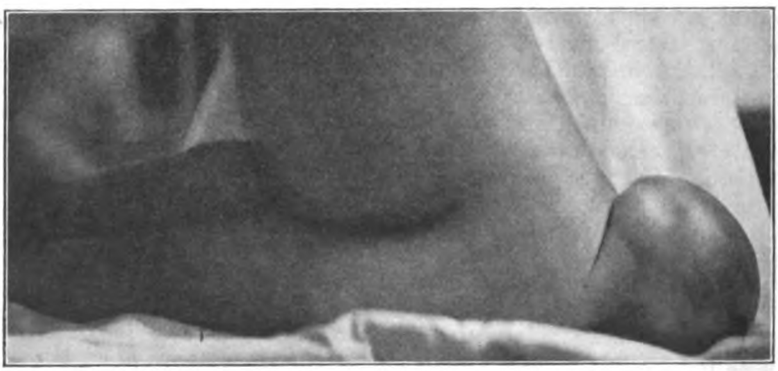

FIG. 269.—Sacrococcygeal teratoma. (Pennsylvania Hospital.)

but is twisted in a spiral direction, the spines rotating towards the concavity, so that they do not give an accurate indication of the degree of curvature. The ribs on the right side are separated, more horizontal, and bent at their angles; the shoulder is raised, the scapula more prominent, and the front of the chest flattened. On the left side the ribs are crowded together and their angles are more obtuse, so that the shoulder is lower, the scapula less prominent, and the chest projects anteriorly. The sternum moves towards the concavity and faces the convexity. In the worst cases the thoracic and abdominal viscera are displaced. The left hip projects and the waist on the right side is more marked. In the initial stages the deformity disappears on bending forward, or on hanging from a bar, but in the fixed stage when the bones have become altered in shape this is impossible. Malaise, backache,

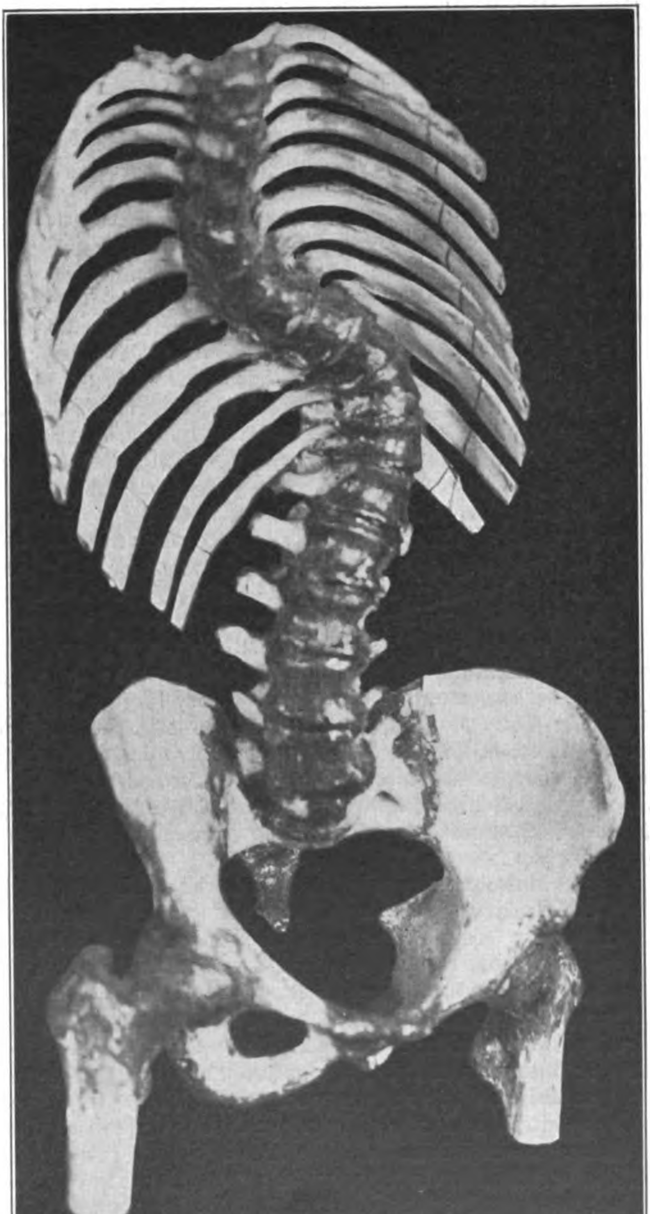

FIG. 270.—Scoliosis. (Philadelphia College of Physicians.)

intercostal neuralgia, dyspnea, and dyspepsia may annoy the patient. The *prognosis* is good if the cause can be removed and the spine straightened by extension. In the later stages improvement may be obtained or at least the progress of deformity interrupted.

The **treatment** is removal of the cause when such is possible, the correction of vicious attitudes, massage and electricity to the weakened muscles, and gymnastic exercises, such as swinging from a bar, riding a bicycle with an inclined seat, balancing a light weight on the head, placing the hands together above the head and bending forwards, etc. The general health should receive attention and the patient should rest in the recumbent posture daily. Braces and supports tend to weaken the muscles, and are employed only when deformity is advancing despite other treatment. In suitable cases *Abbott's method* seems to offer the best prospects for complete recovery. The patient lies with the back flexed in a canvas hammock. Straps are passed around the body in various directions, and fastened to a frame of gas pipe, the bars of which are rotated, thus winding up the straps, until the deformity is corrected as far as possible. A plaster-of-Paris jacket, with pads arranged to maintain the correction, is then applied. After the plaster has hardened windows are cut in the jacket posterolaterally over the site of the previous concavity of the spine, and anterolaterally over the site of the previous convexity. Through these windows felt pads are introduced to increase the amount of correction. The casts are changed every four to six months, until overcorrection is obtained. The patient then wears a celluloid jacket, except when taking exercises to strengthen the muscles, until there is no longer any tendency toward recurrence of the deformity.

Kyphosis, or dorsal convexity of the spine, may involve the whole column, as is physiological in infants, but is usually confined to the dorsal region and may or may not be associated with a compensatory lumbar lordosis. The *causes* are *rickets; faulty postures,* the result of habit (as in piano playing), occupation (cobblers, tailors, etc.), or disease (myopia, dyspnea, asthma, emphysema and chronic abdominal disease); *affections of the spine,* such as tuberculosis, syphilis, malignant growths, aneurysmal erosion, osteoarthritis, ostitis deformans, osteomalacia, hypertrophic pulmonary osteoarthropathy, and acromegaly; *fractures;* and *senile atrophy.* The *round shoulders of adolescence* occurs in the same type of patients as the scoliosis of adolescence.

The **treatment** varies with the cause; many of the forms mentioned above cannot be remedied. In adolescence round shoulders may require the correction of myopia or the removal of adenoids. Vicious postures should be corrected, and the muscles strengthened by massage, electricity, and exercises; rest should be taken on a hard mattress, with a pillow beneath the deformity. If the deformity is progressive, a brace may be required.

Lordosis, or anterior curvature of the lumbar spine, is compensatory in kyphosis, large abdominal tumors, pregnancy, etc. The most common cause is fixation of the hip in flexion, e.g., in congenital or unreduced dislocations and in hip disease or ankylosis. It occurs also in rickets, caries of the posterior part of the vertebral bodies, progressive muscular atrophy, pseudohypertrophic paralysis, and spondylolisthesis. The *treatment* is removal of the cause when such is possible.

Spondylolisthesis is a rare condition confined almost exclusively to the lumbosacral joint. As the result of imperfect development or fracture of the articular processes, the spinal column slips downward and forward from the sacrum, thus causing marked lordosis and shortening of stature. The *treatment* is extension in the recumbent posture. If the patient sits up or walks, a brace will be needed to convey the weight of the body to the pelvis. Ryerson treated one patient successfully by splinting the spine with a bone graft.

Spondylitis deformans is osteoarthritis of the spine which results in locking of the vertebræ by osteophytes. There are pain and tenderness, with kyphosis and perhaps pressure on the nerve roots. The treatment is that of osteoarthritis elsewhere. Braces are occasionally required to prevent increase of deformity.

Typhoid spine is a term applied to a periostitis or ostitis following typhoid fever. There are pain, tenderness, and weakness of the spine, with muscular rigidity. Suppuration rarely occurs. The treatment is a plaster cast or leather jacket, and later massage and electricity.

Acute osteomyelitis of the vertebræ is uncommon and is due to the same causes as osteomyelitis elsewhere. When the arches are involved the condition is easily recognized, but when the bodies are affected the diagnosis is often difficult, the condition being mistaken for typhoid fever, peritonitis, etc. The infection may spread to the meninges, the symptoms then being those of meningitis. The *symptoms* are acute pain and tenderness, rigidity of the spinal muscles, and the constitutional symptoms of sepsis. The abscess may appear posteriorly or anteriorly (retropharyngeal, mediastinal, lumbar, or pelvic). The *treatment* is that of osteomyelitis elsewhere, viz., incision and drainage, and at a later period removal of the sequestrum.

Tuberculosis of the spine (*Pott's disease, angular curvature, spondylitis*) may occur at any period of life, but is most frequent between the sixth and tenth year. Heredity, impaired health, poor hygienic surroundings, and injuries, often slight in nature, provide a favorable soil for the tubercle bacillus. The disease may occur in any portion of the spine, but is most frequent in the lower dorsal region.

The **pathology** is that of tuberculous bone disease elsewhere. The starting point is usually on the anterior surface of the body just beneath the periosteum, or at the upper or lower epiphyseal line; the posterior arches are rarely involved primarily. The cancellous bone of the body is gradually destroyed, and the disease spreads to neighboring vertebræ beneath the anterior common ligament, or by disintegrating the intervertebral cartilages. Caseous changes occur, and pus forms, and burrows in the direction of least resistance. Caries without suppuration (*caries sicca*) and caries with the formation of sequestra (*caries necrotica*) occasionally occur. Owing to the destruction of the bodies of the vertebræ, the spine bends and a posterior angular deformity is produced (Fig. 271). The spinal cord is occasionally involved. Cure is effected by the formation of new bone, ankylosis of the vertebræ, and the organization or calcification of the surrounding inflammatory tissue.

The **local symptoms** are pain, rigidity, deformity, abscess, paralysis. *Pain* is rarely severe, indeed may be absent. It is increased by local pressure, movements, and jarring of the spine. When the nerve roots are irritated the pain is referred to the area supplied by these nerves. *Rigidity* in the early stages is due to muscular spasm, which is nature's effort to protect the diseased part. In the convalescing stage immobility of the spine is due to ankylosis. Movements of the spine are instinctively resisted. The patient walks like a marionette, refuses to jump, stoops by bending the knees and hips and not the back, turns around by moving the whole body as a unit instead of rotating the spine (particularly in cervical caries), and when sitting takes the weight of the upper part of the trunk from the diseased vertebræ (lower dorsal or lumbar caries) by grasping the arms of the chair. The hardening of the muscles is easily appreciable to the fingers. *Deformity* varies in nature and degree according to the location and extent of the disease. In the early stages a slight lordosis in the cervical or lumbar region may be caused by muscular spasm, very rarely by caries of the posterior part of the vertebral body. Disease of the arches does not produce deformity. When the disease affects one side more than the other and lateral curvature occurs, the torsion of the vertebræ is in the opposite direction to that of scoliosis, i.e., the bodies occupy the concave side of the curve. Posterior angular deformity is the typical one; the more vertebræ involved the more obtuse the angle. In the cervical and lumbar regions the spine necessarily becomes

FIG. 271.—Dorsolumbar Pott's disease, with section of vertebræ showing absorption of bodies. (Young.)

straight before posterior deformity can occur; in the former situation it is rarely marked. Compensatory curves form in the remaining parts of the spine, and when the dorsal vertebræ are badly deformed secondary changes in the shape of the thorax occur. *Abscesses* occur in the later stages, and owing to their deep origin usually attain a large size and travel a long distance before being recognized. In the cervical region the pus collects behind the posterior pharyngeal wall (*chronic retropharyngeal abscess*, see pharynx). In the upper dorsal region the abscess usually perforates the intercostal structures and appears posteriorly (*dorsal abscess*); rarely it comes to the surface at the base of the neck. In the lower dorsal or the lumbar region the pus passes backwards (*lumbar abscess*), or enters the psoas sheath (*psoas abscess*) and gravitates downwards, either forming a large swelling in the iliac region or pointing below Poupart's ligament, usually external to the femoral vessels. A psoas abscess may, however, come to the surface on the inner side of the vessels, on the inner side of the thigh, or even as low as the heel; occasionally it bursts into the rectum, bladder, vagina, or on the perineum. *Paralysis* is not frequent (about 7 per cent.) and occurs only in the later stages. It is rarely sudden in onset, and is then probably due to displacement of bone. As a rule it appears slowly as the result of compression of the cord by tuberculous masses or pus, or most commonly pachymeningitis. Sensation is affected later. The *constitutional symptoms* are those of tuberculosis elsewhere.

The **diagnosis** may be difficult before the onset of deformity. Localized tenderness and rigidity are the most important symptoms in this stage. The reflected pains may be mistaken for pleurisy, abdominal disease, neuralgia, rheumatism, etc. Angular deformity may be caused also by syphilis, malignant growths, and aneurysmal erosions. In kyphosis due to other causes, the deformity is usually a long curve rather than a limited angular projection, and rigidity is generally absent. Flexion of the hip due to psoas abscess should not be mistaken for hip joint disease, and it should be recalled that psoas abscess may be due to other causes than tuberculosis, as may also abscesses in the other regions indicated above. The osseous lesion can almost always be demonstrated with the X-ray; the tuberculin test is occasionally of service.

The *prognosis* is good in children who are efficiently treated from the beginning. The higher the disease, the more vertebræ involved, and the older the patient, the worse the prognosis. Abscesses which become infected with pyogenic organisms cause hectic fever and eventuate in amyloid disease unless the infection can be controlled. Paralysis is a grave complication, but with suitable treatment may entirely disappear. Death is usually the result of exhaustion, sepsis, tuberculosis elsewhere, involvement of the cord or meninges, or an intercurrent malady. Sudden death from dislocation may occur in disease of the atlas or axis.

The **treatment** is local and constitutional. For the latter see tuberculosis. The *local treatment* is (1) rest, (2) correction of deformity, (3) evacuation of abscesses and possibly removal of diseased bone, and (4) the care of paralysis if it should occur. Local applications are useless, and blisters and the actual cautery may be harmful in predisposing to bed sores. 1. *Rest* is best obtained by the recumbent posture and the application of extension. In cervical caries extension is applied to the head only (Fig. 272), the head of the bed being slightly elevated, and sand bags being used to prevent lateral motions. In the lower dorsal or lumbar region extension should be applied also to the legs. Restless children may be fastened in a specially constructed box or trough in which an opening has been provided for the discharges from the bowels. After a number of months when the pain and acute symptoms have subsided, or even before in adults or in children who do not stand bed treatment well, a plaster cast or a leather brace should be applied and the patient allowed to walk about. Sayre's plaster jacket is applied as follows: An armless woolen undershirt, reaching below the iliac crests, is put on the patient, who is suspended from a tripod (Fig. 273) with the toes just reaching the ground; instead of using the axillary straps the patient may grasp the cross bar above. In some cases the cast should be applied in the recumbent posture while extension is being made. A folded towel is placed over the epigastrium, and this "dinner pad" is withdrawn after the plaster has set; padding is placed also over the posterior deformity, the iliac crests, and the breasts. Plaster bandages are now applied about the trunk from the axillæ to below the iliac crests. In disease above the middorsal region it will be necessary to apply a jury mast (Fig. 274), or to include the neck in the plaster bandage, so as to take the weight of the head from the body. The

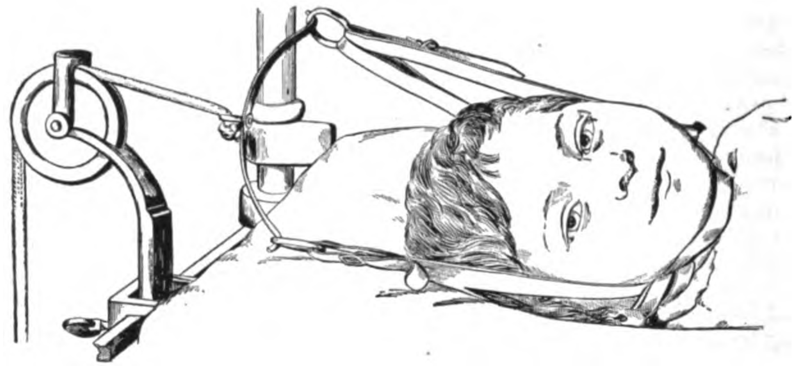

FIG. 272.—Head extension for Pott's disease. (Young.)

cast may be split down the front and provided with hooks for lacing, so that it may be removed and reapplied from time to time, or a new cast may be applied every two or three months. The cast or a suitable leather or felt jacket should be worn for at least six months after the patient is apparently cured. In order to secure ankylosis, the spinous processes of the vertebræ may be

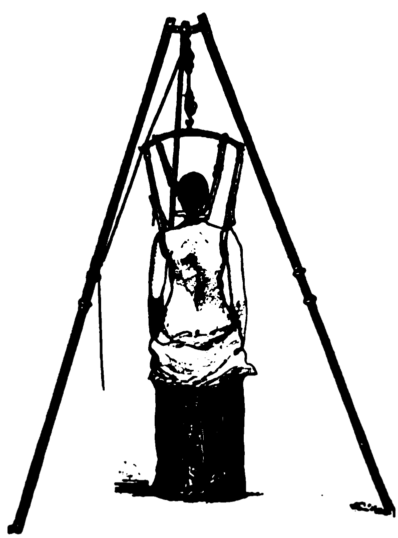

FIG. 273.—Sayre's tripod.

FIG. 274.—Sayre's jury mast.

split longitudinally and a segment of the crest of the tibia (Albee), or of the vertebral border of the scapula (Ombrédanne) implanted into the osseous wound.

2. *Deformity* when recent may be gradually corrected by extension, and gentle pressure over the gibbosity, either by means of a pad left in place or by

daily pressure with the hand. In old cases after ankylosis has occurred, removal of the spinous processes may be indicated. Forcible correction at one sitting, first proposed by Chipault, who also wires the spinous processes together to maintain the reduction, is often called Calot's method because of the enthusiasm with which he has advocated it. Most surgeons consider the method dangerous.

3. *Abscesses* should be evacuated when detected. The general principles of the treatment of chronic abscess have been considered in Chap. VII, and the treatment of retropharyngeal abscess will be described under diseases of the pharynx. In abscesses due to disease of the posterior arches, a free incision should be made, the diseased bone removed, and the cavity disinfected and packed with iodoform gauze. Dorsal, lumbar, and psoas abscesses should be incised at the point where they are nearest the surface, the pyogenic membrane and cheesy masses removed by curetting with a piece of gauze on a long pair of forceps, the cavity irrigated with salt solution and injected with iodoform emulsion, and the wound closed with sutures. Some surgeons prefer to tap with a trocar and cannula, but irrigation is unsatisfactory through a cannula and removal of the débris is impossible. These operations may have to be repeated. If diseased bone is found it should be removed. *Treves' operation* may be performed in disease of the twelfth dorsal or any of the lumbar vertebræ. An incision is made along the outer edge of the erector spinæ from the last rib to the crest of the ilium, and the tissues divided until the quadratus lumborum is exposed, which with the underlying fascia is cut transversely to avoid the lumbar arteries. The psoas is opened, irrigated with bichlorid 1 to 5,000, the pyogenic membrane scraped off with the finger, diseased bone removed with forceps or curette, and the wound closed with sutures. Similar operations have been performed in the cervical and, after resection of the ribs, in the dorsal regions.

4. *Paralysis* is treated by extension and gentle pressure to correct the deformity, care being taken to preserve nutrition, prevent bed sores, cystitis, etc., as indicated under fracture of the spine. As compression of the cord is usually caused by pachymeningitis, and as recovery frequently follows this treatment, laminectomy is employed only when the symptoms persist or increase after months or even a year of extension, when the patient's life is threatened by sepsis the result of cystitis or bed sores, when the posterior arches are diseased, or when the compression is acute in onset, indicating bony displacement.

Spinal meningitis extends from the membranes of the brain or begins as a local affection. *Pachymeningitis* may follow disease or injury of the vertebræ and is often syphilitic or tuberculous in nature. A hemorrhagic pachymeningitis interna analogous to that found in the head occurs, chiefly in the cervical region. The symptoms of pachymeningitis are first those of irritation of the nerve roots, i.e., shooting pains and perhaps spasms in the parts supplied by the nerves, and later those of a gradually oncoming compression of the cord. The *treatment* is removal of the cause, rest, and potassium iodid. Laminectomy may be indicated in the later stages.

Acute leptomeningitis may follow disease or injury of the spinal column, or wounds of the membranes. It usually extends to the cerebral meninges, and then presents the symptoms described under inflammation of the latter structure, and is treated by the same means. *Chronic leptomeningitis* may follow the acute form. When chronic from the beginning it is usually localized, and is prone to attack the syphilitic and alcoholic. The *symptoms* are localized pain in the back, rigidity of the spinal muscles, and evidences of irritation of the nerve roots as described above. If granulations form, the symptoms will be similar to those of tumor. The *treatment* is rest, counter-irritation, sedatives, potassium iodid, and laminectomy if pressure symptoms ensue.

Intraspinal tumors are generally gliomata, gummata, or tuberculous masses. Lipoma (usually congenital), fibroma, angioma, myxoma, chondroma, hydatid and dermoid cysts, secondary carcinoma, and sarcoma also occur. The tumor may be extradural, subdural, or intramedullary. The *symptoms* are those of a gradually oncoming compression with perhaps localized pain and tenderness over the segment involved. The disturbances of motion, sensation, and of the reflexes, develop from below upward and are often at first unilateral. In the beginning the symptoms are those of irritation, i.e., shooting pains, hyperesthesia, localized spasms (perhaps causing lateral curvature, the concavity being on the side of the tumor), and increased reflexes. Later there are paresis, hypesthesia, and decrease of reflexes, and finally paralysis, anesthesia, loss of reflexes, and trophic disturbances. Motion is usually affected before sensation, but this will necessarily depend somewhat on the situation of the growth. The pupils may be affected if the lesion is above the second dorsal segment. The *diagnosis* of the nature of the growth is usually impossible, although a previous history of syphilis, tuberculosis, or a malignant growth elsewhere, should be sought; a tumor occurring soon after birth would probably be a lipoma. The X-ray and the Wassermann and tuberculin tests also may give valuable information. The seat of the tumor is determined by the localizing symptoms (see spinal localization). Intramedullary growths usually produce bilateral symptoms and earlier signs of compression. Extramedullary growths are apt to cause earlier and more severe signs of irritation. Chronic inflammation of the meninges or cord may produce similar symptoms. The *prognosis* is much more favorable than in cerebral tumors. About one-half are operable and about one-half of those operated upon are benefited. The mortality of operation is 10 per cent.

The **treatment**, if syphilis and metastatic growths can be excluded, is laminectomy and removal of the tumor.

Infantile paralysis (*acute anterior poliomyelitis*) usually occurs within the first three years of life, is mildly contagious, and due to a specific microorganism (Flexner and Noguchi), whose point of ingress and egress is the nasal mucous membrane. The biting stable fly (stomoxys calcitrans) and probably also the common fly and the bedbug transmit the disease. It is characterized by slight fever, and sudden paralysis of a group of muscles, followed by rapid atrophy because of the destruction of their trophic centers in the anterior horns of the cord. The face and neck are very rarely involved, but the muscles of the back and abdomen may be affected. In the upper extremity the deltoid, brachialis anticus, biceps, supinator longus, extensors or flexors of the wrist or fingers may be attacked; in the leg, the favorite site, the tibialis anticus and other muscles on the front of the leg; and in the thigh the quadriceps and the adductors. The *surgical treatment*, in the early stages, is to prevent deformity and increase the nutrition of the muscles by massage, electricity, passive and active motions, and special shoes or braces, either during the night, or in bad cases also during the day. When deformity has developed, various measures may be indicated in addition to the above: forcible correction under an anesthetic, tenotomy, fasciotomy, myotomy, tendon transplantation, nerve transplantation, osteotomy, arthrodesis, or rarely amputation when a limb is absolutely useless.

CHAPTER XXIII.

EAR, NECK, THYROID GLAND.

THE EAR.

Only those conditions peculiar to the ear which more or less directly concern the surgeon will be considered in this chapter.

The **external ear** may be abnormally small (**microtia**), or it may be completely or, more commonly, partly absent, and such defects can rarely be benefited by plastic surgery. **Accessory auricles** should be amputated. **Congenital fistulæ and fissures** are the result of incomplete closure of the first branchial cleft; the former may be excised, the latter sutured after paring the edges. Very large ears (**macrotia**) have been reduced in size by the removal of a wedge-shaped section from the upper part of the pinna with subsequent suture. **Prominent ears** may be brought closer to the head by the excision of an elliptical portion of the skin on the posterior aspect with subsequent suture, or by denuding the groove between the ear and the skull and closing the wound with sutures. **Wounds of the auricle** are often slow in healing and are occasionally followed by necrosis of the cartilage; if the meatus is involved it may be necessary to graft skin to prevent atresia. Loss of a portion of the ear may be supplied by a pedunculated flap from the neighboring skin, the pedicle being cut after union has taken place (*otoplasty*); artificial ears of papier-maché or metal are usually more sightly than the shapeless mass which generally follows an attempted otoplasty when the entire auricle has been lost. **Hematoma of the ear** (*othematoma*) generally occupies the concavity of the auricle, the blood separating the perichondrium from the cartilage. It follows injury (*boxer's ear*), or occurs spontaneously, most frequently in the insane, and is then apt to be followed by great thickening and distortion. The *treatment* is aspiration, and pressure by means of a bandage. Should suppuration occur, a free incision will be needed.

Inflammatory affections and tumors of the external ear present the same features and require the same treatment as elsewhere.

Atresia of the meatus, congenital or acquired, when membranous in character may be treated by excision of the membrane and skin grafting.

Impacted cerumen (plugs of wax) causes diminution in hearing, tinnitus, and sometimes vertigo and inflammatory troubles. The diagnosis is made by the speculum. The *treatment* is removal by syringing with warm bicarbonate of soda solution. The wax may first be softened by having the patient retain in the ear for fifteen minutes or longer a mixture of glycerin and water.

Foreign bodies also are removed by syringing. Live insects may be killed with sweet oil; if fastened to the wall of the canal it will be necessary to use angular forceps to remove them, the ear being illuminated with a head mirror. Vegetable bodies which swell should be removed at once by instrumental means if syringing fails. If unskilled, one may do much harm with instruments in the ear, hence if syringing fails the case should be referred to an otologist. Rarely will it be necessary to turn the auricle forwards and enter the meatus from behind.

The **surgical complications of suppurative otitis media** are often of the gravest nature, consequently this condition should never be neglected. *Pyemia* without even local complications may occur, and *miliary tuberculosis* occasionally develops when the affection is tuberculous in nature. The local complications may be (1) extracranial, (2) cranial, or (3) intracranial.

1. The **extracranial complications** are *eczema* and *furuncles* of the meatus, *cervical adenitis*, and *suppurative arthritis* of the temporomaxillary joint.

2. The **cranial complications.**—**Carious or necrotic ossicles** may be removed through the meatus, and disease of adjacent bone is occasionally treated in the same way, but more frequently a mastoid operation will be required and the disease can then be dealt with from behind.

Granulations and polypi may dam up the discharge, and are removed by the currette, forceps, or snare.

Suppuration of the labyrinth can be treated only by providing free drainage of the tympanum; there is considerable danger of extension to the brain.

Facial paralysis is due to neuritis, pressure being exerted by the increase in the size of the nerve and the thickening of its osseous canal. The nutrition of the facial muscles should be maintained by electricity and massage, and if no signs of recovery appear after six months, the nerve may be anastomosed with the spinal accessory or the hypoglossal (see Chap. XVII).

Fatal hemorrhage from erosion of the internal carotid, internal jugular, middle meningeal, or lateral or petrosal sinus is a rare but possible complication.

Mastoiditis of some degree is probably associated with every acute suppurative otitis media, but if the tympanum is promptly drained, no ill effects need follow. The mucous membrane alone may be involved, but what is recognized clinically as mastoiditis is usually an osteomyelitis. There may be a desquamative inflammation which fills the cavities with cholesteatomatous material. Although the mastoid antrum is present at birth, the mastoid cells and the mastoid process are not well developed until after puberty. These cells surround and communicate with the antrum and are very variable in extent; they may extend forwards above the meatus, backwards to the occipital bone, upwards to the parietal bone, and downwards to the apex of the mastoid.

The **symptoms** are pain and tenderness, both of which may, however, be absent in chronic cases with a thick cortex or limited disease. In acute cases there may be fever and leukocytosis. The most important sign is edema and bulging of the upper posterior wall of the auditory meatus. If the infection spreads outwards there will be redness and edema of the skin over the mastoid and possibly the formation of a subperiosteal abscess, which may perforate and form a subcutaneous collection of pus, or spread downwards and give rise to a cellulitis of the neck. Extension inwards through the tegmen tympani may cause inflammation of the external semicircular canal or the facial nerve; upwards, abscess on either side of the dura, septic meningitis, or cerebral abscess; downwards, deep cellulitis of the neck; forwards, a sinus of the meatus; and backwards, thrombosis of the lateral sinus or abscess of the cerebellum. Often the discharge from the ear abates when the mastoid symptoms are active. A skiagraph is often of value in diagnosis.

The **treatment** in acute cases with pain and tenderness only, is draining and cleansing of the tympanum, cold to the mastoid, and the artificial leech. If the symptoms persist for several days, or if there is external edema, continuous headache, or constitutional symptoms, the mastoid should be opened and drained. A mastoid operation is indicated likewise in cases of incurable chronic otorrhea, even when there are no symptoms of mastoiditis. In acute mastoiditis the Schwartze operation, or simple opening of the antrum with drainage, may be all that is required. In chronic cases it will be necessary to clean out and convert into one cavity the antrum, attic, tympanum, and meatus (Schwartze-Stacke operation).

In the **Schwartze operation** the antrum may be opened with a trephine awl, gimlet, or with a bur propelled by a surgical engine, but probably most surgeons use a gouge or a chisel. A curved incision is made about one-fourth inch posterior to and parallel with the insertion of the auricle, from above the ear to the tip of the mastoid, the flap including the periosteum pushed forwards, and the mastoid vein examined for thrombosis (indicating thrombosis of the lateral sinus) and the bone for sinuses. In the absence of a sinus, which should be followed if present, the antrum is opened in Macewen's suprameatal triangle, which is bounded above by the posterior root of the zygoma, in front by the posterior wall of the external meatus, and behind by a line joining these two. With the ear pulled well forward this triangle can be recognized as a depression in the bone. In young children the antrum may be perforated with a curette. In adults the chisel or gouge, one-fourth inch in width, may be used, thin slices of bone being removed in a direction downwards, forwards, and slightly inwards. Unless the bone is thickened the mastoid cells will be encountered just below the surface. The antrum, too, is superficial in the child, but in the adult its depth beneath the surface of the bone varies from one-eighth to three-fourths of an inch. One should never penetrate more than three-fifths of an inch from the anterior edge of the external opening, because of the danger of wounding the facial nerve or the external semicircular canal. The opening should be enlarged, and all infected cells removed with curette, gouge, or rongeur. The dura and sigmoid sinus need not be feared if care is taken to remove very thin slices of bone, and to explore the minutest opening with a probe. The cavity is smoothed with the curette, irrigated with salt solution, packed with gauze, and the external wound partly closed.

In the **Schwartze-Stacke operation** the antrum and all the mastoid cells are obliterated as described above, remembering the extreme limits at which these cells may be found. The postero-superior wall of the meatus is next removed almost as far as the floor of the meatus, but sloping upwards in the deeper parts to avoid the facial nerve. The remains of the tympanic membrane, malleus, and incus are removed. A probe may be passed through the opening between the antrum and attic, to protect the facial nerve and the external semicircular canal, which lie behind, while the bone in front including the outer wall of the attic is removed. The inner wall and floor of the antrum should not be disturbed, because of the danger of injury to the facial nerve or external semicircular canal. After smoothing the walls of the cavity and irrigating with salt solution, the posterior wall of the cartilaginous meatus is split longitudinally, and the flaps thus formed stitched to the posterior margin of the skin wound, so that the whole cavity can be inspected through the meatus. The operation is completed by filling the cavity with gauze, introduced through the meatus and posteriorly, and by partly closing the wound in the skin. When granulations have covered the bone, healing may be facilitated by the use of Thiersch's skin grafts.

3. The **intracranial complications of otorrhea** are *thrombosis of the lateral sinus*, *meningitis*, and *extradural*, *cerebral*, or *cerebellar abscess* (see chapter on the Head).

THE NECK.

In the development of the face and neck four processes (*branchial arches*) are formed on each side, and between these arches are the *branchial clefts*. The first arch joins its fellow in the middle line to form the lower jaw, the malleus developing from its upper end. A process from the base of this arch extends forward to join the fronto-nasal process jutting down from above, and forms the upper jaw; when these processes fail to unite, cleft palate and harelip result. The second arch forms the incus, stapes, styloid process, stylohyoid ligament, and lesser cornu of the hyoid bone. The remains of the cleft between the first and the second arch is seen as the Glasserian fissure, external auditory meatus, tympanum, and Eustachian canal. The third arch forms the body and greater cornu of the hyoid bone, while the rest of the neck develops from the remaining arch.

Branchial fistulæ result from imperfect closure of the branchial clefts; they open on the skin, in the pharynx, or in both places. Fistulæ and fissures in the neighborhood of the ear are vestiges of the first branchial cleft. Congenital fistulæ of the neck are most frequent in the neighborhood of the fourth cleft, and open externally at the anterior edge of the sternomastoid close to its lower end. Fistulæ at the anterior or posterior edge of the sternomastoid at the level of the larynx are the remains of the second or third cleft. The internal opening is usually in the lower part of the pharynx or behind the tonsil. An incomplete internal fistula may cause a congenital diverticulum of the esophagus. Of similar origin are some median fistulæ, which may open into the trachea or larynx, and which when incomplete internally may beget air tumors (*laryngocele or tracheocele*). Other median fistulæ are due to a patent *thyroglossal duct*, which in the embryo passes from the isthmus of the thyroid gland up in front of the trachea and larynx, then behind or through the body of the hyoid bone, to open at the foramen cecum of the tongue. Accessory thyroids may spirng from any portion of this duct. All these fistulæ are lined by mucous membrane and hence give rise to a mucoid discharge.

Cysts of the neck may be congenital or acquired.

Congenital cysts, which may not appear for some years after birth, include the branchial, thyroglossal (either of which may be mucoid or dermoid), and blood cysts, and cystic lymphangioma. **Branchial cysts** arise from unobliterated portions of the branchial clefts, and usually lie beneath the muscles of the tongue or behind the sternomastoid; in the former situation they may be mistaken for ranulæ, in the latter they are often closely connected with the great vessels. They are lined by epithelium and contain a serous or mucoid material (*hygroma*, *hydrocele of the neck*—Fig. 275), or sebum, hair, teeth, etc. (*dermoids*). **Thyroglossal cysts** arise from any portion of the thyroglossal duct, hence are median in position; they may contain mucus or dermoid material. *Sublingual dermoids* and *subhyoid cysts* belong to this class. **Blood cysts** probably arise from a congenital diverticulum of one of the large veins of the neck; if the communication persists, they may be reduced by pressure, and vary in size during respiration. **Cystic lymphangioma** (Fig. 88), sometimes improperly called cystic hygroma, is due to dilated lymph vessels and spaces, hence is multilocular and lobulated; it may spread to the face and into the thorax and is then beyond operative aid.

Acquired cysts may be **sebaceous** (Chap. XIV), **hydatid** (Chap. XIII), **thyroid** (see cystic goiter), bursal, or malignant. **Bursal cysts** may develop over the thyroid cartilage, or between it and the hyoid bone. Occasionally one encounters a carcinoma deep in the cervical tissues without finding a primary growth elsewhere. These cases may be regarded as *branchial carcinomata;* after a time they undergo cystic degeneration (**malignant cysts of the neck**), or break down into a puruloid material, and may superficially resemble a chronic cellulitis of the neck. Sarcoma of the neck likewise may undergo cystic degeneration. The *treatment* of all the conditions mentioned above is excision, which is often a difficult matter. Fistulæ and cysts which cannot be excised may be opened, and the lining membrane destroyed by cauterization. Blood cysts may necessitate suture or ligature of the jugular or subclavian vein.

FIG. 275.—Hydrocele of neck.

Torticollis, or wry neck, is a deformity in which the head is bent towards the shoulder, and the face turned towards the opposite side. **False torticollis** is seen in cases like fracture of the clavicle, and tumors and inflammations of the neck; it results also from rheumatism or cold (stiff neck) and hysteria. The treatment is directed to the cause.

True, or chronic torticollis, may be (1) spasmodic or (2) permanent. 1. **Spasmodic torticollis** (tonic or clonic) usually affects one sternomastoid only, but occasionally that of the opposite side as well as the posterior deep cervical muscles also are involved, so that the head is drawn backwards (*retrocollis*). The spasm may be persistent, or it may intermit for days or weeks, but in either event it is usually absent during sleep. It may result from direct irritation of the nerve supplying the muscles, e.g., by tumors, enlarged glands, cervical caries; or from reflex irritation, such as carious teeth, worms, and pelvic troubles; but is usually seen in the neurotic and hysterical and may possibly be due to irritation of the motor centers. The *treatment* is removal of any source of irritation, the treatment of any associated neurosis, and the administration of antispasmodics. If these measures fail, the spinal accessory nerve may be stretched or severed; the posterior cervical nerves may be similarly treated if the posterior cervical muscles also are affected.

2. **Permanent torticollis** is the result of malformation, vicious intrauterine position, or prenatal disease of the muscle or nerves (*congenital torticollis*); it may be caused also by strabismus, scoliosis, paralysis of the opposite muscle, or by cicatricial shortening of the muscle or surrounding tissues, following laceration at birth or subsequent injuries or inflammations. The sternomastoid alone may be at fault, or the trapezius and deeper muscles also may be implicated and the deep cervical fascia shortened. In congenital cases

(Fig. 276) or those arising soon after birth, the face of the affected side fails to develop as rapidly as the sound side. A compensatory lateral curve, concave towards the affected side, develops in the cervical spine, and a secondary dorsal curve, concave in the opposite direction, is formed, leading to changes in the shape of the vertebræ. The *treatment* in early cases is massage, manipulations to straighten the head, and a brace or support to maintain the corrected position. Any contributory lesion, such as strabismus, scoliosis, etc., likewise should receive attention. In most cases, however, little progress can be made until the sternomastoid muscle has been divided. The subcutaneous operation for this purpose is unsafe and incomplete and will

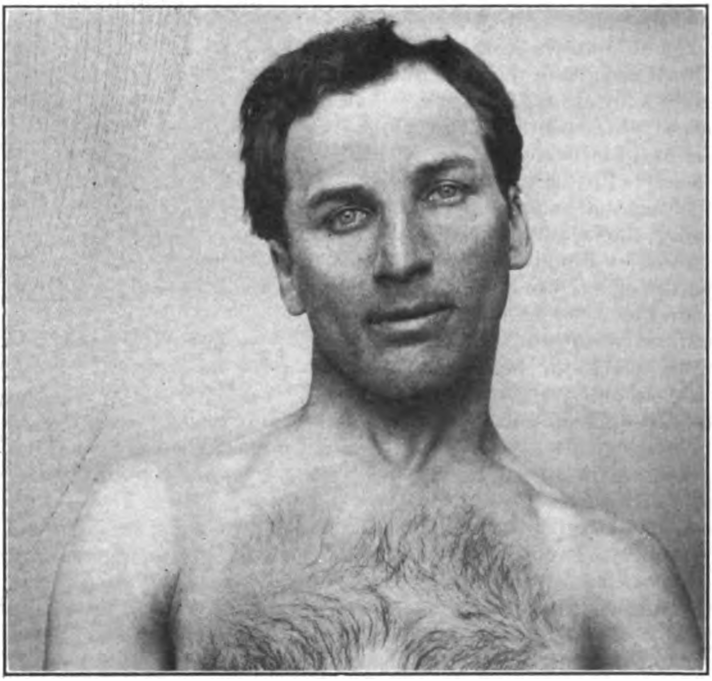

FIG. 276.—Congenital torticollis. The X-ray showed areas of ossification in the contracted sternomastoid and a large exostosis at its clavicular insertion.

not be described. In the open method the muscle is isolated and divided through a transverse incision about one-half inch above the clavicle, the skin is then sutured, and the head fixed in the corrected position by plaster-of-Paris or other apparatus. Mikulicz removes the entire muscle as far as the spinal accessory nerve.

Cervical rib springs from the anterior transverse process of the seventh cervical vertebra. It is bilateral in about two-thirds of the cases; rarely a second cervical rib may arise from the sixth cervical vertebra. The anterior extremity is usually free, but it may unite with the first rib or with even the sternum. The brachial plexus and subclavian artery pass over it, and with the growth of the rib or its ossification these structures are compressed, causing pain, weakness of the arm, trophic troubles, or even obliteration of the pulse and gangrene. There is no edema of the arm, because the subclavian vein lies in front of the middle scalene muscle and escapes pressure. The rib forms a prominence in the neck, which has been mistaken for aneurysm, because it pushes the subclavian artery forwards and upwards. The X-ray will dispel all doubt. If there are pressure symptoms, the rib may be removed through a transverse incision after separating the nerves and vessels.

Cellulitis of the neck is usually secondary to infections in the area drained by the cervical lymph glands, but may follow also cold, injury, and acute infectious fevers. The process varies greatly according to its situation, the virulency of the infection, and the resistance of the individual; thus it may be superficial or deep (with reference to the cervical fascia), circumscribed or diffuse, acute or chronic. *Superficial* inflammatory troubles of the neck differ little from like lesions elsewhere and require no special mention. *Deep* cellulitis or abscess is often of the gravest nature, because of the danger of extension to the axilla, mediastinum, or pleura, or rupture into the trachea or esophagus. External fluctuation and pointing are the exception. In addition to the general septic symptoms the neck is swollen and hardened and the skin red and edematous. The head is bent towards the affected side, and there may be dysphagia, dyspnea, and symptoms of pressure on the vessels or nerves. A streptococcic cellulitis of the submaxillary region is called *angina Ludovici.* A chronic form of cellulitis of the neck with little or no pain and fever, and presenting a board-like inflammatory hardness, has been described by Réclus under the term *phlégmone ligneuse du cou,* or woody phlegmon of the neck. After a time a small abscess forms and healing ensues, although in one case death was due to edema of the glottis. These cases resemble a carcinomatous infiltration of the neck.

The *treatment* in acute cases is prompt incision, never waiting for fluctuation. An abscess may be opened by Hilton's plan (see abscess). Tracheotomy is sometimes necessary. The constitutional symptoms of sepsis should be combated.

Cut throat may be homicidal or suicidal. In the latter the wound is usually between the hyoid bone and the larynx and deepest on the side opposite to the hand employed. In either case, however, the wound varies both as to depth and to situation, and any of the structures of the neck may be involved. The effects of division of the nerves have already been mentioned. The diagnosis of a wound of the air passages is easily made. Injury to the esophagus is much less common and may be accompanied by hematemesis. dysphagia, and the escape of mucus or food through the wound. The immediate *dangers* are shock, hemorrhage, air embolism, and asphyxia due to blood or displaced structures. The secondary dangers are cellulitis, septicemia, pyemia, edema of the glottis, secondary hemorrhage, inspiration pneumonia, and emphysema of the cellular tissues.

The **treatment** is arrest of hemorrhage, even the smallest bleeding point being attended to, because of the danger of blood trickling into the air passages; removal of clots from the trachea; saline infusion and other means to combat shock; disinfection of the wound; and suture of divided nerves, esophagus, trachea, larynx, and muscles. Drainage should be employed in order to provide a vent for blood, air, or esophageal secretions. In an extensive transverse wound of the trachea the sutures almost invariably tear out. If the larynx has been opened, safety demands the performance of a high tracheotomy, as breathing is sure to be obstructed. The neck is dressed with the head flexed on the chest, and the patient fed per rectum or through a tube in the esophagus, if that structure has not been wounded.

Among the *sequelæ* may be mentioned stenosis of the larynx, esophagus, or trachea (q.v.); esophageal fistula, which usually closes after a time; aerial fistula, which if persistent may be closed by freshening and suturing the opening in the air passages, care being taken first to make sure that there is no stenosis above; and lesions which may follow division of nerves, e.g., aphonia from a severed recurrent laryngeal nerve.

THE THYROID GLAND.

The **parathyroid glands** are four in number. They are brownish red, oval bodies, about one-fourth inch in length, lying upon the posterior surface of the capsule of the thyroid gland, one near the pole of each lobe. Each parathyroid has a terminal artery, usually derived from the anastomotic branch between the superior and inferior thyroid arteries. A knowledge of the existence and situation of these bodies is of great importance to the surgeon, as their destruction results in tetany, severe and fatal if none is left, milder if one or two remain. The symptoms of this *tetany parathyreopriva*, as it is called, are those of other forms of tetany, for which the student is referred to a text-book on medicine. The treatment is administration of parathyroid extract or serum, and calcium lactate, in a 5 per cent. solution, by mouth, rectum, or intravenously; transplantation of parathyroids from animals also has been tried.

Wounds of the thyroid cause severe bleeding, which may be checked by sutures or by gauze packing. In some cases it may be necessary to extirpate the gland.

Accessory thyroids may be found about the thyroid gland, in the upper portion of the chest, or along the course of a thyroglossal duct (p. 412) as far as the base of the tongue (*lingual goiter*). If increasing in size or causing pressure symptoms, medical treatment as described below may be tried for a time, but will usually fail, and then extirpation should be performed, first making sure that the normal thyroid is present, as the accessory gland may be the only one the patient has, and its removal would then be followed by myxedema. The presence of an accessory thyroid explains the absence of myxedema in some cases of complete thyroidectomy. The occurrence of a non-inflammatory tumor along the course of the thyroglossal duct, particularly in a woman, should always make one think of the possibility of an accessory thyroid.

Absence or deficiency of the internal secretion, the result of **atrophy or absence of the thyroid,** causes a peculiar group of symptoms, which is called *cretinism* when developing soon after birth, *myxedema* when occurring in adults, and *cachexia strumipriva* when following extirpation of the gland. The essential features of these conditions are a non-pitting edema of the subcutaneous tissues, due to infiltration with a mucin-like substance (myxedema), pallor and dryness of the skin, loss of hair, and in children dwarfing of the body and idiocy, and in adults marked impairment of the intellectual faculties and loss of sexual power. According to Kocher the coagulability of the blood is increased in hypothyroidism. The *treatment* is thyroid extract, one grain three times a day, gradually increased to 10 or more grains, watching for symptoms of thyroidism, i.e., tachycardia, nervousness, delirium, etc. When cure has been effected, it will usually be necessary to administer small doses, perhaps for the rest of the patient's life.

Congestion of the thyroid, evidenced by slight enlargement, may be due to cardiac disease, obstruction to the veins in the mediastinum, anemia, overexertion, or emotion; in women it may occur at puberty, or during pregnancy or menstruation. No surgical treatment is required.

Thyroiditis is usually a complication of one of the acute infectious diseases, but may follow also injury. In addition to the ordinary signs of inflammation there may be pressure symptoms much like those which occur in ordinary goiter. Inflammation of a goiter is called *strumitis*. The treatment is that of inflammation elsewhere, including incision should suppuration occur. Tracheotomy, preceded by division of the isthmus or in some cases extirpation of the organ, may be required if breathing is seriously embarrassed.

FIG. 277.—Sarcoma of the thyroid gland. (Jefferson Hospital.) Note enlarged veins.

Tuberculosis, gummata, actinomycosis, and hydatid cysts are treated as are such conditions elsewhere.

Tumors of the thyroid are sometimes called *malignant goiters*, and indeed it is often difficult to make a sharp distinction between certain goiters and some neoplasms. An adenoma theoretically is distinguished from an adenomatous goiter by its typical microscopic picture, and by the fact that the tumor is circumscribed and separated from the healthy gland tissue. It, however, together with carcinoma and sarcoma (Fig. 277), may give rise to metastases, hence all tumors of the thyroid gland should be regarded as malignant and be extirpated at the earliest possible moment. They usually develop after forty, often from a simple goiter, are hard, fixed, and irregular in contour, grow rapidly, quickly produce pressure symptoms, and often come under observation only when they have invaded the surrounding tissues and are inoperable. If the entire gland is removed, the patient should be fed on thyroid extract subsequent to operation. In the later stages of inoperable growths it may be necessary, in order to prevent death by suffocation, to perform tracheotomy, a most difficult and dangerous procedure under the circumstances, as one must quickly remove sufficient of the tumor to expose the trachea before it can be opened and a tube introduced, and even then it may be found that the site of the compression is retrosternal, in which event a long flexible tracheotomy tube must be introduced, or, if this is not at hand, a flexible catheter.

Goiter, struma, or bronchocele is a hyperplasia of the thyroid gland not of infectious or neoplastic origin. The disease may involve any part or all of the gland, but is most common in the right lobe, and occurs more frequently in females, usually after the tenth year. The *cause* is not known. The theory that it is due to magnesium or calcium salts or some other substance in the drinking water probably has the most advocates. It occurs sporadically in all parts of the world, and is endemic in Central Asia, Switzerland and the contiguous portions of France, Italy, Austria, and Germany; in England it has been called Derbyshire neck owing to its prevalence in that locality; in this country it is most common in certain parts of Michigan and in the mountainous regions of Pennsylvania.

The **varieties** of goiter are: 1. The *parenchymatous*, in which the whole gland is involved, although one lobe may be larger than the other. The swelling is soft, elastic, and painless. When there is an excessive development of the stroma, the gland is harder and perhaps lobulated (*fibrous goiter*); when the connective tissue is small in amount and the acini are distended with colloid material, the gland is softer (*follicular or colloid goiter*). 2. *Cystic goiter* is due to the confluence of the acini. The cysts may be single, or multiple, vary greatly in size, and contain a colloid or serous material, which may be brown or black from the presence of altered blood. Intracystic papillomata are sometimes found. 3. *Adenomatous goiter* (Fig. 278) resembles an adenoma in structure; it may develop in one portion of a normal gland and subsequently involve the whole thyroid, or it may be a secondary change in a parenchymatous goiter, and not infrequently it is followed by the formation of cysts. A sharp distinction cannot be made between adenomatous goiter and adenoma of the thyroid. 4. *Exophthalmic goiter* is described below. In any of these varieties certain secondary changes may occur, e.g., inflammation, abscess, hemorrhage into the gland, calcification, or malignant disease, and in any there may be enlargement of the thymus gland. Simmons found thymic hyperplasia in less than one-half of the cases of ordinary goiter, and in three-fourths of the cases of exophthalmic goiter. Kocher states, however, that in 5740 operations for ordinary goiter he saw not one thymic hyperplasia, and not one patient died from status lymphaticus.

FIG. 278.—Adenomatous goiter.

The **symptoms** are (1) the presence of a tumor, (2) evidences of pressure and (3) signs of excess or deficiency of the thyroid secretion. 1. The *tumor* is horseshoe-shaped or oval, varies greatly in size, sometimes being as large as a man's head, develops insidiously, rises and falls during swallowing, is painless, and, excepting the trachea, is not adherent to the surrounding tissues. Inflamed, malignant, and very large goiters, however, may not move with deglutition, and other cervical swellings, e.g., thyroglossal cysts, subhyoid bursæ, and abscesses, lymph glands, and malignant growths that are adherent to the larynx, trachea, or esophagus, may move with deglutition. 2. The *pressure symptoms* depend upon the situation of the growth, thus a retrosternal goiter quickly produces symptoms, and they may be absent in even the largest goiters. The larynx and trachea may be pushed from the middle line, or the latter may be flattened from side to side, causing dyspnea and cough if both lobes are equally enlarged. Pressure on the esophagus causes dysphagia; on the vessels of the neck headache, flushing of the face, and epistaxis; on the recurrent laryngeal nerve alteration in the voice or, if both are involved, bilateral paralysis of the muscles of the larynx and death; on the pneumogastric alteration of the heart's action; and on the sympathetic dilatation of the pupil, etc. (Chap. XVII). 3. *Signs of excess or deficiency of the thyroid secretion* also may be encountered; the former are given under exophthalmic goiter, the latter under absence of the thyroid.

The **treatment** in the early stages may be medical, viz., iodid of potassium internally, and red oxid of mercury ointment or iodin locally. Thyroid extract is of value, particularly if there are any signs of myxedema. Electrolysis and radiotherapy have temporarily benefited a few cases. Medical treatment is of most value in parenchymatous goiter. If the goiter increases in size or there are pressure symptoms, operation is indicated. Before operation the larynx always should be examined, to determine the condition of the vocal cords, and if there is any suspicion of an intrathoracic growth or if one is not sure of the position of the trachea a skiagram should be made. *Ligation* of the thyroid arteries, and *exothyreopexy*, i.e., drawing the thyroid into a wound in the neck so that it may atrophy, have been employed, while as a palliative or emergency operation in cases of severe dyspnea, the *ribbon muscles* of the neck or the *isthmus of the gland* have been divided. The usual operations are *intraglandular enucleation*, which is indicated in a localized adenoma or a single cyst, or in a small collection of cysts, and *partial excision, or thyroidectomy*, which is indicated in all other varieties, care being taken to leave at least one-fourth of the gland in order to prevent myxedema. Local anesthesia is strongly recommended by many surgeons, in order to prevent the congestion of the neck incident to ether and chloroform, to avoid postoperative vomiting, which may start bleeding, and in order to have the patient speak during the operation, so that the surgeon may know when he is in the vicinity of the recurrent laryngeal nerve. We prefer ether, administered by intratracheal insufflation. The operative field is made prominent by placing a sand pillow under the neck, and, in order to lessen bleeding, the upper portion of the body is elevated (reversed Trendelenburg posture).

Intraglandular enucleation is performed by exposing the gland by a transverse or oblique incision, incising the gland down to the tumor, and shelling out the tumor with the fingers or a director; the wound is then quickly packed with gauze because of the free bleeding, and as the gauze is gradually removed, the bleeding points are ligated or surrounded by sutures. The cavity is closed by catgut sutures and the skin approximated, leaving space for a gauze drain for twenty-four hours.

Partial thyroidectomy usually means removal of one lobe. A curved transverse incision, with the concavity upwards, is made over the tumor from the outer border of one sternomastoid to beyond the middle line, the skin and platysma divided, the ribbon muscles separated in the median line or divided transversely, and the fibrous capsule opened. The fibrous, or surgical capsule, lines the cavity in which the thyroid lies, and is separated from the true, or glandular capsule, by loose areolar tissue. All bleeding is checked, the lobe dislocated from its fibrous envelope, the superior thyroid vessels divided between two ligatures, and the inferior thyroid vessels tied close to the gland in order to avoid the recurrent laryngeal nerve. The thyroidea ima if present also is tied. The parathyroids are avoided by tying all vessels close to the true capsule, or, as suggested by Mayo, leaving that portion which covers the posterior surface of the gland. The isthmus of the gland is crushed with strong forceps and ligated in sections, or it may be divided and the bleeding controlled by sutures. Any attachments to the cricoid are separated, or perhaps better, a thin slice of the gland is left in place in this situation to avoid injury to the recurrent laryngeal nerve. The wound is irrigated with salt solution, and closed after suturing the divided muscles, a small space being left for gauze drainage for twenty-four hours. The normal anatomy is necessarily disturbed in large growths; thus the jugular vein, which has branches coming from the tumor, moves forward with the growth, while the artery, which has no such connections, is pushed backwards and outwards and may lie external to the vein. The tracheal rings may be absorbed or softened, hence more easily injured; in some cases the trachea collapses as soon as the support of the tumor is removed, the patient dying of asphyxia unless a tube is inserted. Sudden death may occur also from reflex inhibition of the heart, the status lymphaticus, or from the absorption of thyroid secretion from the wound. In other cases thyroid intoxication will cause high fever, rapid pulse, and dyspnea subsequently to operation. If too much of the gland is removed, myxedema may follow; and if the parathyroids are excised tetany develops. Kocher's mortality in over 5000 cases is less than 1 per cent.

Exophthalmic goiter (*Grave's disease, Basedow's disease*) is of unknown origin. Ninety per cent. of the cases are females, generally between the ages of fifteen and thirty. It may follow severe emotional storms, overwork, worry, pregnancy, or ordinary goiter (*Basedowified goiter*). Microscopic examination shows a marked increase in the epithelial elements and little or no colloid material. Judging from the results of operative treatment the clinical phenomena are due to derangement of the sympathetic nervous system, in consequence of excessive thyroid secretion, or of some toxin in the blood which, under normal conditions, the thyroid gland destroys. Thus the exophthalmos, long thought to be due to an increase in the orbital fat, is, according to Landström, the result of stimulation of the cervical sympathetic, which presides over Müller muscle, and a film of muscular tissue passing around the eyeball from the fascia behind to the lids and anterior orbital fascia. These muscular fibres pull the eye forwards and the lids backwards, serving normally to antagonize the four orbital muscles, which tend to draw the eye backwards. Recent investigations, however, seem to indicate that Grave's disease is only one of the numerous manifestations of incoordination between the various ductless glands. Of particular interest at the present time is the relationship between goiter and hyperplasia of the thymus. "No Basedow without thymus" is the opinion of Klose. Kocher says that in 61.2 per cent. of the cases of exopthalmic goiter coming to autopsy there is some increase in the parenchyma of the thymus, but that clinically only 30 per cent. show enlargement, the greatest number being in the first two decades, while exophthalmic goiter is most frequent in the second and the third decades. The cardinal *symptoms* are the presence of a *goiter*, in the capsule of which are numerous large vessels, hence pulsation, thrill, and bruit are commonly found; *exophthalmos*, causing a widening of the palpebral fissure (Stellwag's sign), retardation of the movement of the upper lid when the eyeball is rotated downwards (von Graefe's sign), and inability to maintain the eyes in convergence (*Mœbius's sign*); *tachycardia*, often with palpitation and dyspnea; and a *fine tremor*. In the later stages the cardiac muscle degenerates and permanent dilatation ensues (goiter heart). Sometimes scleroderma or symmetrical lipomata develop, and many cases terminate in myxedema. Numerous other symptoms referable to the nervous system, the cardio-vascular apparatus, the gastrointestinal tract, or the anemia, are described, e.g., irritability, attacks of mania, prostration, flushing of the face, excessive sweating, throbbing of the arteries, capillary pulse, indigestion, diarrhea, glycosuria. Kocher says there is leukopenia, particularly of the polymorphonuclears, lymphocytosis, and diminution in the coagulability of the blood. Halstead ascribes the lymphoctyosis to the thymic hyperplasia. The diagnosis is never difficult, except in the *form fruste*, in which the goiter or the exophthalmos, or both, may be absent. Many of these cases are incorrectly diagnosticated hysteria or neurasthenia.

The *treatment* in the beginning is medical. Absolute rest, cardiac sedatives, an ice bag to the heart, ergot, belladonna, phosphate of soda, and extract of the thymus, pituitary, spleen pancreas, or suprarenals are recommended. Thymus therapy benefits 50 per cent. of the patients, causes an increase in the cardiac symptoms in 10 per cent. (Kocher). Electrolysis and the radiotherapy have been employed. Recently encouraging results have been obtained with a serum obtained from animals injected with increasing doses of human thyroid extract. Iodides, thyroid extract, and the injection of various medicaments into the gland are contraindicated. As soon as medical treatment has failed, i.e., after a few months, operation should be proposed before the condition of the patient has markedly deteriorated. *Ligation* of the thyroid vessels (usually the superior) may be indicated in mild cases, as a preliminary operation to thyroidectomy in severe cases, and as an auxiliary procedure to excision of one lobe, the vessels of the other lobe being tied. *Partial thyroidectomy* is the operation of choice. The average results are "71 per cent. cured; 9.6 per cent. improved; 6.4 per cent. unimproved, failures, lost sight of, or partly benefited; and 12.6 per cent. died" (Hartley). Kocher's mortality in 535 cases is 3.1 per cent. but he refuses to operate upon "bad risks." The dangers have been mentioned under partial thyroidectomy. Improvement is immediate, but the exopthalmos may persist for months, and recurrences have been noticed in a few instances. *Bilateral resection of the cervical sympathetic ganglia* gives less favorable statistics, but may be indicated in Grave's disease without goiter, or combined with thyroidectomy, in cases in which the ophthalmic symptoms predominate. *Thymectomy*, without removal of the thyroid, has been performed for Grave's disease by a few surgeons. The thymus should certainly be sought during thyroidectomy, and if enlarged removed. The other operations mentioned under the treatment of goiter also have been employed for Grave's disease.

The thymus gland usually begins to shrink at the end of the second year and at the time of puberty can no longer be found. When it persists and enlarges pressure may be exerted on the trachea, the great blood vessels, or on the left pneumogastric or its recurrent branch. **Hyperplasia,** or **hypertrophy,** as it is sometimes called, may be an independent affection, rarely occurring except in infants, or it may be associated with leukemia, Hodgkin's disease, ordinary goiter, exophthalmic goiter, or the status lymphaticus. Clinically the pressure effects are continuous or intermittent.

In the *continuous form* (*thymic stenosis of the trachea*) there is progressive dyspnea, with stridor and crises of suffocation. The dyspnea is chiefly expiratory, as the gland is drawn down into the mediastinum during inspiration, thus freeing the air passages. The diagnosis is made by feeling a tumor mounting in the episternal notch during expiration and disappearing during inspiration, by dulness on percussion over the manubrium, by the associated lymphocytosis, and by the X-ray, all of which signs, however, may be present when the trouble is due to enlarged mediastinal lymph glands. In one case of enlarged thymus Jackson demonstrated the stenosis by bronchoscopy.

In the *intermittent form* (*thymic asthma*) the attack appears suddenly, possibly as the result of extension of the head or venous engorgement of the gland. Death occurs within a few minutes, or the infant recovers, only to suffer from subsequent paroxysms which become more and more frequent.

The *treatment* of thymic stenosis of the trachea and thymic asthma is exothymopexy (i.e., drawing the gland up over the sternum and securing it with sutures) or, better, subcapsular enucleation, after making a median incision just above the manubrium. Olivier (1912) has collected 42 cases of thymectomy, with 15 deaths. Radiotherapy may possibly be of service in cases not suited for operation.

The **carotid gland or body,** when present, is attached to the carotid sheath at or near the bifurcation of the artery. It is about the size of a grain of corn and is composed chiefly of endothelial cells. Its nature is unknown. Callison and Mackenty have collected sixty endotheliomata or peritheliomata arising from this gland. These "potato tumors of the neck" are located at the bifurcation of the carotid under the sternomastoid, are slightly movable transversely but not vertically, transmit pulsation, thrill, and bruit from the carotid artery, and often exist for a number of years before taking on malignant features, when there is involvement of the vagus (with its recurrent branch) and of other nerves. Carotid tumors should be extirpated, an operation which will sometimes necessitate excision of the carotid artery. Of fifty-four patients operated upon, twelve died; recurrence occurred in eight.

CHAPTER XXIV.

RESPIRATORY SYSTEM.

THE NOSE.

Rhinoscleroma is a very rare infectious disease due to the bacillus of rhinoscleroma. A number of hard nodules, or a stiff infiltration, forms about the nostrils and sometimes about the lips, or in the mucous membrane of the mouth, pharynx, or larynx. The disease is painless, may last for years, and utlimately leads to stenosis. In the early stages recovery may follow excision. Later, treatment is futile. Perhaps radiotherapy, which, so far as we know, has not been employed in this disease, might prove of benefit.

Rhinophyma is a hypertrophic form of acne rosacea in which red greasy masses form on the lower end of the nose, producing a deformity which has been called *hammer nose* (Fig. 279). It may be treated by excision with subsequent skin grafting.

FIG. 279.—Rhinophyma, treated by excision.

Deformities of the nose may be congenital, or result from injury, destructive diseases, or operations, e.g., for the removal of malignant disease. All operative efforts to rebuild a deformed nose are included under the term *rhinoplasty*, which may be partial or complete, according to its extent.

Deformity of the **Roman nose** type is corrected by making a small longitudinal incision in the middle line of the nose, and removing the redundant tissue with a chisel, if bone, or a knife, if cartilage. The wound is then sutured. Expansion of the bridge, or **frog nose,** is commonly caused by intranasal growths, and the treatment is directed to the cause. A **tuberous nose** is treated by removing a wedge-shaped section.

Clefts of the nose are remedied by sutures after freshing the edges. Fig. 280 illustrates Langenbeck's operation for a lateral defect of the nose, Fig. 281 Nélaton's; in each the raw surface left by the transposition of the flap is covered with a Thiersch skin graft. Figs. 282 to 285 also illustrate the repair of a lateral defect. Figs. 286 to 291 illustrate methods of constructing a columna nasi. **Saddle nose** may be caused by injury, but is most frequently the result of syphilitic ulceration of the septum. Various more or less unsatisfactory procedures have been devised for this deformity. Artificial bridges of celluloid, rubber, silver, gold, etc., or a free transplant of bone (rib, anterior surface of the tibia), costal cartilage, or fat may be inserted beneath the skin through an external incision or from within the nose. In some cases the nasal bones have been broken or chiseled from their attachments, and held in an elevated position by a spectacle clip, or by pins inserted beneath them. A transverse incision may be made across the sunken part of the nose, thus allowing the tip to be pulled down. The resulting gap is closed by a flap turned inward from each cheek, the skin surface facing the nasal cavity. A flap from the forehead is brought down to cover the raw surfaces of the cheek flaps, and the wounds in the forehead and cheeks sutured. The subcutaneous injection of sterile paraffin has been used with some success in this deformity. The skin of the nose should be loose, and the melting point of the paraffin (mixed with liquid paraffin or vaselin) above 115° F. The paraffin is melted, injected by a screw piston syringe in a

FIG. 280. FIG. 281.
FIGS. 280 and 281.—Operations for cleft nose. (Esmarch and Kowalzig.)

semi-solid state, and molded with the fingers. The complications are abscess, glazing and thickening of skin, diffusion, and embolism.

Absence of the nose is rarely congenital; it may result from traumatism, but is most frequently due to disease, e.g., syphilis, lupus, and malignant growths. Various methods of complete rhinoplasty have been used with more or less satisfaction. When an operation for the reproduction of the nose is deemed inadvisable, an artificial nose held in place by spectacle rims

FIG. 282. FIG. 283. FIG. 284. FIG. 285.
FIGS. 282 to 285.—Operations for lateral defect of the nose. (Esmarch and Kowalzig.)

may be worn. The *Indian method* for complete rhinoplasty (Figs. 292, 293) consists in supplying the defect by a flap from the forehead. A model of the flap is first cut out of oiled silk. The end of the flap is so shaped as to form, when folded, the alæ and the septum of the nose, the nasal openings being maintained by rubber tubes. When the osseous framework of the nose has been destroyed, this method may be modified by including in the forehead flap the outer table of the skull or a piece of bone or cartilage previously implanted beneath the skin of the forehead. In the *Italian method* the flap is taken from the arm (Fig. 294), which must be fixed by a suitable apparatus until union has occurred; the pedicle is then divided, and the alæ and septum formed from the lower portion of the flap. This method may be varied by taking a flap from the palm, a flap consisting of soft parts and a piece of the ulna from the inner side of the forearm, or a flap containing a previously transplanted segment of bone or cartilage. In the *French method* (Fig. 295) the flaps are formed from the cheeks. Several successful attempts have been made to replace the bony framework of the nose by suturing the freshened end of a

FIG. 286.

FIG. 287.

FIG. 288.

FIGS. 286 to 288.—Methods of constructing the columna nasi. (Esmarch and Kowalzig.)

finger into the upper angle of the nasal defect, and when union has occurred, amputating the finger. The proximal phalanx is flexed to form the columna nasi.

Crooked nose may be congenital or traumatic, and is usually associated with flexion of the septum, the correction of which may straighten the nose. When the nasal bones themselves are deformed, they may be molded into shape after separating their attachments with a chisel, through a small incision at the root of the nose.

Deviation of the septum may be caused by injury or be the result of defective development. The deflection may be vertical, horizontal, or

FIG. 289.

FIG. 290.

FIG. 291.

FIGS. 289 to 291.—Methods of constructing the columna nasi. (Esmarch and Kowalzig.)

oblique, bowed or angular, and the septum may or may not be thickened. A sigmoid deviation is a double curve, one projecting into each nostril. The cartilaginous septum is the portion usually involved. The condition is very common, but in the slighter forms gives no trouble. In more marked cases there may be stenosis of one nostril, and various reflex troubles, such as are to be mentioned under polyps. In the presence of direct or reflex troubles treatment will be required. When there is marked thickening, or the development of cartilaginous or bony *spurs of the septum*, these should be removed with knife or saw, and perhaps no further treatment will be needed.

Warping of the cartilage itself is corrected by incisions along the lines of deviation, in order to lessen the resiliency of the septum. These incisions may be made by introducing a sharp knife beneath the mucous membrane, or by special knives or punches, after which it may be possible to correct the deformity with the fingers. In other cases septal forceps are introduced, one

FIG. 292.

FIG. 293.

FIGS. 292 and 293.—Indian method of rhinoplasty. (Esmarch and Kowalzig.)

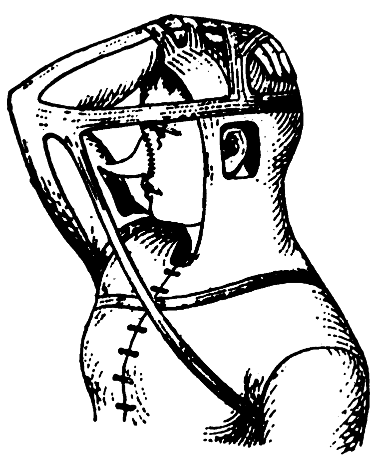

FIG. 294.—Italian method of rhinoplasty. (Monod and Vanverts.)

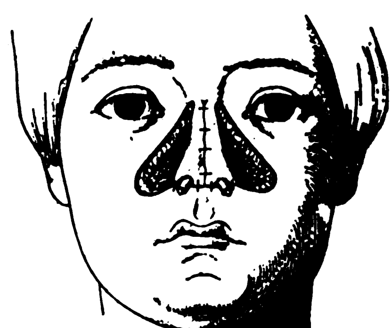

FIG. 295.—French method of rhinoplasty. (Monod and Vanverts.)

blade in each nostril, and the cartilage broken from its attachments and straightened. It is held in a corrected position by nasal tampons of gauze, or by rubber or metal splints. The tampons are removed and the nose cleansed daily until union has occurred. Roberts uses long pins such as have been described under fracture of the nose.

Epistaxis, or bleeding from the nose, may be traumatic, e.g., from blows, fracture of the skull, picking the nose, foreign bodies, etc., or it may be spontaneous, e.g., from plethora, ulcers, tumors, rarefied air, vicarious menstruation, varicose veins, cardiac or pulmonary disease, acute diseases (notably typhoid), and diseases in which there is a tendency to hemorrhage (hemophilia, scurvy, purpura, etc.).

The **treatment** is removal of the cause if possible. When depending upon an intracranial congestion epistaxis may be beneficial, and should be stopped only when it becomes excessive. The head should be elevated, constrictions about the neck and chest removed, and blowing the nose forbidden. Compression of the nostrils will check the bleeding if it be well forward. When further back, the bleeding point may be detected with the speculum and head mirror, and touched with the galvanocautery, or a swab soaked in chromic acid solution. Sprays or douches of ice water, adrenalin solution, or antipyrin, 5–10 per cent., are sometimes efficient and do not possess the disagreeable features of other styptics. In serious cases, however, the

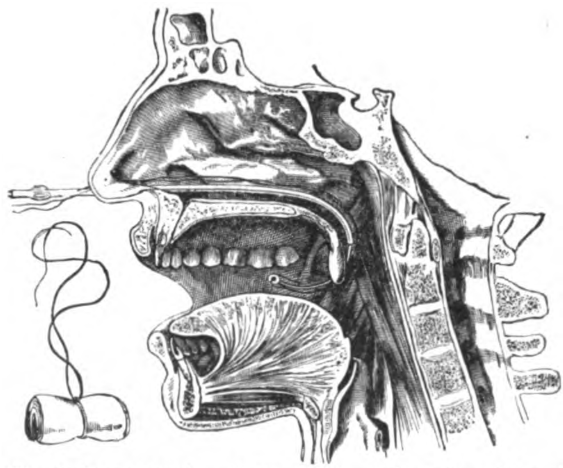

Fig. 296.—The Bellocq cannula. A concealed watch spring with a ring at the end, through which the silk is passed, is made to curl forward into the mouth after the cannula is in position. (Heath.)

nostrils should be at once plugged with gauze moistened with adrenalin. If the bleeding comes from the anterior portion of the nasal passages, it may be controlled by packing through the anterior nares. In other cases it will be necessary to plug the posterior nares in addition. A soft catheter with a long piece of silk passed through the eye is pushed along the floor of the nose until it reaches the pharynx, when the silk is grasped with forceps and the catheter withdrawn, so that the silk passes in through the nose and out through the mouth. Several pieces of gauze, gradually increasing in size, are fastened to the middle of the silk, which is then drawn out through the nose while the finger guides the tampons up behind the soft palate. The ends of the silk are now tied together and the anterior nostrils plugged. After a day or two the posterior pack may be removed by drawing downward on the string through the mouth, and the nostrils sprayed with a mild antiseptic solution. Fig. 296 shows a Bellocq cannula, which may be used to pass the silk through the nose. An easy and sometimes efficient method for making pressure within the nostril is to fasten a condom over a rubber catheter, and when this has been inserted, to inflate the condom and tie the catheter.

Foreign bodies in the nose are most frequent in children, in whom a unilateral purulent discharge should always suggest such accident. Among other symptoms are pain, epistaxis, and stenosis. Removal may be effected by forceps, hook, loop, or snare. The forcible injection of water into the opposite nostril is not recommended. An incrustation of salts about a foreign body or particle of mucus is called a *rhinolith*, the symptoms and treatment of which are much like those of foreign body. *Parasites*, e.g., maggots, may be removed from the nasal cavity by douching with equal parts of chloroform and water.

Tumors of the nasal cavities include many different forms, both benign and malignant, but a sufficiently clear idea of their behavior and treatment may be obtained from a short description of the two common varieties, viz., mucous and fibrous polypi.

Mucous, or myxomatous polypi, most frequently arise in the neighborhood of the middle turbinate bone, often as the result of disease of the accessory sinuses. Cystic, adenomatous, or fibrous changes may occur. They are movable, almost transparent, and of a bluish gray color. The symptoms are a mucopurulent discharge, nasal obstruction, and sometimes epistaxis. Cough, asthma, headache, facial neuralgia, asthenopia, anemia, possibly epilepsy, and other reflex symptoms may be caused by polyps. They should be removed by seizing the growth with forceps, and twisting the pedicle until the growth is loose, or by a wire loop or écraseur, with which the pedicle is gradually cut through. In either case the base should be cauterized with the galvanocautery or some chemical caustic.

Fibrous polypi are much more serious than mucous polyps, as they often contain sarcomatous elements, progress steadily, and press on adjacent parts, causing exophthalmos, disfigurement, etc. The so-called *nasopharyngeal polyp* is always a fibrosarcoma. Fibromata when small may be removed with the snare, but such is always attended with some risk of hemorrhage. When of large size a very formidable operation may be needed, such as resection of the upper jaw (temporary or permanent) or removal of a portion of the roof of the mouth. For anterior growths sufficient exposure has been obtained by incising the mucous membrane between the upper lip and the jaw, cutting through the cartilages of the nose, and temporarily displacing the entire nose upwards. Temporary osteoplastic resections of the nose are made also by an external incision.

Synechia, or adhesion between the intranasal structures, may be congenital, but is usually the result of previous ulceration. Adhesions are most frequent in narrow noses, and interfere with respiration and drainage. They are treated by incision or excision, the raw surfaces being subsequently separated by a plug of rubber, metal, or cotton.

Ozena is a term often applied to any fetid discharge from the nose, but it should be restricted to cases of chronic atrophic rhinitis, a condition in which the nasal fossæ are roomy, the mucous membrane atrophic and covered with scabs, and in which there is a very objectionable odor, not appreciated by the patient. The reader is referred to special text-books for a full consideration of this affection and its treatment. Other causes of a foul discharge from the nose are tumors, foreign bodies, rhinoliths, ulcers (syphilitic, tuberculous, malignant, simple), disease of the accessory sinuses, and necrosis of bone. A unilateral discharge in children is most frequently caused by a foreign body, and in adults by disease of the accessory sinuses. The *diagnosis* requires thorough cleansing of the nose, and careful examination of its interior with the speculum and head mirror. The *treatment* varies widely with the cause, and may involve removal of necrotic bone or cartilage.

Post-nasal adenoids is a term applied to hyperplasia of the pharyngeal lymphoid tissue, or, as it is sometimes called, the pharyngeal or Luschka's tonsil, which is analogous to the faucial and lingual tonsils. Adenoids are most common in children of a tuberculous tendency, and are probably the result of repeated catarrhal inflammations. The *symptoms* are mouth breathing, change in the voice, headache, snoring during sleep, narrowing of the nostrils, and interference with nasal respiration. The child has a stupid look and indeed the mental development may be retarded. There may be a purulent discharge, occasionally mixed with blood, from the nose or pharynx, and deafness or middle ear disease may follow. The palate is often high, the upper incisor teeth prominent, and the cervical glands enlarged. There may be impairment of taste and smell, and later in life deformity of the chest, the ribs being sunken and the spine kyphotic because of interference with deep inspiration. The diagnosis is made by posterior rhinoscopy, or better, in young children, by the finger passed up into the pharynx, when the soft, easily bleeding mass is readily detected.

The **treatment** in practically all cases is removal by operation, although there is a tendency for adenoids to decrease in size or disappear later in life. The patient is etherized and the head allowed to hang over the table. Long curved forceps, such as those of Löwenberg, are passed up behind the soft palate, which is guarded with the left index finger, and the greater portion of the mass removed, care being taken not to grasp the septum or include the openings of the Eustachian tubes. Any fragments which remain may be removed with the finger nail or the Gottstein curette. Bleeding is very profuse but soon ceases.

AFFECTIONS OF THE SINUSES.

Frontal Sinuses.—Fracture of the anterior wall is common and may lead to emphysema of the face and scalp, or in compound cases to necrosis of the bone. If there is much depression the bone may be elevated to prevent deformity, opportunity being afforded at the same time to make sure that the posterior wall is not injured. In rare cases a fistula through which air passes may follow. Reference has already been made to pneumatocele (Chap. XXI). *Foreign bodies* introduced from without, or insects which have ascended from the nose, may cause empyema of the sinus.

Inflammation may be caused by injuries, foreign bodies, disease of adjacent bones, syphilis, or tuberculosis, but is usually secondary to rhinitis. In acute simple cases there is frontal headache which subsides with the acute rhinitis. If the nasofrontal duct (infundibulum) becomes blocked, the sinus distends with mucus (*hydrops*, or *mucocele*) or pus (*empyema*). In the former an enlargement in the region of the sinus is noticed, with egg-shell crackling in the later stages owing to thinning of the bone. In *acute empyema* there may be redness and edema over the sinus with general septic symptoms. The process subsides with the discharge of pus from the nose, or it may extend and involve the frontal bone, meninges, brain, or intracranial venous sinuses. *Chronic empyema* is characterized by pain, tenderness, bulging of the sinus, pus and polypoid granulations in the anterior part of the middle meatus, and sometimes by disturbances of vision and exophthalmos. The X-ray shows the sinus to be enlarged and opaque; the latter sign may be demonstrated also by transillumination, an electric lamp being held in the angle of the orbit.

The **treatment** of acute inflammation is that of the accompanying rhinitis. If suppuration occurs, the sinus should be opened through an incision from the root of the nose outwards through the eyebrow to the supraorbital notch, the anterior wall being perforated with a trephine or gouge just below the line joining the two supraorbital notches and a little away from the median line. The sinus may be curetted, irrigated, and packed with gauze, so that it may close by granulations and shut off the nasofrontal duct, or it may be necessary to remove the entire anterior wall, but this should be avoided whenever possible, owing to the disfigurement. Killian removes the anterior wall and floor of the sinus, leaving a bridge of bone at the inner angle of the orbit to lessen deformity. Some surgeons push a small tube into the nasofrontal duct in order to drain the sinus into the nose, and then close the skin incision. It may be possible for a skilled rhinologist to enter the infundibulum from the nose after removing the anterior tip of the middle turbinate, but the duct cannot be enlarged without great danger, so that, although catheterization may be useful from a diagnostic standpoint, it should not be used as a means of treatment.

Tumors, both benign and malignant, may arise in the frontal sinus. When of large size, they may press on the brain or on the eye, causing blindness and displacement of the eyeball. They should be excised.

Ethmoiditis may cause pain and tenderness at the root of the nose, disturbance of vision, mental hebetude, anosmia, and possibly cellulitis of the orbit, meningitis, or abscess of the brain. There may be a continuous discharge of pus from the nose and polypi in the middle meatus. Probing reveals necrotic bone and opacity can be demonstrated by the X-ray. The *treatment* is excision of the anterior end of the middle turbinate, to permit drainage and removal of the cells by curettage. The best way to reach the ethmoid cells by an external incision is through the inner wall of the orbit, and such is particularly indicated if the pus has perforated in this direction.

The **sphenoidal sinuses** open at the junction of the roof of the nose with the wall of the nasopharynx, and this opening may be enlarged in a downward and outward direction in cases of sphenoidal empyema. Sphenoidal and ethmoidal disease are commonly associated, and may cause meningitis, abscess of the brain, or thrombosis of the cavernous sinus. Pus flows into the superior meatus, necrotic bone may be detected with the probe, and the X-ray shows abnormal density. The sinus may be opened through the posterior ethmoidal cells after the removal of the middle turbinate, through the orbit and posterior ethmoidal cells, or through the antrum of Highmore and posterior ethmoidal cells.

Empyema of the antrum of Highmore (the maxillary sinus) is most frequently due to carious teeth, but may result also from infection of the nasal cavities, or from the entrance into its opening of pus from the frontal or ethmoidal sinuses. Injury is responsible for a small number of cases. The *symptoms* are pain, tenderness, edema of the cheek, and an intermittent unilateral discharge of pus from the middle meatus, most marked when the diseased side is upward or when the patient bends forwards, and accompanied by marked subjective fetor. If the opening into the middle meatus is obstructed, the cavity becomes distended, causing in extreme cases stenosis of the nostril, exophthalmos, depression of the palate, and a prominence beneath the malar eminence due to bulging of the outer wall, which in old cases may crackle under the finger. Acute cases may be associated with septic constitutional symptoms. Percussion over the antrum will give a dull instead of a tympanitic sound, and transillumination, by placing a small electric light in the patient's mouth in a dark room, or the X-ray, will show the diseased much darker than the normal side. In doubtful cases in which pus cannot be seen coming from the antral opening, an exploratory puncture may be made in the inferior meatus, one inch behind the anterior end of the inferior turbinate, or if the nostril is blocked, by making a similar puncture through the canine fossa, pushing the cannula upwards at an angle of 45 degrees.

The **treatment,** when the condition is due to a carious tooth, usually the second bicuspid or the first molar, is extraction of the tooth, and opening upwards through the socket to the antrum by directing the drill or gouge towards the supraorbital notch. The cavity is irrigated, and permanent drainage secured by a gold or silver tube, which may be closed with a stopper during meals. Irrigation may be practised likewise through the natural opening, or through an opening made through the inferior meatus or canine fossa. Small openings of this character are exploratory or palliative and are not suited for chronic cases. The *radical operation* is performed by making an incision at the junction of the buccal and alveolar mucous membranes, and opening the antrum with a gouge through the canine fossa, about one inch above the border of the gum, on a level with the second bicuspid tooth. The opening may be enlarged sufficiently to explore and curette the antrum thoroughly, and a counteropening may be made into the inferior meatus of the nose. A tube may be passed through both of these openings and the cavity irrigated daily.

Tumors of various kinds may develop in the antrum; about two-thirds are malignant. The so-called *hydrops, or dropsy of the antrum,* is practically always due to cystic degeneration of tumors, or to cysts connected with the tooth follicles, although a true dropsy from closure of the natural opening of the antrum is said to occur. Large growths cause expansion of the walls of the antrum, and when malignant soon spread to adjacent parts. Transillumination and percussion will give the same results as in empyema, and the introduction of a small cannula will determine the presence or absence of fluid and the density of the growth. In doubtful cases the cheek may be reflected as for excision of the jaw and the anterior wall of the antrum removed. Polyps, cysts, and other benign tumors may be removed through this opening; if malignant disease is found, the entire upper jaw should be resected.

LARYNX AND TRACHEA.

Congenital fissures and fistulæ, laryngocele and tracheocele, and *wounds of the air passages,* have been referred to in the chapter on surgery of the neck.

Foreign bodies in the air passages may be of any nature, providing they are small enough to enter the larynx or trachea. Those most often found are, in the order of their frequency, a grain of corn, watermelon seed, bean, and grain of coffee. Congenital defects or destruction of the epiglottis by ulceration, certain diseases like bulbar paralysis, and unconsciousness from any cause, predispose to this accident. Foreign bodies may be introduced through the glottis or through an artificial opening in the trachea, and they may penetrate from without, as a bullet, needle, or other sharp body. They may ulcerate into the respiratory tree from the esophagus, mediastinum, or one of the subphrenic organs, stomach, colon, liver, or spleen, and they may be formed in the lung itself (*lung stones*).

If not arrested in the pharynx or larynx, or of such a nature as to catch in the wall of the trachea, the foreign body usually descends into the right bronchus, because of its greater diameter and because the bronchial septum is situated to the left of the median line. Foreign bodies may be expelled through the mouth or through an artificial opening; they may be coughed into the pharynx and swallowed; and rarely may they gain exit through the chest wall by ulceration. Vegetable substances swell and sometimes sprout. Death is due to asphyxia from complete blocking of the respiratory channel or from edema or violent spasm of the glottis, or it occurs later from septic inflammation. Rarely hemorrhage may cause a fatal issue, as in a case in which an inhaled dart pierced the innominate artery. If the foreign body is not large enough to block the air channel completely, there are great dyspnea, violent cough, lividity of the countenance, writhing of the patient, and partial insensibility, followed by expulsion of the foreign body or a variable lull in the symptoms, then by recurrence of the symptoms, and so on until spasm or edema of the glottis causes asphyxia, or the body descends into the lung.

The **diagnosis** is usually made from the history, but if the patient be unconscious or a child from whom no history can be obtained, the symptoms may be mistaken for asthma, pertussis, epilepsy, apoplexy, diphtheria, cardiac disease, spasmodic croup, laryngismus stridulus, edema and ulceration of the larynx, the laryngeal crisis of locomotor ataxia, or for worms. Even after expulsion doubt may arise, owing to the persistence of symptoms due to irritation. In children with sudden respiratory difficulty one should think always of a foreign body. The breathing is slow compared with that of disease, inspiration prolonged and difficult with retraction of the lower ribs, and the respiratory murmur diminished or absent on the corresponding side if there be impaction in the bronchus, the pulmonary resonance, however, remaining normal. The symptoms are intermittent and in the beginning there is no fever. Sometimes the foreign body may be heard rising and falling in the trachea with each respiration. The pharynx may be explored with the finger, the larynx and upper part of the trachea with the laryngoscope, the bronchi with the bronchoscope. It should be recalled that blocking of the esophagus may cause suffocative symptoms. When the infective sequelæ from irritation of a foreign body have become established, the diagnosis may be impossible without a guiding history. These cases must be differentiated from inflammatory diseases from other causes, and from **chronic laryngeal, tracheal, or bronchial stenosis,** which may be extrinsic or intrinsic. As extrinsic causes may be mentioned cicatricial contractures; localized emphysema; enlarged thyroid, thymus, or lymphatic glands; extensive pericardial exudate; dilatation of the left auricle; disease or injury of the clavicle, sternum, or ertebræ; and cervical or mediastinal cyst, abscess, neoplasm, or aneurysm. Among the intrinsic causes are malformations; neoplasms; inflammatory thickening; intussusception of the trachea; paralysis of the posterior crico-arytenoids; longitudinal involution of the trachea after tracheotomy; adhesions of the epiglottis, vocal bands, or arytenoids; cicatrices, syphilitic, tuberculous, or traumatic; and cicatrices following diseases like scarlatina, diphtheria, variola, rubeola, and enteric fever. The characteristic inspiratory dyspnea is sufficient to establish the diagnosis of stenosis. If the voice is altered, with pain and rhoncus in a larynx which rises and falls with each respiration, the lesion is probably in the larynx, and the diagnosis may be confirmed by examination with reflected light. Dysphagia has been observed in some cases, and the head is apt to be held backward in laryngeal constriction, and slightly depressed with extended neck in tracheal stenosis. The respiratory murmur is diminished over both lungs in any constriction above the tracheal bifurcation, and the voice may be weakened owing to the lessened column of air impinging on the vocal bands. Fixed pain and rhoncus, with visual examination through the mouth, would locate the stricture in the trachea. Narrowing of a bronchus may be recognized by physical examination of the chest, or by direct inspection with the bronchoscope. Diminished respiratory dilatation of one lung, as evinced by inspection, palpation, and mensuration, with diminished vesicular murmur and vocal fremitus, and retention of resonance, can be caused only by narrowing of the bronchus or pneumothorax. A whirring rhoncus occupying the same place and having the same character and intensity on different examinations, with fixed pain and thrill over the spot corresponding to a bronchus, will definitely settle the point of constriction. The diagnosis of a foreign body would be made by excluding the other causes of obstruction. An X-ray plate might facilitate the differentiation.

The **treatment** in a great emergency is to thrust a knife through the cricothyroid membrane; if there be less urgency, a low and rapid tracheotomy may be performed; and if the patient is seen during a quiescent period, a careful examination should be made. When above the vocal bands the body may be removed with the finger or forceps, but when in the larynx below this point and irregular or jagged, permanent injury to the vocal bands may follow forcible extraction from above. Foreign bodies in the trachea or the bronchi should, whenever possible, be removed through a bronchoscope. The best *bronchoscope* is probably that devised by Jackson. It is a long, straight, slender speculum, with an electric lamp at the distal end. Under local anesthesia the glottis is exposed with Jackson's direct laryngoscope, the patient being in the dorsal position with the head fully extended, i.e., the occiput is forced down toward the shoulders, thus elevating the anterior part of the neck. The bronchoscope is passed through the laryngoscope into the larynx, the laryngoscope is withdrawn, and a "bite-block inserted to prevent the patient biting the thin walled bronchoscope. The bronchial tree is exceedingly elastic and flexible, and may be explored by following the lumen by sight." During the exploration "the head and neck should be out in the air beyond the table and supported by an assistant, so that the head may be freely movable as needed. For instance, it must be moved to the right for the bronchoscope to enter the left bronchus, and vice versa to enter the right bronchus; and it must be slightly lowered to enter the middle lobe bronchus of the right side, raised to enter the posterior branch bronchi" (Jackson). Secretions are removed by aspiration or by sponging. Foreign bodies are removed with suitable forceps. The sooner the bronchoscopic examination is made the greater the chances of success, as after twelve hours the foreign body may be concealed by swollen mucous membranes. Successful removal has been affected, however, even after years. If impossible or injudicious to extract the body from above, the patient may be inverted and succussed with a pillow, a procedure which is occasionally successful, especially when the alien is small, round, and heavy. Inversion, however, without adequate means for immediately opening the trachea, is dangerous, because of the possibility of death from impaction or spasm of the glottis, the foreign body suddenly striking the larynx from below. If inversion fail, the trachea should be opened low down, though the symptoms are even not urgent, because of the danger of death from impaction or convulsive closure of the glottis, or from subsequent inflammation. The body is frequently expelled as soon as the trachea is opened; expulsion may be facilitated by turning the patient face downward, or by inversion and succussion. These measures failing, a careful search should be made, and removal effected with finger, forceps, scoop, hook, probe, coin catcher, or wire. The bronchi may be inspected with a short bronchoscope introduced through the tracheotomy wound. A powerful magnet may attract bodies like needles, and a Bigelow evacuator may be used to aspirate small foreign bodies. If all efforts are unavailing, the wound should be kept open by sutures or hooks, and a second trial made the next day. A tracheotomy tube would hinder expulsion of the foreign body. Laryngotomy, because of the danger of injuring the vocal bands, should be performed only when the foreign body is in the larynx and cannot be removed in any other manner. Several attempts have been made to remove foreign bodies in the bronchi which could not be dealt with through a low tracheotomy wound, by splitting the sternum or by opening the thorax posteriorly, with, we believe, but a single success. If a foreign body causes pulmonary abscess or gangrene which can be localized, these should be opened and drained, when the irritating body may be detected, or perhaps discharged later.

Edematous laryngitis (edema of the glottis) may be caused by other forms of laryngitis, by injuries, such as fractures of the larynx, scalds, and foreign bodies, by inflammatory conditions in the vicinity, such as cellulitis of the neck, and by Bright's disease, angioneurotic edema, the acute infectious fevers, and the internal administration of potassium iodid for other forms of laryngeal trouble. The *symptoms* are interference with breathing, particularly inspiration, with cyanosis, etc., as the obstruction becomes more complete. The *diagnosis* is made by the laryngoscope and by feeling the swollen epiglottis with the finger. The *treatment* in the milder cases is multiple punctures or scarification of the swollen tissues, the inhalation of steam laden with compound tincture of benzoin, and ice to the neck. In more severe cases high tracheotomy should be performed, not waiting until the patient is *in extremis*. Intubation is to be preferred, providing the swelling is not too great to prevent the introduction of a tube.

Chondritis is always associated with perichondritis, and may be due to trauma, chronic laryngitis, syphilis, tuberculosis, epithelioma, typhoid fever, or the exanthemata. The cricoid and arytenoid cartilages are most frequently affected. Necrosis may occur and pus may form (*abscess of the larynx*), which may discharge internally or externally; subsequently cicatricial contraction is very apt to cause stenosis. The *symptoms* are pain, tenderness, cough, hoarseness, dysphagia, and dyspnea. Swelling may be noticed externally, or perhaps detected only with the laryngoscope. The *treatment* is much like that for edema of the glottis. Abscesses may be opened within the larynx or externally, according to where they point. In the later stages removal of necrotic cartilage may be indicated.

Syphilis of the larynx may appear in the secondary stage as mucous patches or condylomata, and in the tertiary stage as a gummatous degeneration, causing extensive destruction of tissue with subsequent cicatrization and stenosis. A subacute or chronic laryngitis without ulceration, causing little or no trouble beyond hoarseness, also occurs. In the ulcerative form the symptoms are pain, cough, hoarseness, dyspnea, and dysphagia. Syphilitic lesions are present elsewhere and the ulcers revealed by the laryngoscope are usually symmetrical; in the tertiary stage the epiglottis is particularly apt to be affected. The *treatment* is that of syphilis, with the insufflation of iodoform into the larynx. Potassium iodid, however, must be used with caution, lest it produce edema of the glottis. Tracheotomy may be needed for edema, convulsive closure of the glottis, or later for cicatricial stenosis.

Tuberculous laryngitis may be primary, but is usually secondary to phthisis. Tubercles form, break down, and become ulcers, which coalesce and often cause great destruction of tissue. The most common situation for these ulcers is about the arytenoid cartilages, the vocal cords, and the under surface of the epiglottis. Elevated granulations on the posterior wall of the larynx are strongly suggestive of tuberculosis. The subjective symptoms are those of syphilis of the larynx. Tubercle bacilli may be found in the expectoration. The *treatment* is that of tuberculosis elsewhere, with applications of lactic acid and insufflations of iodoform or thymol iodid. Tracheotomy may be needed for the same conditions as in syphilis of the larynx.

Tumors of the larynx may be benign or malignant. The **papillomata** are the most common; they are most frequent on the vocal cords and sometimes undergo an epitheliomatous change. The symptoms are hoarseness or aphonia, cough, dyspnea, and sometimes pain and dysphagia. In adults the growth may be seen with the laryngoscope; the warty-like appearance of the papilloma is distinctive. The *treatment* is intralaryngeal removal by special forceps or snare, or by cauterization. *Cysts* may be incised. In children and in extensive subglottic growths it will usually be necessary to split the thyroid cartilage in the middle line (*thyrotomy*) and deal directly with the growth.

Malignant tumors may be sarcomata, but are usually epitheliomata, which frequently result from previously benign tumors and grow slowly. The *symptoms* are those of benign tumors, but pain shooting towards the ears and hemoptysis are more frequent, and there is likely to be emaciation and lymphatic involvement. The diagnosis in the early stages is often difficult; in doubtful cases a piece of the growth should, if possible, be secured for microscopic examination. The *treatment* is removal of the growth by thyrotomy, or by partial or complete laryngectomy, according to its extent. Cure has been obtained in 26.6 per cent. of the cases (Kocher). Endolaryngeal operations are not competent to deal with malignant disease. In the later stages tracheotomy may be performed to relieve dyspnea.

Tumors of the trachea have in a general way the same features as those of the larynx, except that respiration is more apt to be affected than phonation. The tumor may be of any variety, is often recognized by the laryngoscope, and may in suitable cases be excised through a tracheotomy wound.

OPERATIONS UPON THE AIR PASSAGES.

Subhyoid pharyngotomy may be performed to gain access to the pharynx or upper part of the larynx, but the operation is rarely used. A transverse incision is made between the hyoid bone and the thyroid cartilage and the pharynx opened, the epiglottis being detached from the tongue. Intratracheal insufflation anesthesia, or a preliminary tracheotomy will be necessary in removing growths, etc., which cause much hemorrhage. The structures are sutured at the completion of the operation.

Transhyoid pharyngotomy may be used for the same purposes as the above. An incision is made in the median line from the chin to the thyroid notch, the hyoid bone divided, and the pharynx opened. Etherization by intratracheal insufflation obviates the necessity for a preliminary tracheotomy.

Thyrotomy exposes the interior of the larynx by splitting the thyroid cartilage in the median line, after performing tracheotomy and inserting a tampon cannula into the windpipe, or continuing the anesthesia by intratracheal insufflation. The wound in the thyroid cartilage is widely separated and the interior of the larynx exposed to view. The wound may subsequently be closed by sutures.

Laryngectomy is performed for malignant disease and occasionally for other conditions, such as extensive stenosis or ulceration. It may be complete or partial according to the extent of disease, and in a few cases adjacent portions of the tongue, pharynx, and esophagus have been excised. After unilateral laryngectomy the patient is able to speak, after total laryngectomy he is able to whisper. A low tracheotomy should be performed a week or more before the excision of the larynx, especially if there is much dyspnea, in order to accustom the patient to breathe through the tube, to facilitate anesthesia, and to lessen the time of the larger operation. The patient is etherized through the tracheotomy wound by means of intratracheal insufflation, or chloroformed after the insertion of a tampon cannula. A median incision is made from the hyoid bone to below the circoid cartilage, a transverse cut made at either end of this incision, the flaps reflected, the larynx isolated by blunt dissection, and removed by cutting through the thyrohyoid space above and the trachea below. The upper end of the trachea is sutured to the skin and the wound packed with gauze and partly sutured, the patient being fed by means of a tube introduced into the esophagus through the nose or the mouth. The cervical lymphatic glands are of course removed before completing the operaton. When healing is complete the patient may wear an artificial larynx. Some surgeons prefer performing the tracheotomy immediately before the laryngectomy, others discard the preliminary tracheotomy altogether, and after isolating the larynx sever the trachea, suture it to the skin, and close the opening in the pharynx; this of course prevents the use of an artificial larynx.

Laryngotomy is an emergency operation in cases of laryngeal obstruction from any cause. A vertical incision is made over the cricothyroid membrane, the cricothyroid membrane divided transversely close to the cricoid cartilage, and a tube introduced. The cricothyroid artery may be injured and require a ligature. In a great emergency the whole operation may be completed by a single transverse incision made with a penknife, and the patency of the opening maintained with the handle of the knife. The operation is not applicable to children, owing to the small size of the cricothyroid space; if ever performed before puberty, it should be combined with division of the cricoid and possibly the first ring of the trachea (*laryngotracheotomy*).

Tracheotomy is performed for serious obstruction to respiration, for the removal of foreign bodies, and as a preliminary to operations on the mouth, pharynx, or larynx. The high operation, i.e., above the isthmus of the thyroid gland, is always selected when possible, because in this situation the trachea is superficial and the operation much more simple. When the obstruction is low down, however, or when one desires to search for a foreign body in the trachea or bronchi, the low operation is indicated.

High tracheotomy may be performed under a general or a local anesthetic, or indeed in urgent cases without any anesthetic. A pillow is placed under the shoulders so as to extend the head, and an incision, exactly in the median line, is made from the cricoid downwards for one and one-half inches, dividing the skin and superficial and deep fasciæ. The trachea is now exposed by separating, if necessary, the sternohyoid muscles. The isthmus of the thyroid gland normally lies over the third and fourth tracheal rings. If it be in the way, it may be depressed after dividing the deep fascia tranversely, or it may be incised in the median line, without ordinarily giving rise to much hemorrhage. A tenaculum is inserted below the cricoid to steady the trachea, which is opened from below upwards, being careful to guard the knife with the index finger so as not to injure the posterior wall. Ordinarily two or three rings are divided, the cut being exactly in the middle line. A pair of hemostats should be introduced into the trachea before the knife is withdrawn and a tracheotomy tube inserted as the blades of the forceps are separated. The tenaculum should not be removed until the tube is in place. The tube is held in position by tapes tied around the neck. In the absence of a tube one may suture the edges of the tracheal wound to the skin. Bleeding from the small veins which have been divided usually ceases promptly when the trachea is opened. The wound is sutured, leaving sufficient opening for the tube, a couple of layers of gauze are placed beneath the flange of the tube, and one or two layers moistened with boric acid solution over the orifice of the tube.

In **low tracheotomy** the skin incision may reach the sternum, but the lower part of the wound should be deepened very cautiously because of the danger of wounding the innominate vein or the thyroidea ima. Often the inferior thyroid veins are large and numerous and lie directly over the trachea; they should be ligated or pushed aside. If need be, the isthmus of the thyroid gland may be pushed upwards. The rest of the operation is precisely the same as the high operation. In children the low operation is extremely difficult because of the depth and small size of the trachea, the shortness of the neck, and the large size of the thymus gland. If the obstruction is still below the tracheotomy opening a long tube or catheter may possibly be passed beyond it.

Tracheotomy tubes are made of hard rubber, silver, or aluminum. They are always double, the outer tube having a flange with slots, through which tape may be passed, and the inner tube being fastened to the outer by a little catch on the side, so that it may be removed and cleansed as often as necessary (Fig. 297). Some of these tubes are provided with a long handle or introducer and a special speculum-like apparatus or dilator to facilitate introduction, but such are commonly unnecessary. When a tracheotomy is performed preliminary to operations on the mouth, larynx, etc., a tampon cannula, i.e., one encased in a rubber sac, which may be inflated in order to fill the space between the tube and the tracheal wall, or covered with a compressed sponge which swells when moistened, is sometimes employed to prevent the entrance of the blood into the lungs,

FIG. 297.—Tracheotomy tube.

although with intratracheal insufflation anesthesia such appliances are not needed.

After Treatment.—The room should be kept at a uniform temperature of 75° F., the air moistened by steam, and the gauze over the tube changed as often as the patient coughs, so that the mucus, etc., will not fall back into the tube. The inner tube should be removed every two or three hours by the nurse and cleansed, the outer tube may be removed once a day by the physician for the same purpose. Mucus in the trachea may be extracted by a sterile feather moistened with bicarbonate of soda solution, 20 grains to the ounce. If there is much difficulty in breathing, oxygen may be given by intratracheal insufflation. The tube should be removed permanently as

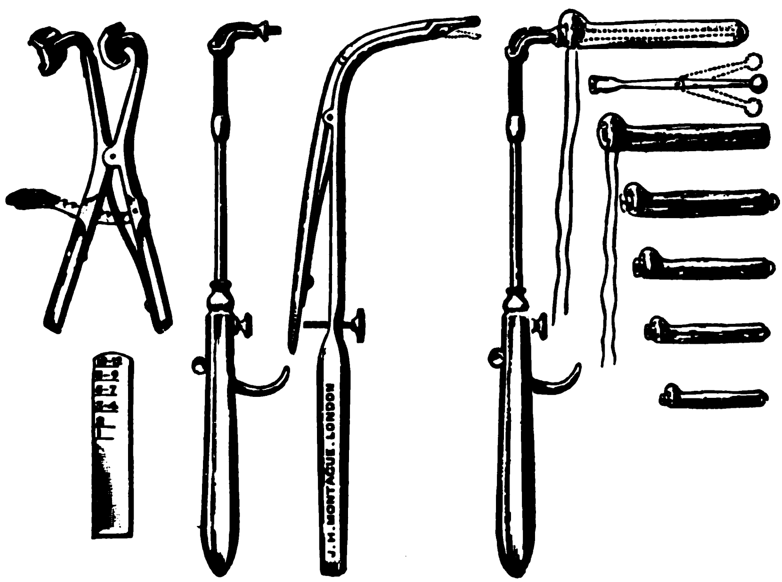

FIG. 298.—To the left is the mouth gag, and the scale for determining the proper sized tube according to the age of the patient. Next is the introducer, next the extractor. On the right are the tubes, which are expanded above to rest on the ventricular bands, with a prominence posteriorly which rests between the arytenoid cartilages. The middle of the tube is enlarged, the enlargement resting just below the vocal cords, to prevent displacement of the tube upwards when it is in position. Between the tubes on the right is the obturator, which fits into the tube and is screwed into the holder, and which is hinged in the middle so that it may be withdrawn after the tube is in position.

early as possible, but the time that it should remain in place will vary greatly with the condition; thus after the removal of a foreign body it may be only twenty-four hours, in some cases of stenosis it may be for the rest of the patient's life. Tubes are constructed with an opening in the convex portion, so that part of the air will pass through the larynx; if breathing is free when the outer opening is plugged, the tube may be removed with safety. Among the *complications* of tracheotomy may be mentioned ulceration of the trachea from a poorly fitting tube, cellulitis, secondary hemorrhage, bronchitis, pneumonia, and stenosis of the larynx or trachea. Stenosis of the larynx may be treated by gradual dilatation with O'Dwyer's tubes, or in some cases by removing the cicatricial tissue and skin grafting the interior of the larynx.

Intubation of the larynx may be used for many forms of stenosis of the larynx, but is chiefly employed in that form due to diphtheria. It is rapidly performed with much less risk than tracheotomy, but requires special instruments, and the presence of the surgeon if the tube should be coughed up. The instruments are shown in Fig. 298. The child is wrapped in a blanket to control the arms and legs, and is held upright by a nurse seated in a chair, while an assistant holds the head upon the nurse's left shoulder and prevents the mouth gag from slipping. A long piece of silk is passed through the small opening in the upper part of the tube, the tube fastened to the introducer, and the silk looped around the little finger. The left index finger is passed into the throat, and lifts the epiglottis while the tube is passed along it into the glottis. The left index finger is then made to press upon the head of the tube, which is released by pulling the trigger on the introducer, which is then withdrawn. When one is assured that the tube is in the right place and that the symptoms are relieved, the silk loop may be cut and withdrawn while the finger is again made to press down on the tube. If the tube is coughed up, it is too small and the next larger size should be introduced. In cases of diphtheria the membrane may be pushed before the tube and cause asphyxia, which, if not immediately relieved by expulsion of the membrane after the tube has been pulled out by the string, will demand tracheotomy, hence instruments for this operation should always be at hand. The patient speaks in a whisper, and is apt to inhale food during deglutition, hence feeding should be per rectum or by nasal tube, although some advise feeding with the head lower than the body, or the giving of semi-solids, which will more easily pass over the glottis. The tube remains in place several days, and is then removed with the child in the same position as for introduction, by passing the left index finger down to the tube and slipping the point of the extractor into its opening, the tube being engaged by pressing the spring on the shank of the extractor.

SURGERY OF THE CHEST.

Contusion of the chest may cause superficial bruising of the skin, laceration of the muscles, fracture of any portion of the wall of the thorax, or more or less extensive injury to the contained viscera. Occasionally a severe blow on the chest or epigastrium (so-called solar plexus blow) will be followed by severe shock or even death, without causing any gross anatomical change; this condition has been termed *concussion of the chest* and is probably due to direct concussion of the heart muscle or its nerve mechanism. Owing to the lack of functionating valves in the jugular and facial veins, forcible compression of the chest of some minutes' duration, such as may occur in a struggling mob, may cause a bluish or black discoloration of the face and neck, subconjunctival ecchymosis, and hemorrhages into the retina and brain (*traumatic asphyxia*). *Rupture of the lung* is recognized by cough, dyspnea, hemoptysis, subcutaneous emphysema, and hemo-pneumothorax. Ruptures of the large vessels, trachea, or esophagus are associated with such widespread injury that death quickly follows. For injuries of the heart see Chap. XV, and for rupture of the diaphragm, Chap. XXVII. The **treatment** of contusion of the chest is reaction from shock, and immobilization of the thorax as in fracture of the ribs. In the presence of marked evidences of internal hemorrhage, thoracotomy and efforts to check the bleeding are indicated. The treatment of pneumothorax is given on a later page.

Wounds of the chest may be penetrating or non-penetrating; the latter are treated as wounds elsewhere. *Penetrating wounds* are usually caused by stabs or bullets. The *diagnosis* may be made by signs of injury to the viscera, or by exploration of the disinfected wound with a sterile finger; the latter is always advisable, particularly in wounds in the neighborhood of the heart, or below the sixth rib, as in this situation penetration of the diaphragm and injury to the abdominal viscera may easily occur. Wounds of the heart have already been discussed and injuries of the abdominal viscera will be considered in a subsequent chapter. The possible symptoms of a *penetrating wound of the lung* are those of rupture of the lung, with a bleeding and a garrulous external wound.

The **treatment** in the absence of serious hemorrhage or the lodgement of a foreign body, is disinfection and suture of the external wound and immobilization of the affected side of the chest. Hemorrhage from the *internal mammary* or *intercostal artery* may be controlled by ligation, or by pushing a gauze sac between the ribs and filling the inner end of the sac with gauze so that when drawn upon it will make pressure from within outwards. Excepting extensive wounds, *bleeding from the lung* is rarely fatal, as the bleeding is checked by collapse of the lung. In the absence of external hemorrhage, serious loss of blood is diagnosticated by the constitutional signs of acute anemia and a rapidly accumulating *hemothorax*. Cases of this sort have been treated by the introduction of a drainage tube in order to admit air and favor collapse of the lung, but in the presence of serious symptoms one or more ribs should be resected, and the wounded lung dealt with directly by sutures or gauze packing. Hemothorax of lesser degree, or that form due to hemorrhagic pleurisy or tumors of the lung or pleura, does not require special surgical treatment unless it causes pressure symptoms or becomes infected; in the former case aspiration, and in the latter resection of a rib and drainage would be indicated. Foreign bodies should be removed if easily accessible, and the same rules as to the examination of the vulnerating instrument, the clothing, etc., apply here as elsewhere. If the foreign body is not easily found, it should be allowed to remain, unless it gives rise to subsequent trouble, when it may be definitely localized by the X-ray and its removal effected, if such be deemed advisable. With the exception of pneumocele, the complications of injuries to the chest are inflammatory in nature, viz., cellulitis, pleurisy, empyema, pneumonia, abscess or gangrene of the lung, mediastinal abscess, and peri-, myo- or endocarditis.

Hernia of the lung (*pneumocele*) is rare; it is the result of laceration of the intercostal structures without involvement of the skin, or follows a wound owing to stretching of the cicatrix. It has an impulse on coughing, crepitates beneath the fingers, and a vesicular murmur can be heard on auscultation. It is treated by a pad or truss. In contradistinction to a hernia, a **prolapse of the lung** is a protrusion of the lung into an open wound. It should be reduced and the opening closed, or if badly infected and gangrenous, or densely adherent, it may be amputated.

Emphysema of the subcutaneous tissues, the result of injury to the lung, rarely requires any treatment and gradually disappears. If excessive and interfering with respiration, multiple punctures may be made.

Pneumothorax (air in the pleural cavity) is almost always associated with the presence of pus, blood, or serum. Ninety per cent. of all cases are due to phthisis. Air may enter the pleural sac through a wound in the chest wall or lung, it may come from the colon, stomach, or esophagus as the result of suppurative or malignant disease, and it may be produced by aërogenic microbes. The **symptoms,** when a large amount of air is suddenly introduced, are pain, dyspnea, cyanosis, and rapid weak pulse. These symptoms are seldom seen during operations involving the pleural cavity, because of the frequency of pleural adhesions and the strong coherence which normally exists between the pleural laminæ. The signs of pneumothorax are bulging and immobility of the affected side, displacement of the heart, lessening or absence of vocal fremitus and breath sounds, tympany on percussion (rarely dulness), metallic tinkling, and a metallic quality in the voice, in the râles, and in the sound heard when percussing the chest by using a coin as a plexor and one as a pleximeter (coin test). There may be signs of fluid in the cavity, and a splashing sound obtained by shaking the patient. The X-ray will give an intense clearness over the air sac. **Treatment** is not required as long as respiration is not impeded, indeed a little pneumothorax may be beneficial in giving rest to an affected lung, but if the breathing be difficult and the heart displaced, the air may be removed by aspiration, or if associated with pus, by resection of a rib and drainage. In cases resulting from an external wound the pleural opening may be sutured or plugged, or the lung or diaphragm may be stitched to the chest wall. The Fell-O'Dwyer apparatus (Chap. II) has been suggested to anticipate and combat acute operative pneumothorax; for the same purpose Sauerbruch operates inside a cabinet in which the air pressure is negative, the patient's head extending beyond the cabinet, an air tight collar being fitted to his neck. Brauer uses positive pressure, i.e., an air tight mask is fitted to the patient's head and the anesthetic, at a pressure above that of the atmosphere, given by a special apparatus. Although more convenient than the Sauerbruch method, difficulty is encountered in adjusting the mask if the patient vomits, a disadvantage which has been met by administering the anesthetic through a tracheotomy wound. Insufflation anesthesia (Chap. II) seems, at the present time, the best method for preventing pneumothorax during intrathoracic operations. Some surgeons, the day before operations on the lung, suture both layers of the pleura together, or slowly induce a pneumothorax. If none of these precautions is taken, a small opening may be made in the chest at the time of operation and the air allowed to enter slowly. Elsberg states that when the patient is in the dorsal position the heart falls backwards and pulls with it the visceral pleura of the anterior mediastinum, thus predisposing to pneumothorax; consequently he advises opening the pleural cavity with the patient in the ventral position.

Serous pleural effusion is usually the result of pleurisy, which may be primary, or secondary to trauma or disease of the lung; it may be caused also by tumors of the lung, or disease of the heart, liver, or kidney. Symptoms may be absent, or there may be pain, cough, dyspnea, and in inflammatory cases fever and leukocytosis. The signs of fluid in the chest are immobility and enlargement of the affected side, widening with perhaps bulging of the intercostal spaces, displacement of the heart, diminished or absent vocal fremitus, dulness or flatness on percussion which may change with alteration in the position of the patient, tympany above the fluid, feeble or absent breath sounds and vocal resonance, and opacity as revealed by the X-ray. In some cases there is bronchial breathing and egophony. The *treatment* of serous effusions when large in amount or producing pressure symptoms, or in any case not quickly relieved by medical treatment, is aspiration.

Pyothorax, or empyema (pus in the pleural cavity), may be due to infection of the pleural cavity by a wound, or to extension of a suppurative process of the lung, neck, or abdomen, but is commonly secondary to infection of a serous pleural effusion. The organism present will vary with the cause; it may be the staphylococcus, streptococcus, pneumococcus, colon bacillus, tubercle bacillus, typhoid bacillus, etc. The **symptoms** and signs are those of serous effusion, with, in a typical case, irregular fever, possibly chills and sweats, leukocytosis, edema of the chest wall, and absence of the whispered pectoriloquy which may be heard in serous effusions (*Baccelli's sign*). The diagnosis is confirmed by exploratory puncture. In some cases the pulsations of the heart are transmitted through the effusion (*pulsating empyema*). The pus may be localized by adhesions (*encapsulated empyema*), or fill the whole pleural cavity (*total empyema*). Spontaneous recovery is possible but very rare. An empyema may perforate the chest wall (*empyema necessitatus*), or it may break into the lung, esophagus, stomach, pericardium, or peritoneum. Rarely it may form a lumbar or psoas abscess. In acute cases the pleura is but little altered, and although the lung is compressed, it readily expands when drainage is established. In chronic cases, however, reexpansion is prevented by sclerotic changes in the lung and by the dense and thickened pleura. In these cases nature tries to obliterate the cavity by causing a hypertrophy of the opposite lung, an ascent of the abdominal viscera on the affected side, a sinking in of the chest, a lateral curvature of the spine, and an abundant growth of granulations from the pleura. If the cavity is large, healing can take place only with the aid of surgery. The *prognosis* is considerably modified by the character of the infection, thus a pneumococcal empyema in the early stages may often be cured by aspiration alone, as the organisms quickly perish, while the presence of other pyogenic bacteria will always indicate free drainage, and even then extensive subsequent operations may be demanded. A tuberculous empyema will of course present a grave prognosis. Cultures in these cases, as well as in a late pneumococcal empyema, may be sterile. The earlier drainage is instituted, the greater the chance of reexpansion of the lung.

The **treatment** of acute cases is aspiration, intercostal incision, or rib resection; chronic cases may demand the Estlander, Schede, or Fowler operation. The principle in acute cases is to remove the pus, in chronic cases to obliterate the cavity by causing the chest wall to collapse or the lung to expand.

Paracentesis thoracis (tapping) may be performed with an ordinary trocar and cannula, but as this permits the introduction of air, aspiration should be employed whenever possible. A hypodermic or an antitoxin syringe, with a long and strong needle of large calibre, may be used for diagnostic purposes. Fig. 299 shows an aspirator. The stopper is inserted into a large glass bottle, the stop-cock A closed and the stop-cock B opened, a vacuum created in the glass bottle by the pump, and stop-cock B closed; after the needle has been inserted into the chest, stop-cock A is opened and the fluid in the pleural cavity enters the bottle. The skin and needle should be disinfected, and the patient placed in a semi-recumbent posture, unless such is contraindicated. Local anesthesia is usually unnecessary, although it is desirable to give a little whiskey before operation. The puncture is generally made in the eighth intercostal space near the angle of the scapula, or in the sixth interspace in the midaxillary line. A small puncture is made over the lower rib with a knife, and the skin pulled upwards, so that the needle, guarded by the index finger, may be introduced close to the upper edge of the rib, in order to avoid the intercostal vessels; thus the opening is valvular and closes as soon as the needle is withdrawn. If the tap be dry, a stylet may be introduced into the needle to make sure that it is not plugged and if fluid still fails to come, the needle should be partly withdrawn, and reintroduced at a different angle. The fluid is withdrawn slowly, and the flow stopped for a time if there is faintness, violent cough, or marked alteration in the pulse. The puncture in the skin is covered with collodion. Although it is true that aspiration will occasionally cure a pneumococcal empyema in a child, it is generally regarded by surgeons as an exploratory or palliative measure. For the latter purpose it may be used in cases of rapid phthisis, or as a preliminary measure to operation in bad cases in which the effusion is very large or exists on both sides. With these exceptions, **thoracotomy** (opening the pleural cavity), with or without resection of a rib, is recommended in all cases. *Thoracotomy without resection* of a rib is indicated when the patient's condition is very serious, as it is easily performed under local anesthesia, by making an incision about two inches in length along the lower border of the sixth or seventh intercostal space in the midaxillary line. A small

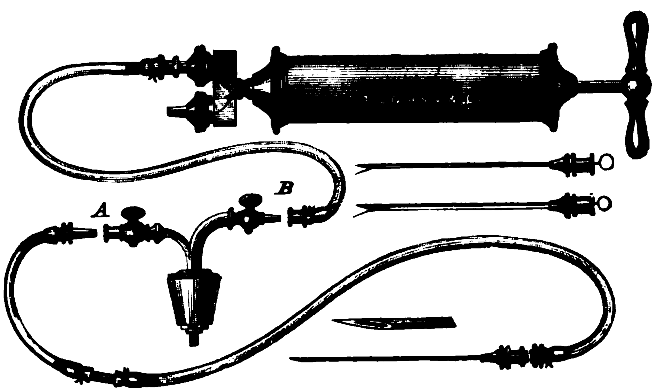

FIG. 299.—Aspirator.

opening is made in the pleura, in order to allow the pus to escape slowly; the opening is then enlarged, loose pieces of lymph removed, and a short rubber tube introduced. The tube should be sutured to the skin, to prevent its expulsion, and transfixed with a large safety pin, to prevent its dropping into the cavity. *Resection* of a portion of a rib is the usual operation, as it allows more room for exploration and free drainage. Ether is contraindicated, because of its effect on the lung. The best general anesthetic is nitrous oxid and oxygen, but chloroform or a local anesthetic may be employed. The patient lies on his back and is brought to the edge of the table. A two or three inch incision, with its center in the midaxillary line, is made over the seventh rib, and the periosteum divided, and separated from the entire circumference of the rib with closed curved scissors or a periosteal elevator. The rib is divided at each extremity of the incision with bone forceps and removed, the intercostal vessels having been pushed aside with the periosteum; the operation then proceeds as in thoracotomy without resection of the rib. Irrigation of the cavity should never be employed in acute cases, as it is occasionally followed by death. In chronic cases, however, in which the adhesions are firm, irrigation with sterile salt solution is often advisable, particularly if the discharge is very fetid. The tube may remain in place until the purulent discharge ceases, or, better, it may be removed at the end of a week, and a Bier suction pump used once or twice daily until the lung is fully expanded. If the sinus persists (pleural fistula), there is caries of a rib or non-obliteration of the cavity. In either case a secondary operation will be required. If the lung fails to reach the chest wall after several months, the chest wall should be taken to the lung by *thoracoplasty* (Estlander or Schede operation). One may first try, however, injections of Beck's bismuth paste (see sinus). The cavity is filled with mixture No. 1 (not more than 100 grams being used)and the opening allowed to close. If the temperature rises above 101° or severe pressure symptoms appear, the accumulated fluid is evacuated and the opening again allowed to close. Repetition of the injection is necessary only when the paste is discharged with the pus.

Estlander's operation consists of the resection of a sufficient number of ribs, with the periosteum, to obliterate the abscess cavity. The length and number of ribs to be removed depend upon the size of the cavity. In a large cavity it may be necessary to remove three or four inches of all the ribs from the third to the ninth. This is best done through an I- or U-shaped incision, although separate incisions may be made in every other intercostal space, and the rib above and below removed through each incision. The cavity is emptied of all débris and packed with gauze.

Schede's operation is more radical and more severe. A U-shaped incision is made from the origin of the pectoralis major at the level of the axilla, down to the lower level of the pleural cavity, then up to the level of the second rib between the spine and the scapula. This flap is reflected upwards, and all the ribs over the cavity from the second down, and from their tubercles to the costal cartilages, excised together with the periosteum, intercostal structures, and thickened parietal pleura. Bleeding is checked, the cavity curetted with gauze, and the flap sutured so as to lie in contact with the lung, drainage being provided by sterile gauze. After any operation for empyema pulmonary gymnastics should be given to expand the lung. The patient should also have been informed that the resulting deformity is necessary to the cure.

Pulmonary decortication, or total pleurectomy (*Fowler's operation*), consists in excision of the sinus, resection of two or more ribs, and stripping of the entire pleura, both visceral and parietal, from the subjacent parts, thus allowing the lung to expand. The flap is replaced and the cavity drained. Further experience is needed to determine the status of this operation, although it may be said that at least partial decortication of the lung is a useful adjunct to either the Estlander or the Schede operation. Ransohoff has recently modified this operation by making longitudinal incisions in the pulmonary pleura (*discission of the lung*).

Pneumotomy, or incision of the lung, is indicated in pulmonary gangrene or abscess, echinococcus cysts, and in certain cases of bronchiectasis and foreign bodies. It has been employed, but is rarely justifiable, for tuberculous cavities. The trouble is first localized by physical examination, the X-ray, and by the aspirating needle. The needle is left in place as a guide, and an incision made exposing the pleura. More room may be obtained by resecting the rib above and below. Often the pleura will be adherent, and the cavity may be at once opened with the thermo-cautery and drained with a soft rubber tube. Loose particles of necrotic tissue are removed, but curettage and irrigation should be avoided. If the layers of the pleura are not adherent, they may be sutured together in order to avoid pneumothorax and infection of the pleural cavity, and the incision into the lung postponed for twenty-four hours, or longer if there be no urgency. The positive and negative pressure methods for preventing pneumothorax are described under pneumothorax.

Pneumectomy, or excision of a part of the lung, may be indicated in pneumocele, bronchiectasis, pulmonary neoplasms, or in tumors of the chest wall which have invaded the superficial portion of the lung. The operation has been performed for tuberculosis but cannot be recommended, because in the localized form recovery frequently follows medical treatment, and in the diffuse variety the disease cannot be removed. The measures already indicated to guard against pneumothorax should be taken, the base of the affected portion of the lung surrounded with an elastic ligature or clamped, the diseased tissue resected, and the stump sutured. Any bleeding points that remain may be controlled by sutures, ligatures, the cautery, or by gauze packing. The bronchial stump is difficult to close satisfactorily. Myer crushes, ligates, and invaginates the cut end of the bronchus. Garré sutures lung tissue over it. Giertz suggests covering it with a free transplant of fascia lata.

Pneumolysis is a term applied by Friedrich to an operation which he practises for unilateral phthisis pulmonalis. After making an incision like that for Schede's operation, the ribs, from the second to the tenth, and from the costal cartilages back to and including the heads, are removed without opening the pleura, thus allowing the chest wall to collapse, putting the lung at rest, and favoring cicatrization of the cavities. Murphy has injected nitrogen gas into the pleural cavity with the same end in view. Pneumolysis is still in the experimental stage.

In addition to the operations mentioned above **tuberculosis of the lung** has been treated by the injection of antiseptics into the tuberculous cavity; by extrapleural tamponage, i.e., compression of the lung by means of paraffin or fat introduced between the thoracic wall and the parietal pleura; by division or crushing of the phrenic nerve or the intercostal nerves; and by bilateral chondrotomy of the first costal cartilage, which is supposed to encourage the apices of the lungs to expand.

Bronchiectasis has been treated by pneumotomy, pneumectomy, division of the phrenic nerve, division of the phrenic nerve with subdiaphragmatic transposition of the lower lobe of the lung, thoracoplasty as for empyema, pneumolysis, compression by means of paraffin or fat as for phthisis, and, in order to induce the pulmonary tissue to shrink, by ligation of the artery supplying the affected lobe. The results of these operations, thus far, have not been encouraging.

Pulmonary alveolar emphysema, according to Freund, is the result, not the cause, of the dilated, rigid thorax characteristic of this disease. He, therefore, excises about two inches of the ribs, from the second to the sixth, including the costochondral junctures, with, he states, marked benefit in some cases.

Mediastinal abscess may be traumatic, or secondary to a suppurative process in the neck or intrathoracic organs. The symptoms are those of sepsis (except in chronic cases), and pressure, as in aneurysm, from which the condition may be distinguished by the absence of thrill, bruit, and expansile pulsation, and by the X-ray. In doubtful cases a fine needle may be introduced. Various **tumors**, both benign and malignant, may originate in the mediastinum and produce identical pressure symptoms. Abscesses should be drained after localizing them with the aspirating needle. Tumors are for the most part beyond the aid of present-day surgery, but in a few instances operative relief may be attempted. The anterior mediastinum may be approached by resecting a portion of the sternum; the posterior mediastinum has been opened extrapleurally by resecting the ribs near the spine. The possibility of removing foreign bodies impacted in the thoracic portion of the esophagus, as well as resecting portions of the gullet for malignant disease, is presented by the latter route.

CHAPTER XXV.

DISEASES OF THE BREAST.

Congenital malformations such as absence of the nipples (*athelia*), incomplete development (*micromazia*) or absence of the breasts (*amazia*), and supernumerary nipples (*polythelia*) and mammæ (*polymastia*) require no treatment.

Retracted nipples may be congenital or due to contraction from ulceration, mastitis, or tumors. Occasionally the condition may be benefited by repeatedly drawing the nipple out with the fingers or with the breast pump. Nursing can often be accomplished by means of the nipple shield.

Mammilitis, or inflammation of the nipple, is almost invariably associated with lactation, the delicate epithelium becoming macerated by milk and saliva, and easily excoriated (*fissured or cracked nipples*). The inflammation may extend to the surrounding skin, or cause an abscess of the breast by spreading along the milk ducts or lymphatics; occasionally the nipple is destroyed by ulceration. Nursing is painful and often followed by bleeding, hence is often postponed, thus leading to engorgement of the breast. The **treatment** should begin before the trouble is inaugurated. Towards the end of pregnancy the epithelium may be hardened by bathing with alcohol, during lactation the nipples should be washed before and after nursing with boric acid solution, and carefully dried. If a small fissure forms, it may be sprayed with peroxid of hydrogen, washed with boric acid solution, and dusted with boric powder, a nipple shield being used during nursing. In the more severe forms the child should be weaned, the secretion of milk suppressed by the application of belladonna ointment and a pressure bandage, and the nipple treated with peroxid of hydrogen, boric acid solution, and applications of silver nitrate.

Paget's disease (*malignant dermatitis*) is a chronic destructive inflammation of the nipple, usually occurring in women past middle life. Some consider certain psorosperms as the cause of this condition, but such has not been proved. At first there is a moist desquamation, later a sticky yellowish discharge with the formation of crusts, beneath which the surface is red and raw. The nipple may be retracted or even destroyed, and the condition may extend to the skin of the breast. It is not a simple eczema, which, however, may attack the nipple, but a precursor of carcinoma of the breast. The *treatment* is, therefore, excision of the diseased area, and also the breast and axillary glands if there are any indurations in the breast.

Abscess of the areola requires incision and drainage. It usually arises from the sebaceous follicles, and is most frequent in girls about puberty.

Tumors of the nipple include papilloma, epithelioma, fibroma, angeioma, myxoma, and myoma. Sebaceous cysts may arise from the nipple or the areola.

Neuralgia of the breast (*mastodynia*) is usually associated with hyperesthesia of the skin and deep tenderness of the gland, but no organic change can be detected. It is most common in young unmarried women and may be associated with ovarian disturbances. Local treatment should be avoided and the general health improved.

Hypertrophy is generally bilateral, begins at puberty, and does not interfere with the general health; occasionally the patient complains of neuralgia. The growth is slow, but the breasts may attain an enormous size. The consistency may be normal, or there may be a diffuse firmness due to an increase in the fibrous tissue. Unilateral hypertrophy has been mistaken for a tumor of the breast. Amputation is the only remedy.

Gynecomazia is hypertrophy of the male breast or breasts, a condition often associated with malformation of the sexual organs.

Acute mastitis, or mammitis, is occasionally seen in women as a metastatic process during the course of mumps. In girls and sometimes in boys about the age of puberty the breast may become large and tender, and after persisting for weeks go on to resolution, although suppuration is occasionally seen. A somewhat similar condition is encountered in children soon after birth, particularly if the nurse has tried to "break the nipple string" by pulling or rubbing. Acute mastitis, however, is most often seen during the puerperium, usually as the result of cracked nipples, the infection passing along the milk ducts or the lymphatics.

The **symptoms** are pain, tenderness, swelling, localized heat, hardening of the breast, and the constitutional signs of fever. If *abscess of the breast* follows, the skin becomes red and edematous, the pain more intense, and in the later stages fluctuation appears. The pus may be between the skin and the gland (*supramammary abscess*), in the gland (*intramammary abscess*), or beneath the breast (*submammary abscess*) as the result of extension from the deep lobules. The last may be due also to disease of the ribs and like conditions.

The *treatment* of acute mastitis is suspension of nursing, depletion by means of the breast pump, support of the gland by a sling or bandage, and the application of ichthyol or an evaporating lotion. Fissures should be disinfected and the general health improved. In the later stages resolution may be hastened by gentle massage. If pus forms, the treatment is the same as for suppuration elsewhere. In an intramammary abscess the incision should radiate from the nipple, so as to be parallel with the milk ducts, and a finger should be introduced to open any adjacent lobules which may be distended with pus. When the abscess is in the upper portion of the breast, it is often desirable to make a counterincision below and introduce a drainage tube. A retromammary abscess is best opened at the lower and outer side.

Milk fistulæ follow abscesses or incisions, and are treated as sinuses elsewhere.

Chronic mastitis may be divided primarily into the non-suppurative and the suppurative, although the term is often used to designate the former only. Chronic non-suppurative mastitis occurs in two forms, the circumscribed and the diffuse. **Chronic circumscribed, or lobar mastitis,** may follow trauma or pregnancy, but is most frequent in women approaching the menopause. One or more of the lobes become enlarged, indurated, tender, and sometimes the seat of severe neuralgia, which is apt to be worse during menstruation. The condition may persist for months or years, but never terminates in suppuration. **Chronic diffuse, lobular, or interstitial mastitis** may occur at any time after puberty, but is most frequent after lactation or at the climacteric. There is a marked increase in the connective tissue, which ultimately contracts, causing induration, shrinkage of the breast, depression of the nipple, and the formation of cysts owing to pressure on the ducts, which prevents the escape of degenerated and liquefied epithelium which has undergone proliferation. There may be pain, tenderness, and a watery discharge from the nipple. The disease rarely disappears, but usually terminates in atrophy of the breast, the gland becoming hard, nodular, and shrunken, or in general cystic degeneration, or possibly carcinoma. The *diagnosis* from carcinoma may be difficult or even impossible without microscopic examination. The involvement of the opposite breast, the absence of a distinct tumor, the presence of small cysts, the long duration, with preservation of the general health, and without infiltration of the perimammary tissues or involvement of the axillary glands, all point to interstitial mastitis.

The **treatment** of the above forms of chronic mastitis is the removal of any source of irritation, such as badly fitting corsets; support by a bandage; local applications of belladonna and mercury; and the internal administration of potassium iodid. If there be doubt as to the nature of the condition, if there be a diffuse cystic change, or if the disease cause much pain or anxiety, the breast should be amputated.

Chronic suppurative mastitis is characterized by the formation of pus, often without symptoms of inflammation; it follows lactation, probably as the result of infection of galactoceles, or it may be due to syphilis, tuberculosis, or actinomycosis. The abscess wall is often so thick as to resemble a tumor, and in several instances the breast has been removed as the result of an incorrect diagnosis. A hollow needle or an exploratory incision will dispel all doubt. The treatment is incision, disinfection, and drainage, or, if the breast is totally destroyed, amputation.

Tuberculosis of the breast may be localized (*cold abscess*) or diffuse, but is not common. In the diffuse form the breast is riddled with sinuses which discharge caseous pus. The disease may be primary, or secondary to tuberculosis of neighboring parts. The *treatment* of the diffuse form is amputation of the breast. Sharply localized disease may be treated by excision, or by incision and curettage.

Syphilitic affections of the breast include chancre, mucous patches, condylomata, and gummata, the appearances and treatment of which have already been given.

Tumors of the breast may be of almost any variety, but only the most common forms require special description. In palpating a breast for a tumor, the gland should be pressed against the chest wall with the flat of the hand, as picking up the tissues between the fingers gives a deceptive sense of a new growth.

Fibroadenoma is the most common benign tumor of the breast. Pure adenoma and pure fibroma are very rare. Fibroadenoma usually originates in women between puberty and the thirtieth year. It is hard, slightly nodular, freely movable, generally but not always painless, and unassociated with impairment of the general health, axillary involvement, or retraction of the nipple. Cystic changes occur in a few cases, but sarcomatous or carcinomatous degeneration is rare. The *treatment* is enucleation of the growth from its capsule, the incision radiating from the nipple. In order to conceal the scar, Thomas makes the incision along the lower margin of the breast, which is then turned upward, and the growth removed from behind by a V-shaped incision that is subsequently sutured. If the growth is large the deformity occasioned by excision may be avoided by filling the cavity with a free

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transplant of fat, taken from the subcutaneous tissues of the buttock or abdomen.

Cystadenoma, or adenocele, is characterized by dilatation of the acini and small ducts of adenomatous tissue into cysts, into which fibropapillomatous vegetations project, hence the terms *proliferous mammary cyst, intracanalicular fibroma*, and *duct papilloma* (the last term is often restricted to a small cyst situated near the nipple and containing a warty growth). The tumor grows slowly but may attain a large size, and in the later stages adheres to the skin and may even break through it. It is nodular, encapsulated, movable, occurs between the thirtieth and fortieth years, is generally painless, and may be associated with a bloody discharge from the nipple, as the result of intracystic hemorrhage. It is hard, but varies in consistency according to the size of the cysts. It does not infiltrate the surrounding tissues or involve

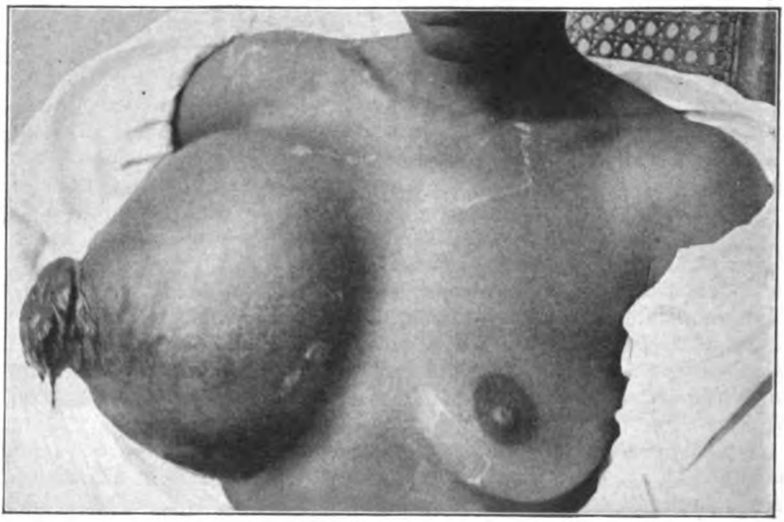


FIG. 300.—Round-celled sarcoma of the breast which had broken through the skin and given rise to repeated hemorrhages. (Jefferson Hospital.)

the axillary glands. Carcinomatous and sarcomatous degeneration are possibilities. The *treatment* in the early stages is removal of the growth alone, but in the later stages it will usually be necessary to amputate the breast.

Sarcoma (Fig. 300) constitutes less than 5 per cent. of all breast tumors; the cells may be of any type, authorities differing as to whether the round- or the spindle-celled variety is the most frequent. Cyst formation occurs in about half the cases, as the result of hemorrhage, degeneration, or obstruction to the tubules (*cystosarcoma*). *Adenosarcoma* is that form which develops from an adenoma or a fibroadenoma, or in which the tubules and acini proliferate. Inflammation and suppuration are common and myxomatous, fatty, calcareous, and telangiectatic changes may occur. Sarcoma usually appears between the ages of twenty-five and thirty, grows rapidly, is encapsulated, is firm or soft according to the constituent cell, causes distention of the overlying veins, and does not involve the axillary glands until ulceration has occurred; it does, however, give rise to early metastases in the viscera. Pain is often severe, and discharge from the nipple frequent. It differs from carcinoma in that it occurs at an earlier age, is more movable, grows more rapidly, is less uniform in consistency, does not retract the nipple or cause enlargement of the lymph glands, except in rare cases, and even when ulcerating does not infiltrate or markedly thicken the skin. The prognosis is very grave. The *treatment* is removal of the breast and the axillary glands.

Carcinoma constitutes over 80 per cent. of all breast tumors, so that any lump in the mammary gland must be regarded as malignant unless positive proof to the contrary is forthcoming. It attacks the male breast in about one per cent. of the cases. The influence of heredity is probably very slight, but the frequency of preceding trauma or inflammation seems to be more than a coincidence. The importance of Paget's disease as a precancerous condition has already been mentioned. Cancer of the breast is said to be more common in women who have borne children, but this statement is greatly weakened when the comparatively small number of nulliparæ is considered. It is more frequent in the left breast than in the right, and is usually encountered after the age of thirty-five, although it may occur at a much earlier period. There are three primary varieties, viz., (1) the spheroidal-celled or acinous, (2) the columnar-celled or duct cancer, and (3) the squamous-celled or epithelioma of the nipple. (1) The *acinous* form may be medullary, simple, or scirrhous. Colloid or myxomatous cancer is a rare variety in which one of the former has undergone mucoid degeneration. *Medullary, encephaloid, or soft cancer* grows rapidly, quickly ulcerates, causes early metastases, and appears earlier in life; as a rule the skin is distended rather than dimpled, and the nipple is not retracted. As it may feel hot, owing to its vascularity, and often follows pregnancy, it may be mistaken for mastitis or an abscess. A *simple cancer* approaches the normal in the relative amount of fibrous and epithelial tissues, and is midway between the encephaloid and the scirrhous in hardness and malignancy. The *scirrhous or hard cancer* grows more slowly, and is nodular and of a stony hardness; it infiltrates the glandular tissue, and cannot be moved without carrying the breast with it. In the early stages, with the breast held firmly, the tumor may be moved perpendicularly to but not parallel with the milk ducts. Later it invades the pectoral muscle, when the whole breast (not the tumor) may be moved up and down, but not in the direction of the muscle fibres; and finally it adheres to the chest wall and becomes absolutely immovable. Owing to the contraction of the fibrous septa of the breast, small depressions appear in the skin, which has been likened to pig's skin, or the rind of an orange. The growth is most frequent in the upper and outer segment of the gland. When it orginates in or invades the tissues near the nipple, the nipple is retracted, shrunken, and fixed, and occasionally exudes a thin bloody discharge. Further, owing to the contraction of the growth, the nipple often occupies a higher position than the one on the normal breast and the areola is diminished in size (Fig. 301). Pain is absent at first, but in the final stages becomes agonizing owing to involvement of the axillary nerves: Cachexia also is a late symptom. Ulceration is preceded by a reddish or purplish discoloration of the skin. A scirrhous ulcer is deep and has an offensive sanious discharge, a sloughing base, and hard, irregular, everted margins. Extensive infiltration of the skin is called *cancer en cuirasse.* Occasionally cysts form, probably as the result of obstruction of the ducts. The axillary lymph glands are enlarged in the early stages and probably harbor cancer cells within even the first few weeks. Later the supraclavicular glands become enlarged. Pressure on the axillary vein and lymph vessels causes a solid edema of the upper extremity. When the lymphatics running to the axilla are blocked, and when the growth involves the sternal half of the gland or its costal surface, metastases occur in the chest, the lymph from the inner half of the gland entering the anterior mediastinum through the second and fourth intercostal spaces, and that from its costal surface passing backwards to the posterior mediastinum. Occasionally the opposite breast and the glands in the opposite axilla become enlarged, because of the free lymphatic anastomosis across the middle line. A scirrhus is never of great size, and occasionally in old women the contracting fibrous tissue is so abundant that the tumor shrinks rather than enlarges (*atrophic or withering scirrhus*); these cases may last for many years. An ordinary untreated scirrhus usually causes death in from two to three years, an encephaloid in from six to twelve months. (2) *Duct cancer* springs from the duct walls, particularly in cystic

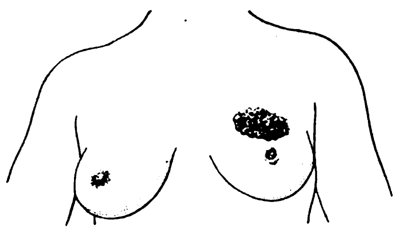


FIG. 301.—The nipple in scirrhus of the breast is retracted, shrunken, fixed, and higher than normal; the areola is smaller than normal and its skin fixed. In inflammatory troubles of the breast the nipple may be retracted and fixed, but the areola may be larger than normal and on a lower plane.

disease of the breast, but is not common. It involves the skin and lymph glands late, and is softer than scirrhus. There is often a bloody discharge from the nipple. (3) *Epithelioma of the nipple* presents the same features as epithelioma elsewhere; it is often preceded by Paget's disease of the nipple.

The **treatment** is amputation of the breast and evacuation of the axilla as soon as the growth is detected. Some recognize no contraindication to operation excepting visceral metastases, and remove portions of the chest wall or even the entire upper extremity. Most surgeons exclude cases of *cancer en cuirasse* and those in which there is extensive involvement of the axilla and supraclavicular glands. In an atrophic scirrhus in an old woman the prognosis may be better without than with operation.

Halsted's operation aims to remove in one piece the entire breast and overlying skin, the costal portion of the pectoralis major, the pectoralis minor, and all the fat and glands of the axilla. The supraclavicular glands are removed in a second piece. An incision (Fig. 302) is carried through the skin and fat, and the triangular flap A B C turned back. The costal portion of the pectoralis major is divided close to the ribs and separated from the clavicular portion, which with the overlying skin is divided up to the clavicle, exposing the apex of the axilla; these flaps are drawn upwards with a retractor and separated from the underlying tissues, and the muscle further split as far as the humerus, where it is severed close to the bone. The breast, pectoralis major, and all fat are stripped from the chest wall, including the pectoralis minor, which is divided at each end, thus exposing the entire axilla, which is cleansed of fat and lymphatic glands from above and within, downwards and outwards, all small vessels being ligated close to the axillary vessels, which, with the nerves, should alone remain. The triangular flap of skin is drawn outwards and the lateral and posterior walls of the axilla likewise cleared, the subscapular vessels being ligated, and the subscapular nerves preserved if possible. The mass is then turned inward, and removed from the chest by cutting from B to C. A vertical incision is now made along the posterior margin of the sternomastoid, and the supra- and infra-clavicular fat and glands removed by dissecting from the junction of the internal jugular and subclavian veins downwards and outwards. The cervical wound is sutured, and the edges of the chest wound appproximated by a buried purse-string suture of silk, which includes the base of the triangular flap, the apex being spread over the axilla. The rest of the wound is covered with Thiersch's skin grafts. The axilla is not drained. The disability resulting after such an extensive operation is surprisingly slight.

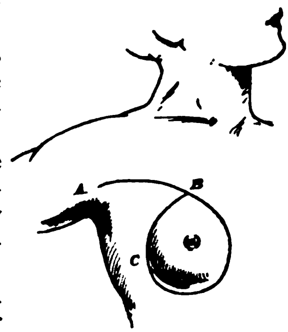


FIG. 302.—(Binnie.)

The *author's operation*, to quote from the Transactions of the American Surgical Association, 1915, "embodies the principles laid down by Halstead, with the following: The axilla is attacked first, to determine the extent of the lymphatic involvement and the feasibility of radical treatment (Gross); to secure, once for all, at their origin, the blood vessels supplying the breast, thus minimizing hemorrhage, economizing time, and preventing shock (Meyer); to suppress lymphatic drainage as early as possible and prevent neoplastic dissemination (Gerster); and to leave the breast as a warm covering for the thorax until the final stage of the operation. The incision permits free exposure, including the subscapular space, which is sometimes neglected; does not run onto the arm or through the axilla, in which situations a contracting scar may interfere with the functions of the arm or press on the blood vessels and the nerves; and, with extensive undermining, can almost always be closed. When primary closure cannot be obtained the raw surface is covered with pedunculated flaps from the abdomen and the back. Owing to the situation of the incision a second opening is not needed for drainage, and the dressing of the wound is simplified. The drain, when employed for lymphorrhea, is removed at the end of two days, and never replaced. Leaving the wound open and prolonged drainage mean infection and much fibrous tissue. An incision, skirting the upper margin of the breast, is made from a point on the edge of the sternum farthest from the growth and on a level with the nipple, to a point on the same level at the posterior axillary fold (Fig. 303). The skin is undermined from the incision to the clavicle and the head of the humerus, and from the sternum to the posterior axillary fold. The clavicular is separated from the costal portion of the pectoralis major, and the tendon of the latter severed close to the humerus. The costocoracoid membrane is divided, and the pectoralis minor cut at its point of insertion. With a self retaining retractor, and a smaller retractor held by an assistant, the entire axilla is exposed for evacuation (Fig. 304), which progresses from above and within, downward and outward. The vessels supplying the breast are divided between ligatures. The subscapular vessels are tied at each end and, with the environing areolar tissue, pushed toward the median line, thus laying bare the latissimus dorsi, teres major, subscapularis, and serratus magnus. The ends of the original incision are joined by a cut which skirts the inferior margin of the breast (Fig. 305), and the skin undermined to the level of the lowest portion of the costal arch, or even lower. Through this incision one may remove, as suggested by Handley, the deep fascia over the upper portion of the abdominal muscles; we have not adopted this procedure as a routine measure. Next the breast is turned toward the opposite side of the body, the origin of the pectoralis minor cut, the perforating vessels seized before divi-

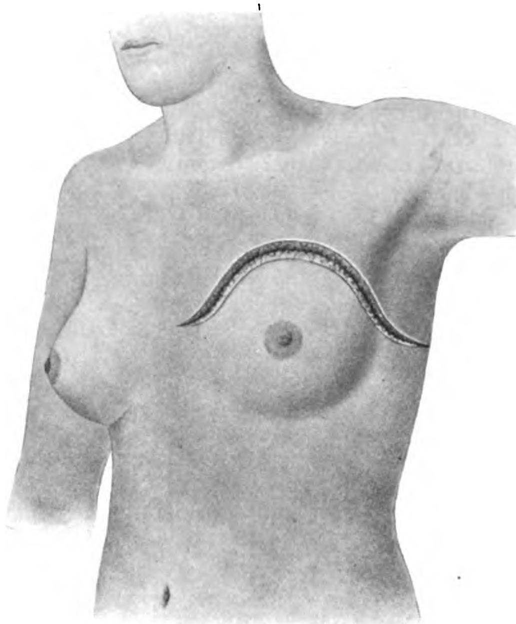


FIG. 303.—Amputation of the breast; primary incision. The towels which should be attached to the margins of the wound are not shown.

sion, and the mass removed by severing the costal origin of the pectoralis major. The wound is irrigated with hot salt solution, and closed with several combined retention and coaptation sutures of silkworm gut (Fig. 69), and a continuous suture of celluloid thread, except at the axillary end, where one suture is left untied, to provide an exit for a gauze drain (Fig. 306), which is removed in forty-eight hours and the suture tied. The arm is not bandaged, and the patient is allowed to put it into any position she desires. Edema of the arm immediately following operation we regard as a favorable sign; it indicates that the operation has been thorough, that all the lymphatic structures in the axilla have been removed, and the lymphatic drainage of the arm completely interrupted. It usually disappears in from two to four months, but may last longer, and indeed be permanent. Edema appearing after an interval is due to pressure on the axillary vein by a cicatrix, by a recurrent growth; to a neoplastic invasion of the vein; to venous

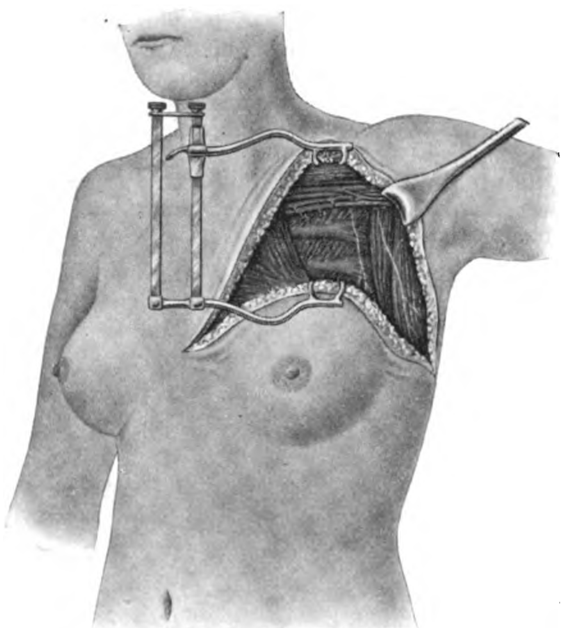


FIG. 304.—Amputation of the breast; dissection of axilla.

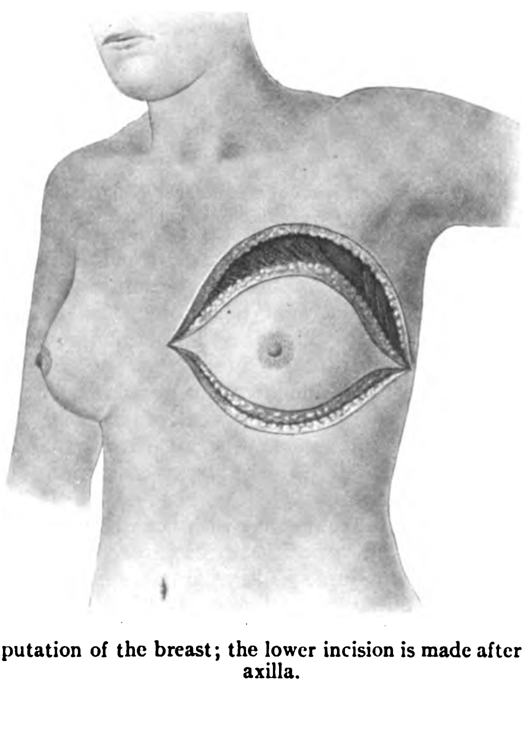


FIG. 305.—Amputation of the breast; the lower incision is made after evacuation of the axilla.

thrombosis; to a tardy lymphangitis or lymphthrombosis; hence is not always, as is sometimes thought, a premonitory sign of early dissolution." Suggestions for the treatment of lymphedema will be found under lymphedema, Chap. XVI; for inoperable carcinoma under carcinoma, Chap. XIII. The mortality of the modern breast amputation is less than 3 per cent. The percentage of permanent cures, i.e., after three years, is about 20 per cent.

Cysts of the breast are to be distinguished from cystic degenerations, which may occur in any form of mammary tumor, but particularly in sarcoma and cystadenoma.

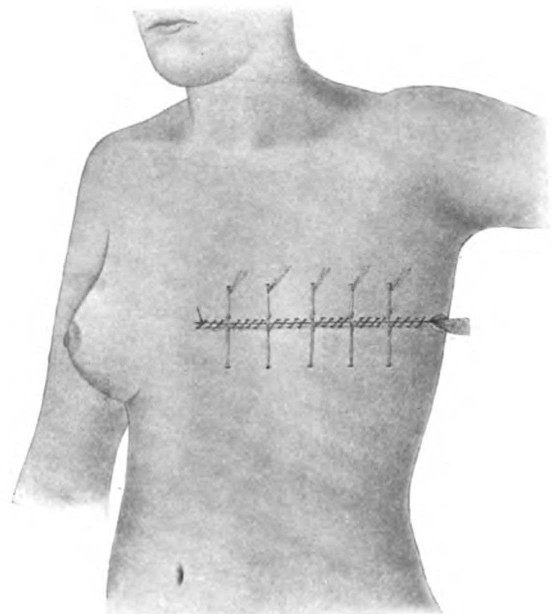


FIG. 306.—Amputation of the breast; wound closed.

Acinous or retention cysts are caused by blocking of the ducts, and pressure upon them will often cause a discharge from the nipple. Such cysts, when occurring during the nursing period, contain milk (*galatocele*). A milk or lacteal cyst is round, situated near the nipple, and usually painless; it fluctuates, except in old cases in which the wall is thick or the contents solid. The *treatment* is incision and drainage. *Involution cysts* (*cystic degeneration of the breast*) occur in the course of interstitial mastitis, or after the menopause when the breast is undergoing degenerative changes. They are small and numerous, and may contain intracystic fibropapillomatous vegetations. Both glands are usually affected. The *treatment* is amputation of the breast, because of the danger of carcinoma.

Interacinous cysts are unconnected with the ducts, do not cause a discharge from the nipple, contain no intracystic growths, and are lined with endothelium instead of epithelium. They contain serum, and are supposed to originate from the lymph spaces. They may be single or multiple. The diagnosis may be made in doubtful cases by the use of the exploring needle. The treatment is excision of the cyst. *Hydatid and dermoid* cysts also occur in the breast, but are rare, and are treated by excision.

CHAPTER XXVI.

UPPER DIGESTIVE APPARATUS.

THE LIPS.

Hare-lip is a congenital cleft in the upper lip due to non-union of the frontonasal and superior maxillary processes (p. 412). The term is misleading, as the cleft is not central as in a hare's lip, although a ***median hare-lip*** is a possibility. Hare-lip may be single or double, incomplete or complete, and it may or may not be associated with cleft palate (Fig. 307). It is more frequent on the left side, more common in males, and is sometimes hereditary. When double, the intermaxillary bones often fail to unite and, with the central portion of the lip, project forward. In all cases the nose is broadened and flattened.

FIG. 307.—Hare-lip and cleft palate. The nasal septum is fused with the right palatine process. Note the width of the face.

The best time for **operation** is between the third and sixth months of life, i.e., before dentition begins. The principles of any operation for hare-lip are to pare the edges of the cleft, bring the flaps together without tension by separating the lip from the gum, and to have the vermillion of the lip in alignment and a little projection at the edge formerly occupied by the gap. The suture material is usually silkworm gut, introduced through the entire thickness of the lip, and removed at the end of a week. In order to avoid the scarring of stitches, chromicized catgut, passed through all the tissues except the skin and tied within the mouth, may be employed, an additional subcuticular stitch being used if necessary. In order to prevent aspiration of blood, the patient should be placed in the Trendelenburg posture, or on the back with the head hanging over the end of the table (Rose's position). No dressing need be applied to the wound, although some surgeons prefer to use collodion. Some measures, such as splinting the elbow joint, should be employed to prevent disturbance of the wound by the child's fingers. The child is fed with a spoon or medicine dropper, until able to return to the breast. Figs. 308 to 313 illustrate various operations for incomplete hare-lip, and Figs. 314 to 324 operations for complete single hare-lip. Operations for double uncomplicated hare-lip are illustrated in Figs. 325 to 333. Double hare-lip complicated by protrusion of the intermaxillary bone must be treated by removing or replacing the projecting bone, the soft parts being united by one of the methods previously indicated. Excision alters the contour of the face and removes the central incisor teeth; reposition may be followed by necrosis, non-union, or backward eruption of the teeth; hence judgment

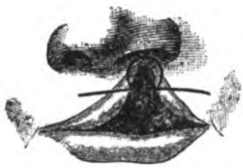


FIG. 308.

FIG. 309.

FIGS. 308 and 309.—Malgaigne. (Esmarch and Kowalzig.)

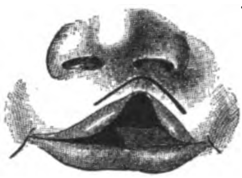


FIG. 310.

FIG. 311.

FIGS. 310 and 311.—Nélaton. (Esmarch and Kowalzig.)

FIG. 312.

FIG. 313.

FIGS. 312 and 313.—Mirault. (Esmarch and Kowalzig.)

is required in individual cases in deciding whether or not the bone should be removed. It may be stated, however, that a rudimentary bone attached to the tip of the nose should be excised, and that one which projects but slightly should be bent back into position.

Oblique facial cleft, running from the lower lid to the mouth, and resulting from non-closure of the naso-orbital fissure, is a rare deformity. **Cleft of the lower lip** or **lower jaw** is very rare, and due to non-union of the mandibular processes in the middle line. **Macrostoma,** or enlarged mouth, is due to defective union of the maxillary and mandibular processes; **micro-**

stoma, or small mouth, to excessive fusion of these processes. All these conditions may be remedied by plastic operations.

Cracked or chapped lips, the result of cold, and *herpes labialis*, or fever blisters, are treated by the application of cold cream, or better a strong solution of silver nitrate. Cracks and fissures radiating from the angles of the mouth are due to congenital syphilis. Chancre, mucous patches, and tuberculous ulcers also may occur on the lips.

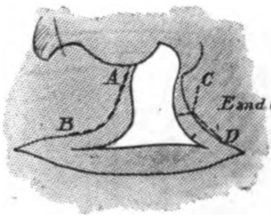


FIG. 314.

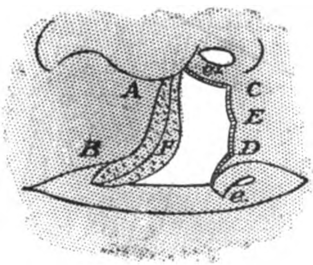


FIG. 315.

FIGS. 314 and 315.—Collis' operation. (Binnie.)

FIG. 316.

FIG. 317.

FIG. 318.

FIGS. 316 to 318.—Giraldès. (Esmarch and Kowalzig.)

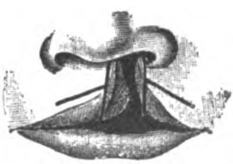


FIG. 319.

FIG. 320.

FIG. 321.

FIGS. 319 to 321.—Konig. (Esmarch and Kowalzig.)

Macrocheilia, or hypertrophy of the lip, usually the lower, may be due to lymphangiectasis, tertiary syphilis, or a tuberculous predisposition (*strumous lip*). If excessive, a horizontal wedge of mucous membrane and submucous tissue may be excised. **Mucous cysts** appear as rounded, translucent swellings. They are caused by blocking of the orifices of the glands, and are treated by excision. Warts, horns, and nevi also may be seen on the lips.

Epithelioma almost invariably attacks the lower lip, and is seldom seen in women. The irritation of a short clay pipe is responsible for some cases.

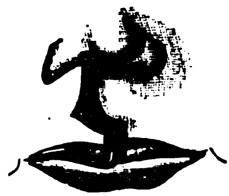




FIG. 322. FIG. 323. FIG. 324.

FIGS. 322 to 324.—(Esmarch and Kowalzig.)

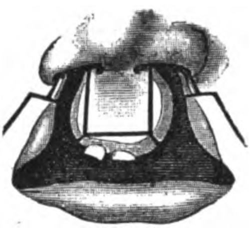
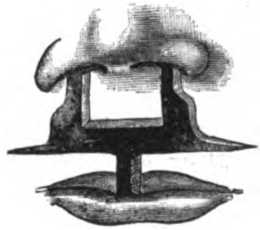
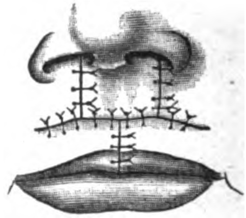




FIG. 325. FIG. 326. FIG. 327.

FIGS. 325 to 327.—Maas. (Esmarch and Kowalzig.)

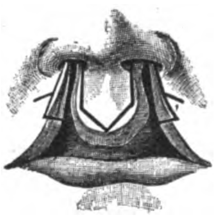
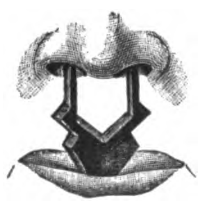




FIG. 328. FIG. 329. FIG. 330.

FIGS. 328 to 330.—Hagedorn. (Esmarch and Kowalzig.)



FIG. 331. FIG. 332. FIG. 333.

FIGS. 331 to 333.—(Esmarch and Kowalzig.)

It begins as a small fissure, infiltration, or warty growth, which ulcerates and is covered by a scab (Fig. 334). The ulcer slowly spreads, is situated on a hard base, and ultimately invades the jaw. Sooner or later the cervical glands are involved, but visceral metastases are uncommon. In old men the disease is often very slow, and may not cause death for a number of years.

The **treatment** is early and thorough excision, with the glands in the submaxillary and submental triangles. Permanent cure may be obtained in from 50 to 60 per cent. of the cases thus treated. All incisions should be at least a half inch away from the growth. Small growths may be excised by

FIG. 334.—Epithelioma of lip.

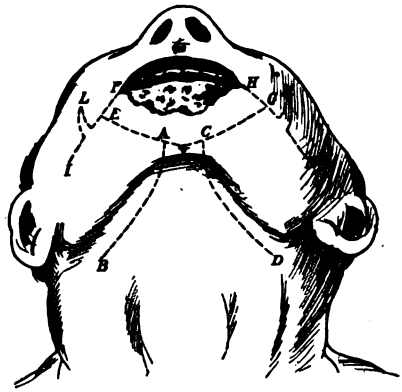


FIG. 335.—Dowd's operation. (Binnie.)

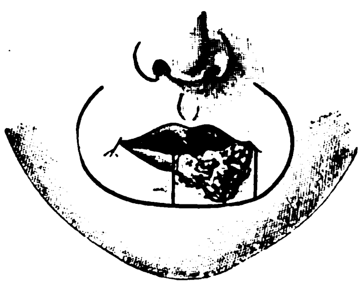


FIG. 336.

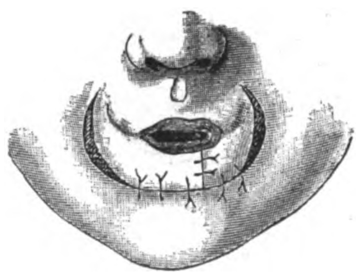


FIG. 337.

FIGS. 336 and 337.—Bruns. (Esmarch and Kowalzig.)

the classical V-shaped incision, and the glands removed from both sides of the neck by separate incisions. In larger growths Dowd's operation (Fig. 335) may be employed. The cervical incisions are made first, in order to remove the fat, lymph glands, and submaxillary salivary glands before opening the mouth. The incisions, I E and G K, sufficiently long for approximation of the flaps, are made by dividing the skin about one-third inch lower than the mucous membrane, so that the latter may be stitched to the skin of the new lower lip. The edges E A and G C are approximated after excising wedged-shaped pieces of skin at L and M. Figs. 336 to 345 show other methods of cheiloplasty.

FIG. 338.

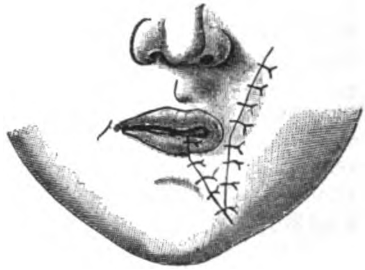


FIG. 339.

FIGS. 338 and 339.—Estlander. (Esmarch and Kowalzig.)

FIG. 340.

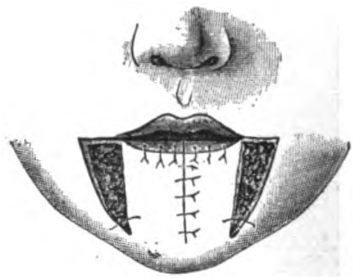


FIG. 341.

FIGS. 340 and 341.—Dieffenbach. (Esmarch and Kowalzig.)

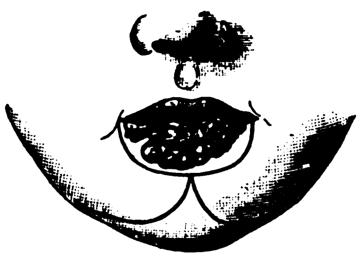


FIG. 342.

FIG. 343.

FIGS. 342 and 343.—Blasius. (Esmarch and Kowalzig.)

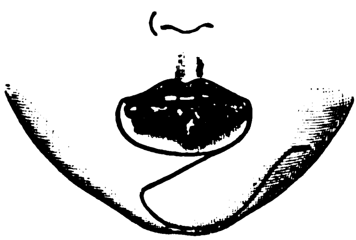


FIG. 344.

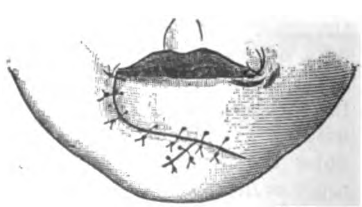


FIG. 345.

FIGS. 344 and 345.—Langenbeck. (Esmarch and Kowalzig.)

THE SALIVARY GLANDS.

Parotitis is most often seen as *mumps*, an acute, contagious, self-limited, specific inflammation, which may involve also the submaxillary and sublingual glands. Suppuration is rare, but metastasis to the testes, ovaries, or mammæ may occur. A true orchitis is produced in the testicle, which usually undergoes subsequent atrophy; the condition is generally unilateral, however, and sterility does not follow. A *non-suppurative parotitis* may follow also injury, salivary calculi, and disease or injury of the abdomen. The symptoms are pain and swelling, with perhaps some elevation of temperature. The *treatment* is the application of ichthyol or belladonna ointment, and an antiseptic mouth wash, as oral sepsis is a factor in many cases.

Suppurative parotitis rarely follows the forms described above, but is commonly the result of pyemia or one of the acute infectious fevers. In addition to the swelling, and the redness and edema of the skin, pain and constitutional symptoms are usually severe, owing to the firmness of the surrounding fascia. This fact explains also the tendency of the pus to burrow deeply into the surrounding tissues rather than point externally. The *treatment* is incision parallel with the fibers of the facial nerve and in front of the line for the external carotid.

Mikulicz's disease is a chronic symmetrical enlargement of all of the salivary glands and of the lachrymal glands, the nature of which is not clearly understood. It is sometimes congenital, sometimes associated with gout, syphilis, tuberculosis, or leukemia. There is neither pain nor tenderness, but there may be interference with speech and mastication and considerable deformity. Some benefit may follow the administration of arsenic and the iodids.

Salivary calculi consist of carbonate and phosphate of lime, and may form in any of the ducts. The symptoms are those of obstruction to the flow of saliva, which may be caused likewise by cicatrices, tumors, etc. There are swelling and tenderness of the gland during meals, and in old cases a permanent thickening of the glandular tissues. The calculus may be detected with the finger, probe, needle, or X-ray. It may be removed by dilating the duct, by incision from within the mouth, or, in large calculi in the submaxillary, by removal of the gland.

Ranula is a cystic tumor due to obstruction of one of the ducts of the sublingual glands, or more rarely the duct of the submaxillary gland. It contains a mixture of mucus and saliva. Similar in nature are the mucous cysts which may form on the floor of the mouth as the result of obstruction to the ducts of the mucous glands. *Dermoid cysts* in this region frequently spring from the thyroglossal duct, hence are situated in the median line and often cause a swelling beneath the chin. The **treatment** of ranulæ and mucous cysts is removal of the anterior wall and cauterization of the posterior wall, so that the cavity will be filled by granulations. In some cases cure can be obtained only by dissecting out the entire cyst and removing the salivary gland. Dermoid cysts require an external incision and careful dissection.

Tumors of the parotid gland are usually of a mixed nature. A *benign* parotid tumor is usually a mixture of chondroma, fibroma, myxoma, and adenoma, hence it is hard and nodular in certain parts and soft in others. It grows very slowly, and is usually superficial to the important vessels and nerves, except in the later stages. A *malignant* parotid tumor may be sarcoma, carcinoma, or endothelioma. It is often the result of a malignant change in a benign tumor, from which it may be distinguished by its immobility, greater pain and rapidity of growth, more frequent association with facial paralysis, and by its tendency to enlarge the lymph glands. The *lymph gland* lying near the surface of the parotid may enlarge as the result of inflammation, tuberculosis, or a neoplastic change; it is distinguished from a parotid tumor by its uniform consistency and its more superficial situation.

The **treatment** is excision. Benign tumors may be enucleated through an incision parallel with the course of the facial nerve. Malignant tumors require removal of the entire gland through a vertical incision, supplemented, if need be, by a tranverse cut running forwards from the middle or lower end. The dissection should proceed from below upwards, so that the external carotid artery may be ligated in the early part of the operation. The facial nerve is, of course, destroyed, and of this the patient should be previously warned. The operation is very difficult and recurrence almost inevitable. Somewhat similar tumors are encountered in the other salivary glands, but such are much more easily excised.

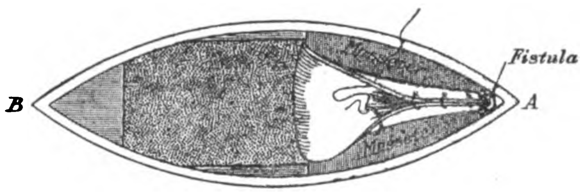


FIG. 346.—Braun's operation. (Binnie.)

Salivary fistula is usually caused by disease or injury of Steno's duct, which is about one-eighth inch in diameter, opens into the mouth opposite the second upper molar tooth, and is represented by a line drawn from the lowest part of the cartilage of the ear to a point midway between the angle of the mouth and the ala nasi. If small, the fistula may sometimes be closed by cauterization or by sutures, first dilating any existing stricture in the distal portion of the duct. If this method fails or if the distal portion of the duct is obliterated, the central portion may be isolated, and its orifice sutured to the mucous membrane of the mouth, the external wound being closed. Some surgeons make an opening from the fistula into the mouth, and keep this opening patent by a rubber tube or seton, until it is lined with epithelium; the external opening is then closed. When the fistula is near the gland, a new duct may be constructed from the mucous membrane as shown in Fig. 346. Jianu cut the facial vein at two different points, anastomosed the posterior end of the isolated venous segment with Steno's duct, and the anterior end with the mucous membrane of the mouth. Ferrarini suggests anastomosing the parotid with the submaxillary gland. When all other forms of treatment fail, the nerve of secretion (auriculo-temporal) may be avulsed, or the gland removed (Leriche).

THE TONGUE.

Malformations, such as bifid tongue, hemiatrophy, and total absence of the tongue, are very rare. *Tongue-tie,* or shortness of the frenum, may interfere with sucking and later cause lisping; the frenum may be nicked with a pair of blunt scissors, and if this does not produce sufficient mobilization, the rest of the frenum may be torn with the finger, thus avoiding troublesome hemorrhage. The frenum may be abnormally long and allow the tongue to fall backwards and interfere with respiration. *Ankyloglossia*, in which the tongue is adherent to the floor of the mouth, may be congenital or follow ulceration in this region. The adhesions should be separated, a procedure which may be very difficult in acquired cases. *Macroglossia*, or elephantiasis of the tongue, is usually congenital, and is due to an increase in the connective tissue and lymphangiectasis. Lymphatic cysts and hypertrophied papillæ may be seen on the surface, and recurring glossitis augments the volume of the organ. The tongue protrudes from the mouth, becomes indurated and purplish, interferes with speech and swallowing, and causes deformity of the teeth and jaws. The treatment is removal of a wedge-shaped portion. Enlargement of the tongue may be caused also by stomatitis, particularly the syphilitic variety, and is seen in acromegaly and sometimes in idiots.

Wounds of the tongue are seldom serious, although in a few cases death from hemorrhage has followed. Sutures should be of silk, as the moisture and movements of the tongue will quickly loosen catgut. Ordinarily bleeding is controlled by closure of the wound, although if the ranine artery is opened a ligature may be necessary.

Acute parenchymatous glossitis is caused by infection of the tongue with pyogenic organisms. It may arise from injuries, or from stomatitis, particularly the mercurial form and those varieties accompanying low fevers. The tongue becomes red and painful, and swells rapidly, so that it may protrude from the mouth and interfere with speaking, swallowing, and breathing. Ulceration, abscess, or even gangrene may follow. There is drooling of saliva and constitutional symptoms of sepsis. The *treatment*, in the milder cases, is a chlorate of potassium mouth wash and the sucking of particles of ice. If the swelling increases, a free incision should be made into the tongue on each side of the median line. In the presence of threatening asphyxia tracheotomy will be required.

Abscess of the tongue may be of an acute nature, but is often chronic, and encapsulated by dense inflammatory tissue, which often leads to the diagnosis of a neoplasm. The treatment is incision, and disinfection with antiseptic mouth washes.

Acute superficial glossitis is but a part of a general stomatitis and need not be described as a separate affection, although a special form, involving one-half of the tongue (*hemiglossitis*), usually with herpes, and probably of nervous origin, occurs.

Chronic superficial glossitis, or leukoplakia (*psoriasis or ichthyosis of the tongue*), is commonly attributed to syphilis, smoking, whiskey drinking, chronic dyspepsia, or ragged teeth. Thin bluish-white or yellowish patches form on the tongue (Fig. 347) and perhaps on the lips and cheeks. The disease is very chronic and is often followed by epithelioma. In some instances the patches are shed and the tongue becomes red and glazed or cracked and fissured. The discomfort is usually slight, although in severe cases there may be marked tenderness and interference with speaking and eating. The *treatment* is removal of all sources of irritation, such as tobacco, alcohol, and highly seasoned food. The teeth should be put in order and an alkaline mouth wash used, such as sodium bicarbonate, 20 grains to the ounce. Applications of tincture of benzoin or myrrh are useful, the benzoin or myrrh being precipitated as a varnish. Caustics should be avoided. If the disease is not too extensive, excision of the patches is the best treatment.

Hyperkeratosis linguæ (*black tongue*) is a rare condition in which the mucous membrane just in front of the circumvallate papillæ becomes dark or black and covered with long, waving papillæ resembling hairs. The color is supposed to be due to bacteria.

Ulceration of the tongue due to trauma, ragged teeth, dyspepsia, and stomatitis readily heals on removal of the cause. *Herpetic ulcers* follow herpes, and are treated with applications of silver nitrate and an antiseptic wash. *Lupus* and *actinomycosis* are rare. *Tuberculous ulcers* may be primary, but are usually secondary to disease of the lungs. As a rule they are on or near the tip of the tongue and have sharply defined irregular edges, pale flabby granulations, and but little induration. They are very painful and may reach a large size. The treatment is excision. The most important ulcers of the tongue are the syphilitic and the malignant.

Syphilis of the tongue is seen as the chancre, mucous patches, condylomata, ulcers, glossitis, and gumma. *Syphilitic glossitis* may be of the chronic

FIG. 347.—Leukoplakia. The patch is raised, nodular, and whitish. (Butlin.)

superficial variety, or the whole tongue may be enlarged, hardened, and marked by deep fissures, which result from contraction of newly formed fibrous tissue. *Gumma* is usually on the dorsum near the median line and may be multiple. It is preceded by a chancre, associated with lesions in other parts of the body, is apt to occur in the earlier half of life, is more common in the female, and begins as a submucous infiltration which finally ulcerates. The ulcer is round or oval, punched out, deep, nearly painless, and covered by the characteristic gummy material. Induration is slight, the submaxillary glands frequently unaffected, the tongue mobile, articulation and deglutition but little disturbed, and cachexia absent. In doubtful cases a piece may be excised for microscopic examination, a Wassermann test made, and the effect of iodid of potassium internally tried.

Cancer of the tongue is always a squamous epithelioma. It is most frequent in men after forty, and is often preceded by some form of irritation, such as that produced by irregular teeth, smoking or chewing tobacco, leukoplakia, or gumma. It may attack any portion of the tongue, but is most frequent in the anterior half of the margin of the organ. It may begin as a crack or nodule, but usually starts as an ulcer, which spreads rapidly to the floor of the mouth and the jaw, so that the tongue becomes fixed, and articulation and deglutition difficult. The ulcer is surrounded by an indurated area and is often exceedingly painful. The edges are thick and everted, the base foul and sloughing, and the discharge fetid (Fig. 348). There is incontinence of saliva, and bleeding occurs on slight provocation. The sub-

FIG. 348.—Epithelioma of the tongue The edges of the ulcer are thick and everted; the rest of the tongue is covered with a thick green-black fur due to the foul condition of the mouth and the immobility of the tongue (Butlin).

maxillary glands are involved early and cachexia promptly supervenes. The condition is easily recognized in the later stages, but at the onset the diagnosis may be impossible without a microscopic examination, which should be promptly made in all doubtful cases.

The **treatment** is excision of the growth with the lymphatic area into which it drains. Without operation death generally occurs in from one year to eighteen months; with early and thorough operation 20 per cent., according to Butlin, remain free from recurrence after three years. Very small growths may be removed by a V-shaped or ellipitcal incision which is subsequently sutured, but in most instances it will be necessary to remove half or all of the tongue. The teeth should first be cleansed by a dentist, and the mouth rinsed every three or four hours with an antiseptic mouth wash. The mortality of excision is about 5 per cent., most deaths occurring from septic pneumonia, the result of inhalation of blood and wound discharges, hence the patient should be put in the Trendelenburg or the Rose posture during operation. Some surgeons perform a preliminary tracheotomy, and pack the pharynx with gauze at the time of operation, but this is unnecessary if one employs intratracheal insufflation anesthesia.

Whitehead's operation consists in removal of the tongue through the mouth. The jaws are separated by a gag and the tongue drawn forward by a ligature passed through its tip. The tongue is then separated, with the sublingual gland, from the floor of the mouth by scissors, the lingual arteries being seized with forceps before they are cut. A ligature is now passed through the glosso-epiglottic fold, and the tongue severed in front of the ligature. The ligature is left in place twenty-four hours, in order to pull the epiglottis forward if there be bleeding or trouble with breathing. The wound is painted with Whitehead's varnish (Friar's balsam in which the alcohol is replaced by a saturated solution of iodoform in ether). The cervical lymph glands are then removed. Most surgeons, however, prefer to excise the glands first, as this permits ligation of the lingual artery and postpones invasion of the mouth until the clean part of the operation is finished. The patient sits up as soon as the effects of the anesthetic have passed, and is fed by mouth from the beginning, or, if need be, by the nasal tube or by the rectum. Removal of half of the tongue is accomplished in the same manner, except that the organ is split in the middle line.

Kocher's operation is indicated in cases in which the floor of the mouth or the jaw is involved. An incision is made from below the symphysis to above the hyoid bone, then to the anterior margin of the sterno-mastoid, and lastly upwards to the mastoid process. The flap is turned upwards and all the lymphatic glands in this region, with the submaxillary salivary gland, excised, the lingual and facial arteries or, perhaps better, the external carotid being ligated. The hyoglossus and mylohyoid muscles are divided and the mouth entered; the tongue is drawn through this opening, and divided close to the epiglottis and hyoid bone. The same precautions as in the Whitehead operation should be taken in regard to the stump of the tongue. The incision in the neck is partly closed, and the cavity packed with gauze. The patient is fed through the nose or per rectum, until the power of deglutition returns. The mouth and the wound should be irrigated frequently with boric acid or salt solution.

Sedillot's operation is performed by dividing the lower lip in the median line and extending the incision to the hyoid bone. The lower jaw is sawed through in the middle line and the two halves retracted. The tongue is then removed with scissors or, as performed by Kocher, who has recently adopted this operation, with the cautery. A small amount of xeroform is rubbed into the wound, the divided jaw wired, and the wound in the soft parts closed except below, where a gauze drain finds exit.

Sarcoma, benign tumors, and cysts occur in the tongue but are very rare.

THE MOUTH, JAWS, AND PHARYNX.

Stomatitis, or inflammation of the mouth, may be caused by mechanical or chemical irritants, dyspepsia, fevers, and by a specific fungus, oidium albicans (*thrush*). The simple *catarrhal* form presents the ordinary phenomena of inflammation, and quickly subsides when the cause is removed. *Aphthous stomatitis* occurs as small whitish vesicles, which form ulcers surrounded by a red areola. It is seen in children with digestive disturbances. *Ulcerative stomatitis* occurs in debilitated children, and in adults with diabetes or Bright's disease. Attention has already been called to gangrenous, syphilitic, and mercurial stomatitis. Certain forms of skin eruptions also may attack the mucous membrane of the mouth. The *treatment* of stomatitis is removal of the cause, attention to the general health, proper feeding, and the use of a mouth wash containing chlorate of potash. Ulcers may be touched with silver nitrate.

Pyorrhea alveolaris (*Riggs' disease*) is characterized by a collection of tartar and chronic suppuration beneath the margins of the gums, which atrophy and recede from the teeth, leaving them loose. It may be responsible for fetid breath, dyspepsia, anemia, cervical adenitis, and various forms of so-called cryptogenic sepsis. The *treatment*, which can be carried out only by a dentist, consists in removal of the tartar and frequent antiseptic douches.

Alveolar abscess is due to irritation from a decayed tooth. When superficial it is known as *gum boil*. Occasionally the pus passes beneath the periosteum and causes necrosis of the jaw. In the upper jaw the antrum may be opened, in the lower jaw the pus may point in the neck. The treatment is drainage of the abscess cavity, and generally extraction of the tooth. If, however, the tooth is but slightly diseased, it may be saved by appropriate dental treatment.

Necrosis of the jaw may be caused by injury, caries of the teeth, phosphorus, mercury, syphilis, tuberculosis, actinomycosis, and the exanthemata. The symptoms in the beginning are pain, swelling of the face and gums, fever, and the formation of an abscess, which may point in the mouth, or externally on the face or neck. The discharge is offensive, and dead bone can be felt with the probe, or seen with the X-ray. An involucrum may form in the lower jaw, but is uncommon in the upper jaw. The *treatment* is incision for the purposes of drainage, and antiseptic mouth washes until the sequestrum is loose, when it should be removed through the mouth, or if this is not possible, by an external incision. The defect may be closed by one of the methods to be mentioned under excision of the lower jaw.

Cysts of the jaws generally arise in connection with the teeth, or are the result of a cystic change in solid tumors, particulary sarcoma and epithelioma. *Dental cysts* occurring in connection with completely developed teeth are of inflammatory origin, the fluid collecting between the root and the peridental membrane. The treatment is extraction of the tooth. *Dentigerous cysts* (follicular odontomata, Chap. XIII) are caused by the non-eruption of a tooth. The swelling is at first hard, but later egg-shell crackling may be noted. Occasionally suppuration occurs. The permanent tooth is absent, but sometimes the milk tooth persists, and may be mistaken for a permanent one unless an X-ray examination is made. The *treatment* is excision of the anterior wall of the cyst, removal of the unerupted tooth, and gauze packing. *Fibrocystic disease of the lower jaw* (epithelial odontome) is a multilocular cystic formation, which may attain a great size, and is most frequently observed in the young. It has been mistaken for sarcoma. The *treatment* is excision.

Tumors of the jaws comprise the fibroma, enchondroma, osteoma, odontoma (Chap. XIII), sarcoma, and epithelioma. In many tumors of the jaws, especially in the young, one should first make sure, by X-ray examination, puncture, or even incision, that the growth is not a benign cyst, before deciding on extirpation. **Epulis** is a term applied to tumors originating in the alveolar periosteum. A *simple epulis* is smooth, round, red, elastic, and generally fibromatous in nature. It may ulcerate or become ossified.

A *malignant epulis* (Fig. 349) is a myeloid sarcoma, which is soft and purplish, grows rapidly, bleeds easily, and may ulcerate. The treatment of epulis is excision of the alveolar process as far as one tooth on each side of the growth. **Fibroma** and **enchondroma** are more apt to appear early in life, grow slowly, and sometimes recur after removal, possibly because of the presence of some sarcomatous tissue. The treatment is removal, with that portion of the jaw to which they are attached. **Osteoma** occurs later in life and sometimes follows injury or inflammation of the bone. It should be removed. **Sarcoma** (Fig. 350) may occur at any period of life, and is the most frequent form of tumor attacking the jaws. It may be of any variety. The soft forms (containing round cells) grow rapidly and invade or displace the surrounding structures; thus in the upper jaw there may be a projection beneath the cheek; depression of the palate, obstruction of the nose with the discharge of blood or pus, epiphora, exophthalmos, and severe pain owing to implication of the nerves. **Epithelioma** occurs in the

FIG. 349.—Malignant epulis (sarcoma).

FIG. 350.—Sarcoma of lower jaw. (Pennsylvania Hospital.)

later period of life, and begins in the mucous membrane of the mouth, nose or antrum. The symptoms are much like those of sarcoma, but ulceration is more frequent and the lymphatic glands are quickly involved. The *treatment* of sarcoma and epithelioma is partial or complete excision of the jaw, according to the extent of the growth.

Excision of the upper jaw may be required for the removal of growths within or behind the bone. Inspiration of blood is prevented by placing the patient in the Rose position, and employing intratracheal insufflation anesthesia. Bleeding may be lessened by ligation of the external carotid, or by temporary occlusion of the common carotid by means of Crile's clamp. An incision is made from the malar bone along the margin of the orbit to half inch below the inner canthus, thence downwards along the side of the nose and around the ala to the median line, at which point the upper lip is divided. The flap is reflected, and the malar bone and nasal process divided with a saw, after the infraorbital periosteum has been separated and carefully retracted upwards. The central incisor tooth of the affected side is extracted, and the mucous membrane of the roof of the mouth divided in the median line as far as the soft palate, and then transversely between the hard and soft palates. A narrow saw is now passed into the nose, and the alveolus and hard palate divided from before backwards. The bone is seized with lion-jawed forceps and twisted from its bed by fracturing the pterygoid processes and the lateral mass of the ethmoid. The bleeding vessels are caught and tied, and the cavity filled with gauze packing. The entire skin wound is sutured, the gauze being subsequently removed and irrigations practised through the mouth. The patient is at first fed by the rectum or by an esophageal tube. The resulting deformity may be corrected by means of an obturator and cheek-plate.

Temporary resection of the upper jaws (Kocher) is useful in exposing certain nasopharyngeal growths. The upper lip is split into one nostril and both flaps separated from the bone. The alveolar process and palate are then split in the middle line with a chisel, and both upper jaws divided horizontally on a level with the lower portion of the nasal processes, thus permitting retraction. At the completion of the operation the bones are wired in place.

Excision of the lower jaw is performed for tumors and necrosis. Small portions of the jaw can often be resected through the mouth. If the symphysis is removed, the muscles attached to the genial tubercles are divided, and a ligature must be passed through the tongue to prevent its falling backwards. The periosteum should be preserved whenever possible. Resection of the entire lower jaw is performed by dividing the bone in the median line and dealing with each half separately. The incision for removal of one-half the lower jaw is made from below the free margin of the lower lip downwards in the median line, then along the under surface of the jaw and upwards along the posterior border of the ramus to below the line for the facial nerve. The facial vessels are tied, the soft parts separated from the bone, the central incisor tooth extracted, and the jaw sawed through the empty socket, thus avoiding the genial tubercles. By pulling the bone outwards the internal soft parts can be separated and the inferior dental artery tied. The jaw is now depressed and the coronoid process and the condyle separated by cutting close to the bone, recalling that the internal maxillary lies very near the condyle. The buccal mucous membrane is sutured to that of the floor of the mouth and the external wound closed. In order to correct the resulting deformity, which is increased by the passage of the remaining half of the bone towards the affected side, splints of aluminium, hard rubber, and even bone grafts (rib, crest of tibia) have been inserted. Morestin implants a piece of bone or cartilage beneath the skin of the arm, and, after vascular connections have been obtained, transplants it by the Italian method to the jaw. Operations of this character are less apt to succeed here than elsewhere, because complete asepsis cannot be secured.

Closure of the jaws may be caused by *ankylosis* of the temporomaxillary joint the result of injury or inflammation; *cicatricial contraction* of the soft parts following noma, burns, etc.; *trismus* (spasm of the muscles), the result of tetanus, hysteria, or local causes, such as an unerupted wisdom tooth or caries of the teeth; and by *inflammatory or neoplastic* lesions which mechanically interfere with opening of the mouth, e.g., mumps and malignant growths.

The **treatment** of temporary closure of the jaws depends upon the cause. Permanent closure due to bony or fibrous ankylosis of the temporomaxillary joint is best treated by resection of the condyle, with the interposition of a flap from the temporal or masseter muscle. The dangers are injury to the facial nerve and internal maxillary artery. When the jaws are bound together by extraarticular cicatrices, a wedge-shaped section of bone, with the apex towards the alveolar process, should be excised in front of the cicatrix, and a false joint established by the interposition of muscle or fascia.

Cleft palate is a congenital deformity caused by failure of the palatine processes to unite. Beginning posteriorly the cleft may extend a variable distance, the mildest form presenting itself as a bifid uvula, and the severest form as a wide cleft involving the whole palate and dividing anteriorly to embrace the os incisivum and the middle segment of the upper lip. The septum of the nose may be free or it may have united with one of the palatine processes, usually the right. Cleft palate interferes with sucking and in later life with swallowing and articulation.

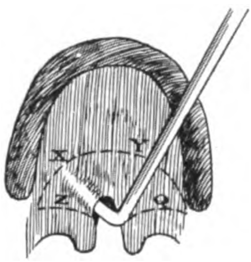


FIG. 351.—Z and Q. Line of separation of attachments of velum to hard palate. X, Y, Z, Q, Area in which muco-periosteum (continuous with the velum) is separated from the bone. (Binnie.)

Operation may be performed in early infancy if the patient is in good condition. Some surgeons, however, prefer to wait until the second or third year, the patient being fed in the meantime with a spoon or tube with the head thrown well back. All agree that operation should be done before habits of faulty articulation have developed. If there is an associated hare-lip the cleft palate should be closed first. At the time of operation, preferably in the spring or summer, the child should be free of local and general disease. The nose and mouth should be cleansed for a few days before operation with a solution of boric acid. The child is anesthetized with chloroform, placed in the Rose or the Trendelenburg posture, and a mouth gag introduced.

Staphylorrhaphy, or suture of the soft palate alone, is performed by paring the edges of the cleft, which is then united with silk sutures. If this cannot be done without too great tension, relaxation may be secured by dividing the tissues which attach the soft to the hard palate, excepting the oral mucous membrane, and by undermining the muco-periosteum of the hard palate (Fig. 351). Division of the muscles of the soft palate is not advisable.

Uranoplasty, or suture of the hard palate, may be performed as follows: The edges of the cleft are pared with a tenotome (Fig. 352), and the muco-

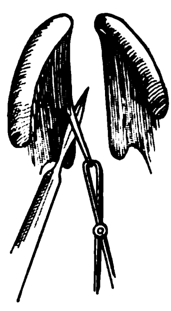


FIG. 352.—(Binnie.)

FIG. 353.—(Binnie.)

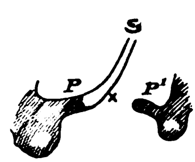


FIG. 354.—(Binnie.)

periosteum separated from the hard palate with a periosteal elevator (Fig. 353) as far as the alveolar process, being careful to avoid injury to the vessels passing through the anterior and posterior palatine canals. The soft palate is separated from the hard palate as in staphylorrhaphy. The edges are now united with interrupted sutures of silkworm gut. If the edges do not come together without tension, an incision on one or both sides is made through the muco-periosteum near the alveolus, from the lateral incisor tooth to the posterior edge of the hard palate. Tension may further be relieved by dividing the hamular process with a chisel. Some surgeons chisel also through the hard palate on each side, pry the bone inwards, and pack the resulting gap with gauze. Although special needles are recommended for this operation, a sharply curved needle and a needle holder are sufficient for every purpose. The sutures remain in place ten days, during which time liquid or soft food only should be given. Antiseptic sprays may be employed.

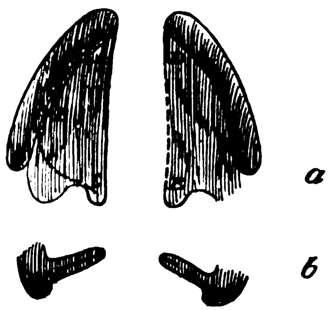


FIG. 355.—(Binnie.)

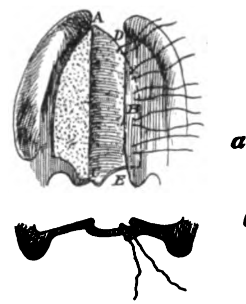


FIG. 356.—(Binnie.)

Brophy's operation is applicable during the first six months of life while the bones are still soft. By means of a special needle, a loop of silk, then a piece of silver wire, is passed through both upper jaws above the palate just behind the malar processes. A second piece of wire is passed through the anterior portion of the upper jaw, and the ends of these wires are twisted together over a lead plate while the cleft is closed by pressing the two superior maxillary bones together, the edges of the cleft having previously been pared. Fig. 354 illustrates a plan in which the lower part of the septum is used to close a unilateral cleft palate. The septum is severed at X, and the

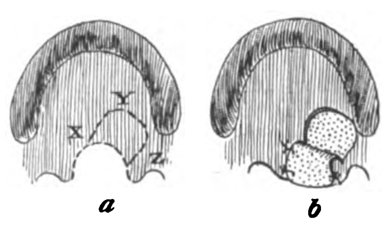


FIG. 357.—(Binnie.)

lower portion sutured to the pared edge of the free palatine process. Figs. 355, 356, and 357 illustrate other operations for cleft palate. In about one-half of the cases a second operation is required. A cleft may be closed also by means of an obturator, fitted by a dentist.

Perforations of the palate are usually caused by syphilis, occasionally by traumatism or lupus. If the local disease is cured, the perforation may be closed by a plastic operation, although in most syphilitic cases better results are obtained by the use of obturators.

Elongation of the uvula when troublesome may be remedied by removing the lower portion with scissors.

Suppurative tonsillitis, or quinsy, may follow exposure to cold or polluted air. Certain individuals are predisposed to this affection, particularly during adolescence. The tonsils, the fauces, and the soft palate are swollen and edematous, causing interference with breathing, swallowing, and speaking. There are pain in the throat, enlargement of the cervical glands, and marked constitutional symptoms. Both tonsils may be involved, and the patient may be unable to open the mouth. The *treatment* in the initial stage is an ice bag externally, scarification of the tonsil, a chlorate of potash gargle, and symptomatic internal treatment. When pus forms, the abscess may be opened with a sharp pointed tenotome, the incision being parallel with the anterior pillar of the fauces and directed towards the middle line.

Hypertrophy of the tonsils is most frequent in children and indeed may be congenital. It may follow repeated acute attacks of inflammation and is often a manifestation of a tuberculous diathesis. It is usually associated

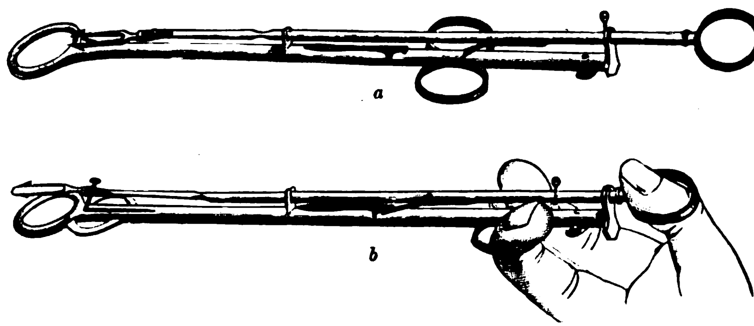


FIG. 358.—Tonsillotome. (Zuckerkandl.)

with adenoids and hence presents the same symptoms as the latter. Caseous and calcareous concretions may form in the crypts of the tonsils, and cysts occasionally develop from blocking of the orifices of the follicles. The *treatment* is attention to the general health and removal of a portion (tonsillotomy) or of the whole gland (enucleation). Caustics are slow and painful. The galvanocautery is often recommended in adults because of the greater risk of severe hemorrhage at this time of life. *Tonsillotomy* may be performed with a bistoury or with the guillotine. In the first instance the tonsil is drawn inwards with a tenaculum, and removed by cutting from below upward with a blunt pointed bistoury, the blade of which is wrapped to within an inch of the point with adhesive plaster. The guillotine, or tonsillotome (Fig. 358), facilitates the operation. The ring of the instrument is passed over the tonsil, which is pressed inwards with the fingers behind the angle of the jaw; then by approximating the fingers and thumb the tonsil harpooned, and amputated with the ring-shaped knife. Before either operation adhesions to the arches of the palate should be separated. *Enucleation* is now preferred to tonsillotomy, as after the latter the portion of gland left behind may lead to recurrence. With a finger or blunt dissector the tonsil is shelled from its bed, and then expressed from between the faucial pillars with an écraseur or blunt tonsillotome. Hemorrhage after these operations usually ceases promptly, but occasionally persists, the blood coming from the tonsillar branch of the facial. If it cannot be controlled by adrenalin and pressure, the wound should be united by deep sutures; rarely will it be necessary to tie the external carotid.

Tumors of the tonsils are generally malignant, lympho-sarcoma being the most frequent variety. Epithelioma is usually secondary. Both these growths cause enlargement of the lymph glands, interfere with deglutition and respiration, and undergo ulceration, which often causes a serious or fatal hemorrhage. The *treatment* is extirpation. A small encapsulated sarcoma may be enucleated through the mouth, but most malignant growths will have to be dealt with from the neck. An incision is made along the anterior border of the sternomastoid, the lymphatic glands removed, the external carotid tied, and the growth excised. It may be necessary to divide the lower jaw, or to incise the cheek from the angle of the mouth backwards.

Retropharyngeal abscess may be acute or chronic, and is most frequent in children. *Acute abscesses* may be caused by foreign bodies, or by infection of the lymph glands in this region, which drain the nose and nasopharynx. The *chronic form* is usually the result of caries of the spine or base of the skull, and is not associated with the fever and inflammatory phenomena characteristic of the former. In either case the posterior wall of the pharynx bulges forward, exhibits fluctuation, and may interfere with deglutition and respiration. If unopened, the abscess will break into the pharynx, point externally in the neck, or gravitate into the posterior mediastinum. The *treatment* is evacuation through the mouth in acute cases, and through the neck in chronic cases, as in the latter secondary infection should be prevented. When the abscess is to be opened through the mouth, the head should hang over the edge of the table in order to prevent the entrance of pus into the air passages, and the abscess opened with a knife, the edge of which is covered with adhesive plaster to near the point. Anesthesia is dangerous. When the abscess is opened through the neck, an incision is made along the posterior border of the sternomastoid from the apex of the mastoid downwards, unless the abscess points in some other region. The finger or a pair of forceps is passed along the anterior surface of the bodies of the vertebræ and a drainage tube inserted.

THE ESOPHAGUS.

The **esophagoscope** is a long, straight, cylindrical speculum, illuminated by an electric lamp, best placed, as in the Jackson instrument, at the distal end. For esophagoscopy anesthesia is not essential, although the pharynx and the upper end of the esophagus may be cocainized if the operator so desires. The esophagus below its pharyngeal opening is insensitive. Etherization renders the operation less difficult, hence, unless contraindicated, may be selected by the beginner. Cocain is dangerous in children, and if there is a foreign body in the esophagus pressing on the trachea ether should not be given except by intratracheal insufflation. The patient lies on the back with the head extending over the end of the table. An assistant places his right forearm beneath the neck of the patient and holds the forehead with his right hand. "The esophagoscope is inserted at the right of the patient's tongue, and the pyriform sinus sought immediately to the right of the right arytenoid. Once the tube is in the sinus, very gentle pressure is used, and the lumen of the mouth of the esophagus is watched for and followed at the moment of inspiration. Absolutely no force should be used, and no attempt to advance the tube should be made except when the patient takes a deep breath. It is the spasm of the inferior constrictor at the cricoid level that gives the trouble. Once this is passed, the lumen of the cervical esophagus is easily explored, and the thoracic esophagus opens widely at each recurrence of the inspiratory negative intrathoracic pressure. Passing the hiatus esophageus requires a moment for relaxation of the spasm, and tube must be directed slightly upward (recumbent patient) and to the left" (Jackson). As with the bronchoscope suitably constructed forceps are provided for the removal of foreign bodies and bits of tissue. Instruments for applying medicaments to the wall of the esophagus, for cutting or divulsing strictures, etc., also are employed.

Congenital malformations of the esophagus include fistulæ, diverticula, and cystic growths, such as have already been mentioned in speaking of the branchial clefts. Stenosis, atresia, and absence of the esophagus also have been noted, as well as double esophagus and opening of the esophagus into the trachea.

Acquired diverticula occur in three forms. *Pulsion or pressure diverticula* most frequently originate in the posterior wall at the junction of the

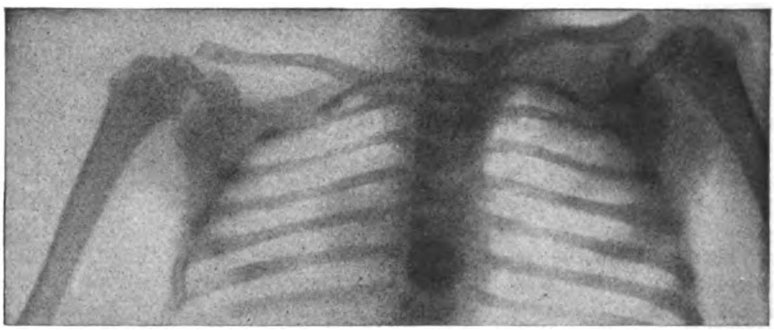


FIG. 359.—Skiagraph showing location of penny in eosophagus above a stricture, the result of swallowing lye. (Polyclinic Hospital.)

pharynx and esophagus, at which point there are few muscular fibres. When consisting of mucous membrane alone, they are sometimes called *pharyngoceles.* A sacculation may be formed from the pressure of food also above a stricture. *Traction diverticula* are due to the contraction of scar tissue, such as may follow inflammation of the bronchial glands, hence they are most frequent on the anterior wall near the bifuraction of the trachea. They are usually small, seldom cause trouble, and are recognized postmortem only. *Pseudodiverticula* are formed by the cavity of an abscess or cyst which has emptied into the esophagus.

The *symptoms* of pressure diverticula are dysphagia, swelling of the neck after taking food, and regurgitation after taking more food, owing to the pressure of the distended sac on the esophagus, or when the sac is pressed upon with the fingers. Cough and dyspnea may arise from pressure on the trachea or nerve irritation. A bougie may enter the sac at one time and pass along the esophagus at another. Plummer passes a bougie, threaded on silk, as described under stricture of the esophagus. If a stricture is encountered the level of the tip of the bougie is not affected by tightening the thread, but if there is a diverticulum, the tip ascends to the opening into the esophagus, then descends in the esophagus. After a bismuth meal the sac may be outlined with the X-rays. Examination with the esophagoscope may reveal the opening in the sac. The *treatment* is incision along the anterior edge of the left sternomastoid (the esophagus inclines towards the left), retraction of the muscle and the carotid packet to the left and the trachea to the right, isolation and amputation of the diverticulum (which may be identified with a bougie), suture of the opening in the esophagus, and gauze drainage.

Idiopathic dilatation of the esophagus (*cardiospasm*) is characterized by atony and dilatation of the gullet with spasm of the cardia; which of these is the primary lesion is a matter of dispute. It may be associated with esophagitis or disease of the stomach or liver, but in many instances no cause for the spasm can be found, beyond the fact that the patient is nervous. The *symptoms* are first those of spasmodic stricture, and, as the spasm becomes continuous, those of organic stricture (vide infra). The X-ray and the esophagoscope are important aids in making a diagnosis. The *treatment* is dilatation through the mouth by means of large bougies; by means of a rubber bag attached to a tube, and distended after it is in place; or by means of a special divulsor introduced through the esophagoscope. In the worst cases the cardia may be stretched with the fingers or a uterine dilator, after opening the stomach. More severe operations, e.g., division of the cardia longitudinally with transverse suture, resection of the cardia, esophagoplication through the abdomen or thorax, should very rarely be indicated.

Wounds of the esophagus from without have already been referred to under cut throat. Internal injuries, e.g., from foreign bodies, bougies, and the swallowing of caustics, cause painful dysphagia, bleeding, and emphysema if the wall is perforated. The patient is fed by rectum for a week or more, and sounds used when healing has occurred, in order to prevent the development of a stricture. After the swallowing of a caustic the proper antidote should, of course, be administered.

Foreign bodies in the esophagus are most frequent in children and lunatics. They are apt to be arrested at the narrowest portions of the tube, viz., opposite the cricoid cartilage (six inches from the teeth), at the level of the left bronchus (12 inches from the teeth), and at the diaphragmatic opening (16 to 18 inches from the teeth). The *symptoms* are dysphagia, pain, and sometimes dyspnea. Sharp or rough bodies may cause hemorrhage; prolonged impaction may lead to perforation and death. Owing to the irritation which is produced, the symptoms sometimes persist for a time, even after the foreign body has been removed. Foreign bodies may be detected with the bougie, the esophagoscope, or, if dense, with the X-ray (Fig. 359). When lodged in the cervical portion of the tube, external palpation may be of some value. The patient is usually able to indicate the site of impaction. The best *treatment* is extraction under the eye by means of long slender forceps introduced through an esophagoscope. Of 193 cases of esophagoscopy for foreign bodies, performed by skillful operators, the foreign body was removed 155 times, and escaped into the stomach 26 times. Twelve of the patients died (Jackson). If one has no esophagoscope, or no skill in using it, and the patient cannot be sent to a specialist, one of the older methods of extraction must be selected, for which purpose the size, shape, situation, and nature of the body should be ascertained whenever possible. Bodies like pins and fish bones may be extracted with the expanding horsehair probe (Fig. 360), discs and coins with the coin-catcher (Fig. 361). Round and smooth objects may sometimes be pushed into the stomach. When in the cervical portion of the esophagus, the offending substance may often be removed with long curved forceps. *Esophagotomy* is indicated when a body is impacted in the upper part of the tube, the esophagus being exposed in the neck as described in the treatment of diverticula, and sutured after extraction of the foreign body. Impaction in the lower part of the esophagus may demand gastrotomy, and extraction of the foreign body by the finger or forceps introduced through the cardiac orifice of the stomach. The mortality of cutting operations for foreign bodies in the esophagus is 20 per cent.

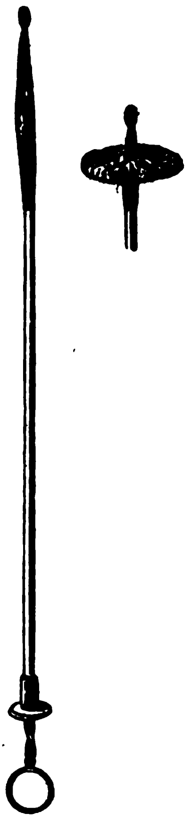


FIG. 360.—Expanding horsehair probang.

FIG. 361.—Coin-catcher.

FIG. 362.—Esophageal bougies.

Stricture of the esophagus may be (1) inorganic or (2) organic.

1. **Inorganic or spasmodic stricture** (*esophagismus*) is usually hysterical in origin, the spasm beginning below and ascending (*globus hystericus*), but occasionally occurs in tetanus, and as the result of reflex irritation in diseases of the larynx (opposite the larynx), liver, and stomach (at the cardia). In the last situation it may become permanent and give rise to the so called idiopathic dilatation of the esophagus (q.v.). The *symptoms* are sudden in onset, intermittent in character, and associated with evidences of the causative lesion. There is a spasmodic choking sensation, with dysphagia and some-

times regurgitation of food. Anesthesia relaxes the spasm and permits the passage of a full-sized bougie. The treatment is directed to the cause. The passage of bougies will do more harm than good in hysterical cases.

2. **Organic stricture** is usually (a) cicatricial or (b) malignant, although it may be congenital or be caused by foreign bodies or the pressure of aneurysms, tumors, etc. (a) **Fibrous or cicatricial stricture** is generally the result of the swallowing of corrosives, but may follow also other injuries and ulcerations. It is most frequent in the young and often situated opposite to the cricoid cartilage. In some cases there are multiple strictures.

The **symptoms** come on slowly, there first being difficulty in swallowing solids and finally in swallowing liquids. When the stricture is near the stomach, food may not be returned immediately, but may collect in the pouch which forms, and be regurgitated after an interval, the reaction being alkalin, not acid as would be the stomach contents. Pain is slight or absent and, as a rule, the patient is able to locate the site of obstruction. In the later stages there is marked emaciation from starvation. The diagnosis is confirmed and the stricture located with an esophageal bougie (Fig. 362), which in the adult should normally enter the stomach 16 to 18 inches from the teeth. The patient is seated with the head forward and the jaws open; the bougie is warmed, lubricated with glycerin, and passed downward into the esophagus while the left forefinger depresses the tongue and guards the orifice of the larynx. Great force should never be employed, particularly if cancer is suspected, as perforation and death may follow. Furthermore, it is well to rule out the presence of aneurysm before passing a bougie. In all cases there is a delay in the swallowing sound, which is normally about four seconds in length, i.e., from the time the patient begins to swallow a mouthful of water until the last gurgle into the stomach is heard; the ear is applied to the vertebral groove near the angle of the left scapula. Finally the esophagoscope may be used to determine the nature and site of the stricture, and the seat of narrowing may be graphically depicted by a radiogram, after the ingestion of bismuth.

The **treatment** is *gradual dilatation* by passing increasing sizes of bougies every second or third day. In order safely to penetrate a minute stricture, a filiform bougie may be inserted under direct inspection through the esophagoscope. Plummer has the patient swallow six yards of fine silk, three in the evening and three the following morning. The portion first swallowed passes into the intestine, so that the thread hanging from the mouth may be pulled taut. A bougie with a perforated olive tip is then threaded on the silk, which acts as a guide to the orifice of the stricture. In cases in which dilatation cannot be practised a *Symond's tube* may be used. This is a rubber tube, funnel-shaped at the upper end where it rests against the stricture. It is inserted by a whalebone introducer, and removed every two or three weeks by means of a piece of silk attached to its upper end and issuing from the mouth. *Retrograde dilatation* by means of the finger or bougie may be practised after opening the stomach when the lesion is near the cardiac orifice. *Abbe's operation* is applicable to strictures in the thoracic portion of the esophagus which have resisted other means of treatment. A shot clamped to the end of a fine piece of silk is swallowed by the patient. The stomach is then opened, and coarse silk attached to the thread and pulled through the stricture, which is then divided by sawing movements, while it is made tense by the pressure of a bougie passed from below. In some cases the silk is brought out through an esophagotomy wound in the neck instead of through the mouth. The calibre of the esophagus is maintained by the passage of bougies. *Ochsner's method* consists in opening the stomach, and passing a long loop of silk through the stricture by means of a whalebone probe. A small rubber tube is passed through this loop, and drawn through the stricture while on the stretch. When released the rubber swells and dilates the stricture. Increasing sizes of tubes are thus employed. *Internal esophagotomy* by means of an instrument with a concealed knife, *forcible dilatation* by special divulging instruments, and *electrolysis* have been successfully utilized with the aid of the esophagoscope. *External esophagotomy* has been employed in high strictures, the contraction being divided, dilated, or even excised. *Esophagostomy* consists in suturing the mucous membrane of the esophagus below the stricture to the skin, thus making an artificial mouth. *Gastrostomy* is indicated when swallowing is impossible, in order to feed the patient. A stricture which is thus rested may after a time become passable to bougies. If the stricture remains impermeable *esophagoplasty* (vide infra) may be tried.

(b) **Malignant stricture** is most frequent in men after the age of forty, and most common at the narrowest portions of the esophagus, viz., opposite the cricoid, at the level of the left bronchus (being epitheliomatous in both instances), and at the cardia, when it is a columnar-celled carcinoma. The symptoms are those of cicatricial stenosis, but there are greater pain, more rapid emaciation, and often cough, and regurgitation of blood-stained food. The tumor may be felt when the cervical portion is involved. Other symptoms may arise owing to invasion of surrounding structures. As the appearances of carcinoma are distinctive, the diagnosis may be made, even in the earliest stage, by means of the esophagoscope, a bit of tissue being removed for microscopic corroboration; and since resection of the esophagus has been successfully performed, early diagnosis is essential, if more patients are to be saved. The bougie and the X-ray are valuable only in the later stages, for determining the site of the stricture, but are incompetent to establish definitely its carcinomatous nature. Moreover, since the bougie is blind and a carcinomatous stricture often friable, esophageal sounding is attended by greater danger than exploration under the guidance of the eye. The **treatment** in the early stages is generally the passage of a soft rubber bougie to keep the canal open. Symond's tube has been used in some cases. The insertion of a capsule of radium through the esophagoscope is a palliative measure of some value. Gastrostomy, which permits the patient to be fed and puts the esophagus at rest, should not be postponed until swallowing is impossible, but should be performed as soon as the dysphagia becomes pronounced. Esophagectomy should, we believe, be recommended in suitable cases.

Esophagectomy for a growth limited to the cervical portion of the gullet has been performed successfully a number of times. In one case we removed the cervical esophagus, the larynx, the trachea as far as the manubrium, and the thyroid gland. Excision of the thoracic portion of the esophagus has been attempted extrapleurally, after resecting a portion of several ribs near the spine, but more room can be obtained by the transpleural route, the operation being conducted, in order to prevent collapse of the lung, with the aid of differential pressure (positive or negative), or, better, with the aid of intratracheal insufflation anesthesia. Efforts to anastomose the esophageal segments left after excision of the growth, or to anastomose the upper segment with the stomach, have resulted in failure. Torek's patient, who is still living eighteen months after excision of the thoracic esophagus, was operated upon in two stages. A gastrostomy was first performed. At the second operation a cut was made through the entire length of the seventh left intercostal space, thence upwards through the seventh, sixth, fifth, and fourth ribs, between their angles and tubercles. A rib spreader was placed between the seventh and the eighth ribs, the esophagus separated by blunt dissection, cut at each end between ligatures, and removed. The upper end was brought out at the base of the neck, the lower end invaginated. The chest was closed by passing sutures around the seventh and the eighth ribs, the lung being fully inflated before the last stitch was tied. Zaaijer and Ach have successfully excised a carcinoma of the cardia. Zaaijer first established a gastrostomy. In the second stage he resected a number of ribs so as to allow the thoracic wall to collapse, thus lessening the distance to the growth. At the third operation the pleural and the peritoneal cavities were opened, the diaphragm was split up to the hiatus, the growth removed between clamps, the stomach closed, and the lower end of the esophagus sutured to the skin near the posterior axillary line. After operations of this character food may be led from the lower end of the remaining portion of the esophagus to the opening in the stomach by means of a rubber tube, or an artificial esophagus may be constructed as described in the next section.

Esophagoplasty, or the formation of an artificial esophagus, may be tried in cases of impassable, inoperable, cicatricial stricture of the esophagus, or in cases in which the esophagus has been resected. The skin between the esophageal and the gastric fistulæ may be fashioned into a tube, the outer surface of which is covered with flaps from the chest (Bircher). The upper part of the jejunum (Roux) or the transverse colon (Kelling, Vulliet) may be isolated, except for the mesenteric attachment, and drawn up beneath the skin of the thorax, the lower end of the transplanted intestine being anastomosed with the stomach, the upper with the stump of the esophagus. Hirsch suggests employing the anterior wall of the stomach, Jianu the whole length of the greater curvature; in these methods one end of the new esophagus is already attached to the stomach. Fink proposes severing the pylorus, drawing it up beneath the thoracic skin, and performing posterior gastroenterostomy. Intra- instead of antethoracic transplantation of a segment of the stomach or the intestine also is a possibility.

CHAPTER XXVII.

ABDOMEN.

Abdominal section (*celiotomy, laparotomy*) is incision into the abdomen for surgical purposes. The preparation and after care of the patient, the precautions in reference to instruments and sponges, and the indications for and dangers of drainage, are given in the chapter on Surgical Technic; the postures different operations may require and the situation of the incisions for exposure of various organs, in the description of the operations on the viscus concerned. In order to give an idea of the way in which the abdomen is opened and closed, we shall here describe only the median incision, since it is often selected, not only because it causes comparatively little bleeding, but also because it permits exploration of both sides of the abdominal cavity. When it is necessary to pass the umbilicus, the left side is chosen to avoid the round ligament of the liver, although some operators excise the umbilicus because it is often infected and is difficult to suture. After incising the skin and subcutaneous tissues, instead of locating the linea alba with nicety, the anterior sheath of the rectus is split, the muscular fibres separated with the finger or the handle of the knife, and the posterior sheath and transversalis fascia divided. The peritoneum, which is recognized by the presence of fatty tissue in front of it, is now elevated from the viscera with forceps and opened sufficiently to admit the finger, which guards the intestines while the opening is enlarged with the scissors. After the operation has been completed the wound is closed with great care in order to prevent the development of a hernia. Figs. 363 to 370 illustrate various methods of closing the abdominal wound. Buried sutures should be of catgut, sutures which are subsequently removed of silkworm gut. Through and through sutures (Fig. 363), which are introduced about one-fourth inch from the edge of the wound and about one-half inch apart, obliterate all dead spaces, stop oozing, give firm support, and permit rapid work. Suture of the individual layers of the abdominal wall (Fig. 370) is anatomically more accurate, and, owing to the smaller amount of tension on each suture, less apt to cause necrosis. The various ways of closing the skin incision, when the tier suture is employed, are given in the chapter on Wounds. The author, whenever possible, puts a purse-string suture of catgut in the peritoneum, thus making a dot instead of a line of scar tissue and lessening the chances of adhesions; passes through and through sutures of silkworm gut through the remaining layers; closes the fascia with a continuous suture, using the same thread that was placed in the peritoneum, thus drawing the peritoneum up under the fascia and preventing the formation of a dead space; and finally ties the silkworm-gut sutures. The wound is dressed with aseptic gauze, retained in place by adhesive plaster and a firm binder. The patient is not allowed to sit up for from ten days to three weeks or longer, according to the situation and length of the incision and the presence or absence of drainage or infection. In most instances the patient should wear an abdominal support for some time after leaving bed.

Contusions of the abdomen vary from a superficial ecchymosis to the most extensive shattering of the viscera. Sudden and immediate death following a blow on the abdomen, without gross injury to the viscera, has been attributed to shock, or disturbance of the solar plexus, but is probably

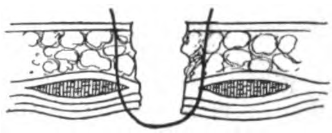


FIG. 363.

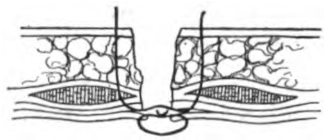


FIG. 364.

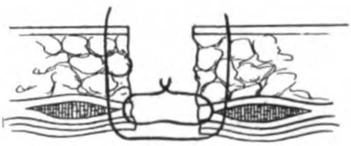


FIG. 365.

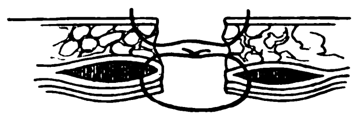


FIG. 366.

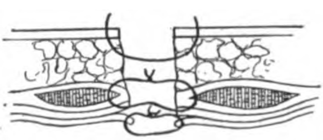


FIG. 367.

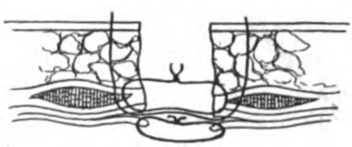


FIG. 368.

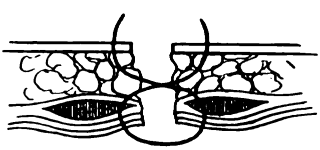


FIG. 369.

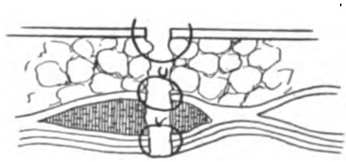


FIG. 370.

FIGS. 363 to 370.—(Binnie.)

the result of violence to the heart or to its nerve mechanism. **Hematoma** and **suppuration** of the abdominal wall may follow a contusion as elsewhere. **Muscular rupture** follows a violent force to a normal muscle in extreme tension, or a trivial injury to a degenerated muscle. The rectus tends to rupture more frequently than the broad muscles of the parietes. A ruptured muscle should be sutured because of the subsequent danger of hernia. When a blow is expected, the body is bent, the muscles contracted, and the force expended on the abdominal wall, but a blow received when the muscles are flaccid is very apt to injure the viscera. The most serious intraabdominal injury may be present without any evidence of injury to the skin or muscles. The **effects of visceral injury** are manifested *immediately*, as shock, hemorrhage, or peritonitis; *intermediately*, as when peritonitis follows a perforation through a contused necrotic patch in the intestine, the patient having been apparently well for one or more days; or *remotely*, as adhesions, stricture of the bowel, aneurysm, etc., developing after a prolonged period.

Ruptures of most of the large **intraabdominal vessels** have been recorded. Providing there be time, the abdomen should be opened and the hemorrhage checked. If the vessel be severely contused, bleeding may be postponed until sloughing of the arterial wall ensues, or thrombosis, embolism, stenosis, or aneurysm may develop, and the parts supplied by the artery may become gangrenous.

From its elasticity and more protected position beneath the ribs, **the stomach** is less liable to be affected by trauma than the intestines. The anterior wall is the most frequent site for rupture. One or all the coats may be torn. The symptoms are those of shock and perforative peritonitis. Hematemesis may be present or absent. The stomach should be sutured and the treatment for peritonitis instituted.

Rupture of the intestine is frequently the result of a horse-kick, a man-kick, or a run-over accident, the intestine being crushed between the vulnerating body and the bony parts behind. A fall from a height or a blow upon the back also may tear the intestine, particularly where it is firmly fixed, e.g., the duodenum. The most important **symptoms** are pain, tenderness, rigidity of the abdominal wall, and an anxious facial expression. Shock is slight or absent in 25 per cent. of the cases. Absence of liver dulness with a flat abdomen is a valuable sign. Cellular emphysema is rare and indicates a lesion of the bowel beyond the limits of the peritoneal space. Movable dulness in the flanks is a sign of fluid in the peritoneal cavity, which may be serous, sanguineous, or fecal. Fecal extravasation is rarely great in rupture of the bowel, owing to the contraction of the muscular coat, while hemorrhage is slight unless the mesentery or other vascular structure is torn. Abdominal distention, fever, and other symptoms of widespread peritonitis are later symptoms, and usually mean that the favorable time for operation is past. Vomiting immediately after the accident is unimportant, but recurring vomiting is ominous. There may be absence of peristalsis and a friction sound on auscultation, and tenesmus with a frequent desire to defecate is sometimes encountered. Rectal examination in some instances may detect resistance in the vicinity of the rupture, due to the formation of adhesions around the laceration. Bright blood in the stools points to a rent in the large bowel, tarry movements to a lesion higher. The temperature, pulse, and respirations augment with the spread of the peritonitis, which will cause also a leukocytosis and a rise in the blood pressure. The rectal insufflation of hydrogen or ether to detect the perforation is too dangerous to be employed.

The **treatment** is laparotomy, suture of the perforation, cleansing of the peritoneal cavity, and drainage as described under peritonitis. Death is almost inevitable without operation; with operation 20 per cent. recover. The difficulty is to make an early diagnosis. In the presence of the first four signs mentioned above, exploration is urgently demanded. As a rule a median incision is made below the umbilicus, and the rupture found between the seat of the surface injury and the spine; the possibility of more than one perforation should be kept in mind and discolored spots treated as ruptures. Resection or extraperitoneal isolation of the injured bowel (according to the condition of the patient) may be indicated, because of the severity of the contusion, the extent of the laceration, or because of detachment or injury of the mesentery.

In tears of the **omentum and mesentery** the immediate danger is hemorrhage. Later an inflammatory mass or embarrassing adhesions may develop. When the mesentery is violently contused, or stripped from the bowel, intestinal gangrene follows. The intestine may become strangulated through a slit in the mesentery. Sanguineous mesenteric cysts also may develop. The *treatment* is ligation of the bleeding vessels, and excision of omentum or intestine, if such be needed.

The **liver** is frequently lacerated, particularly the right lobe. One-half of the cases die within twenty-four hours from hemorrhage. Pain is severe and shock profound, and there are symptoms of internal bleeding, with movable dulness in the flanks. In some cases, probably as the result of biliary absorption, the pulse is slow instead of rapid. Hepatic dulness is increased. Jaundice sometimes develops after twenty-four hours, and bile and sugar may appear in the urine. Peritonitis frequently occurs in those who survive the initial shock and subsequent hemorrhage. Operation is imperative to check hemorrhage, which may be controlled by suture, ligature, cautery, or tampon. Sutures should be given the preference; to prevent their tearing out the capsule of the liver may be fortified by a transplant of fascia, but if they fail to stop the bleeding, or if the wound is so situated as to make suturing difficult, the wound may be stuffed with gauze, or, better, with omentum, muscle, or fat, held in place, when possible, with a few sutures of catgut. Cauterization is not suitable for large wounds and is liable to be followed by secondary hemorrhage.

Ruptures of the gall-bladder, cystic, hepatic, and common bile ducts have occurred. The *symptoms* are pain, shock, biliary ascites, and later in some cases peritonitis, as the bile is irritating even if sterile. In a complete rupture of the hepatic or common duct there would be jaundice, cholemia, and inanition. The gall-bladder may be sutured or removed, according to the degree of laceration. Drainage is the treatment when the ducts are damaged, although in a suitable case anastomosis would be the ideal procedure.

The **spleen** is not as frequently ruptured as the liver. Enlargement of the organ predisposes to injury. Hemorrhage is the great danger, but is not as quickly fatal as one would suppose, owing to the elasticity of the organ, and to the fact that the blood coagulates rapidly because of the large number of leukocytes present. Abscess or peritonitis may follow. The *symptoms* are those of internal hemorrhage, with pain and tenderness over the spleen. Splenic dulness is increased, and frequently does not disappear when the patient is turned on the right side, because the blood is often clotted. Operation should be immediate; its nature depends upon the condition of the patient and of the spleen. If the patient has lost much blood, if the spleen is large and extensively adherent, and if the tear is favorably situated, suture with a transplant of fascia, as for the liver, is to be chosen. If the capsule is thin, the spleen soft, and the tear unfavorably situated, packing with gauze, omentum, muscle, or fat is to be considered. Ordinarily a large laceration in a normal spleen is best treated by splenectomy. Of thirty-four cases of splenectomy for rupture, 41.2 per cent. were fatal.

The **pancreas** is seldom ruptured alone. In the absence of fatal hemorrhage, gangrene, suppuration, or chronic pancreatitis may ensue. The so-called traumatic cysts of the pancreas are probably collections of blood and pancreatic fluid in the lesser peritoneal cavity, the foramen of Winslow having been closed by adhesions. The *symptoms* are those of shock and internal hemorrhage. The bleeding is checked in the same way as bleeding from the liver, or by partial excision, being careful to preserve the canal of Wirsung. Posterior drainage through the left lumbar fossa is to be employed, to drain off any leakage of pancreatic juice, which may cause peritonitis or fat necrosis.

The **kidney** is well protected by its position and by an enveloping bed of fat, yet it is not infrequently injured. The rupture is usually transverse to the long axis of the kidney. If the capsule remains intact, hemorrhage takes place into the organ; if it is torn, blood and urine collect in the perinephritic tissues. If the peritoneum is lacerated, urine and blood accumulate in the abdominal cavity. Bilateral and occasionally unilateral injuries of the kidney may be fatal from anuria, in the latter instance the sound kidney refusing to act from reflex inhibition. The *symptoms* are shock, pain, and hematuria. Hematuria may be absent if the kidney is separated from the renal vessels or the ureter, or if there be a clot in the ureter, or an extensive laceration of the pelvis of the kidney. Absence of hematuria has been caused also by thrombosis of the renal vessels and a preexisting stricture of the ureter. Cystoscopy in these cases will show that no urine is coming from the ureter on the injured side. Brownish urine coming from the ureter indicates clotting in the pelvis of the kidney. Hemorrhage and sepsis are the dangers. Symptoms of internal hemorrhage, with an increasing tumor in the loin, demand immediate exploration. If the kidney is hopelessly destroyed, or if ligation of the renal vessels be necessary to control the bleeding, the organ should be removed. If but moderate laceration is present, disinfection and drainage, with suture or partial nephrectomy, is indicated. If tamponage is chosen, fat or muscle, held in place with a few sutures, is probably superior to gauze as a hemostatic agent. Defects in the pelvis, if too large for simple suturing, may be repaired by turning down a flap of the capsule, or by transplanting a piece of fascia. The possibility of injury to the intraperitoneal organs should not be forgotten. Mild cases are treated by ice to the loin, internal astringents, urinary antiseptics, and rest.

Rupture of the ureter is caused by its being crushed against the transverse process of the third, fourth, or fifth lumbar vertebra, or by traction on the ureter. All ruptures are above the pelvic brim. Shock is neither profound nor persistent, unless there be some injury to the other abdominal organs. A few drops of blood in the urine, with persistent pain and tenderness in the side, point to injury of the ureter. If the duct be completely ruptured, cystoscopy will reveal no urine escaping from the affected ureter, and a retroperitoneal accumulation of urine and blood will appear after several days. Complete obstruction of the ureter will cause atrophy of the kidney; partial obliteration may result in a pyo- or hydronephrosis. If the injury be uncomplicated, the danger to life is slight, although there is little tendency towards spontaneous repair. A tear in the peritoneum may lead to a fatal peritonitis. Immediate anastomosis is the ideal *treatment*. Lumbar incision and drainage are indicated after infection has taken place; if a ureteral fistula follows it should be treated as described in Chap. XXIX.

Rupture of the bladder is extraperitoneal, intraperitoneal, or combined extra- and intraperitoneal. Laceration of the mucous membrane alone, with hematuria, may follow a blow on the hypogastrium. *Extraperitoneal rupture* is usually associated with fracture of the pelvis. *Intraperitoneal rupture* is generally caused by a forcing backward of the distended viscus against the promontory of the sacrum, although in some cases it may result from *contre coup*. In uncomplicated cases the rent is vertical and occurs at the upper and posterior part of the bladder. Normal urine may come in contact with the peritoneum without causing inflammation, but when bacteria are present inflammation quickly ensues. The injury is fatal without operation. With operation over one-half die from shock, hemorrhage, or peritonitis. The *symptoms* are shock, hypogastric pain, a sensation of something having given way, rectal tenesmus, and an urgent desire but inability to urinate. The catheter reveals a little bloody urine or no urine at all; it may pass directly into the abdominal cavity. Cases have occurred in which unstained urine has been withdrawn from a torn bladder. A measured quantity of boric acid solution may be injected into the bladder; if the same amount returns, the bladder is probably intact. Air or hydrogen may be pumped into the bladder, and if the viscus is intact, it will rise above the pubes as a symmetrical tumor, tympanitic on percussion, and the air will rush out again when allowed to do so. When the tear involves the peritoneum, the gas will cause a general distention of the belly; when the rent is extraperitoneal, an emphysema of the extravesical connective tissue. These injection tests are not infallible, and may spread infection. Movable dulness in the flanks suggests intraperitoneal rupture, unilateral tenderness and tumor extraperitoneal rupture. A differential diagnosis is, however, unimportant before operation. When symptoms of rupture are present, the prevesical space should be opened through a suprapubic incision, and if this be healthy, indicating the absence of extraperitoneal rupture, the incision may be continued upwards and the abdominal cavity opened. An intraperitoneal rupture should be sutured and the peritoneal cavity cleansed and drained. As a rule in extraperitoneal rupture, drainage is all that can be done.

Rupture of the diaphragm (see Diaphragmatic Hernia).

Wounds of the abdomen may be penetrating or non-penetrating. **Non-penetrating wounds** are treated as wounds elsewhere, care being taken to approximate the muscles, if such have been divided, in order to guard against hernia. **Penetrating wounds,** including those produced by gunshots and stabs, are readily recognized if the viscera or the contents of the viscera escape through the wound. The symptoms and the dangers of visceral injury are those of contusions of the abdomen. The *treatment*, even without symptoms of visceral injury, is immediate enlargement of the wound, in order to explore the abdomen, check hemorrhage, and close such visceral perforations as may be found. The abdomen is then flushed with salt solution, and closed or drained, according to the amount of soiling present. If the omentum protrudes it should be ligated and removed, while coils of intestine should be carefully washed with salt solution and returned to the cavity. In cases in which there is doubt as to whether or not a wound enters the peritoneal cavity, such wound should be enlarged and the diagnosis positively made, being prepared at the same time to treat any visceral injuries that may be found. In gunshot wounds on the battle field an exception has been made to the rule of immediate exploration, because it has been found that the chances of recovery are somewhat better without than with operation undertaken in the absence of proper facilities. Symptoms of internal hemorrhage or of injury to the viscera, under even these circumstances, require laparotomy.

Phantom tumor of the abdomen generally occurs in hysterical females. It is due to either a localized contraction of the abdominal muscles, usually a section of the rectus, or a tetanic spasm of the intestine. The swelling may be as hard as bone, but as a rule varies in consistency on different examinations, and disappears under anesthesia, with gurgling if it be intestinal. The treatment is that of hysteria.

THE UMBILICUS.

Inflammation and abscess are commonly the result of uncleanliness, especially after separation of the cord, or in corpulent adults in whom the umbilicus is deep. Eczema likewise is observed. Tetanus neonatorum and erysipelas may be caused by infection of the umbilicus soon after birth. Benign and malignant **tumors** may occur in this region, but are rare. Among the **cysts** may be mentioned the dermoid, sebaceous, vitelline (developing from an unobliterated portion of the vitelline duct), serous (due to a shutting off of an empty hernial sac), and the urachal. The last are caused by distention of an unobliterated portion of the urachus, which normally extends from the bladder to the umbilicus; they are properitoneal, median in situation, sometimes of large size, and may open both into the bladder and at the umbilicus. The treatment of cysts is excision. In some urachal cysts this is not possible, and incision and drainage are all that can be accomplished.

Umbilical fistulæ may be congenital or acquired. *Fecal fistulæ* resulting from non-closure of the omphalo-mesenteric duct (Meckel's diverticulum) are first observed after the umbilical stump has separated. The mucous membrane may become everted and form a red tumor, which has been called a *polypus or adenoma* when the communication with the intestine has become obliterated. When the duct is wide and short a portion of the intestine may protrude through the opening. Fecal fistulæ in the new-born have been caused also by including within the ligature which surrounds the cord a small umbilical hernia. Acquired fecal fistulæ follow conditions like strangulated hernia and tuberculous peritonitis. *Urinary fistulæ* are caused by non-obliteration of the urachus, *mucous fistulæ* by the omphalo-mesenteric duct or the urachus which has become closed at the visceral end. These fistulæ should be excised and the opening into the viscus closed. A *biliary fistula*, following perforation of the gall bladder, is occasionally seen at the umbilicus. It should be excised and the diseased gall bladder drained or removed after extracting any stones that may be present. *Umbilical sinuses* are the result of abscesses, and require incision and packing.

Umbilical hernia (see Hernia).

THE PERITONEUM, OMENTUM, AND MESENTERY.

Peritonitis, or inflammation of the peritoneum, is practically always bacterial in origin. It is divided primarily into the acute and chronic forms.

Acute peritonitis is caused by perforations of the hollow viscera, wounds of the abdomen, extension of inflammatory processes from the abdominal organs by contiguity or continuity (e.g., from the Fallopian tubes), and by infection coming through the blood or lymph vessels. Idiopathic peritonitis does not exist; rheumatic peritonitis probably seldom or never occurs. A great variety of micro-organisms have been cultivated from cases of peritonitis, and in most instances the infection is a mixed one. The streptococcus pyogenes is responsible for the most severe forms; the staphylococcus pyogenes is less virulent. The colon bacillus is usually found in cases secondary to intestinal lesions. The diplococcus of pneumonia and the gonococcus are much less virulent in this situation than are other organisms. Two forms of aeute peritonitis are described, (1) the localized, and (2) the diffuse, or generalized.

1. **Acute localized peritonitis** is most frequent in the vicinity of the Fallopian tubes and appendix. There is a subperitoneal collection of round cells, and the peritoneum becomes congested, loses its luster, sheds its endothelium (especially in virulent infections), and exudes a sero-fibrinous material, which surrounds the affected area, and which may become purulent, forming a localized abscess. The pus may break through the barrier of adhesions and cause a generalized peritonitis, or it may break into one of the hollow viscera. In rare cases it points externally, and in a few instances in which it is well encapsulated, it becomes inspissated or even calcareous. The fibrinous material which glues adjacent peritoneal surfaces together may be absorbed, or become organized into fibrous adhesions. The *symptoms* are localized pain, tenderness, and muscular rigidity, with fever, increase in the pulse rate, vomiting, and constipation. Later the inflammatory mass may be palpated, giving either a dull or tympanitic note on percussion. When near the surface, redness and edema of the abdominal wall may be noted. Unless the infection is well encapsulated, leukocytosis is present. The *treatment* is given under the conditions which give rise to the localized peritonitis, as it varies somewhat according to the region affected and the cause, thus acute pelvic peritonitis caused by the gonococcus is usually treated symptomatically until quiescent, while localized peritonitis the result of appendicitis requires early operation. It should not be forgotten, however, that a diffuse peritonitis always begins as a more or less localized process, and that in many instances prompt and efficient treatment of the infection while still limited may prevent its generalization.

2. **Acute diffuse or generalized peritonitis** is generally the result of an extension of a localized peritonitis, although a large area of the peritoneum may be flooded with infective material from the bursting of a localized abscess, or the perforation of a hollow viscus. The peritoneum is congested and lusterless and in fulgurant cases death may occur from toxemia before further changes take place. As a rule, however, there is some serous exudation, and fibrinous patches form on the area from which the endothelium has been shed. At a later period the exudate becomes purulent and occasionally bloody.

The **symptoms** at the onset are those of localized peritonitis, or when a large amount of infective material has been suddenly diffused, as in perforation, there will be sudden violent pain, profound shock, and in some cases death within a few hours. The patient usually survives the shock, however, and the temperature ascends to and then above normal, and finally falls to subnormal as death approaches, but the pulse remains quick, and becomes hard and wiry owing to the rise in blood pressure, though in the final stages it is running and compressible. Chills are uncommon except in puerperal cases. The abdomen is rigid, tender, and later tensely distended and tympanitic, with an amelioration in the pain. Vomiting is early and persistent, and in the final stages stercoraceous material is regurgitated without effort.

The patient lies on the back with the knees drawn up, and the face has a characteristic anxious and pinched look. Movable dulness in the flanks may sometimes be observed when the effusion is great. The abdomen is motionless, the breathing being quick, shallow, and entirely thoracic. On auscultation peristaltic gurgling is absent, and occasionally friction sounds can be heard, more often in the upper abdomen, where, owing to the action of the diaphragm, the viscera cannot be kept entirely at rest. Hiccough is not uncommon. There is usually obstinate constipation, although diarrhea may be present. Leukocytosis is present unless the infection is overwhelming. There may be absence of liver dulness in cases due to perforation of the gastrointestinal canal. The urine is scanty, often contains albumin and indican, and sometimes tube casts (toxic nephritis).

Treatment with poultices or ice to the abdomen may make the patient more comfortable, but do not influence the disease. Purgation is contraindicated, but the lower bowel may be emptied by an enema. Opium theoretically discourages diffusion of the inflammation by quieting peristalsis. Most surgeons advise immediate operation in all cases, excepting puerperal peritonitis, unless the patient is moribund; all advise immediate operation in perforative peritonitis; and a few in the non-perforative variety adopt the *Ochsner method*, which consists in gastric lavage, no food, water, or purgatives by mouth, and operation when the process becomes localized. The Ochsner method undoubtedly lowers the operative mortality, but that it lessens the number of deaths from peritonitis remains to be proved. The most important principles involved in any operation for peritonitis are rapidity and gentleness. Unless the starting point of the inflammation can be localized, the incision should be made in the middle line below the umbilicus, and the cause of the peritonitis, e.g., a gangrenous appendix, surrounded with gauze and quickly removed. The gauze packing prevents further dissemination of the infection and absorbs a large quantity of the peritoneal exudate. The peritoneal cavity should then be thoroughly douched with hot (115° F.) salt solution by means of a large rubber tube passed first to the least infected parts of the abdomen, especial attention being given to each kidney pouch and the pelvis, and the flow continued until the water returns clear. A tube or a piece of gauze should next be passed into the lowest portion of the pelvis for drainage (gaining exit, in the female, through the vagina); a separate incision may be made in each loin for the same purpose. The patient may then be put in the semi-sitting posture, or the head of the bed raised two or three feet (Fowler's position), in order to drain the fluids into the pelvis and away from the diaphragm, in which region absorption is said to be most active. In the gravely ill, however, the depressing effects of the upright posture upon the heart far outweigh the theoretical advantages just mentioned. The writer prefers to place the patient in the Sims position, i.e., almost on the abdomen, on the right side if the incision is right-sided or median, on the left side if the incision is on the left side. Water should be given by bowel, eight ounces every three hours, or by continuous *proctolysis* (*Murphy method*), i.e., by means of a fountain syringe, the reservoir of which, surrounded by hot water bags, is but slightly higher than the rectum, so that the water shall enter no faster than absorption takes place, the patient getting perhaps a pint or two in the course of an hour (see enteroclysis). This stimulates the heart and kidneys, eliminates septic material which has entered the circulation, and reverses the current in the lymphatics of the peritoneum, making that membrane a secreting instead of an absorbing one. Occasionally proctolysis seems to increase the distention and provoke vomiting, in which event salt solution may be given intravenously or subcutaneously. Nothing is given by mouth until the stomach is retentive, stimulants are freely administered, and an early movement of the bowels is secured. When there is great distention which cannot be relieved by purgatives, enemata, or the rectal tube, an artificial anus may be established. The *prognosis* will depend upon the character, duration, and extent of the infection, and the resistance of the individual. Including all forms, irrespective of the cause, the mortality is from 15 to 20 per cent. in cases which are in fair condition at the time of operation, and 50 per cent. or more in those in bad condition. Some surgeons omit irrigation, others drainage, and both classes claim good results.

Chronic peritonitis may be (1) simple or (2) tuberculous.

1. **Simple chronic peritonitis** may be localized or diffuse. It generally follows the acute form, but may in mild infections be chronic from the start. The peritoneum is thickened, and the adjacent surfaces fastened together by more or less firm adhesions. Sacculated effusions are sometimes encountered. Syphilis is said to be responsible for some cases. The treatment is directed to the cause. Adhesions may be separated if they give rise to symptoms, e.g., pain or obstruction.

2. **Tuberculous peritonitis** may be primary, but is usually secondary to disease in a distant organ, or to tuberculosis of some other abdominal structure, particularly the lymph glands, the intestine, or the Fallopian tubes. It is more common in females, and is rarely seen before the third or after the fiftieth year. Three forms are described: (a) The *ascitic* form presents itself as a free or sacculated serous, sero-fibrinous, or occasionally purulent exudate, as the result of a diffuse miliary invasion of the peritoneum; it is sometimes complicated by cirrhosis of the liver. (b) The *fibrous or adhesive* variety is characterized by a slow course and the absence of fluid. The abdominal organs are glued together, and gray or yellow tubercles are found among the adhesions. Not unusually the omentum is rolled upon itself and is palpable as a transverse mass in the upper part of the abdomen. (c) The *caseous or suppurative* form is a later stage of the adhesive variety. The tubercles caseate and give rise to abscesses, which may point externally, especially at the navel, and lead to fecal fistulæ, the bowel often being opened by ulceration.

The local **symptoms** may arise suddenly and resemble those of acute appendicitis or other acute intraabdominal condition, or the general symptoms may predominate and typhoid fever be simulated. Most of the cases, however, are chronic. Pain and tenderness are rarely severe and may be entirely absent. Dysuria is not uncommon, particularly in women. The digestion is disturbed, although vomiting is rare, and diarrhea is absent unless there is disease in the intestine. The temperature rises one or two degrees in the evening, night sweats may occur, and there is a gradual loss of weight. The subcutaneous abdominal veins are generally distended, and free or encapsulated fluid may be detected in the peritoneal cavity and not infrequently in a patent processus vaginalis or canal of Nuck. The rolled up omentum can be felt and sometimes seen. Masses of adherent intestine or enlarged lymph glands may be found on external, vaginal, or rectal palpation. Symptoms of stenosis of the intestine may be present, the liver and spleen are often enlarged, and tuberculosis may be detected in distant parts of the body.

The **treatment** may be medical or surgical. *Medical treatment* includes the general measures employed for tuberculosis elsewhere and local applications of green soap, mercurial ointment, iodin, elastic collodion, or guaiacol. The X-ray and intraperitoneal injections of a weak solution of iodin also have been used. *Surgical treatment* is of the greatest value in the ascitic form, in which laparotomy is followed by at least 50 per cent. of permanent cures. All that is needed is to open the abdomen, evacuate the fluid, and close without drainage. If the cause of the disease, e.g., a tuberculous appendix or Fallopian tube, be discovered, this may be removed. Separation of adhesions is not infrequently followed by fecal fistulæ. The reason for the beneficial effect of a simple laparotomy is not known. It has been supposed that the operation causes hyperemia, and the outpouring of an antitoxic serum. If fluid recollects, it may be aspirated or a second laparotomy performed.

Malignant disease of the peritoneum may be primary (endothelioma), but is usually the result of secondary deposits from a papilliferous cyst of the ovary or a carcinoma of the ovary, stomach, liver or intestine, the cancer cells having been diffused by the peritoneal currents and the movements of the viscera. The symptoms are those of cachexia and ascites. The fluid withdrawn by tapping is often blood stained and sometimes contains the tumor cells. Multiple nodules can be felt through the abdominal wall and by rectum.

Paracentesis abdominis is performed for the removal of fluid from the peritoneal cavity. The bladder should be emptied, and a spot of absolute dulness selected in the median line below the umbilicus. The patient sits up, and a broad flannel binder with an opening in front is passed around the abdomen and held by an assistant behind, so as to make pressure upon the abdomen. The skin is then sterilized, a small incision made in the skin with a scalpel, the trocar and cannula inserted, and the trocar withdrawn.

Subphrenic abscess is an abscess just beneath the diaphragm. About one-third of the cases are due to ruptured gastric or duodenal ulcer, one-fourth to appendicitis, one-fifth to infections of the liver and biliary ducts, and the remainder to perforation of the intestine, trauma, pyemia, and suppurative processes in the female generative organs, spleen, pancreas, kidney, ribs, vertebræ, or pleura, hence the abscess may be (a) intraperitoneal or (b) retroperitoneal. (a) In the *intraperitoneal* variety (83 per cent. of 890 cases collected by Piquand) the infection is transmitted from the primary focus by the intraperitoneal lymph stream, which flows towards the diaphragm, or by a spreading peritonitis. Its situation depends upon the location of the causative lesion and the arrangement of the subphrenic peritoneal fossæ, which are five in number, four phreno-hepatic, formed by the cruciform reflection of the peritoneum from the liver to the diaphragm, and one phreno-splenic (Fig. 371). (1) *Right anterior phrenohepatic* abscess is the most frequent (36 per cent.); it lies between the right lobe of the liver and the diaphragm, to the right of the falciform ligament, and in front of the coronary and right lateral ligaments. (2) The *right posterior* form (10 per cent.) is behind the coronary ligament, extends down towards the right kidney, and is often associated with the right anterior form. (3) *Left anterior* abscess (30 per cent.) presents in the epigastrium, adhesions limiting it below. (4) A *left posterior* collection (3 per cent.) distends the lesser peritoneal cavity, consequently is behind the stomach. (5) *Phreno-splenic* or *perisplenic* abscess (4 per cent.) occupies the space above and about the spleen. (b) In *retroperitoneal* abscess the infection travels by way of the lymph vessels or by a spreading cellulitis. (1) *Right retroperitoneal* abscess (15 per cent.) may extend forwards between the layers of the coronary and falciform ligaments and point in the epigastrium, or downwards and point in the right loin; (2) *left retroperitoneal* (2 per cent.) forwards between the layers of the left lateral ligament and downwards to the left loin. A subphrenic abscess often contains gas, owing to the presence of the colon bacillus, or to perforation of the gastro-intestinal canal or lung. It may cause empyema, rarely pyopericardium, by breaking into the pleural cavity or pericardium, or by extension of the infection along the lymphatics through the diaphragm without perforation. It may break also into the lung, the general peritoneal cavity, the stomach, the intestine, the mediastinum, or in rare instances externally (hypochondrium, epigastrium, loin).

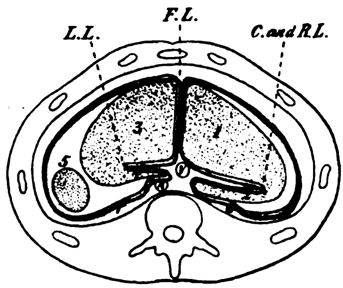


FIG. 371.—Diagram showing the various locations of subphrenic abscess. Liver and spleen shaded. Peritoneal reflection to diaphragm in red. *V*. Vena cava. *A*. Aorta. *F. L.* Falciform ligament. *L. L.* Left lateral ligament. (1) Right anterior, (2) right posterior, (3) left anterior, and (4) left posterior phrenohepatic spaces. (5) Phrenosplenic or perisplenic space. (6) Right and (7) left retroperitoneal spaces.

The **symptoms** are usually preceded or accompanied by those of the causative lesion. The general phenomena are those of sepsis. Locally there are pain and tenderness, muscular rigidity, perhaps swelling and edema, and, on percussion, a tympanitic area which moves with the position of the patient, or dulness. Friction sounds are occasionally heard and when the abscess contains gas all the signs of pneumothorax may be present, hence the term false pneumothorax. Fluoroscopic examination reveals elevation and possibly immobility of the diaphragm on the affected side, below which is a clear area if the abscess contains gas. The liver or the spleen is depressed. Exploratory aspiration may be made in the tenth, ninth, eighth, and seventh interspaces, in the order named, first below the scapula, and then, if no pus is found, in the midaxillary line, but never through the peritoneum, and only when all preparations have been made for immediate operation in case the abscess is located. The *diagnosis* of subphrenic abscess is often difficult, and the conditions which it resembles are often associated with it. In hepatic abscess there may be jaundice and gas is never present. Pancreatitis may reveal itself by the laboratory tests for this condition. In empyema the pulmonary symptoms are more marked, the upper level of the fluid is concave instead of convex, the heart is pushed to one side rather than upwards, the liver is not depressed, the obliquity of the ribs is increased (being decreased in subphrenic abscess), the level of the diaphragm as shown by the X-ray is not disturbed, the Litten phenomenon (visibility of the excursions of the diaphragm in the intercostal spaces) is absent, and Traube's space is rarely obliterated, a sign which may occur in left subphrenic abscess. Bronchial breathing, owing to compression of the lung, is sometimes heard in subphrenic abscess, but never egophony. In empyema on exploratory puncture, the pus is more superficial, escapes under greater pressure during expiration (the reverse being true in subphrenic abscess), and the needle does not oscillate. When the needle passes through the diaphragm its outer end ascends on inspiration, descends on expiration.

When a serous pleural effusion and a subphrenic abscess are both present, one may obtain serous fluid superficially and fetid pus at a deeper level, or serum in the sixth or seventh interspace and pus in the ninth or tenth. The *mortality* of subphrenic abscess is almost 100 per cent. without operation, 50 per cent. with operation.

The **treatment** is evacuation. According to the situation of the abscess, the incision will be made in the epigastrium, the hypochondrium, the loin, or through the diaphragm after resecting the ninth or tenth rib and pushing the pleura upwards (subpleural route), or sewing the diaphragm to the parietal pleura (transpleural route).

The **omentum** has been called "the policeman of the abdomen," because of its tendency to adhere to and surround diseased processes and prevent their diffusion; it, therefore, participates in diseases common to the peritoneum.

Volvulus of the omentum in most instances is caused by forcible taxis of an epiplocele, although it may occur without the presence of a hernia. The omentum becomes gangrenous, and the patient is usually operated upon with the idea that he has a strangulated hernia or appendicitis. A doughy abdominal tumor coming on after attempts to reduce a hernia should make one suspicious of an omental torsion. The involved portion should be excised.

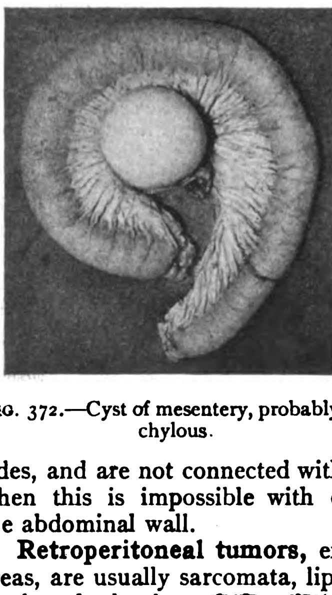


FIG. 372.—Cyst of mesentery, probably chylous.

Tumors of the omentum and mesentery are uncommon, and are generally sarcomatous in nature, although benign growths and secondary carcinoma may occur. Free fatty tumors in the peritoneal cavity represent lipomata of the omentum or epiploic appendages, the pedicle of which has broken. The rolled up tuberculous omentum has already been described. Cysts of the omentum and mesentery also are rare, and are frequently caused by the echinococcus or by cystic degeneration of malignant disease. In the mesentery serous, sanguineous, chylous (Fig. 372), and dermoid cysts have been observed. These tumors and cysts are freely movable, surrounded by tympany on all sides, and are not connected with the pelvis. The treatment is extirpation; when this is impossible with cysts, they may be opened and stitched to the abdominal wall.

Retroperitoneal tumors, excluding those of the kidney and the pancreas, are usually sarcomata, lipomata, or dermoids. Secondary tumors of the lymph glands, and chronic abscesses, most frequently originating in a tuberculous spondylitis or lymphadenitis, also are observed. The tumor is behind the stomach and intestines, as is shown by its immobility and the presence of tympany. The possibility of aneurysm should not be forgotten. Retroperitoneal tumors may be extirpated from the front, thus going through the anterior and posterior parietal peritoneum. Abscesses should be drained extraperitoneally, by an incision in the loin or above Poupart's ligament.

Thrombosis or embolism of the mesenteric vessels causes gangrene of that portion of the intestine supplied by the vessel involved, unless the vessel be small, when there may be only engorgement of the intestine, or ulceration, followed perhaps by perforation. In some cases the mesentery is distended with extravasated blood. The condition is rare in children, most of the cases occurring between the thirtieth and the seventieth years, men being affected nearly twice as often as women. Embolism is frequently the result of cardiac disease, and is sometimes associated with the presence of emboli in other portions of the body. Thrombosis is caused by acute or chronic phlebitis, the result of infection from the intestine or other organ, or by chronic endarteritis. In Trotter's collection of 366 cases, the arteries were involved in 53 per cent., the veins in 41 per cent., both in six per cent. The superior mesenteric vessels were more often occluded than the inferior. The diagnosis, before operation or autopsy, was made thirteen times. The *symptoms* are sudden intense pain, bloody diarrhea in half the cases, vomiting, subnormal temperature, rapid pulse, meteorism, and abdominal rigidity. The **treatment** is resection of the gangrenous intestine, if the process be sufficiently limited. If the superior mesenteric artery is occluded near its origin, the entire small intestine, with the ascending and transverse colon, will be gangrenous and no treatment applicable. In Trotter's series 36.2 per cent. of those operated upon recovered.

THE STOMACH.

Congenital stenosis of the pylorus is due to spasm or to what is probably the result of persistent spasm, hypertrophy of the sphincter with fibrous overgrowth of the submucous tissues. The **symptoms,** which usually begin a few days after birth, are vomiting, intermittent if caused by spasm of the pylorus, persistent, regular, and not bile stained if the result of complete stenosis; distention of the upper abdomen, due to dilatation of the stomach; retraction of the lower abdomen, due to collapse of the bowel; palpable pyloric tumor in two-thirds of the cases; visible gastric peristalsis, passing from left to right; emaciation, progressive in complete stenosis; and constipation, alternating with diarrhea in pylorospasm, and extreme in complete stenosis, an additional sign of which is the failure of methylene blue to appear in the stools after its administration by mouth. X-ray examination, after the administration of bismuth, shows the gastric dilatation; in pylorospasm the bismuth may be retained in the stomach for a variable period and then passed rapidly into the duodenum; in complete stenosis the bismuth remains in the stomach until vomited.

The **treatment** of spasmodic or incomplete stenosis is daily gastric lavage; small quantities of peptonized milk or beef juice by mouth, supplemented by nutrient enemata and cod-liver oil inunctions; heat to the abdomen; and small doses of the bromides or opium per rectum. If vomiting and emaciation continue, or if there are signs of complete occlusion, gastroenterostomy should be performed, an operation which saves 50 per cent. of the patients.

Rupture of the stomach (see Contusions of the Abdomen).

Foreign bodies which are swallowed may give no trouble, and finally be expelled through the anus. Balls of hair, etc., which have formed as the result of the habit of swallowing small particles of such material, may reach a great size and be mistaken for a neoplasm. In these cases, or in case a small foreign body lodges and causes mischief, gastrotomy may be performed and the offending material removed. The X-ray will often be of value for diagnostic purposes.

Peptic ulcer of the stomach is due to auto-digestion of the gastric wall as the result of excessively acid gastric juice (*hyperchlorhydria*), the resistance of the mucous membrane often being lowered by anemia, gastritis (especially the alcoholic form), sometimes by thrombosis, and occasionally by injury. Ulcers due to syphilis, tuberculosis, neoplasms, certain forms of toxemia (hemorrhagic erosion), the swallowing of corrosives, etc., are not included under this heading, although the symptoms may be identical with those of peptic ulcer. Ninety per cent. of the peptic ulcers are situated on the posterior wall of the pyloric region near the lesser curvature, because it is against this point that the gastric contents are hurled, during digestion, by the contraction of the greater curvature. Two forms are described, the acute and the chronic.

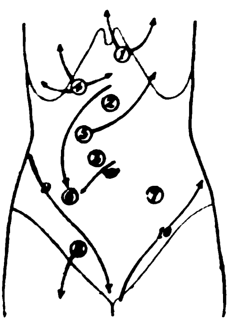


FIG. 373.—Tender points in some abdominal affections. 1. Ulcer on lesser curvature of stomach to the left of the median line; pain may radiate up beneath the sternum and to the heart. 2. Ulcer near the pylorus. 3. Duodenal ulcer. In 1, 2, and 3, pain may strike through to the back. 4. Affections of the gall-bladder (Robson's point); pain may radiate to epigastrium, around the right side to the back, and up to the right shoulder. 5. Chronic pancreatitis (Desjardin's point); pain radiates to the epigastrium and sometimes to the left shoulder. 6. Appendicitis (McBurney's point); pain often begins in the epigastrium or about the umbilicus. 7. Diverticulitis. 8. Ovaritis; pain may radiate down the thigh. 9. Renal colic; pain radiates from the loin, along the ureter, to the genitals. 10. Direction of pain radiated from incipient inguinal hernia, affections of the testicle and spermatic cord, vesiculitis.

Acute ulcer is round, smooth, and funnel-shaped, with the base towards the cavity of the stomach. The edges are sharply defined, have little or no induration, and healing takes place with scarcely any contraction. Acute ulcer is most frequent in chlorotic females between the fifteenth and the thirtieth year. It is generally single, but sometimes there are multiple ulcers, which may involve not only the stomach, but also the duodenum and the lower end of the esophagus.

Chronic ulcers are usually solitary (95 per cent.), have indurated edges, and may be large and irregular. They produce great contraction when they heal, are often adherent to adjacent viscera, and usually occur in males (75 per cent. of the cases) between the ages of thirty and fifty. According to Mayo two-thirds of all ulcers of the stomach and duodenum are duodenal.

Symptoms may be entirely absent (*latent ulcer*). In a typical case there are flatulence, acid eructations, heart burn, a sensation of heaviness and distention in the epigastrium, and pain and tenderness in the region of the ulcer (Fig. 373), often passing to the back and relieved by vomiting, which occurs a variable time after taking food, according to the situation of the ulcer. In ulcers to the left of the median line pain may be experienced as soon as food enters the stomach; in pyloric ulcer pain may not occur for one, two, or three hours after meals. When pain is deferred until near the next meal the ulcer is usually in the duodenum (p. 516). Pain after eating is due to peristalsis, physiologic congestion, increase in the HCl, and to direct irritation of the food. In acute ulcer and in the early stages of chronic ulcer vomiting is due to pylorospasm; in late cases, generally to mechanical obstruction. Rigidity of the epigastric muscles is most frequent when the ulcer has spread to the peritoneum. Hematemesis occurs in one-third of the cases, the quantity of blood varying from a few drops to a pint or more. In some cases visible or occult blood may be found in the stools. In chronic cases a tumor may sometimes be felt. As a rule the appetite is good, and the symptoms recur periodically, oftener in winter than in summer, so that relapses after apparent cure are common. Emaciation is induced in those cases with persistent vomiting. Examination of the stomach contents shows an excess of HCl. After administering bismuth, the ulcer, if deep, may show on a skiagram as a notch with the base towards the stomach, and opposite this there may be a sharp indentation of the greater curvature, due to spasm. An aëro-bismuth diverticulum, i.e., a light stain superimposed on a dark stain, means penetration into a neighboring viscus, usually the pancreas or the liver, hence may require a profile picture for its demonstration. In most instances, however, the ulcer does not show, and the X-ray demonstrates merely a dilatation of the stomach, due to pylorospasm or cicatricial stenosis, with a delay, often of six hours or more, in the passage of the bismuth into the duodenum. Reversed peristalsis and numerous large peristaltic waves, as observed with the fluoroscope, is indicative of pyloric stenosis. Among the complications and sequelæ are perforation (general peritonitis, subphrenic abscess, etc.), grave hematemesis, tetany, stenosis of the pylorus or cardiac orifice (spasmodic or cicatricial), hour-glass stomach, perigastric adhesions, and carcinoma.

The **treatment** of acute ulcer is entirely medical. Chronic ulcer should be treated by gastroenterostomy if marked improvement or recovery does not occur after three months of medical treatment. The mortality of chronic ulcer treated medically is 25 per cent. (Robson), of gastroenterostomy for this condition 5 per cent. As to the late results about 75 per cent. regain good health, 10 per cent. are much improved, 5 per cent. are slightly improved, and 5 per cent. develop a recurrence, a carcinoma, or some other complication or sequel. Moynihan, in addition to gastroenterostomy, inverts the ulcer with sutures to prevent perforation, and ties all visible vessels leading to the ulcer to prevent hemorrhage. Gastroenterostomy drains the stomach, puts the ulcer at rest, and, by allowing a slight reflux of bile and pancreatic juice through the anastomotic opening, partly neutralizes the gastric acidity. When the pylorospasm ceases food tends to pass again through the pylorus, thus occasionally leading to recurrence of the ulcer. This fact, with the observation that the best results are obtained when the pylorus is stenosed, has suggested that, whenever gastroenterostomy is performed, the pylorus, if open, be closed artificially (see Exclusion of the Pylorus). Excision of the ulcer, followed by gastroenterostomy, is recommended by a few surgeons for all cases, but as the operation is more difficult and dangerous (mortality 10 per cent.) than gastroenterostomy alone, it should be practised only when the induration be such as to give rise to a suspicion of cancer, when the ulcer is so situated, e.g., a a distance from the pylorus, as to be little influenced by gastroenterostomy, or when the ulcer has given rise to repeated hemorrhages. Excision gets rid of the ulcer, but unfortunately not of the cause of the ulcer, hence does not exclude, as some believe, the possibility of recurrence and carcinoma. For the methods of excision see Partial Gastrectomy. If, at operation, no ulcer can be demonstrated a gastroenterostomy should not be performed on the theory that it will do no harm, because it is not indicated, and it may do harm, especially in the neurotic. The inexperienced may easily be deceived by the localized muscular contraction of the gastric wall that follows pinching; this hard area, if watched for a short time, can be seen to relax. When no ulcer is present the other abdominal organs should be reviewed and any lesion in them corrected. The appendix should be mentioned particularly, as it not infrequently produces symptoms closely resembling those of gastric ulcer (*appendicular dyspepsia*).

Perforation of the ulcer occurs in about 10 per cent. of the cases, and is much more frequent on the anterior than the posterior wall, owing to the formation of protecting adhesions to the pancreas in the latter situation. The **symptoms** vary in intensity according to whether the perforation is *acute* (no adhesions, wide diffusion of stomach contents through peritoneal cavity), *subacute* (minute opening and gradual leakage), or *chronic* (protecting adhesions and localized peritonitis). *Acute perforation* is announced by sudden violent pain in the epigastrium, which often radiates to the back, up to the left shoulder, and down into the right iliac fossa. There are great tenderness, marked rigidity of the abdominal muscles, and shock of varying severity. There may be absence of liver dulness and movable dulness in the flanks. In about half the cases the stomach contents are vomited, but rarely is there any blood. In 10 per cent. of the cases there is no previous history of indigestion. There may be a leukocytosis.

The **treatment** is immediate abdominal section, any existing shock being combated while the preparations for operation are under way. The incision is made in the middle line above the umbilicus, the perforation closed by a double row of Lembert's sutures of silk without excising the ulcer, the abdominal cavity cleansed with salt solution, and a gauze drain passed down to the vicinity of the perforation. If there is a generalized peritonitis, a second incision should be made above the pubes and the pelvis drained. In cases in which suture is impossible, the opening may be closed by the omentum, a loop of intestine, or gauze packing. The possibility of a second perforation should never be forgotten. Some surgeons perform gastroenterostomy at the time the perforation is closed, a practice which must necessarily increase the mortality, which, at present, is between 40 and 50 per cent.

Hematemesis, or gastrorrhagia, becomes a complication of ulcer of the stomach when it is persistent or grave. It may occur at any time during the progress of the ulceration, and is the cause of death in from 3 to 5 per cent. of all cases (Welch). In the *acute form* the patient vomits a large quantity of blood, sometimes a quart or more, and may never have another hemorrhage, or the hematemesis may be repeated at intervals of several days or longer. Death from one hemorrhage is not common, but such may take place, even without the vomiting of blood, when a large artery is opened. The *chronic form* consists in repeated small hemorrhages. The **diagnosis** involves a differentiation from hemoptysis, and conditions, like *epistaxis*, in which the blood has been swallowed and subsequently vomited. In *hemoptysis* the blood is frothy, bright red, and alkalin instead of acid; it follows coughing, and the physical signs of phthisis are present. An examination of the nose and throat will usually reveal a lesion if the blood has been swallowed. Besides ulcer, hematemesis may be caused by a *leaking aneurysm*, rupture of *varices* of the stomach or esophagus due to obstruction of the portal circulation (e.g., in affections of the heart, spleen, pancreas, and liver, particularly atrophic cirrhosis), *cancer of the stomach* or other tumor, ingestion of *caustics*, "*hemorrhagic erosion*" (e.g., in uremia, phthisis, chronic alcoholism, yellow fever, scorbutus, and leukemia), *post-operative hematemesis*, supposed to be of infectious origin and follows abdominal operations, *neuropathic* hematemesis, and *vicarious menstruation*. For clinical purposes it may be said that a gastric hemorrhage occurring in those in perfect health, or in those who complain of dyspepsia, is due to an ulcer.

The **treatment** of a first attack of *acute hemorrhage* is medical, i.e., absolute rest, no food by stomach, ice to the epigastrium, ergotin hypodermatically, and adrenalin by mouth. Chlorid of calcium, one to two grams per rectum, and the subcutaneous injection of gelatin also have been recommended. With this treatment the hemorrhage will cease in 93 per cent. of the cases, operation under the same circumstances has a mortality of 37 per cent. Should the hemorrhage be repeated once, or at most twice, operation may be undertaken, but is often unsatisfactory, as the bleeding point may not be found, or, if found, hemostasis may be difficult or impossible. The stomach is exposed by a median incision and the exterior examined for evidences of the ulcer (adhesions, scar, thinning of the coats); if such are absent, the stomach is opened, emptied, everted, and the mucous membrane carefully examined. The bleeding point is ligated, sutured, or cauterized; or the ulcer is ligated *en masse* or excised (*partial gastrectomy or pylorectomy*). If the bleeding point cannot be found, or if there is general oozing, or pyloric stenosis, a gastroenterostomy should be performed. *Chronic hemorrhage* is treated by gastroenterostomy, with infolding or, better, excision of the ulcer.

Perigastric adhesions may be caused by ulcer of the stomach or duodenum, by trauma, by inflammatory affections of the biliary apparatus, pancreas, spleen, or intestine, and by tuberculous peritonitis. The *symptoms* are those of stenosis of the pylorus, or indigestion, with pain, particularly when the organ is distended. X-ray examination may show an abnormal position of the pylorus, too slight or no displacement on different observations in different postures, or deformity of the pylorus or the stomach. The adhesions may be separated (*gastrolysis*), and the raw surfaces covered with the omentum to prevent recurrence. There is danger of tearing the stomach or opening a latent perforation. If the pylorus be constricted or an ulcer be present, the operation should be completed by a gastroenterostomy.

Gastric tetany presents the same symptoms as other forms of tetany. It is very rare and almost always associated with gastrectasia, hence the treatment is that of dilatation of the stomach.

Stenosis of the pylorus may be congenital (p. 495) or acquired, extrinsic or intrinsic. The *extrinsic causes* are perigastric adhesions, kinking of the pylorus as the result of prolapse of the stomach, and compression by aneurysm, tumors, cysts, or inflammatory affections of the kidney, liver, pancreas, gall-bladder, or lymph glands. The *intrinsic causes* are pylorospasm (due to ulcer or hyperchlorhydria), cicatricial contraction (ulcer, tuberculosis, syphilis, caustics), tumors, and foreign bodies. The *symptoms* are those of dilatation of the stomach (q.v.), plus in some cases the detection of a tumor at the pylorus. The *treatment* of the extrinsic cases is removal of the cause. or, if such be impossible, gastroenterostomy. Cicatricial stenosis and pylorospasm are best treated by gastroenterostomy. Digital and instrumental dilatation of the pylorus, after gastrotomy, have been abandoned, but pyloroplasty is still employed by a few surgeons. Pylorectomy is indicated in malignant cases, or when there is suspicion of malignancy.

Stenosis of the cardiac orifice (see stricture of the esophagus).

Bilocular stomach (*hour-glass stomach*) may be congenital, but is usually due to cicatricial contraction of a healing ulcer; it may be caused also by perigastric adhesions and cancer. The *symptoms*, when the constriction is small, are those of dilatation of the stomach, the cardiac pouch being dilated owing to interference with the onward passage of food. Occasionally the sulcus may be seen or felt through the abdominal wall, and an X-ray picture taken after the ingestion of bismuth will show the outlines of the stomach (Fig. 381), or at least the cardiac pouch. A diagnosis mus never be made, however, from a single skiagram, as a typical picture of an hour-glass contracture may result from a localized spasm of the muscular coat. Repeated plates on different days should be taken or the stomach watched with the fluoroscope. The spasm will sometimes cease after the application of heat and the administration of atropin. Spasm, it should be noted, may be indicative of an

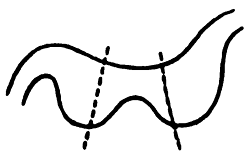


FIG. 374.

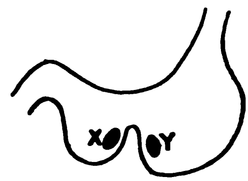


FIG. 375.

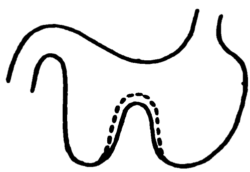


FIG. 376.

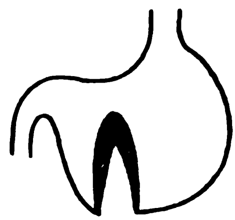


FIG. 377.

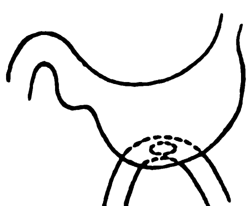


FIG. 378.

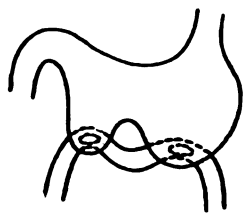


FIG. 379.

FIGS. 374 to 379.—(Moynihan.)

ulcer on the lesser curvature. If the cardiac pouch is filled with fluid, a swelling on the left side of the abdomen may be seen, which gradually passes to the right side, perhaps with an audible gurgle, as the fluid passes through the constriction. In some cases fluid injected into the stomach can only partly be recovered, although a splashing sound persists, and after a time a large quantity of semi-digested food may be returned through the tube. The diagnosis is confirmed by exploratory laparotomy, and one must be careful to examine the whole stomach, otherwise a constriction near the cardiac orifice will be missed. The *treatment* is resection of the stricture (Fig. 374), if it be in the middle of the stomach and the pylorus be patent, or in similar cases a gastrogastrostomy (anastomosis between the two pouches—Fig. 375) or gastroplasty (similar to pyloroplasty—Figs. 376, 377) may be performed. Gastroenterostomy (Fig. 378) is indicated when the cardiac pouch is large or the pylorus closed. If the pyloric pouch also is large, a double gastroenterostomy (Fig. 379) should be performed.

Dilatation of the stomach (*gastrectasia*) may be acute or chronic. **Acute dilatation** of the stomach is a sudden paralytic distention of uncertain origin, but probably the result of disturbed innervation. About 40 per cent. of the cases arise after operations, usually on the upper abdomen (hence shock, sepsis, purgation, handling of the viscera, and the anesthetic have been held responsible), 20 per cent. during exhausting fevers (typhoid, pneumonia, etc.), 10 per cent. after errors in diet, particularly the ingestion of enormous quantities of food or drink, and the rest as the result of trauma, emotional attacks, childbirth, peritonitis, and spinal deformity, especially when there is lordosis, which may encourage pressure on the duodenum. The enormously dilated stomach forces the small intestine into the pelvis and renders its mesentery taut. As a consequence the duodenum is compressed between the root of the mesentery and the superior mesenteric vessels in front and the vertebral column behind. Some surgeons regard this constriction of the duodenum as primary, hence the terms *gastromesenteric ileus* and *arteriomesenteric occlusion*. Even if this is not true, it is certain that a secondary factor is thus added which serves to augment and perpetuate the condition. The **symptoms** are pain; profuse vomiting; severe thirst; distention of the stomach, which interferes with the action of the heart and lungs, and which may be so great as to fill the whole abdomen; gastric splashing sounds on succussion; constipation, perhaps with clay-colored stools; scanty urine; and finally collapse, with, if proper treatment is not quickly administered, death in two-thirds of the cases. The *diagnosis* from peritonitis is made by the absence of fever, leukocytosis, tenderness, and rigidity. In high intestinal obstruction there is little or no distention.

The **treatment** is gastric lavage; placing the patient on the right side with the pelvis elevated, in the knee-chest posture, or prone, in order to relieve the duodenum of pressure; salt solution subcutaneously or intravenously; strychnin, atropin, or eserin salicylate hypodermically; electricity to the epigastrium; and, as a last resort, gastroenterostomy.

Chronic dilatation is usually the result of pyloric stenosis, but may be caused also by duodenal obstruction (e.g., from ulcer, cancer, and, in enteroptosis, compression by the superior mesenteric vessels), overeating, chronic gastritis, and general malnutrition (*atonic dilatation*). The *symptoms* are dyspepsia, often hunger and thirst, and vomiting at intervals of large quantities of decomposing food, some of which has lain in the stomach for several days. The patient emaciates, passes small quantities of urine, is constipated, and may have attacks of tetany. Examination of the stomach contents reveals the sarcina ventriculi and many other bacteria; the amount of hydrochloric and lactic acids will depend upon the cause of the dilatation. The stomach is prolapsed to below the umbilicus, and is often visible through the abdominal wall. Peristalsis passing from left to right likewise may be seen at times. On palpation the cushion-like resistance of the stomach may be felt, a splashing sound often elicited, and in some cases a tumor detected in the pyloric region. The size of the stomach is determined by percussion, after filling the stomach with air or water; by measuring the quantity of fluid which the stomach will hold; or by gastrodiaphany (transillumination by means of an electric lamp passed into the stomach). If the patient takes 10 grains of salol, which is decomposed and absorbed in the intestine only, salicylic acid may not appear in the urine for many hours; normally it should be detected within one hour. The absorptive power of the stomach is determined by giving several grains of potassium iodid and testing the saliva for iodin, which should be found normally in from ten to fifteen minutes. The size, shape, position, and activity of the stomach may be shown also by the X-rays, after administering from two to four ounces of bismuth subcarbonate in a pint of milk or koumyss (Fig. 382). Normally the stomach should be free of the bismuth in from three to six hours. Partial retention after six hours, however, is not always due to organic gastric disease. It may be the result of pylorospasm excited reflexly by a lesion in another adbominal organ

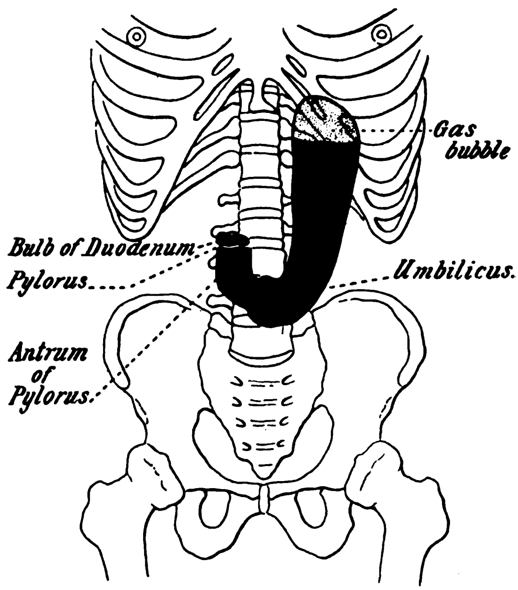


FIG. 380.—Diagram of X-ray shadow of normal stomach after bismuth meal, patient standing.

by toxins (nicotin, morphin, etc), or by emotional causes. With the fluoroscope the peristaltic movements can be kept under continuous observation. A peristaltic wave normally passes over the stomach about every twenty seconds. An increase in the number of waves is seen in stenosis, and also in certain affections of the nervous system (locomotor ataxia). One would suspect organic stenosis if there were numerous waves of great depth. Reversed peristalsis may occur in stenosis from any cause. The shape of the stomach is normal in functional stenosis, plate-like, with displacement of the pylorus to the right, in organic stenosis.

The **treatment** in atonic cases is medical, i.e., lavage, regulation of the diet, electricity, etc. If medical treatment fails, gastroplication may be performed. In those cases depending upon obstruction to the outlet of the stomach, the treatment is that of pyloric stenosis.

Gastroptosis, or prolapse of the stomach, is usually secondary to gastric

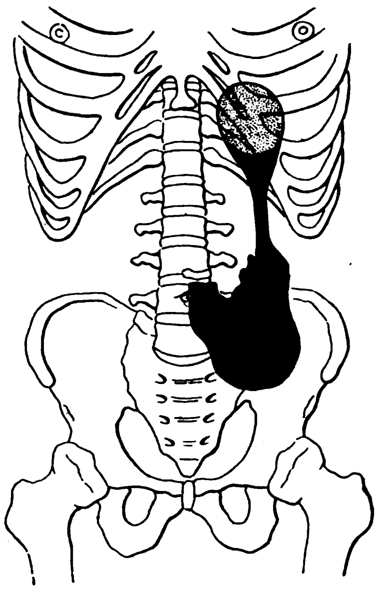


FIG. 381.—Diagram of X-ray shadow of hour-glass stomach after bismuth meal, patient standing.

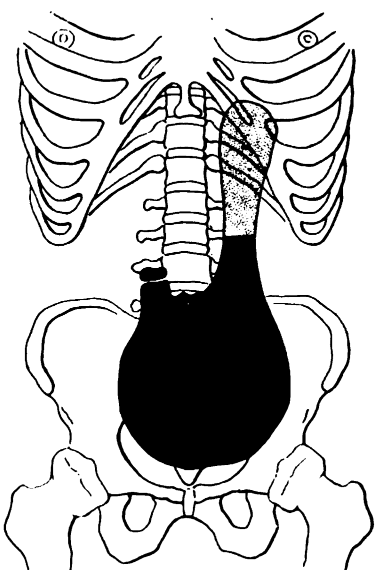


FIG. 382.—Diagram of X-ray shadow of gastrectasia, patient standing.

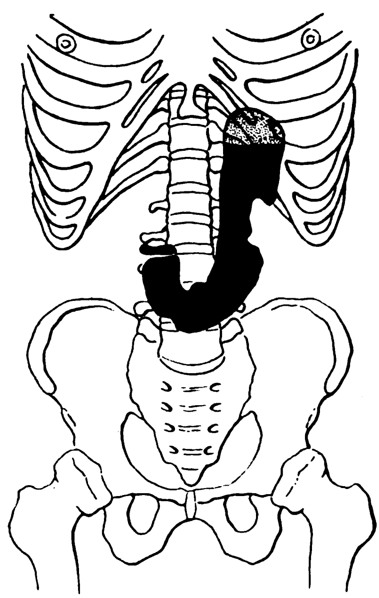


FIG. 383.—Diagram of X-ray shadow of stomach with carcinoma of the greater curvature, patient standing.

dilatation, when the symptoms and treatment will be those of gastrectasia. It forms part also of the general visceral ptosis called Glénard's disease. *Primary or essential gastroptosis* is probably very rare, and is constantly linked with dilatation, from kinking of the pylorus, or from pylorospasm the result of hyperacidity. The symptoms are therefore usually those of chronic indigestion and gastric stasis. The position of the stomach may be determined by percussion, after filling the stomach with air or water, or by the X-ray (vide supra). The *treatment* of the essential form is gastroenterostomy, with or without gastropexy.

Carcinoma of the stomach is very frequent, sarcoma and innocent tumors are rare. Carcinoma may involve any portion of the stomach, but most often affects the pylorus (60 per cent.), often starting from an old ulcer. It is more frequent in the male, and is unusual before the fortieth year. It may be of any variety, but is usually scirrhous in nature. It always begins in the mucous membrane, infiltrates the remaining coats of the stomach, and finally invades the surrounding organs, particularly the liver and pancreas. Perforation of the stomach occasionally occurs. The lymphatic glands, particularly those along the lesser curvature, are invaded at an early period, and distant metastases also may occur. The "leather bottle stomach" is a diffuse carcinomatous infiltration of the whole organ. The disease is fatal in from a few months to two years or longer, according to the nature and situation of the growth.

The **symptoms** at first are those of chronic gastritis or nervous dyspepsia, i.e., interference with the appetite, thirst, a sense of fulness, eructations, nausea, vomiting, and usually constipation. Pain in the epigastrium and back may be an early symptom, but is sometimes absent in even the later stages; it may be increased or relieved by food. If in spite of careful medical treatment, symptoms of this character persist for a month or longer, and are associated with a progressive loss of weight, in a patient past forty, one should always suspect carcinoma, and advise an exploratory incision, which is the most reliable diagnostic measure. This is the time for successful surgical treatment. Among the later symptoms are coffee-ground vomit (decomposed blood), cachexia, palpable tumor (absent in 40 per cent.), ascites, distention of the superficial abdominal veins, swelling of the legs, femoral phlebitis, and jaundice owing to involvement of the common bile duct. Enlargement of the lymph glands at the base of the neck due to metastasis up along the lymphatics of the mediastinum is a rare sign. Metastases in Douglas's pouch or in the ovaries may occur, and operation should never be performed without first making a rectal or vaginal examination. The laboratory methods of diagnosis are unreliable in the early stages, and are of the greatest value only when the growth is inoperable. At this time examination of the gastric contents shows an absence of free hydrochloric acid and an increase in the amount of lactic acid, both of which conditions may be found in other gastric diseases. Microscopic examination of the stomach contents may show small portions of the neoplasm and the Oppler-Boas bacilli, and these bacilli and occult blood may be found in the stools. The motor and absorptive powers of the stomach are lessened. Blood examination shows a reduction in the hemoglobin and an absence of the digestive leukocytosis. Finally may be mentioned the possibility of making a diagnosis by the esophagoscope, introduced into the stomach; by transillumination with an intragastric lamp, showing a tumor on the anterior wall; and by the X-rays, after the ingestion of an emulsion of bismuth, the tumor appearing as a marked indentation in the outline o' the stomach (Fig. 383). The situation of the growth has a marked influence on the symptoms. When the cardiac orifice is involved the symptoms are those of stricture of the esophagus, and a tumor cannot be felt. When the growth is at the pylorus, the symptoms are those of dilatation of the stomach, and the tumor is more apt to be palpated. When neither orifice is involved, vomiting may be absent, and a tumor may or may not be felt, according to its size and situation.

The **treatment** is exploratory incision, and if possible, removal of the growth by partial or complete gastrectomy. Kocher claims 8 per cent. of permanent cures from operation. If the patient is very weak and the growth situated at the pylorus, one may perform gastroenterostomy and after the patient has regained strength proceed with the pylorectomy. In inoperable growths of the cardiac orifice (see Stricture of the Esophagus), gastrostomy will be indicated for the purposes of feeding. In inoperable cancer of the pylorus gastroenterostomy may be performed, in order to allow the passage of food into the bowel. When the entire stomach is hopelessly invaded, the only possible measure which promises relief is jejunostomy, or the making of an artificial opening into the jejunum in order to feed the patient.

Gastritis obliterans (*plastic linitis*) is a rare affection, characterized by great thickening of the walls of the stomach as the result of hyperplasia of the submucosa, and a progressive diminution in the size of the stomach. It is a cirrhotic inflammation, the cause of which is unknown. The *symptoms* are pain, vomiting immediately after taking food, and emaciation. The *treatment* is pyloroplasty or gastroenterostomy, when the pyloric portion is chiefly involved; or partial or complete gastrectomy.

Volvulus of the stomach also is rare. It may be associated with diaphragmatic hernia. The *symptoms* are pain, shock, and distention of the upper abdomen. Vomiting cannot occur. The *treatment* is laparotomy, reduction of the twist, and shortening of the gastrohepatic omentum.

OPERATIONS ON THE STOMACH.

Gastric lavage is required in cases of poisoning, as a preliminary to operations on the stomach, and as a therapeutic measure in many gastric diseases, particularly dilatation. The stomach tube is lubricated with glycerin, guided over the epiglottis by the forefinger, and pushed into the stomach while the patient makes efforts at swallowing. Water or other fluid is then poured into the funnel end of the tube until the requisite amount has been introduced, when it is carried to a lower level than the stomach while still full of liquid, thus syphoning off the contents of the stomach. The washing may be continued until the stomach is clean.

Gastrotomy, or incision into the stomach, may be performed for exploratory purposes, gastric hemorrhage, the removal of foreign bodies from the esophagus or stomach, and for the dilatation of stricture of either orifice of the stomach. A median abdominal incision is made, and the stomach drawn into the wound, isolated with gauze, and incised at the desired point. The wound is sutured with catgut, passing through all the coats, and over this is placed a layer of Lembert sutures of silk. The operative field is then cleansed with salt solution, and the abdomen closed without drainage. The patient begins to take water after the vomiting has ceased, and solid food at the end of two or three weeks.

Gastrostomy is the making of a permanent opening into the stomach, for the purpose of feeding a patient with inoperable stricture of the esophagus. The opening should permit feeding, prevent the external leakage of the gastric contents, and be as near the cardiac orifice as possible. **Hartmann** and others make a vertical incision through the outer border of the left rectus, retract the inner portion of the muscle towards the right, and open the posterior sheath and peritoneum near the middle line. A cone of the stomach is pulled through the wound, and sutured to the parietal peritoneum and the skin. The apex of the cone is opened, and the patient fed with a rubber tube.

Frank's operation is recommended when the stomach is not too small; a two inch incision is made below and parallel with the left costal margin, then a cone of the stomach is drawn through this incision, and passed upwards under the skin to a second incision, about one inch in length, situated over the costal margin. The stomach is sutured to the muscles of the first incision, and to the skin of the second incision, where it is opened and a tube inserted.

In **Witzel's operation** the abdomen is opened through the left rectus, a catheter passed into the stomach through a small opening and there

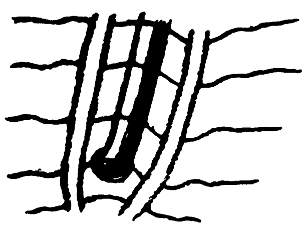


FIG. 384.—Witzel's gastrostomy. (Binnie.)

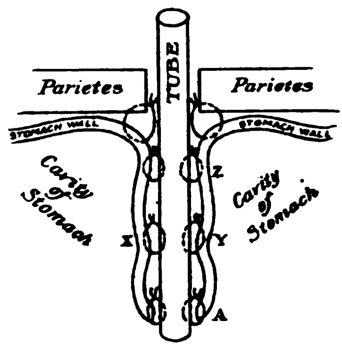


FIG. 385.—The Stamm-Kader gastrostomy. (Binnie.)

sutured with catgut, and a canal formed about the tube by suturing the walls of the stomach over it with Lembert sutures (Fig. 384). The outer opening of the canal is sutured to the parietal peritoneum and the abdomen closed. The **Stamm-Kader operation** is shown in Fig. 385. Other methods, similar to those proposed for esophagoplasty, have been suggested, but are too complicated and dangerous, unless one desires to build an artificial esophagus.

Gastroplication consists in lessening the size of the stomach by the introduction of inversion sutures into its anterior wall. It is doubtful if this operation should ever be employed.

Gastropexy also is of doubtful value. The stomach has been sutured to the anterior abdominal wall and to the liver. Beyea shortens the gastrohepatic and gastrophrenic ligaments by the introduction of reefing sutures.

Gastroenterostomy, or the formation of a fistula between the stomach and the intestine, is indicated in pyloric stenosis, gastrectasia, and gastric ulcer. The operation is very frequently performed at the present time with the most satisfactory results. The mortality in benign cases is 5 per cent., in malignant cases about 20 per cent.

Anterior gastroenterostomy, or Wolfler's operation (Fig. 386), is indicated in cases in which the posterior operation is not applicable because of the presence of adhesions, etc., and in cases of malignancy when every minute should be saved. Its disadvantages are the presence of a long loop of intestine attached to the stomach, which may cause obstruction by pressure on the transverse colon or by allowing adjacent coils of intestine to slip into the noose. It also puts out of commission a long segment of intestine which is of great importance for the purposes of digestion and absorption. After

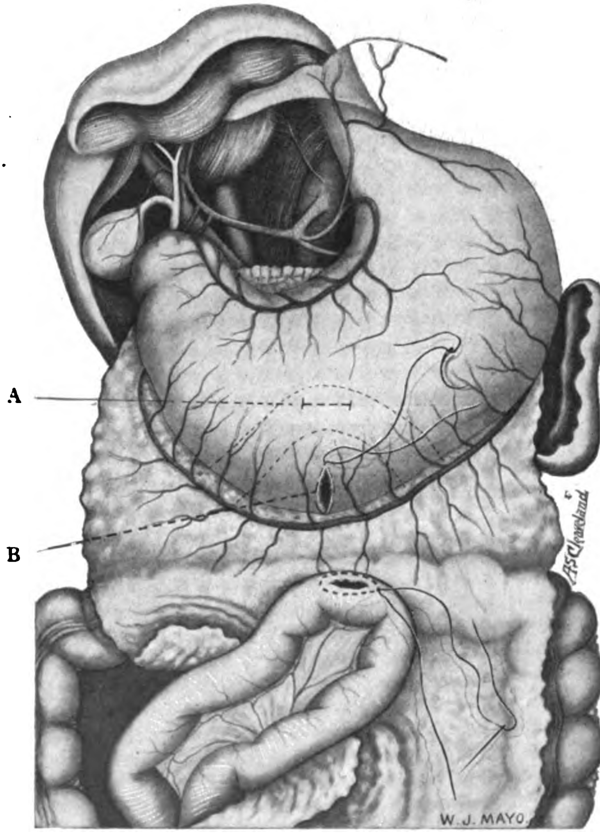


FIG. 386.—B. Proper position for opening in stomach. A. Improper position, allowing formation of intragastric pouch. (Mayo.)

opening the abdomen in the middle line above the umbilicus, the omentum is pulled upwards, and a loop of jejunum, about a foot from the duodenum, brought up over the transverse colon and anastomosed with the lowest point on the anterior wall of the stomach, by suturing; the Murphy button and the McGraw elastic ligature are no longer employed. The loop of intestine and that portion of the stomach to be opened are first secured by clamps, the blades of which are covered with rubber tubing, in order to prevent leakage and bleeding. It is usually desirable to unite the stomach to the bowel with a few additional sutures on each side of the opening in order to prevent a sharp

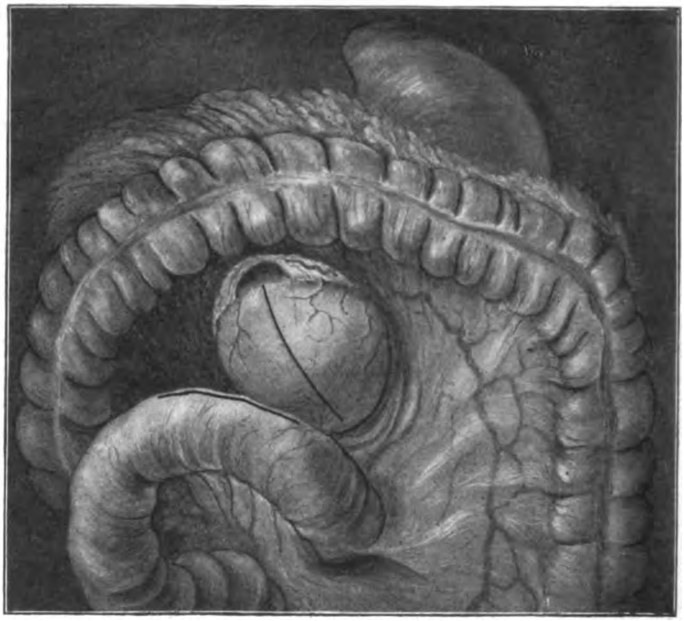


FIG. 387.—Showing posterior wall of the stomach drawn through a rent in the transverse mesocolon. Note slight separation of gastrocolic omentum from its attachment to the stomach, permitting anterior wall of stomach to appear, and insuring drainage at lowermost level. Black lines mark site of proposed anastomosis; the jejunum shows at its origin. (Mayo.)

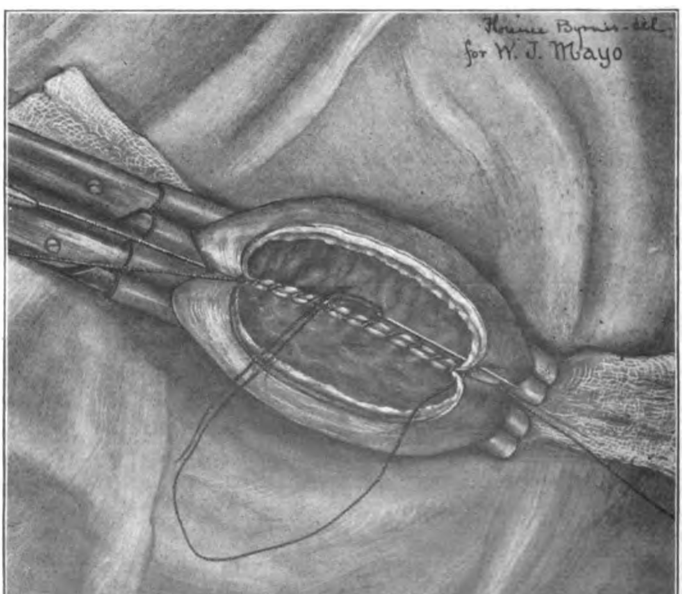


FIG. 388.—Forceps in place and anastomosis half completed by suture. (Mayo.)

kink. Kocher places the afferent limb of intestine posteriorly and invaginates its wall transversely, in order to form a valve which will direct the stomach contents into the efferent limb of intestine.

Posterior gastroenterostomy, or Von Hacker's operation, has advanced to its present state of efficiency largely through the labors of Peterson, Czerny, Mikulicz, Moynihan, and Mayo. The gastric opening should be at the lowest point of the posterior wall of the stomach, in the same plane as the cardiac orifice, and directed obliquely from above downward and from right to left, in order to avoid angulation of the jejunum, which normally passes in this direction. Har mann, however, states that when the anastomosis is made in the cardiac portion of the stomach the gastric contents flow through the pylorus, when in the pyloric antrum, which is the motor part of the stomach, they pass almost entirely through the anastomosis. The opening in the intestine should be longitudinal and opposite the mesentery, as near the origin of the jejunum as possible, usually from two to four inches, thus utilizing that portion which normally lies immediately behind the stomach and avoiding a loop. Clamps should be used, both on the intestine and the stomach, to prevent extravasation of contents and bleeding during the operation. The operation is performed as follows: The abdomen is opened by a four inch incision, separating the fibers of the right rectus muscle. The transverse colon and omentum are turned up over the epigastrium, and the mesocolon torn through at a bloodless spot within the loop of the middle colic artery. A fold of the posterior wall of the stomach is drawn through this opening and clamped with long Doyen forceps, the blades of which are covered with rubber tubing. The forceps should include a portion of the greater curvature, the great omentum being separated slightly for this purpose (Fig. 387). The jejunum just below its origin is now brought to the surface and clamped. The origin of the jejunum may be found by carrying the finger along the root of the transverse mesocolon to the left of the spine. The clamps are laid side by side and surrounded by gauze pads. With a continuous Lembert suture of silk or celluloid thread the stomach is sutured to the intestine for at least two and one-half inches. Both the stomach and intestine are now incised down to the mucous membrane, about one-fourth of an inch in front of the suture line. The mucous membrane exposed by the retraction of the outer coats is excised, and the stomach united to the intestine all around the anastomotic opening by a continuous catgut suture, passing through all the coats in order to give firm apposition and stop bleeding (Fig. 388). The clamps are now removed and the continuous Lembert suture continued around the opening to its point of origin. The edges of the tear in the mesocolon are fastened to the stomach to prevent hernia, and the abdomen closed without drainage. After operation the patient is put in the semi-sitting posture and fed as after gastrotomy.

The **vicious circle** is a term applied to the passage of stomach contents into the afferent limb of gut, thence back into the stomach, which is emptied by vomiting. Kocher's method for preventing this accident has already been mentioned. In operations with a loop an anastomosis may be made between the lowest portion of the loop and the jejunum. In addition to this measure the afferent loop may be ligated with silk, fascia, etc., between the two points of anastomosis, or the pylorus may be closed (see Exclusion of the Pylorus). In Roux's method "en Y" the jejunum is divided, the lower segment anastomosed with the stomach, and the upper segment with the side of the lower segment several inches below the stomach. The posterior operation without the loop is very rarely if ever followed by the vicious circle. When vomiting occurs after these cases, it is due to the passage of large quantities of bile into the stomach through the anastomotic opening, kinking of the bowel, or contraction of the anastomotic opening. Persistent vomiting unrelieved by gastric lavage requires a secondary operation for the relief of the obstruction.

Peptic ulcer of the jejunum may follow gastroenterostomy, owing to the corrosive action of the gastric juice. It is probably more frequent than is generally thought, many cases being unrecognized. Roojen (1910) has collected 89 cases, most of which occurred after the anterior operation, the reason for this being that the upper portion of the jejunum, such as is utilized in the posterior operation, is more resistant to the digestive action of the gastric juice, owing to the presence of bile and pancreatic fluid. The onset of symptoms varied from ten days to nine years after the gastroenterostomy. The ulcer is usually in the descending limb of bowel, but may attack the

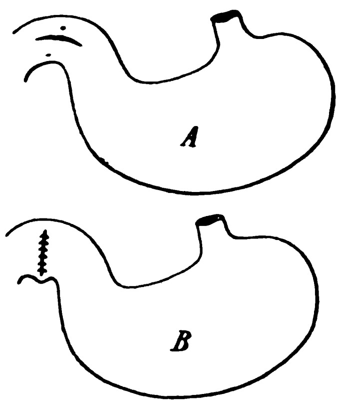


FIG. 389.—Heineke-Mikulicz pyloroplasty. *A*. Direction of incision in pylorus. *B*. Incision sutured.

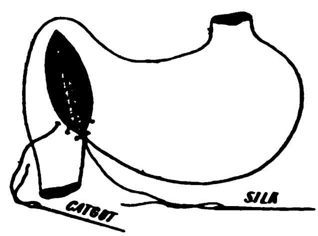


FIG. 390.—Finney pyloroplasty, the posterior sutures of silk and catgut and the first anterior sutures of catgut inserted.

anastomosis itself or the afferent limb; in several cases there were multiple ulcers. Not one occurred after gastroenterostomy for cancer, hydrochloric acid generally being absent in these cases. The ulcer may perforate into the transverse colon, into the general peritoneal cavity, or it may cause a localized peritonitis. These cases emphasize the importance of treatment after gastroenterostomy, particularly in the presence of hyperacidity. Cases of acute perforation may be saved by operation. In chronic cases a new gastroenterostomy may be made as far from the pylorus as possible, in order to avoid the acid-forming portion of the stomach.

Exclusion or occlusion of the pylorus has been performed to prevent or to break the vicious circle (vide supra), to promote the healing of a duodenal fistula, to give ulcers of the pylorus and duodenum complete rest, and to maintain the patency of a gastroenterostomy opening, which, if the pylorus remains open, tends, it is said, to contract and finally to close. The last-mentioned indication is of doubtful importance, since, although the gastric contents after gastroenterostomy often prefer the old to the new exit, it is unlikely that a well-made anastomotic opening, unless complicated by ulceration at the suture line, would, even if non-functionating, suffer obliteration. Von Eiselberg's unilateral exclusion of the pylorus is effected by dividing the pyloric antrum between clamps, and then closing the wounds on each side of the division. Dobbertin leaves the gastric wound open, and anastomoses it, behind the colon, with the antimesenteric border of the upper jejunum. Bartlett draws up and kinks the pylorus with a skewer, clamps the base of the loop, passes mattress sutures through the four walls between the skewer and the clamp, amputates above the sutures, applies another series of stitches to the four exposed cut edges, and covers them with a continuous Lembert's suture. Biondi incises down to the mucosa, which is separated as a cone without being opened, ligated in two places, and divided between the ligatures. The ends are invaginated, and the incision in the outer coats closed. The operation has been modified by simply ligating the cone of mucosa with a transplant of fascia (Strauss). Girard incises the outer coats of the pylorus transversely to its long axis and sutures parallel with the axis. The pylorus may be occluded by puckering the outer coats with invagination sutures (Doyen), or by ligation with silk (Kelling), wire, aluminium bands (Brewer), etc., or with a transplant of omentum, fascia (Wilms), or round ligament of the liver (Polya). The value of pyloric closure as an adjuvant to gastroenterostomy cannot be doubted. Von Eiselberg's operation is sure to exclude the pylorus, but it increases the risk of death. Henle reports a mortality of over 16 per cent. with exclusion, 6 per cent. with gastroenterostomy alone. Ligatures of foreign material usually cut their way into the pylorus, which again becomes permeable. Personally we employ a strip of fascia from the rectus, or the round ligament of the liver. Clinically the results have been good. In one patient who was reoperated upon over a year later the pylorus was found still closed.

Operations for Hour-glass Stomach (see Figs. 374 to 379).

Pyloroplasty is used by a few surgeons for benign pyloric stenosis. The *Heineke-Mikulicz operation* consists in making a longitudinal incision through the stricture and suturing the wound transversely (Fig. 389). This has been superseded by *Finney's pyloroplasty,* which not only enlarges the pylorus, but also lowers the outlet of the stomach. After applying clamps to the stomach and duodenum the greater curvature of the stomach is sutured to the posterior surface of the duodenum with silk. An incision is then made in front of these sutures on the inferior surface of the pylorus and continued into the stomach and duodenum. The posterior, then the anterior, lips of this incision are united by catgut, the clamps removed, and the Lembert suture continued anteriorly as in gastroenterostomy (Fig. 390).

Gastrectomy may be partial or complete.

Partial gastrectomy is performed for ulcer or for localized tumors of the gastric wall. A piece of the *anterior wall* of the stomach or of the greater curvature is easily excised, the wound being closed as in gastrotomy. Excision of a portion of the *lesser curvature,* e.g., for ulcer, is more difficult. The method we have adopted is to make an opening in the gastrohepatic, and another in the gastrocolic, omentum. Clamps, applied from below, are placed across the whole width of the stomach, on each side of the ulcer. This is much easier than trying to isolate the ulcer alone by clamping the lesser curvature from above. The coronary vessels are ligated to the right and the left of the ulcer; the ulcer is excised by a V-shaped incision; the clamps are lifted and rotated, so as to bring in contact the peritoneal surfaces on each side of the incision in the posterior wall; tenaculum forceps applied to the inverted upper and lower ends of the posterior incision, to maintain the inversion and prevent slipping of the clamps; the posterior peritoneal surfaces sutured, through the anterior wound, with celluloid thread, the posterior mucous surfaces with catgut; then the anterior mucous surfaces with catgut, the anterior peritoneal surfaces with an inversion suture of celluloid thread. The clamps are removed, the openings in the omenta closed. The suture line runs perpendicularly to the long axis of the stomach; suturing in the opposite direction produces too much narrowing of the gastric cavity. If there is a large saddle ulcer or an hour-glass constriction the entire middle segment of the stomach may be removed by *circular resection* (Fig. 374). Excision of a portion of the *posterior wall*, e.g., for ulcer, may be accomplished after pushing the posterior wall through an opening in the gastrohepatic or the gastrocolic omentum, or through the transverse mesocolon. When the ulcer

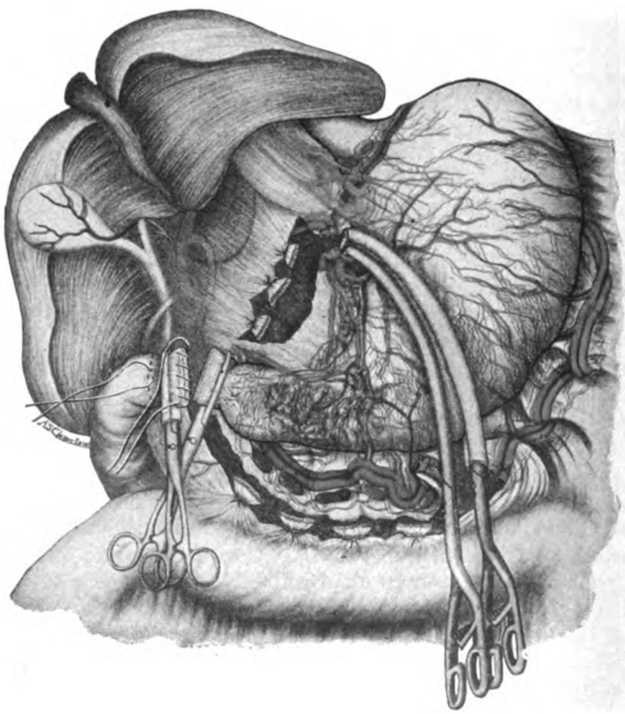


FIG. 391.—(Mayo.)

is densely adherent Mayo performs *transgastric partial gastrectomy*. The anterior wall of the stomach is incised, and through the stomach the ulcer is removed and the resulting wound sutured. The incision in the anterior wall is then closed. Resection of the *cardiac orifice* is described under Stricture of the Esophagus. The term *pylorectomy* may mean not only resection of the pylorus alone, but also resection of the pylorus and a large amount of the stomach. Perhaps it would be better to designate the latter as *subtotal gastrectomy*. These operations are described below.

Pylorectomy is usually performed for carcinoma, occasionally for peptic ulcer. Rodman urges the more frequent use of this procedure in gastric ulcer, in order to remove the ulcer bearing portion of the stomach and prevent the development of carcinoma. After the pylorus has been removed there are several ways of restoring the continuity of the gastrointestinal canal. In Billroth's first method the open end of the duodenum was sutured to the lower end of the wound in the stomach, the superfluous part of the stomach wound being closed by sutures; leakage often occurred where the three lines of suture met. The whole of the gastric wound, or, as will be described later, only the lower part, may be anastomosed with the side of the jejunum. In Kocher's method the stomach wound is closed and the end of the duodenum anastomosed to the posterior gastric wall. In Billroth's second method, the procedure now generally employed, both the wound in the stomach and that in the duodenum are closed and a gastrojejunostomy performed. Mayo

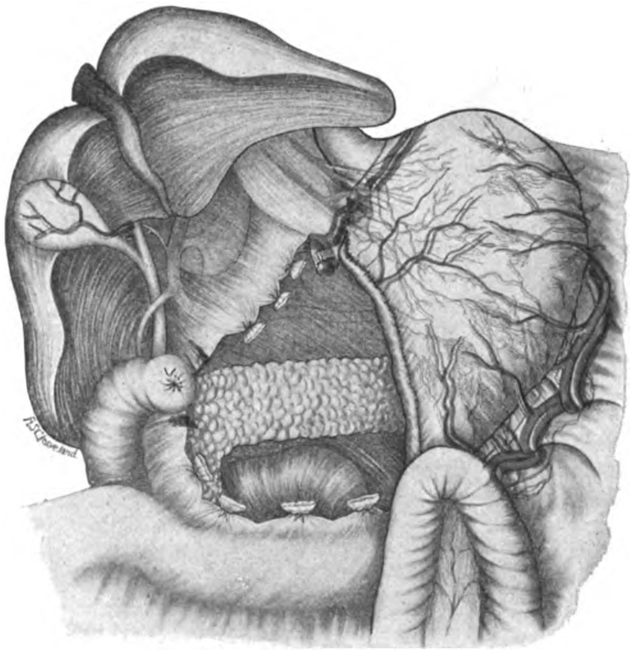


FIG. 392.—(Mayo.)

performs the operation as follows: "Open the abdomen by a longitudinal incision from the ensiform cartilage to the umbilicus; ligate and divide the gastric artery near the stomach, ligate and divide the gastrohepatic omentum close to the liver and tie the superior pyloric artery. Free the upper part of the duodenum and, with the finger as a guide beneath the pylorus in the lesser peritoneal cavity, ligate the right gastroepiploic or gastroduodenal artery. Tie and sever the gastrocolic omentum near the colon as far as the desired point on the greater curvature, and here secure the left gastroepiploic vessels. Apply two short clamps to the duodenum, sever the duodenum between the clamps with the cautery, and close it by a continuous catgut suture which is buried by a purse-string suture of silk. Double clamp the stomach along the Mikulicz-Hartmann line (Fig. 391), and sever between the clamps with the cautery. Close the stomach by a continuous suture of catgut and a continu-

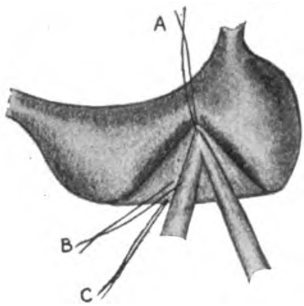


FIG. 393.

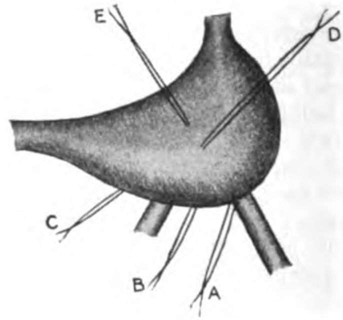


FIG. 394.

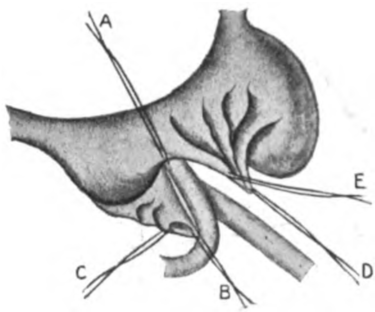


FIG. 395.

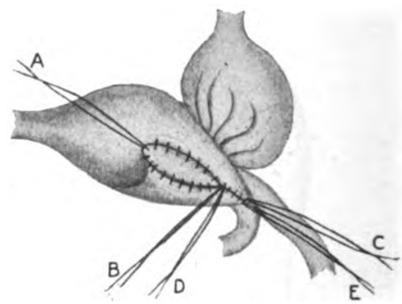


FIG. 396.

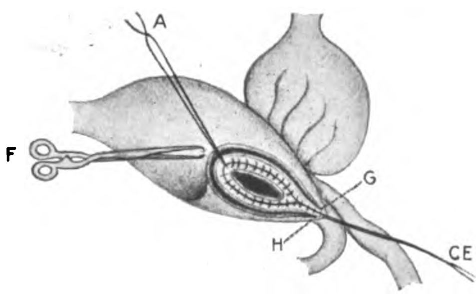


FIG. 397.

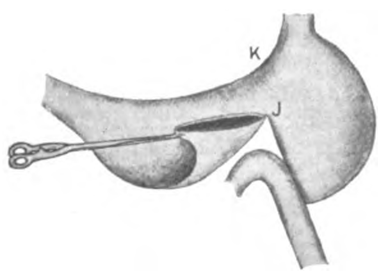


FIG. 398.

FIG. 399.

FIGS. 393 to 399.—Subtotal gastrectomy.

ous Lembert suture of silk. Perform a gastrojejunostomy (Fig. 392)." This operation removes the growth and the lymphatic glands into which it drains, i.e., those along the lesser curvature, and those along the greater curvature near the pylorus. The latter group of glands drains the adjacent third of the stomach, the lymph stream flowing from left to right, hence the absence of involvement, in pyloric carcinoma, of the lymph glands along the left two-thirds of the greater curvature. The mortality of pylorectomy for cancer is between 10 and 20 per cent., while permanent cures may be obtained in from 5 to 10 per cent. of the cases.

The **author's method of subtotal gastrectomy** "consists in removing the diseased segment of stomach from left to right, after performing an end-to-side anastomosis between the lower portion of the incision that amputates the stomach and the upper part of the jejunum, the operation being so conducted that the suturing necessary to unite the stomach to the intestine is completed before either viscus is opened. The gastric artery is doubly ligated at the upper end of the proposed line of section of the stomach, and divided between the ligatures. The gastrohepatic omentum is tied in sections and severed. The left gastroepiploic artery is ligated about one-half inch on each side of the lower end of the proposed line of section of the stomach, and the segment of artery between the ligatures excised. The gastrocolic omentum is tied and cut, from a point about two inches to the cardiac side of the selected line of gastric amputation to the duodenum. The transverse mesocolon is drawn taut, without pulling the colon from the abdominal cavity, and a hole torn in this membrane, from the upper side, within the arc of the midcolic artery. The upper end of the jejunum immediately bulges into this opening and is drawn into the lesser peritoneal cavity. A suture is passed through the greater curvature of the stomach, midway between the ligatures on the left gastroepiploic artery, and through the antimesenteric border of the jejunum, at a point about five or six inches below the origin of the jejunum, the distance varying according to the degree of dilatation of the stomach. By pulling upwards on this suture the posterior wall of the stomach and the upper segment of the jejunum are brought in contact. A suture uniting the posterior wall of the stomach to the intestine is inserted about three inches above the original suture, and a third suture is passed through the posterior wall of the stomach alone, an inch or more above the second suture (Fig. 393), both of these sutures being on the line through which the stomach is to be amputated. Two sutures are now placed in the anterior wall of the stomach, at points corresponding to the upper sutures in the posterior wall (Fig. 394). The point at which each anterior suture is to be inserted may be determined easily by grasping the stomach with the left hand in such a way that the index finger presses the point of insertion on the posterior wall up against the corresponding point on the anterior wall, which point is marked by the thumb. Suture A is now drawn upwards to the right (i.e., towards the patient's right shoulder), sutures B and D downwards to the left (i.e., towards the patient's left hip) and tied together, sutures C and E likewise downwards and to the left and tied together (Figs. 395 and 396). The upper segment of the jejunum is thus surrounded by the stomach, the anterior wall of which lies against the right side of the bowel, the posterior wall against the left side of the bowel. Between sutures B, D and sutures C, E the anterior and the posterior walls of the stomach are in contact, which contact is made permanent by the introduction of a seroserous suture of celluloid thread, which suture is continued from B, D to A, uniting the anterior wall of the stomach to the bowel, and from A back to B, D, uniting the posterior wall of the stomach to the bowel (Fig. 396). This seroserous suture is overlaid by a through-and-through catgut suture, and sutures B and D are cut off short. The greater curvature of the stomach is grasped with forceps about one-half inch from A (Fig. 397), and the lesser peritoneal cavity filled with gauze. The portion of the antimesenteric border of the intestine exposed between the rows of sutures is excised, and an incision made in the stomach close to the suture line, beginning at G, passing between A and F, and ending at H (Fig. 397). After ligating any vessels which have not been caught by the sutures, thread A is cut and the stomach allowed to straighten itself (Fig. 398). A clamp is placed across the stomach to the pyloric side of the line of section, and the amputation completed after approximating the anterior and the posterior walls of the stomach, between J and K (Fig. 398), by several through-and-through sutures of catgut, which sutures are buried by an inversion seroserous suture of celluloid thread. It is well, but not essential, to insert the uppermost inversion suture before completing the amputation of the stomach, since by pulling on this suture the raw edges, which are already inverted at the lower end (J, Fig. 398), recede between the serous coats, which can then be rapidly sutured (Fig. 399). The pyloric segment of the stomach is drawn from the abdominal cavity and turned over on the patient's right hypochondrium, the superior pyloric and the gastroduodenal arteries secured above and behind the pylorus, the duodenum severed between ligatures, and the duodenal stump inverted. The edges of the rent in the transverse mesocolon may be attached to the jejunum or, if there is much gastrectasia, to the stomach. The operation just described may be performed in any case of gastrectomy in which posterior gastroenterostomy is applicable, and perhaps in some in which, owing to the small size of the gastric stump, posterior gastroenterostomy would be injudicious. With equal practice in the two operations the newer one should be less difficult and more rapid; there is less cutting to be done, consequently less suturing; the lower part of the incision for amputating the stomach serves at the same time for the anastomotic opening. In the newer method the anastomotic opening is at the lowest part of the stomach, and all of the anastomotic sutures and a portion of the sutures which close the stomach above the anastomosis, are in place before either the stomach or the intestine is opened. When the incisions are made the cut edges are in view, unrestrained by clamps, so that hemostasis may be made absolute" (Trans. of the Amer. Surg. Assoc., 1914).

Complete, or total gastrectomy has been performed twenty-five times, with thirteen recoveries. It is indicated in the rare cases in which almost the en ire stomach is cancerous, but in which the surrounding organs are free. The greater and lesser omenta are ligated and divided, and the entire stomach removed between clamps. The open end of the duodenum is closed, and the esophagus anastomosed to the upper jejunum with sutures or a Murphy button. In some cases it may be possible to anastomose the esophagus to the duodenum.

THE INTESTINES.

Ulcer of the duodenum is usually solitary and located on the anterior wall within two inches of the pylorus, at the point where the acid gastric contents, ejected through the pylorus, strike the duodenal mucosa. It is due to the same causes and occurs twice as often as ulcer of the stomach, is more common in men (4 to 1) between the ages of thirty and fifty, and, unlike gastric ulcer, shows little tendency towards carcinomatous degeneration. The symptoms are much like those of gastric ulcer, but vomiting is less frequent and occurs at a longer period after meals; blood is more apt to be passed by bowel than vomited, so that serious bleeding, although causing faintness, pallor, etc., may not be suspected unless the stools are examined; the pain occurs several hours after eating, not infrequently after the patient has retired for the night, and is often relieved by food (hunger pain), probably because the food gives the HCl something to act upon and stimulates the secretion of the alkaline duodenal juices; and the tender point is just above and to the right of the umbilicus (Fig. 373). The X-ray, after the ingestion of bismuth, shows no pylorospasm but rather incontinence of the pylorus, the bismuth flowing at once from the stomach, which may be empty at the end of two or three hours, and is always empty at the end of five or six hours; a notch with the base towards the duodenum is seen only in very deep ulcers. Perforation and fatal hemorrhage may occur. The treatment is that of gastric ulcer. (See also Curling's ulcer of the duodenum, under burns.)

Wounds of the intestine (see contusions and wounds of the abdomen).

Congenital stenosis of the intestine may occur near the common bile duct, and in the lower ileum at a point corresponding to the situation of Meckel's deverticulum. Imperforate anus is considered on a later page. **Meckel's diverticulum** is a persistent omphalo-mesenteric duct, which generally arises from the ileum about three feet above the ileocecal valve. It exists in 2 per cent. of human beings. It may open at the umbilicus (*congenital fecal fistula,* see umbilicus), or be obliterated in whole or part, the obliterated portion persisting as a cord attached to the umbilicus, the mesentery, or other viscus. In many cases the diverticulum hangs free in the peritoneal cavity, its interior being lined with mucous membrane and communicating with the intestine. The structure may become inflamed, the symptoms and treatment being the same as those of appendicitis, or it may cause intestinal obstruction by kinking or twisting the bowel, by invaginating into the bowel (*intussusception*), or by acting as a band or noose which constricts or ensnares a coil of intestine. Obstruction is most common in early life and the patient may exhibit other deformities, but there is nothing distinctive in the symptoms. When inflamed or giving rise to obstruction, the diverticulum should be excised, and the opening in the bowel closed with Lembert sutures.

Acquired diverticula are most frequent in the descending colon and sigmoid of fat constipated men past middle life. They are usually multiple, may be very minute or as large as a cherry, and represent hernial protrusions of the mucosa through the muscularis, often at the points where vessels pierce the bowel wall to enter the appendices epiploicæ. **Diverticulitis** often results from the irritation of a fecal concretion. The *symptoms* of the acute form are those of appendicitis, except that the trouble is in the left abdomen (Fig. 373). Perforative peritonitis or localized abscess may follow. In the chronic variety the colon about the diverticulum participates in the inflammation and finally becomes thick, hard, and contracted, causing symptoms of chronic obstruction, and closely mimicking scirrhous carcinoma. The *treatment* of perforation is suture; of abscess, drainage; of stricture, excision.

Idiopathic dilatation of the colon (*Hirschsprung's disease*) may occur at any period of life, but is usually of congenital origin and most frequent in male infants. Although mild cases may remain stationary, the disease generally progresses and terminates, in from a few weeks to many years, in death from peritonitis, toxemia, or pneumonia. The whole colon, or only a part, usually the sigmoid, may be involved. The bowel is greatly dilated (the circumference in one case reaching 30 inches), hypertrophied, sometimes elongated, often kinked, and frequently contains stercoral ulcers, which on healing may lead to stenosis. The *symptoms* are obstinate constipation (the bowels may not move for weeks), sometimes alternating with diarrhea; emaciation; possibly convulsions or tetany; ballooning of the abdomen; visible, audible, and palpable peristalsis; foreshortening of the thorax; flaring of the costal margins; and interference with the action of the heart and lungs from pressure. The *treatment* is at first medical, viz., liquid diet, tonics, strychnin, colonic lavage, electricity locally, and abdominal massage. If these measures fail appendicostomy and daily irrigations of the colon, short circuiting of the colon by ileosigmoidostomy, or excision of the colon or its most affected part may be performed. In desperate cases right inguinal colostomy is indicated, more radical measures being adopted after improvement has occurred.

Pericolitis has been explained in three ways. The evolutionary theory is that the membranous bands described below develop to support the intestine, which, owing to the erect posture of man, tends to gravitate toward the pelvis; the developmental theory that the bands result from abnormalities in the rotation and descent of the cecum (but the condition may be found also about the descending colon and the sigmoid); the infectious theory that the membranes are due to infection transmitted through the walls of the bowel to the peritoneal covering, as the result of chronic colitis or colonic stasis. Pericolitis arising from other causes, e.g., diverticulitis, is not included under this heading. The advocates of the infectious theory point out that normally the large gut is firmly attached at its highest point, the splenic flexure, to the diaphragm by the short phrenocolic ligament, and at this point there is a spur, because the adjacent portions of the transverse and the descending colon lie in contact, sometimes for a distance of five or six inches. "According to Cannon, the purpose of this arrangement is to prevent the rapid entrance of fecal matter from the upper portions of the colon into the sigmoid. The function of the former is absorptive, of the latter, eliminative. Hence we find that ordinarily the cecum, ascending and transverse colon are distended with fecal matter and gas, while the sigmoid is empty and contracted. A similar though less pronounced arrangement exists at the hepatic flexure (Glénard). The resistance offered by the splenic flexure on one side, and by the closure of the ileocecal valve on the other, renders consecutive peristaltic and antiperistaltic locomotion of the intestinal contents between these points possible." If this normal or quasi-normal retardation is exaggerated, undue desiccation takes place above the splenic flexure, and habitual constipation follows, with catarrhal colitis and bacterial penetration of the intestinal wall (Gerster).

Pathologically the peritoneum is thickened, and in places, notably the cecum, ascending colon, and splenic flexure, adhesions develop, often broad and membranous (*Jackson's membrane*), but sometimes long and cord-like. These adhesions interfere with normal peristalsis by compressing or stiffening the gut, or by accentuating the normal flexures as the result of the glueing together of the adjacent segments ("double-barrel stenosis"), thus rendering the constipation still more obstinate. Complete obstruction, however, rarely occurs.

The **symptoms** are those of chronic colitis, chronic constipation, auto-intoxication, and neurasthenia. There is general abdominal uneasiness, and sometimes real pain and tenderness over the cecum, which, when thickened and distended, can often be outlined by palpation. Occasionally there are sharp attacks of colicky pain in this region, particularly after dietary indiscretions, which attacks are relieved by a free bowel movement or the expulsion of gas. Many of these cases are operated upon for appendicitis, which, it is true, not infrequently is associated with and due to colitis. Removal of the appendix, however, does not relieve the patient of the colitis or pericolitis, evidences of which conditions should be sought for whenever the abdomen is

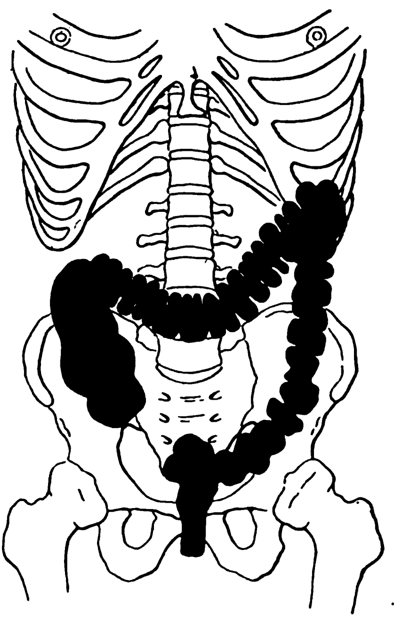


FIG. 400.—Diagram of X-ray shadow of normal colon, after bismuth ingestion, patient standing.

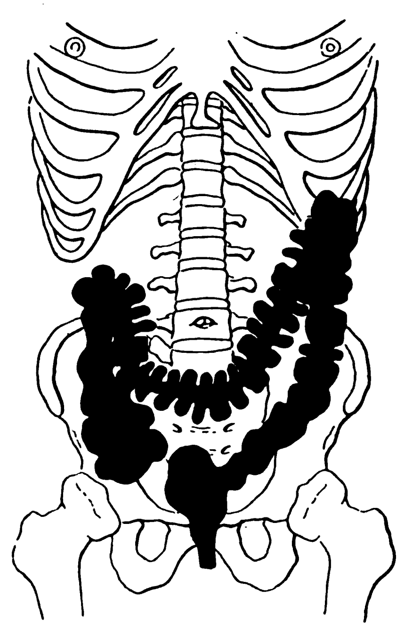


FIG. 401.—Diagram of X-ray shadow of colon in pericolitis, patient standing.

opened for nonsuppurative lesions in the right iliac fossa. Wilms thinks many of these cases of cecal colic are due, not to fixation of the cecum, but to abnormal laxity of its attachments, a condition which he calls *cecum mobile*, and which he treats by attaching the cecum to the parietal peritoneum (cecopexy). Others believe spasm or atony to be the most important factor, hence the terms *typhlospasm, typhlatomy, typhlectasia.*

In pericolitis X-ray examination, after a bismuth meal, shows retention of the bismuth in the cecum, sometimes for 24 or 48 hours, dilatation of the colon, and abnormalities in its position, e.g., ptosis, double-barrel stenosis (Figs. 400, 401).

The **treatment** of pericolitis is first, medical measures directed against the chronic catarrhal colitis. If medical treatment fails operation is indicated, care being taken, however, to exclude cases of neurasthenia and hysteria not secondary to the condition under discussion. Even when operation is undertaken it must not be forgotten that it should be followed by dietary, medicinal, and hygienic measures, if the best results are to be obtained. Usually an incision should be made in the right iliac region, the appendix removed, and any restraining adhesions, if membranous, severed transversely to the direction of the adhesions and sutured longitudinally, or, if cord-like, ligated and divided. In some cases the membranous film over the cecum has been completely detached and sutured behind the cecum, the resulting raw surface being covered with peritoneum. Lane calls attention particularly to adhesions which sometimes are attached to and drag upon the lower end of the ileum, forming a V-shaped kink. In cases in which the colon is hopelessly crippled it may be short circuited by ileosigmoidostomy (see exclusion of the intestine) or excised. Appendicostomy or cecostomy is indicated only in the severe ulcerative forms of colitis.

Typhoidal perforation of the intestine is probably responsible for one-third of the fatalities in enteric fever. The accident usually occurs during the third, fourth, or fifth week, although it may happen at any stage of the disease. As a rule the pain is sudden in onset, begins in the right lower quadrant of the abdomen, quickly becomes generalized, and persists despite the hebetude of the patient. Tenderness is most marked in the region of the perforation, usually the right iliac fossa, and may be elicited also on rectal or vaginal examination. Rigidity of the abdominal muscles is the most valuable sign; it is at first localized over the area of perforation, thence becoming generalized with the spread of the infection. The hardening of the belly wall due to meteorism, to emaciation, to the application of cold water, or to associated pulmonary disease should not mislead the surgeon. The remaining symptoms are identical with those of diffuse peritonitis (q.v.). Typhoidal perforation may be confounded with almost any other lesion producing a peritonitis, with any form of intestinal obstruction, and with spontaneous rupture of the spleen, but as the treatment of all these cases is laparotomy, a failure to differentiate them is not productive of harm. One must be most careful, however, to exclude constipation, distention of the urinary bladder, catarrhal cholecystitis, pleurisy, iliac phlebitis, and epididymitis, all of which may simulate perforation, and none of which requires operation. The most difficult differential diagnosis is that between intestinal hemorrhage and perforation, as the symptoms are sometimes identical; to mistake hemorrhage for perforation means an unnecessary operation at a very critical period, to mistake perforation for hemorrhage means death. Blood in the stools is not conclusive, since the two conditions may coexist. A reduction in the number of red cells and in the hemoglobin would point towards hemorrhage, leukocytosis and a rise in the blood pressure towards perforation. Opium should be withheld in cases of hemorrhage in which perforation is suspected, because of the danger of clouding the symptoms.

The **treatment** is immediate operation. Pain, rigidity, and tenderness always demand exploration, which may be conducted under local anesthesia. If the diagnosis is confirmed, ether should be employed, as the operation can be performed more quickly and the abdominal cavity cleansed more thoroughly without subjecting the patient to the deleterious effects of fright and struggling. If shock is present the danger of delay far outweighs the danger of a rapid operation. The incision is made in the right iliac region, as 90 per cent. of all perforations are found in the last twenty or thirty inches of the ileum or in the cecum or appendix. If the perforation is not found in the ileum and there are evidences of peritonitis, the sigmoid, the colon, and the remaining portion of the small intestine should be explored in the order mentioned. The perforation should be sutured with a double row of Lembert sutures of silk, without excising the ulcer. A large perforation may be sutured obliquely, so as not to interfere with the fecal current. Search for a second perforation should always be made, as in 18 per cent. of the cases the openings are multiple. All suspicious spots should be treated as perforations. In some cases suture is impossible because of the size of the opening, the number of openings, or because of gangrene of the bowel. Resection in these cases consumes so much time that surgeons have been afraid to try it. Plugging the hole with omentum, or suturing the omentum over the perforation has been suggested, and isolation of the affected portion of bowel by gauze packing may sometimes be used. The safest plan is to anchor the intestinal loop outside the abdominal cavity, in order to make the isolation more complete; this will also relieve the distention and permit local treatment of the remaining typhoid ulcers. After dealing with the perforation, the treatment is that of the diffuse peritonitis (q.v.). The writer has operated upon forty patients with typhoidal perforation of the intestine; fifteen recovered.

Tuberculosis of the intestine is most frequent in the lower ileum and in the cecum, probably because the slow fecal current in this region permits the deposition of the bacilli. There are two forms. The *entero-peritoneal* form is the result of active caseation. There is little or no tendency towards healing, hence stricture does not occur. A subacute abscess forms in the right iliac fossa and this may finally break externally, often through one of the hernial rings, and eventuate in a fecal fistula. Diarrhea with blood and mucus in the stools is caused by ulceration of the mucosa, and phthisis is frequently present. The *hyperplastic* form arises when the reparative forces are in excess. The tubercles are encased in dense fibrous tissue, which converts the gut into a thick, rigid, contracted tube. The mucous membrane is ulcerated and the lymph glands enlarged. The symptoms are those of chronic obstruction, with a hard, movable, cylindrical mass in the right iliac fossa. In either form of intestinal tuberculosis the bacilli may be found in the stools. The *treatment* is excision. When this is impossible the affected segment may be short circuited by ileosigmoidostomy.

Splanchnoptosis, or *Glénard's disease*, is a displacement downwards of the abdominal viscera, and includes gastroptosis, enteroptosis, hepatoptosis, splenoptosis, nephroptosis, retrodisplacement or prolapse of the uterus, and sometimes cardioptosis owing to displacement of the diaphragm. The most important cause is relaxation of the abdominal wall, which may be congenital, or the result of trophic changes, pregnancy, ascites, and like conditions. Traumatism, corsets, and kyphosis also have been held responsible for this condition. It is much more common in women than in men. The **symptoms** are usually those of dyspepsia and neurasthenia, although they vary according to the organ which is most affected. The abdomen is flat above and prominent below, the wall flabby, and the recti often widely separated. The displaced organs may be palpated, or outlined by percussion. The gastrointestinal canal is often narrowed at its most fixed points. This fact, with the position and activity of the stomach and intestines, can be determined by X-ray examination, after the administration of bismuth. Stiller's sign is abnormal mobility of the tenth rib. The **treatment** is the application of an abdominal support, massage, electricity, tonics, and often lavage of the stomach. If these measures fail, the fascia between the recti may be excised and these muscles sutured together, in order to lessen the size of the peritoneal cavity and tighten the abdominal wall. One or more of the displaced structures may be fastened in place. In enteroptosis the splenic and hepatic flexures of the colon have been fastened to the abdominal wall. Operations for the fixation of other organs are mentioned in the sections treating of these organs. When intestinal stasis is a prominent feature Lane performs ileosigmoidostomy (end-to-side) and, if there has been much pain, resects the colon down to the anastomosis.

Intestinal obstruction, or **ileus,** may be true (mechanic) or false (intestinal paralysis). True obstruction may be classified, from an etiologic standpoint, as shown in the subjoined table.

Causes of intestinal obstruction	A. *Compression* (rarely traction), from causes outside the intestine	1. Bands and adhesions. 2. Apertures (including hernia). 3. Volvulus (included here because the obstruction is due to an adjoining segment of bowel). 4. Extraintestinal tumors and viscera other than the intestine.
	B. *Strictures*, from causes in the intestinal wall	1. Congenital strictures. 2. Cicatricial strictures. 3. Neoplastic strictures. 4. Spasmodic strictures.
	C. *Obturation*, from causes in the lumen of the intestine	1. Foreign bodies. 2. Fecal impaction. 3. Polyps. 4. Intussusception.

The conditions enumerated above will be described after a general consideration of the subject of intestinal obstruction.

The **pathological changes** in the bowel above the obstruction are dilatation, congestion, and, if the obstruction lasts long enough, hypertrophy of the muscular coat and ulceration of the mucosa, the last of which may lead to perforative peritonitis, abscess formation, or fecal fistula. Below the obstruction the gut is pale, empty, and contracted. At the site of obstruction in the first three conditions in class A and in intussusception, the intestine may be gangrenous from strangulation (see strangulated hernia for details); in class B it exhibits simply the changes incident to the causative lesion; and in class C it may be ulcerated from the pressure of the obturating agent. The pressure exerted by extraintestinal tumors and viscera other than the intestine is seldom great enough to produce ulceration or gangrene.

Clinically intestinal obstruction may be divided into three forms, the acute, the subacute, and the chronic. Although the symptoms may appear suddenly or gradually in any of the conditions mentioned above, acute obstruction is usually due to the first three causes in class A or to the last in class B and C, subacute obstruction to the first three in class C, and chronic obstruction to the first three in class B or the last in class A.

The **symptoms of acute obstruction,** in which the lumen of the bowel is suddenly and completely closed, e.g., in volvulus, acute intussusception, and strangulation by bands, adhesions, or apertures, are (1) those of shock, (2) those due solely to the obstruction, and (3) those of acute toxemia (1) *Shock* generally indicates strangulation, and is more severe, the more sudden the onset, the higher the obstruction, the tighter the strangulation, and the greater the amount of bowel involved. The shock passes after a time, but the pulse remains rapid, and the temperature does not rise above normal until peritonitis supervenes, when all the symptoms of this affection ensue. (2) The most important symptoms of *obstruction per se* are pain, vomiting, constipation, increased peristalsis, and tympanites. The pain is sudden in onset, due to the strangulation; severe and colicky, owing to the violent peristaltic movements of the intestine above the obstructed point; usually referred to the neighborhood of the umbilicus, rarely to the site of the lesion; and is sometimes relieved by, but is often worse after, pressure, also after taking food, purgatives, or enemata. General abdominal tenderness and rigidity are absent until the advent of peritonitis, in the later stages of which pain and peristalsis are no longer present. Vomiting of the contents of the stomach occurs soon after the onset of the pain, probably as the result of reflex nervous disturbances. Later, owing to the obstruction, the material becomes bilious and finally stercoraceous, being regurgitated without effort. This regurgitant or gushing vomiting is characteristic, and occurs earlier and is more severe, the nearer the obstruction is to the stomach; rarely, in obstruction of the lower colon, it may be absent. As the result of the excessive loss of fluid by vomiting there is great thirst, sometimes cramps in the legs, and a marked diminution in the amount of urine excreted. Indicanuria occurs in many cases. Constipation, if the bowel below the occlusion is empty, becomes absolute, not even gas being expelled. Notwithstanding the constipation peristalsis is increased, and may be felt, heard, and occasionally, if the abdominal wall is very thin, seen; as a rule, however, visible peristalsis indicates hypertrophy of the muscular coat of the bowel, hence chronic obstruction, which, it must be noted, generally terminates with acute symptoms. Tympanites is due principally to bacterial decomposition of the contents of the bowel above the point of obstruction. The lower the obstruction, the greater the distention of the abdomen. (3) *Acute toxemia* is due to absorption of the decomposing intestinal contents, or to peritonitis as the result of gangrene or perforation of the gut, hence represents the final stage, or the stage of collapse, in which the symptoms are those of exaggerated shock (q. v.). If unrelieved, acute obstruction usually causes death within a week, as the result of toxemia, exhaustion, or interference with the intrathoracic organs from tympanites. Although rare, spontaneous recovery is possible; thus a fistula may connect the bowel above and below the obstruction or empty externally, a foreign body may pass, a kink be straightened, or the invaginated portion of an intussusception may slough and separate.

The **diagnosis** is seldom difficult, but the seat and cause are often undetermined until an exploratory incision has been made. Intestinal paralysis (q.v.) differs from obstruction in the absence of peristalsis, and the presence of the symptoms of the causative lesion, both before and after the onset of obstructive symptoms; thus in peritonitis there will be fever, rigidity, leukocytosis, etc. *The seat of obstruction* may occasionally be located by the palpation of a mass through the rectum, vagina, or abdominal wall, or by the situation of the pain or tenderness. The greater the distention, the later the vomiting of stercoraceous material, and the larger the amount of urine excreted, the lower in the intestine is the obstruction. When the central portion of the abdomen alone is distended, the lesion is above the ileocecal valve; when both loins also are distended, the obstruction is in the sigmoid or rectum; and when the right loin is greatly distended the transverse colon is involved. Tenesmus generally indicates a lesion of the large bowel. Rectal injections of air or water for the purpose of diagnosis are not recommended. It is said that if six quarts of water can be introduced, the obstruction is in the small intestine; if but a pint or quart, in the rectum or sigmoid. *The cause of obstruction* may be an external *hernia*, which must first be excluded in all cases; if such be found and be irreducible, it should be investigated by incision. If a hernia has been replaced and the symptoms continue, the possibility of a *reduction en bloc*, i.e., reduction without the relief of strangulation, should be recalled. Excluding hernia the most common cause of intestinal obstruction is, in the new-born, imperforate anus; in infants, intussusception or adhesions due to tuberculous peritonitis; in adults, bands, adhesions, or volvulus; in old age, carcinoma of the bowel or fecal impaction. Severe collapse indicates a tight strangulation. The previous history should be elicited, particularly with reference to biliary colic, chronic constipation, peritonitis, abdominal operations, tuberculosis, syphilis, dysentery, and pelvic disorders. The distinguishing features of the various forms of obstruction are noted in the description of the individual diseases responsible for the obstruction.

The **treatment** is, with few exceptions, abdominal section. While preparations are being made for operation, morphin should be given hypodermatically to quiet peristalsis, the stomach emptied by lavage, and the rectum evacuated by an enema unless such has already been done. Purgatives are contraindicated. In the absence of a definite diagnosis as to the point of obstruction, the abdomen should be opened in the median line below the umbilicus. If the cecum is distended, explore the sigmoid; if the sigmoid is collapsed, the obstruction is in the large bowel between it and the cecum. If the cecum is collapsed, it will be necessary to follow the small bowel until the obstruction is found. Another rule is to select the most dilated and congested coil of bowel and follow it in the direction of the increasing congestion and distention. In the most *urgent cases* no attempt should be made to find the seat of obstruction, but the abdomen should be opened under local anesthesia, and an artificial anus established in the first presenting *distended* coil of intestine. Before or after dealing with the obstruction, particularly in late cases in which peristalsis is feeble or absent, the great distention should be relieved by incising one or more coils of intestine and allowing the contents to escape, subsequently suturing the wounds. The obstruction itself is dealt with according to its cause (vide infra).

In **subacute obstruction** the symptoms are midway in intensity and duration between those of acute and those of chronic obstruction. The initial shock is absent, but, in most instances, the obstruction progresses until the bowel is completely occluded, when the symptoms are those of acute obstruction.

In **chronic obstruction** there is gradually increasing constipation and abdominal uneasiness, which is often attributed to intestinal indigestion. At irregular intervals there are colicky pain, obstinate constipation, abdominal distention, visible, audible, and palpable peristalsis, and vomiting; the last, however, is often absent in stricture of the colon until the obstruction becomes complete. Purgatives often dislodge the impacted food or feces responsible for the transient obstruction. Diarrhea may thus alternate with constipation. Finally acute and complete obstruction ensues. The treatment is described with the different lesions.

Bands and adhesions are a common cause of intestinal obstruction. *Adhesions* result from acute or chronic peritonitis, or from the reparative processes following operation and injuries. They may exist in any portion, of the peritoneal cavity but are most frequent in the four corners of the abdomen and in the pelvis, from lesions of the appendix, stomach and duodenum (especially ulcer), gall bladder, perisplenitis, diverticulitis, and inflammatory affections of the uterus, tubes, and ovaries. These adhesions may be short and numerous, binding adjacent segments of bowel in a V-, N- or W-shape; they may be broad and membranous, and spread out over the bowel so as to interfere with its peristaltic action or to compress it (see pericolitis); or they may be moulded into bands, the bowel being kinked by traction (rare), or strangulated by passing under or hanging over the band or by slipping into a noose formed by the band (Fig. 402). Bands or cord-like structures are formed also by adherent omentum, appendix, appendices epiploicæ, Fallopian tubes, or Meckel's diverticulum.

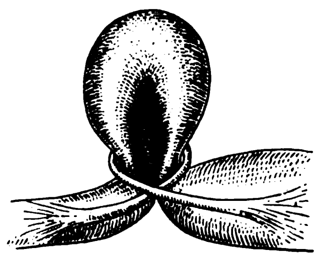


FIG. 402.—Intestinal obstruction from a band of adhesions.

Symptoms may be absent even with extensive adhesions. When symptoms arise they vary from the mildest form of chronic constipation to the most severe form of acute obstruction. The latter is generally due to acute kinking or strangulation of a coil of the small intestine, usually the lower ileum. Intestinal obstruction from adhesions should be suspected if there is a history of previous peritonitis or of an abdominal operation or injury.

The **treatment** of obstruction due to limited adhesions is separation of the involved coils of bowel, and, if possible, covering of the raw surfaces with peritoneum. When the intestines are extensively and intricately matted together, e.g., in tuberculous peritonitis, an anastomosis may be made between the bowel above and the bowel below. If there is strangulation the band should be divided between ligatures, making sure that such band is not a Meckel's diverticulum, which should be excised in the same way as the appendix. If the bowel is gangrenous it should be treated as described under strangulated hernia.

FIG. 403.—Volvulus of the intestine. Note distention of the loop and of the bowel above the obstruction.

Apertures are responsible for all forms of hernia (q.v.). Abnormal openings, either congenital or traumatic, may be found also in the omentum and mesentery.

Volvulus, or torsion of the intestine, is most common in the sigmoid flexure, then in the small intestine, then in the cecum and ascending colon. The bowel may be twisted on its mesenteric axis, the usual variety (Fig. 403), on its own axis, or two coils of intestine may be twisted together. When the twist is tight the circulation is suppressed and gangrene follows.

Volvulus of the sigmoid flexure is most frequent in constipated men between forty and sixty. The sigmoid is normally predisposed to twisting, in that it forms a long loop whose origin and termination are closely approximated, and this predisposition is accentuated when the loop is elongated by habitual overdistention, or when its limbs are drawn together at their bases by cicatricial contraction of the mesentery. As a rule the proximal limb falls down over the distal in consequence of straining to empty the bowel, stooping to lift a weight, or similar efforts involving a change in position and muscular exertion, and the twisting thus induced may continue for two or even three complete turns.

The **symptoms** usually appear very suddenly, although the initial shock may be less severe than in most other forms of acute obstruction. The distinguishing features, aside from the age of the patient and the history of chronic constipation, are late vomiting; extreme distention of the abdomen; a rounded tympanitic tumor in the left iliac fossa; and often tenesmus, without, however, the passage of anything from the rectum. Death generally occurs within two or three days, from peritonitis or pressure on the diaphragm. In rare instances a partial twist may straighten out, only to recur at irregular intervals (*chronic or intermittent volvulus*).

Volvulus of the small intestine may affect one coil or the entire ileum, the twist usually being from left to right. Vomiting occurs early, and sometimes the rounded tympanitic tumor can be felt in the region of the umbilicus.

Volvulus of the cecum or ascending colon may occur as the result of congenital malposition, or when these structures possess a long mesentery. The symptoms are not so severe as in sigmoid volvulus, and the rounded tympanitic tumor may be found in the right iliac fossa.

The **treatment** of volvulus is to untwist the loop of intestine. In some cases it may be necessary to evacuate the affected coil of bowel by puncture before this can be accomplished. If the gut is viable the puncture is closed with a purse-string suture and the bowel replaced in the abdomen. Shortening of the mesentery or fixation of the bowel to the abdominal wall has been suggested to prevent recurrence. If the bowel is gangrenous it must be resected, or if the patient's condition forbids this, brought out of the abdominal wound and an artificial anus established. Chronic volvulus is treated by resection.

Extraintestinal tumors, cysts, and abscesses may compress the bowel, as may also viscera other than the intestine, e.g., pregnant or retroverted uterus, floating kidney or spleen. Compression by the superior mesenteric vessels is described under acute dilatation of the stomach. The rectum or sigmoid is affected in over half of the cases, not only because of the frequency of pelvic tumors, but also because a tumor in this region cannot expand without encroaching on the bowel, owing to the unyielding nature of the pelvic ring. The *symptoms* may be acute or chronic, usually the latter. The *treatment* is that of the causative lesion.

Stricture of the intestine may be congenital (see congenital stenosis of the intestine) or acquired (cicatricial, neoplastic, spasmodic).

Cicatricial stricture is caused by the repair of ulcers due to tuberculosis, syphilis, dysentery, pressure (e.g., from foreign bodies, constriction in strangulated hernia), rarely typhoid, as the ulcers in this disease are longitudinal; by the repair of wounds due to partial rupture from contusion, or due to extensive lacerations, perforations, or intestinal anastomosis, especially when too much bowel is inverted by the surgeon; and by the repair of areas of inflammation, e.g., due to diverticulitis or pelvic cellulitis. Cicatricial stricture of the small intestine is usually caused by tuberculosis, that of the colon by dysentery, that of the rectum by syphilis or pelvic cellulitis (see rectum).

Neoplastic stricture is almost always due to **carcinoma of the colon.** *Sarcoma* is rare and usually involves the small intestine. Benign tumors are generally polypoid in nature, and cause obturation, hence, following the classification we have adopted, will be described after foreign bodies and fecal impaction. Carcinoma occurs in the large bowel in 95 per cent. of the cases, in the following order of frequency: sigmoid, cecum, ascending colon, transverse colon, splenic flexure, hepatic flexure, descending colon. This computation does not include carcinoma of the rectum, which is classed with the diseases of the rectum. Carcinoma of the colon is cylindrical-celled, and may project into the lumen of the bowel like a cauliflower, or, more frequently, spread around the lumen and produce an annular stricture. It infiltrates contiguous coils of bowel or other viscera, and sometimes ulcerates into them, forming an internal fistula. In the later stages the growth may diffuse itself over the peritoneal cavity (see malignant disease of the peritoneum) or metastasize to the liver, lymph glands, or lungs. Metastasis, however, is often postponed for a much longer period than in carcinoma elsewhere.

The **symptoms** of cicatricial and malignant stricture are at first those of chronic obstruction; as the contents of the small bowel are liquid, however, the fecal current may suffer no interruption until its lumen is almost totally occluded. Tumors of the intestine are seldom suspected unless they interfere with the fecal current. In stricture of the lower colon the stools may be deformed or diminished in caliber, and sometimes the stricture can be seen with the sigmoidoscope. After giving bismuth by mouth or rectum the stricture may show in a skiagram; with the fluoroscope the progress of the bismuth along the intestine can be kept under continuous observation. In *cicatricial stricture* the small bowel is more often involved (60 per cent.), and a history of one of the causes mentioned above may be obtained. In *carcinoma* blood, mucus, and occasionally fragments of the growth may be found in the stools; the tumor can be felt in 40 per cent. of the cases; the patient is usually over 40, but it should be recalled that before 30 carcinoma is more frequent in the colon than in other situations, and that cachexia is often absent until the growth diffuses itself over the abdominal cavity.

The **treatment** of the forms of stricture mentioned above is enterectomy, with, if the disease be malignant, a V-shaped portion of the mesentery and the lymph glands. In urgent cases an artificial anus should be established and the resection performed at a later date (see colectomy). When the growth is irremovable the intestine above and below may be united by lateral anastomosis, or the affected segment side-tracked as described under intestinal exclusion.

Spasmodic stricture (*enterospasm, dynamic obstruction*) is due to tetanic contraction of a segment of intestine. It may be caused by lead poisoning, irritating intestinal contents, hysteria (see phantom tumor), and trauma, hence occasionally follows abdominal operations. It is the first step in the development of many cases of intussusception. The *symptoms* may be those of acute or subacute obstruction; sometimes the contracted segment of bowel can be felt. The *treatment* is directed to the cause; heat to the abdomen and large doses of atropin are of value in relaxing the spasm.

Foreign bodies, including **gall-stones** and **enteroliths,** rarely cause obstruction. Foreign bodies may be swallowed accidentally, e.g., artificial teeth, or intentionally by children, lunatics, hysterical women, and showmen. The body may lodge in the esophagus, stomach (see esophagus and stomach) or intestine, and cause obstruction or perforation, but, as a rule, if it passes through the esophagus the rest of its journey along the alimentary canal is uneventful. Foreign bodies that have been left in the peritoneal cavity, e.g., forceps, sponges, etc., may ulcerate into the bowel. Enormous snarls of *intestinal worms* sometimes form in and occlude the intestine. *Gall-stones* of sufficient size to produce obstruction must enter the intestinal tract, usually the duodenum, by ulceration. Stones even of large size passing directly into the hepatic flexure rarely block the colon. *Enteroliths* (intestinal concretions) are composed of phosphate of lime and hardened feces, often with some indigestible material as a nucleus; of masses of vegetable residue, e.g., oatmeal husks, with calacreous salts (avenoliths); or of medicinal substances, e.g., bismuth, magnesia, salol.

The **symptoms** of obstruction from foreign bodies are generally of a subacute nature. The diagnosis may be possible if a clear history is obtained, if the foreign body can be felt, and if it can be seen with the X-ray. The seat of impaction is usually the lower ileum, since this is the narrowest portion of the bowel. Gall-stone ileus seldom occurs before fifty.

The **treatment** is removal of the foreign body by enterotomy, after displacing it upwards to a more healthy portion of the bowel. If the bowel is gangrenous or badly ulcerated it should be resected or isolated extraperitoneally.

Fecal impaction is most common in old ladies with chronic constipation. The masses may be semisolid or as hard as stone, are generally coated with mucus, and often produce ulcers by pressure (*stercoral ulcers*), which ulcers occasionally perforate. Fecal impaction is most frequent in the sigmoid and rectum, but in some cases the mass fills the entire colon, which is dilated, elongated, hypertrophied, and prolapsed.

The **symptoms** are those of chronic constipation merging into chronic and finally into subacute obstruction. The fecal masses can be felt along the course of the colon or in the rectum, sometimes moved from one portion of the bowel to another, and can be seen on X-ray examination. Pitting on pressure, a characteristic sign of ordinary feces in the colon, is often absent. The stercoral ulcers may betray themselves by fever, tenderness on pressure, and a mucopurulent sanious discharge from the rectum. The last is often associated with tenesmus.

The **treatment** is copious enemata, massage, and laxatives. When situated in the rectum the mass may be broken up with the finger. Purgatives and massage are contraindicated if the bowel is inflamed. The prognosis is good, although death may occur from associated diseases, toxemia, or perforation.

Benign intestinal tumors (fibroma, myxoma, lipoma, adenoma) usually project into the lumen of the gut as **polyps**, are often multiple, and seldom cause obstruction unless there is a kink in the bowel or unless they induce an intussusception. If the polyps ulcerate, blood, mucus, and pus may appear in the stools. Tenesmus occurs when the growths are in the lower bowel, in which situation they may be detected with the finger or the sigmoidoscope, and from which situation they can be removed through the anus (see polypus recti). Isolated polypi causing obstruction and not accessible through the anus must be excised after enterotomy. *Multiple adenomata of the colon* generally occur in young adults and show a decided tendency to malignant degeneration; the only remedy for this condition is excision of the colon.

Intussusception is the telescoping of one part of the intestine into the segment below. The swallowed portion is called the *intussusceptum*, the swallowing segment the *intussuscipiens* (Fig. 404). The cause is irregular peristalsis, sometimes induced by worms, diarrhea, polypoid tumors, or other form of irritation. The author has had two cases of traumatic origin. As the peritoneal surfaces of the entering and returning layers of the intussusceptum tend to adhere, and the mucous surface of the returning layer readily slips over the mucous surface of the intussuscipiens, the intussusception elongates at the expense of the intussuscipiens and the apex is always represented by the same piece of bowel. The intussusception is not straight as in the diagram, but curved, with the apex directed towards the mesenteric border. This crescentic arrangement is due to the unyielding nature of the mesentery. The mesentery is drawn down between the layers of the intussusceptum, hence is stretched, bunched, and constricted. The circulation is further impeded by inflammatory exudation, and this leads to desquamation of the mucous membrane (hence blood and shreds in the stools), and finally to strangulation and gangrene. Intussusception is responsible for 39 per cent. of the cases of intestinal obstruction. The anatomical varieties, in the order

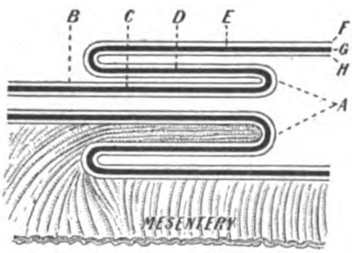


FIG. 404.—Diagram of intussusception. *A*. Apex. *B*. Neck. *C*. Entering layer and *D*. returning layer of intussusceptum. *E*. Intussuscipiens. *F*. Peritoneum. *G*. Muscularis. *H*. Mucosa.

of their frequency, are the *ileocecal* (44 per cent.), in which the ileocecal valve and ileum pass into the colon, the *enteric* (30 per cent.), usually involving the jejunum, the *colic* (18 per cent.), involving the colon alone, and the *ileocolic* (8 per cent.), in which the ileum passes through the ileocecal valve. Multiple retrograde intussusceptions sometimes occur in the dying, probably from rigor mortis. Double intussusception, in which an intussusception slips into the gut below, and triple intussusception, in which a double intussusception slips into the gut below, are extremely rare.

Clinically two forms must be distinguished, the acute, which is the usual variety, and the chronic.

The **symptoms of acute intussusception** are often so typical that no difficulty is experienced in distinguishing the condition from other forms of acute obstruction. Acute intussusception is most frequent in male infants and sometimes follows a straining diarrhea. Distension is not so marked and stercoraceous vomiting not so common as in most other forms of acute obstruction. There is usually tenesmus, which is more severe and frequent the nearer the intussusception is to the anus, and the passage of blood and mucus, the passages becoming particularly offensive when the intussusceptum sloughs. A sausage-shaped tumor, concave towards the umbilicus, can often be felt in the course of the tranverse or the descending colon. The tumor becomes harder and more prominent with each recurrence of the griping pain, and progresses slowly towards the anus, which may be relaxed, and through which the apex of the intussusceptum, feeling like a soft os uteri, may be palpated. The right iliac fossa may feel empty, the bowel in this region having passed along the colon. Without treatment death usually takes place in from one to eight days.

The **symptoms of chronic intussusception** are not so typical as those of the acute variety. The condition is most common in men between twenty and forty, is often due to the dragging of a polyp, and may last for a number of months or even a year. There are attacks of pain, vomiting, and diarrhea, often with tenesmus and the passage of blood and mucus. The tumor can be felt through the abdomen in half of the cases, and by rectum in one-third; sometimes it disappears between the attacks. Visible peristalis and other signs of chronic obstruction are in evidence. Death occurs in about 95 per cent. of the cases, from acute obstruction, peritonitis, or hemorrhage. In about one-fourth of the cases the intussusceptum sloughs and is passed by the bowel, but only a very few of these terminate in recovery.

The **treatment** of acute intussusception by the administration of opium and belladonna, and the injection of air or water into the rectum should be discarded. It wastes valuable time, is uncertain, and, since it necessitates anesthesia and may rupture the bowel, is just as dangerous as laparotomy. The abdomen should be opened, as early as possible, in the median line, and the intussusception reduced, not by traction, which may tear the bowel, but by milking or pressing the intussusceptum upwards. It has been suggested, in order to prevent recurrence, to shorten the mesentery or suture it to the ascending mesocolon, or to fix the bowel to the abdominal wall. When reduction is impossible, i.e., in half of the cases, the intussusceptum may be resected (see Maunsell's method), a lateral anastomosis made between the bowel above and below the intussusception, or an artificial anus established. Resection of the entire intussusception is indicated only when the intussuscipiens is gangrenous. In children the mortality is between 30 and 40 per cent. when reduction is easy, and over 90 per cent. when reduction is impossible. In chronic intussusception, which demands the same operative procedures, the mortality is not so high.

Intestinal paralysis, *adynamic ileus*, or *pseudoobstruction*, may occur with or without gastric paralysis (see acute dilatation of the stomach); in the former event the term gastrointestinal paralysis is applicable. Intestinal paralysis is most frequently caused by peritonitis, but it occurs also in enteritis, acute pancreatitis, thrombosis or embolism of the mesenteric vessels, biliary and renal colic, strangulation of the omentum, injury to the ovary or testicle, in diseases and injuries of the central nervous system, and as a terminal event in other maladies, particularly those accompanied by delirium or coma. Fracture of the spine, uremia, and pneumonia should receive special mention. That form occurring after abdominal section, not due to peritonitis, is caused by the sudden relief of chronic pressure (e.g., the removal of a large tumor) or by undue handling of the intestines. The *symptoms* are almost identical with those of acute obstruction. There may, however, be evidences of the causative lesion, and peristalsis is absent. In intestinal obstruction increased peristalsis is a cardinal sign which is absent only in the final stage, when paralysis ensues. Rectal ballooning, which is sometimes described as a sign of appendicitis, obstruction of the bowel, etc., is really an indication of intestinal paralysis from any cause. The *treatment* is that of the cause. In addition the stomach may be washed out, a tube passed into the colon, enemata administered, and strychnin, eserin, pituitarin, or atropin given hypodermatically. Intestinal paralysis of severe degree is generally fatal. An artificial anus may be established, but usually does not drain more than the coil in which it is made.

OPERATIONS ON THE INTESTINES.

Intestinal Localization.—The large intestine is differentiated from the small intestine by its mesenteric attachment, greater size, longitudinal bands, sacculations, and by its appendices epiploicæ. The method for finding the upper end of the jejunum is given under gastroenterostomy. In order to determine the situation and direction of a loop of intestine, the following facts, according to Monks, are of great value: The average length of the small intestine is twenty-one feet. The upper third occupies the left hypochondrium (duodenum excluded); the middle third, the middle section of the abdomen; the lower third, the pelvic and right iliac regions. The intestine, from above downwards, decreases in size and thickness, becomes less opaque,

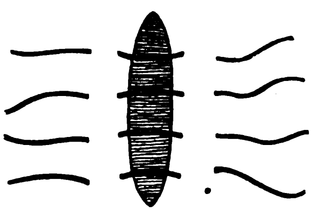


FIG. 405.—Lembert suture. (Binnie.)

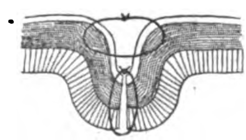


FIG. 406.—Czerny-Lembert suture. (Binnie.)

has smaller vessels, which are nearer together, and changes in color from bright pink or red to pinkish or yellowish gray. In the upper jejunum large and numerous valvulæ conniventes may be felt, but are imperceptible beyond the fourteenth to the sixteenth foot. The fixation of the two ends of the intestine may be felt; and the consistency of the contents increases from above downwards. The mesentery is thin and transparent at the upper part, thick and opaque in the lower third. The lunettes between the vessels are perceptible in the upper eight feet or more, but cannot be seen in the lower third Tabs of fat extending onto the intestine begin to appear at about the fourteenth foot and become more and more prominent. In the upper third the mesenteric vessels are large and far apart, form primary loops as far as the fourth foot when secondary loops appear, and give off long, regular, unbranching vasa recta to the intestine. In the lower third the mesenteric vessels are small and close together, have many loops often obscured by fat, and give off small, short, and irregular vasa recta. The root of the mesentery is to the left of the median line above, to the right below. If a loop of bowel is placed parallel with the root of the mesentery, the upper end will be nearer the duodenum, providing there is no twist in the mesentery.

Enterotomy signifies an incision into the intestine for the purpose of removing a foreign body or for exploration. A longitudinal incision is made opposite the mesentery, and the wound closed with Czerny-Lembert sutures.

Enterorrhaphy, or suture of the intestine, is performed with a fine straight round needle and fine silk or celluloid thread. It is essential that the wound be air-tight, and that the edges be inverted so that serous membrane shall come in contact with serous membrane. The Lembert suture (Fig. 405) is placed at right angles to the wound. The needle is inserted about one-fourth inch from the edge of the wound, goes down to and through the submucous coat but not through the mucous membrane, is brought out one-eighth inch from the edge of the wound, and is inserted in a similar manner on the opposite side, so that when tied the edges of the wound are inverted. The stitches are about one-eighth of an inch apart. The Czerny-Lembert suture (Fig. 406) consists of a deep suture going through all the coats of the

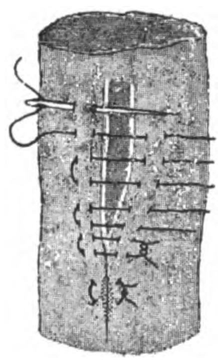


FIG. 407.—Halstead mattress suture (Monod and Vanverts.)

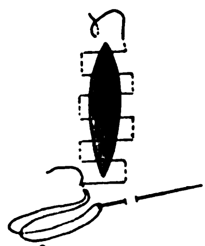


FIG. 408.—Cushing's suture. (Binnie.)

bowel and a superadded Lembert suture. Either or both of these sutures may be interrupted or continuous. When using a suture going through all coats it is better to place the knot within the lumen of the bowel and to use catgut. The Halstead mattress suture is shown in Fig. 407 and the Cushing right angle suture in Fig. 408; both these sutures are inserted with the precautions used in employing the Lembert suture.

Enterostomy is the making of an opening into the intestine in order to feed a patient or to drain away the contents of the intestine (*artificial anus*); according to the situation of the opening the operation is called duodenostomy, jejunostomy, ileostomy, or colostomy.

Duodenostomy or **jejunostomy** is occasionally performed to give rest to the stomach in cases of gastric hemorrhage, and to feed the patient in gastric cancer when a gastroenterostomy is inapplicable. As the idea is to introduce food and prevent the escape of intestinal contents, the principles used in the Witzel or the Stamm-Kader gastrostomy should be employed. Complete division of the bowel, with suture of the upper end of the lower segment to the skin, and anastomosis of the upper segment with the side of the lower segment is a much more serious operation and is very rarely indicated.

Ileostomy may be demanded in cases of intestinal obstruction, above the ileocecal valve, in which the patient's condition is so bad that search for or removal of the cause of the obstruction is contraindicated. The operation is performed in the same manner as colostomy. If the patient survives, the obstructing lesion and the artificial anus are removed at a second operation, or the obstruction alone is dealt with at the second operation and the continuity of the ileum restored at a third operation. Closure of the artificial anus, however, must not be delayed longer than is absolutely necessary, because of its interference with nutrition, which is more marked the higher the opening, and because of the digestive effect of the intestinal juices on the skin.

Colostomy, or colotomy, as it is sometimes called, is commonly employed for the relief of obstruction, and occasionally for the purpose of giving the large bowel rest and allowing irrigation in cases of chronic dysentery or other severe ulcerative lesions. Irrigation of the colon, without diversion of the fecal current, is best performed through the appendix (see appendicostomy), or when this is not possible, because of stricture of the appendix, through a valvular opening in the cecum (*cecostomy*), which is made in the same way as the Stamm-Kader gastrostomy, but which in this region is called *Gibson's operation*. In order to interfere as little as possible with nutrition, an artificial anus should be made as low in the colon as the condition for which it is done permits. Hence when *sigmoidostomy* is contraindicated, because of obstruction in the descending colon, the opening should be made in the transverse colon, and not, as is customary, in the cecum or the ascending colon. *Transversostomy*, in addition to its preserving more of the large bowel for the purpose of nutrition than an artificial anus in the right inguinal region, is, owing to the long transverse mesocolon, easier to perform, does not produce so much irritation of the skin, and is easier to close, a tleast by resection and anastomosis. The incision is made in the abdomen above the umbilicus, through the middle line or the left rectus. The rest of the operation is similar to inguinal colostomy, which, since it is the usual procedure, will be described in detail.

Inguinal colostomy (*Littre's operation*) is performed through an incision, two or three inches long, made at right angles to a line drawn from the anterior superior spine to the umbilicus, its middle crossing this line at the junction of the outer and middle thirds. A loop of the colon is pulled into the wound, the upper limb of the loop being made taut in order to prevent subsequent prolapse, and the gut fastened by passing a glass rod through the mesentery and suturing the parietal peritoneum and then the skin to the bowel. Instead of the glass rod, gauze or other material may be used, or the middle of the skin incision may be united beneath the bowel. If, owing to absence or extreme brevity of the mesocolon, a sufficiently long loop cannot be obtained, the colon should be mobilized by incising the peritoneum on the outer side of the gut (see colectomy). The bowel is opened with scissors or cautery, at the end of two or three days, after protecting adhesions have formed; no anesthetic is required. If the artificial anus is to be temporary the incision should be longitudinal; if permanent, transverse, but the gut should not be completely divided for a week or ten days, otherwise it may retract within the abdomen. When immediate opening of the intestine is mandatory, there is considerable risk of infecting the peritoneal cavity with feces. The author prevents this in the following manner: The loop of bowel is emptied by pressure, and a clamp placed at each extremity, the whole being surrounded by gauze. One-half of a Murphy button is inserted into the empty loop of intestine through a small incision, and the other half is squeezed into the end of a long rubber tube whose calibre is slightly smaller than that of the flange of the button, thus making a tight joint (Fig. 409). The two halves of the button are then pressed together, or in other words a lateral implantation is made between the rubber tube and the bowel. The feces drain through the rubber tube into a receptacle on the floor. By the time the button has sloughed through the bowel, i.e., at the end of two or three days, adhesions will have closed the peritoneal cavity. The bowels should move once or twice a day, the anus being closed at other times by a hollow rubber bulb, shaped somewhat like a dumb-bell; one end is placed in the intestine and the bulb is then distended with air. The opening may be provided with a more or less satisfactory sphincter by drawing the bowel through the split rectus muscle or through a McBurney incision.

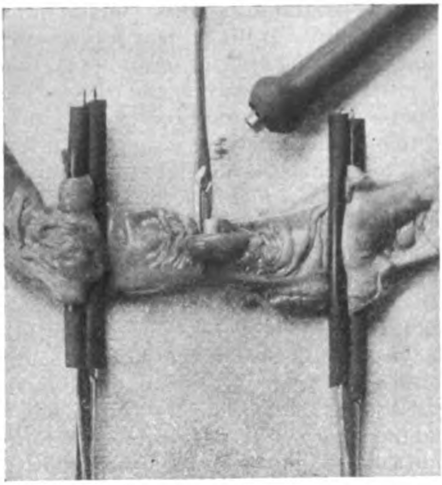


FIG. 409.—Immediate enterostomy.

Bodine's operation facilitates the closure of the artificial anus. A long loop of bowel is drawn from the abdomen, and the two limbs sutured together for at least six inches, first near the mesenteric attachment and again near the anterior longitudinal band. The loop is then replaced in the abdomen except for its end, which is sutured to the abdominal wall, and later opened. When the artificial anus has served its purpose, the long spur between the two limbs of the loop is cut through with a heavy clamp, which generally takes about one week. The bowel around the artificial anus is then separated as far as the peritoneum, the opening closed with inversion sutures, and the muscles and the skin drawn together over the suture line.

In **lumbar colostomy** the large bowel is approached extraperitoneally through the loin. The operation has been abandoned, because, as compared with iliac colostomy, is is more difficult, does not completely divert the feces, and the resulting opening is not well situated for cleanliness.

Operative closure of the artificial anus will be required in those cases in which the condition for which it has been established has been removed. The manner of closure after Bodine's operation is described above. In other cases the opening in the bowel is disinfected with carbolic acid, stuffed with gauze, and closed with sutures. The abdomen is then carefully scrubbed, and opened by an elliptical incision surrounding the anus, the involved segment of bowel being resected, and the fecal circulation re-established by an end-to-end-anastomosis. In many cases the lower segment will be so contracted that the surgeon will prefer a lateral anastomosis.

A **fecal** or **intestinal fistula** differs from an artificial anus in that only a portion, and not all, of the intestinal contents escape through the abnormal opening. It may be congenital (see umbilical fistula) or follow injury, ulceration, strangulation, and malignant tumors of the bowel, or inflammatory lesions of the abdominal cavity secondarily involving the bowel. Occasionally a fecal fistula is deliberately established by the surgeon. *External fistula*, i.e., opening on the skin, may proceed from any portion of the intestinal canal. The discharge from the duodenum or the upper jejunum is fluid, acid, intensely irritating to the skin, and contains bile and undigested food; that from the lower ileum or the cecum is neutral or alkaline, much less irritating, and contains less undigested food; that from the lower colon is semisolid or solid fecal matter. If there is any doubt as to whether the bowel is open or not, e.g., after some operations for appendiceal abscess in which the discharge is very foul, methylene blue may be given by mouth; if there is an intestinal fistula the discharge will become blue, the earlier the higher the fistula in the bowel. A high intestinal fistula discharges very quickly anything that is taken into the stomach, thus producing rapid emaciation and death. When of large size, an external fecal fistula requires the same *treatment* as artificial anus. Smaller fistulæ, particularly in the large bowel, often close spontaneously. If the tract is lined by mucous membrane, this should be destroyed with the cautery. When opening into the small bowel, even minute fistulæ sometimes refuse to heal. In these cases the external opening should be treated as mentioned above for artificial anus, the tract dissected out, and the opening in the bowel closed with sutures. When these methods are inapplicable or inadvisable, exclusion of the intestine, which is described on a later page, may be performed. An *internal fistula* between the stomach and the colon causes rapid emaciation, the appearance of undigested food in the stools, and of fecal matter in the vomitus; between the intestine and the bladder, fecal matter in the urine and infection of the urinary tract. If the condition is not due to inoperable tuberculosis or carcinoma the viscera should be separated and the opening in each closed.

Enterectomy, or resection of the intestine, is performed for many conditions, of which the following are the most important: gangrene, extensive injury, tumors, artificial anus, cicatricial stenosis, tuberculosis, and injury to the vessels supplying the segment of bowel. The portion of gut to be removed is drawn from the body, and the peritoneal cavity protected by gauze packing. The loop is emptied by stripping with the fingers, and rubber-coated clamps placed on the bowel on each side of the proposed incisions, i.e., four clamps are used. In the absence of intestinal clamps, gauze or rubber tubing may be tied around the bowel. The mesentery is then ligated in sections, a short distance from the bowel, and divided; in malignant disease particularly, a V-shaped portion of the mesentery is removed, great care being exercised not to cut off the blood supply of the bowel which is to remain. The bowel is divided somewhat obliquely, removing more at the free than at the mesenteric border, in order to give a greater circumference, and to assure a good blood supply to the antimesenteric portion. The continuity of the intestine is re-established by circular enterorrhaphy, lateral anastomosis, or lateral implantation (vide infra). The opening in the mesentery is closed, and any excess folded and held in place by sutures.

Colectomy, or removal of a part or the whole of the colon, requires special consideration, because of the arrangement of the peritoneum around the large bowel. The middle of the sigmoid and the transverse colon can generally be withdrawn from the abdomen, resected like the small intestine, and anastomosed by circular enterorrhaphy. Unlike the small intestine, however, the transverse colon has attached to it three peritoneal shelves that must be dealt with, the gastrohepatic omentum, the greater omentum, and the mesocolon, the last containing the blood supply. The ascending and the descending colon are, as a rule, only partly covered with peritoneum, and are fixed to the posterior abdominal wall. Thanks to the arrangement of the vascular supply, however, which approaches the bowel from the mesial side, these portions of the colon can be completely mobilized, and brought to a safe place outside the abdomen for operative attack, by incising the peritoneum to the outer side of the gut, bluntly separating the loose cellular tissue over the kidney and the ureter, and displacing the gut toward the median line. On the left side the splenic flexure can be liberated by cutting the phrenocolic ligament. Thus, if necessary, the entire colon can be exteriorized, almost bloodlessly, through a median incision. After mobilization the affected segment can be resected with as little difficulty as a piece of small intestine, and the continuity of the bowel re-established by one of the methods described below. Lateral anastomosis, however, is to be preferred in the ascending and the descending colon, because of the incomplete peritoneal investment; if circular enterorrhaphy is performed in these parts of the large bowel, the anastomosis should be isolated from the general peritoneal cavity by vaselinized gauze, as leakage not infrequently follows. Primary resection of a portion of the colon, unless the bowels have been thoroughly evacuated previously, is so dangerous (mortality 30 to 40 per cent.) that in all cases of obstruction the patient should be operated upon in two or more stages (mortality 10 per cent.); this statement applies particularly to cases of malignant disease of the colon. At the first operation the chief indication is to relieve the fecal stasis, by the formation of an artificial anus. At a later period the growth is removed and, if possible, the artificial anus closed; or the work may be done in three stages, by separating the excision of the growth and the closure of the artificial anus by an interval. Since closure of the artificial anus, by resection and anastomosis, is often a formidable undertaking, perhaps the best plan, in suitable cases, is to remedy the mischief in four stages. (1) The loop containing the growth is mobilized, the growth brought out of the abdomen, and the limbs of the loop sutured together and fastened to the abdominal wall as in Bodine's colostomy. A rubber tube is anastomosed, as described under colostomy, with the extraabdominal portion of the bowel above the growth. (2) When the tube comes away the growth is amputated. (3) At the end of a week the spur between the limbs of the loop is cut through with a clamp. (4) After the clamp has done its work, i.e., about a week, the artificial anus is closed, as after the Bodine operation. The chief objection to the proceeding just outlined is that it prohibits extensive removal of the lymph channels and glands, but, according to Butlin, over 60 per cent. of the deaths from colonic carcinoma are due to obstruction, and occur before metastasis takes place. If one does perform a primary resection for an obstructing growth in the colon, an artificial anus above the anastomosis should be made at the same time.

End-to-end anastomosis, or *circular enterorrhaphy*, may be performed by simple suturing or with the aid of special apparatus. *Simple suturing* is always to be preferred. The best plan is to bring the clamps together as in gastroenterostomy (Fig. 388), suture the apposed peritoneal surfaces, paying special attention to the mesenteric border as described below, and then to finish the operation like a gastroenterostomy. If this is not done the ends of the intestine may be brought together and two sutures inserted on opposite sides of the bowel, each midway between the free border and the mesenteric attachment. These sutures are left long and held by an assistant, in order to act as guides. A third suture is now inserted at the mesenteric border (Fig. 410), so as to obliterate the space normally present between the layers of the mesentery at this point. The two segments are now united by a continuous suture of catgut, passing through all the coats in order to secure firm apposition and stop bleeding. After the posterior margins have been united, the suture may be inserted like a Cushing right angle suture, except that it passes through all the coats (Fig. 411). This layer of sutures is buried by a continuous Lembert or Cushing suture of silk, extending around the whole circumference of the anastomosis. It is well to insert an

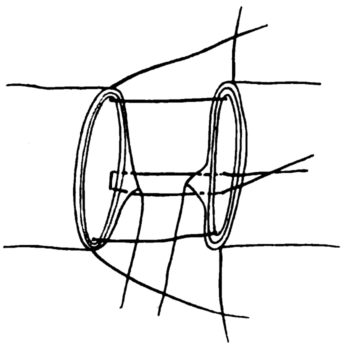


FIG. 410.—Mesenteric stitch.

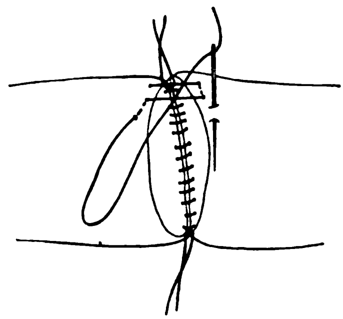


FIG. 411.

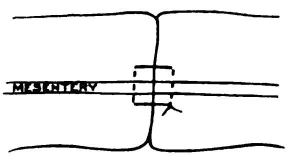
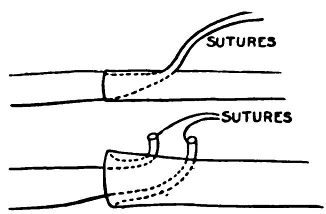


FIG. 412.



FIGS. 413 and 414.—Maunsell's operation.

extra suture at the mesenteric insertion as shown in Fig. 412. When the ends of the bowel are of unequal size, the larger opening may be partly closed by sutures, or the smaller end may be cut obliquely and the larger transversely; under these circumstances, however, it is much better to close both ends and perform a lateral anastomosis. In *Maunsell's operation* the ends of the gut are first united by two sutures, one at the mesenteric and one at the free border, the knots being placed within the lumen and the sutures left long. A longitudinal incision is then made in the free margin of the segment of bowel with the larger diameter, about an inch from its end. These sutures are drawn out through the lateral opening (Fig. 413) and by traction an artificial intussusception is produced (Fig. 414). The edges of the protruded intussusception are united by sutures passing through all the coats of the bowel, the intussusception reduced, and the longitudinal opening closed by Lembert sutures. The union may be reinforced by an extra layer of Lembert sutures.

Of the many forms of *special apparatus* which have been suggested to facilitate end-to-end anastomosis, the Murphy button alone will be described, although it too is almost never employed at the present time. The button consists of two hollow, flanged, metallic cylinders. When one cylinder is inserted into the other and pressed home the flanges cannot be separated except by unscrewing, there being two spring catches (S.S. Fig. 415) on opposite sides of the smaller cylinder, and a screw thread in the interior of the larger. In one-half of the button there is an additional flange (P. Fig. 415) separated from the first by a spring (C. Fig. 415) which exercises constant pressure on the bowel, and thus induces necrosis and liberates the button, the segments of bowel having in the meantime united. A purse-string suture is inserted into each end of the divided intestine, special attention being given to the mesenteric insertion so that it will be included within the grasp of the button. One-half of the button is inserted into the open end of each segment of bowel and the purse-string suture drawn tight and tied. Any excess of mucous membrane is cut off and the two halves of the button pressed together. The button should be passed with the feces in from two to three weeks. The disadvantages of the button are that it is a foreign body which may become impacted or retained, producing obstruction or ulceration of the bowel, and that its use may be followed by leakage, the result of a spreading of the necrosis which it necessarily induces. The button should always be tried before operation, as many are defective in construction.

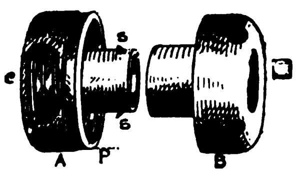


FIG. 415.—Murphy button. A, Male half; B, female half. The round holes are for drainage.

Lateral anastomosis is performed to short-circuit a portion of the intestinal canal, and sometimes instead of end-to-end anastomosis after resection of the bowel. The advantages over end-to-end anastomosis are that broader contact of the serous surfaces can be secured without narrowing the lumen; that necrosis is less apt to occur, as the mesenteric vessels are not involved in the suture; that the opening can be made as large as desired, hence post-operative contraction may be discounted; and that a difference in the size of the segments makes the operation no more difficult or dangerous. The disadvantages are that the feces are apt to be propelled past the opening into the blind end of the proximal segment, which may give way under the pressure; that the circular fibres are cut, thus predisposing to impaction at the site of anastomosis; and that the blind end of the distal segment may invaginate. While surgeons differ as to the importance to be attached to the above considerations, all agree that lateral anastomosis is safer when the bowel is not completely surrounded by peritoneum, e.g., in the ascending and descending colon. When selected after resection of the bowel, the open ends of the gut are closed by sutures, and the anastomosis effected as close as possible to the ends of the segments, care being taken to maintain the normal direction of the fecal current whenever possible (Fig. 416). When the ends of the intestine cannot be sufficiently mobilized for this purpose, the bowel may be arranged as shown in Fig. 417. After the loops have been emptied clamps are applied and the operation completed in the same manner as gastroenterostomy with suture The *Murphy button* is applied much in the same way as in end-to-end anastomosis. A purse-string suture passing through all the coats is introduced into each segment of bowel opposite its mesenteric attachment, incisions made into each loop of bowel within the area embraced by the suture, each half of the button inserted, the sutures drawn tight and tied, and the button locked.

Lateral implantation (Fig. 418), or end-to-side anastomosis, may be performed by simple suturing or by means of the Murphy button.

Exclusion of intestine whose removal is impossible, e.g., because of an extensive neoplasm, or whose removal is unnecessary, e.g., in chronic inflammatory lesions, may be performed in three ways. (1) The bowel above and below the diseased segment is united by lateral anastomosis (Fig. 419). This does not divert the fecal current completely and, unless there is total obstruction in the short-circuited bowel, is often followed by contraction of the anastomotic opening. (2) The bowel above the disease is severed, the distal end closed, and the proximal end united with the bowel below, either by lateral implantation (Fig. 420) or by lateral anastomosis. This operation is called unilateral exclusion. Its disadvantages are, when applied to the

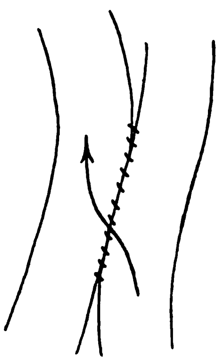


FIG. 416.—Lateral anastomosis. (Binnie.)

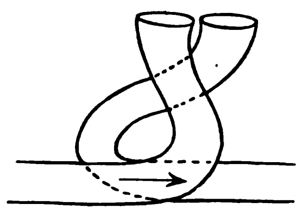


FIG. 417.

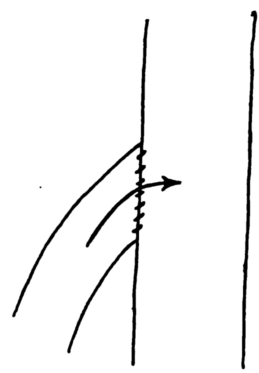


FIG. 418.—Lateral implantation. (Binnie.)

colon, retrograde transportation of the feces and diarrhea. It really creates a long artificial cecum, in which the intestinal secretions and the regurgitated feces may accumulate (fecal impaction), putrefy (gas pains), generate toxins (intoxication), and perhaps cause ulceration, perforation, and death. These dangers may be lessened, but not obviated, if the lower end of the ileum is anastomosed with the transverse colon (ileotransverseostomy). Lane recommends ileosigmoidostomy, end-to-side (Fig. 420), for chronic constipation and for many other ills that he believes are due to intestinal stasis. (3) The bowel is anastomosed as just described, and then the lower end of the excluded segment divided above the anastomosis and the open ends of the gut closed (bilateral exclusion, Fig. 421). This method necessitates drainage of the excluded segment, which otherwise would become distended with retained secretions, causing pain, toxemia, and possibly peritonitis from perforation, hence if the excluded segment is not already connected with the skin by a fistula, one must be established. Sometimes one end or both ends of the excluded bowel are left open and fastened to the skin. In order to avoid the inconvenience of an external fistula several suggestions have been made. The ileum may be united with the sigmoid by lateral anastomosis in two places, and ligated between the anastomoses. A lateral anastomosis may be made between the cecum and the sigmoid (typhlosigmoidostomy). The sigmoid may be divided, the lower end anastomosed, end-to-end, with the cecum, the upper with the side of the lower segment (typhlosigmoidostomy en Y). In all of these methods both ends of the colon are said to be drained. In the first the ileocecal valve would probably interfere with the drainage of the cecum. In the second and the third at least some of the feces would prefer the normal to the artificial route, and flow up the ascending colon. In all a stricture above the site of operation, e.g., in the transverse colon, would create two culs de sac. Hence these operations do not exclude the large bowel, and after bilateral exclusion one must accept the external fistula or excise the colon.

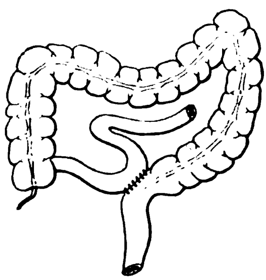


FIG. 419.—Incomplete exclusion of colon.

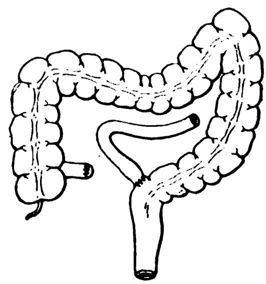


FIG. 420.—Unilateral exclusion of colon

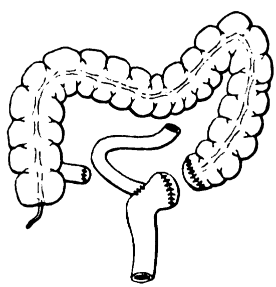


FIG. 421.—Bilateral exclusion of colon.

APPENDICITIS.

The **vermiform appendix** varies in length from a fraction of an inch to one foot, but is generally about three inches. It may point in any direction, but most frequently it runs downward and inward or upward and inward. It usually arises from the postero-internal part of the cecum, which it resembles in structure, except that it contains a large amount of lymphoid tissue, a fact which has gained for it the title "abdominal tonsil." Although it may be entirely retroperitoneal, it is almost always supplied with a mesentery (meso-appendix), in whose free border runs the artery of the appendix, which is a branch of the posterior ileocecal; one or two vessels may run also outwards on the body of the organ within the folds of the mesoappendix. In the female the appendix is said to be occasionally connected with the ovary by a fold of peritoneum (appendiculo-ovarian ligament) which carries a small artery from the ovarian, thus giving additional blood supply. The orifice of the appendix is slightly narrowed by a mass of lymphoid tissue, called the valve of Gerlach. The function of the human appendix is not known, although some believe it has a slight influence on digestion by reason of its secretion.

The **causes** of appendicitis are predisposing and exciting. Among the *predisposing causes* must first be mentioned the peculiarities of the appendix itself. It is a long, narrow, blind sac communicating with the intestinal canal and often constricted at its orifice. Furthermore the mesoappendix is often short, thus coiling or kinking the appendix and interfering with its drainage and blood supply. Although it may occur at any age, appendicitis is most frequent between the tenth and thirtieth years. It is slightly more common in males, and is probably more frequent in the summer than in the winter. Other conditions which predispose to this affection are tonsillitis, rheumatism, influenza, and disorders of the gastrointestinal canal, e.g., gastroenteritis, dysentery, typhoid fever, and constipation. One attack markedly predisposes to subsequent attacks. The *exciting causes* are enteritis (including intestinal indigestion, typhoid, dysentery, etc.) which spreads to the appendix, traumatism, exposure to cold, and foreign bodies. Foreign bodies, such as intestinal parasites, seeds, stones, etc., are uncommon, but fecal concretions are often encountered. Tuberculosis, actinomycosis, and certain neoplasms also may involve the appendix, and inflammation of neighboring structures, e.g., the uterine appendages, may cause a secondary appendicitis. No matter what the source of irritation, however, the most important factor is infection of the walls with micro-organisms, especially the colon bacillus. The ordinary pyogenic bacteria, particularly the streptococcus pyogenes and less frequently other organisms, also are found, either alone or as a mixed infection. The appendix is normally inhabited by hordes of bacteria, which become vicious only when they enter the wall of the appendix through an abrasion, e.g., by a fecal concretion, or through the lymphatics without an abrasion, e.g., when the drainage of the organ is defective as the result of kinks, adhesions, tumors, concretions, foreign bodies, swelling of the mucous membrane of the cecum, etc.

The **pathological anatomy** varies with the virulence of the infection, the depth of the inflammation, the duration of the process, and the complications. *In catarrhal appendicitis* the mucous membrane is swollen and congested and sometimes presents hemorrhagic foci; the process may subside if drainage is free, or it may extend to the outer walls (*interstitial appendicitis*), the entire organ then being swollen and congested, and containing pus (*empyema of the appendix*), blood, or feces. Interstitial abscesses also may be found. If the appendix empties itself into the cecum, the patient may recover from the attack, but the organ is permanently crippled and a chronic or recurring inflammation ensues. More often the disease progresses to ulceration or gangrene. *Ulcerative appendicitis* may arise also primarily, e.g., in typhoid fever or dysentery, or from a foreign body. One or more of these ulcers may perforate (*perforative appendicitis*), either into the free peritoneal cavity, or much more commonly after the general peritoneal cavity has been protected by inflammatory adhesions. In the latter instance a localized abscess will be formed. Ulcers which do not perforate, but cicatrize, cause strictures and deformities of the appendix. When such contraction is universal, the entire cavity may disappear (*obliterating appendicitis*). The appendix occasionally becomes distended with mucus distal to a stricture (*hydrops or mucocele of the appendix*). *Gangrenous appendicitis* may follow any of the preceding varieties, or it may be caused by a sudden and overwhelming infection, or by a cutting off of the blood supply as the result of thrombosis, or obstruction of the vessels by kinks, etc. This variety may develop within a few hours (*fulminating appendicitis*). The organ undergoes moist gangrene, being soft, swollen, and green or black in color, and soon separating from the healthy tissues. In fulminating cases it may lie free in the peritoneal cavity. In any case, however, in which the inflammation progresses beyond the mucous membrane, adhesions are apt to form about the appendix, thus serving as a protective barrier in the event of gangrene or perforation. The exudate thus formed may become purulent, even in the absence of perforation and gangrene. The situation of the appendix determines the location of the abscess, which may rupture through the abdominal wall, into a neighboring hollow viscus, or into the general peritoneal cavity. Among the other *complications* of suppuration about the appendix may be mentioned perforation of the iliac vein or artery, psoitis, lymphangitis or lymphadenitis, phlebitis (iliac, femoral, mesenteric, or portal), abscess of the liver, kidney, spleen, or lung, subphrenic abscess, empyema, endocarditis, meningitis, parotitis, and pyemia.

The **symptoms** may be described under two headings, according to whether the disease is acute or chronic. The most important symptoms of *acute appendicitis* are pain, tenderness, and rigidity of the muscles over the appendix, which is generally in the right iliac fossa, but may be in the loin, pelvis, or any part of the right side of the abdomen; in rare instances it is to the left of the median line. The first symptom is pain, which usually develops suddenly, is paroxysmal in the beginning and confined to the epigastric or umbilical region, and later becomes constant and localized in the region of the appendix. The pain in the appendiceal region is increased by direct pressure over the appendix, and by indirect pressure induced by movements of the right thigh, abdominal respiration, and deep palpation of the left abdomen. Traction on the right spermatic cord may, by stretching the peritoneum in the neighborhood of the internal inguinal ring, cause acute pain, especially when the appendix is situated in the pelvis. The pain may disappear entirely after the onset of gangrene or suppuration. The situation of the most marked tenderness also varies with the situation of the appendix, hence may require rectal or vaginal examination for its development; in most instances, however, it is at McBurney's point (one and one-half to two inches from the anterior superior spine of the right ilium on a line running to the umbilicus, Fig. 373). The skin over the inflamed area also may be hyperesthetic. Rigidity, often board-like in character, likewise is most intense over the appendix, and its degree and extent usually indicate the degree and extent of the underlying inflammation. Vomiting occurs with the epigastric pain, then subsides, and recurs with the development of peritonitis. Constipation is present in about two-thirds of the cases. The temperature usually rises two or three degrees, but in many cases there is no fever until abscess or peritonitis or other septic complications ensue. Chills are rare and generally indicate gangrene of the appendix or metastatic abscesses. The pulse, in the absence of complications, may be normal or but slightly accelerated; it becomes rapid with the development of peritonitis. The respirations are costal, but the rate is not influenced to any great extent until peritonitis develops. The facial expression may be that of pain, but is not characteristic in the absence of peritonitis. The tongue is usually coated. The late symptoms, in a progressive case, are those of peritonitis. In the early stages the underlying structures cannot be palpated because of the muscular rigidity, but with the formation of an abscess or a fibrinous exudate about the appendix, a mass may be felt and sometimes seen. This tumor is smooth, fixed, usually tympanitic, and rarely fluctuating. After the infected focus has become well encapsulated, the rigidity often disappears. Rough or powerful pressure should never be used in acute cases because of the danger of rupturing the appendix or an environing abscess. Leukocytosis, increasing with the extent of the infection, unless such be overwhelming, is a sign of some value when considered with the clinical phenomena. The progress of the disease varies greatly in different instances. In the mildest forms in which the infection does not extend beyond the appendix, complete recovery may follow in a few days, but subsequent attacks are the rule (*recurring appendicitis*). In fulminating cases the peritoneum may be involved within a few hours. Unfortunately it is impossible to foretell from the character of the symptoms which cases will recover and which will progress to perforation, gangrene, or abscess formation. In the midst of even the mildest symptoms, sudden perforation or gangrene with their disastrous sequelæ may occur. *Chronic appendicitis* may be such from the beginning or it may follow an acute attack. The symptoms are pain and tenderness in the region of the appendix with chronic indigestion. Occasionally a thickened appendix may be felt. Chronic appendicitis in which acute attacks occur at intervals is called *relapsing appendicitis*.

The **diagnosis** is generally easy, but may be very difficult or impossible. In many cases a failure to make a definite diagnosis entails no serious consequences, because the surgeon recognizes the necessity for operation in order to deal with some intraabdominal catastrophe. Pain, tenderness, and rigidity are prominent features in this group of cases, which includes among other conditions the following: Perforation of any portion of the gastrointestinal canal, intestinal obstruction, inflammation of Meckel's diverticulum, volvulus of the omentum, acute infections of the gall-bladder, abscess of the kidney, floating kidney with twisted ureter, extrauterine pregnancy, inflammatory lesions of the right tube or ovary, ovarian cyst with twisted pedicle, acute pancreatitis, thrombosis of the mesenteric vessels, and tuberculous peritonitis. In a second group of cases a mistake in diagnosis may lead to an unnecessary operation. A partial list of these cases is as follows: Acute indigestion, intestinal colic, acute enteritis, Henoch's purpura, typhoid fever, gastric ulcer, dysentery, hepatic colic, renal colic, movable kidney, ureteritis, epididymitis, dysmenorrhea, lead poisoning, incipient inguinal hernia, pneumonia, pleurisy, Pott's disease, cerebrospinal meningitis, abdominal crisis of locomotor ataxia, and distention of the urinary bladder. A mass in the right iliac region may be due to fecal impaction, neoplasm of the structures in this region, cysts, lymphadenitis, foreign body in the intestine, intussusception, aneurysm, abscess (from the vertebræ or pelvic bones, iliopsoas or abdominal muscles), pelvic cellulitis, inflamed undescended testicle, properitoneal hernia, enlarged gall-bladder, displaced kidney, and phantom tumor. Space cannot be spared in this place to give a separate enumeration of the symptoms of the above conditions, but in most instances the differential diagnosis is possible if care is taken to obtain a full history and make a complete examination.

The **treatment** is operation as soon as the diagnosis is made. There are certain exceptions to this rule, e.g., the presence of some other grave malady which will render operation extremely dangerous, or the absence of a competent surgeon. Under these circumstances or when operation is refused, the patient should be confined to bed and, if seen early in the attack, given a laxative. Purgatives are contraindicated at a later period, because of the danger of causing perforation, or spreading the infection if such be outside the appendix; in these cases the bowels should be moved by enemata. The diet should be liquid; if vomiting persists, the stomach should be washed out and the patient fed by rectum. An ice bag or hot water bag may be applied over the appendix. Opium may be given to quiet peristalsis and relieve pain, but under no circumstances before a positive diagnosis is made, because of the danger of clouding the symptoms. The mortality with medical treatment is said to be 25 per cent., that of early operation while the infection is still confined to the appendix is less than 1 per cent.; in cases in which a localized abscess has formed the mortality of operation is from 5 to 10 per cent., in those with diffuse peritonitis between 10 and 25 per cent. The practitioner is sometimes advised to wait for an interval before operating in cases with mild or subsiding symptoms, but operation in these cases is just as safe as in an interval, and the danger of a sudden exacerbation is precluded. In appendicitis with peritonitis a few surgeons adopt the Ochsner method of treatment (see peritonitis). If a patient has passed through one attack of undoubted appendicitis, removal of the organ is recommended because of the danger of subsequent attacks; this advice becomes progressively stronger with the number of attacks which have been experienced.

Operation in clean cases, i.e., early in an attack or in interval cases, is as follows: The abdomen is opened by an incision through the outer border of the right rectus muscle, beginning at the level of the umbilicus and extending downwards two or more inches, according to the amount of room desired. When one is positive there is no extraappendiceal infection, the McBurney method of opening the abdomen is ideal, because no nerves are severed and subsequent hernia is practically impossible. A two or three inch skin incision is made in the direction of the fibers of the external oblique, the center of the incision being about one and one-half inches from the anterior superior spine of the ilium on a line to the umbilicus. The fibers of the external oblique are separated and retracted, likewise the fibers of the internal oblique and transversalis muscles, which run almost at right angles to the superficial wound (Fig. 422). The transversalis fascia and peritoneum are severed in the same direction as the internal oblique. At the completion of the operation each of these layers is separately sutured with catgut. The appendix may be found as soon as the abdomen is opened. In other cases it will be necessary to identify the cecum, and follow the anterior longitudinal band, which always leads to the base of the appendix. If adhesions are encountered, they should never be separated without protecting the general peritoneal cavity with gauze, as they may harbor a focus of suppuration. The mesoappendix is perforated close to the cecum with an aneurysm needle, armed with catgut (Fig. 423) ligated, and divided. Hemostatic forceps are placed on the appendix near its base, to prevent soiling of the wound during amputation, which may be effected by one of a number of different methods. The easiest plan is to crush the base of the appendix with a second pair of forceps, ligate the crushed tissue with catgut, amputate beyond the ligature, and cover the stump with a purse-string inversion suture of silk or celluloid thread, after touching the exposed mucous membrane with carbolic acid, and then with alcohol. Since this method necessitates the strangulation of infected tissue, which is occasionally followed by abscess, the author removes the appendix as follows: The ligated stump of the mesoappendix is buried by means of a Lembert suture of celluloid thread, which is continued as far as the base of the appendix, when the needle is arrested in its passage through the folds that have been raised on each side of the appendix (Fig. 424), and the appendix amputated close to the cecum, the left thumb being placed beneath the eye half of the needle, the left index finger beneath the distal half, to insure

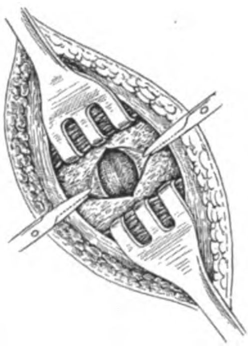


FIG. 422.—Intermuscular incision.

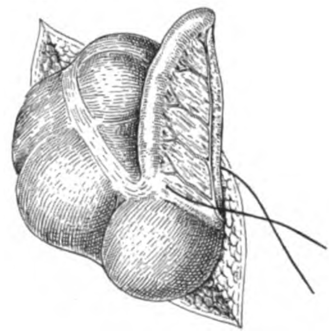


FIG. 423.—Ligation of mesoappendix.

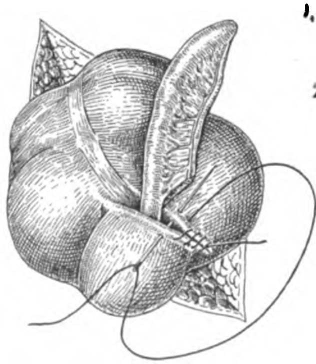


FIG. 424.—Inversion. The hemostat and hands are not shown.

1. Reflection of flap of serosa.
2. Purse string suture Crush. cut - sterilizing c carbolic then alcohol.
3. Turn in infected mucosa.

against retraction of the bowel into the abdomen. After inspecting the cut surface, to make certain that there is no bleeding, the needle is pulled through, thus inverting the edges of the wound, the closure being completed with two or three additional stitches. The suture line is then buried by a second continuous Lembert suture, made with the same thread, and terminated at the point of origin of the first suture. Rarely a bleeding point is observed at the site of amputation, in which event the wound is made dry with an extra stitch before completing the inversion. The wound in the abdominal wall is closed without drainage.

Operation for appendiceal abscess is performed through an incision made over the mass. If edema of the abdominal wall be found, the abscess is probably adherent to the parietes, and will be opened on cautiously deepening the wound. All that is then needed is to insert a drainage tube and allow the cavity to heal by granulation. If, however, the appendix is loose in the abscess cavity, or can be removed without opening the general peritoneal cavity, such should, of course, be done. In other cases the appendix may be removed after the abscess has healed, when there is no longer danger of infecting the peritoneum. If, on incising the abdominal wall, the abscess is not adherent to the parietes, it should be carefully isolated from the general peritoneal cavity by gauze packing. A small opening is then made into the abscess by separating the adhesions with the finger, and the pus removed with gauze pads as quickly as it appears. When the pus ceases to flow, the opening is enlarged with the finger, the cavity dried with gauze, and the appendix removed by one of the methods already mentioned, using catgut, however, for the inversion suture, since a non-absorbable suture in these cases may give rise to a troublesome sinus. The cavity is mopped with salt solution, dried, and drained with gauze; the author uses the Mikulicz drain, as described under surgical technic (Chap. IV). After the outer packing is removed, the superfluous portion of the wound is closed with sutures. If the protecting gauze packing has been efficiently arranged during the operation, the abscess cavity may be safely washed with salt solution after the pus has been removed.

For **operation for diffuse peritonitis** following appendicitis see peritonitis.

The **sequelæ** of operation in abscess cases, or in those complicated by peritonitis, are secondary abscess, intestinal obstruction, fecal fistula, suppuration of the superficial wound, and hernia.

Appendicostomy (Wier's operation) is employed to permit irrigation of the colon in chronic dysentery and other ulcerative lesions of the large bowel. The abdomen is opened by a McBurney incision, the mesoappendix ligated and severed, the appendix sutured to the parietal peritoneum and skin, the superfluous portion of the wound closed, the appendix opened to make sure that it is patulous (if strictured a Gibson operation, as described under colostomy, is indicated), a ligature applied to prevent leakage, and after several days the protruding part of the appendix amputated. The colon may now be irrigated daily with salt solution, silver nitrate, 1–5000, bismuth and starch water, 1 dram to the ounce, etc., by passing a catheter through the appendix and introducing a tube into the rectum. When the fistula is no longer needed it may be closed by cauterizing the mucous membrane.

THE LIVER.

For **injuries of the liver** see contusions and wounds of the abdomen.

Abscess of the liver is most frequent in the inhabitants of tropical countries and in alcoholics. Infection may be direct, as in wounds or when it extends from neighboring organs; it may travel up the bile ducts, particularly when they are obstructed; and it may be carried by the blood stream, either hepatic, as in general pyemia, or portal, as in abscesses following infective lesions in the area drained by the portal vein, e.g., appendicitis, and dysentery or other forms of intestinal ulceration. Hydatid cysts may suppurate, and in tropical countries a contusion may be followed by an abscess. The organisms most frequently found are streptococci, staphylococci, and the colon bacillus.

In that form following amebic dysentery (*tropical abscess*) the pus is frequently sterile, the organisms probably having perished as the result of the chronicity of the case. Ascarides, distoma, and coccidia are possible but rare causes of hepatic suppuration. Tropical and traumatic abscesses are usually solitary and occupy the right lobe; pyemic abscesses small, multiple, and hence rarely amenable to treatment.

The **symptoms** in acute and pyemic abscesses are pain reflected to the right shoulder, tenderness and enlargement of the liver, occasionally friction sounds owing to involvement of the peritoneum, rarely edema of the skin or fluctuation, chills, fever, sweats, leukocytosis, perhaps slight jaundice, and sometimes cough from irritation of the phrenic nerve or invasion of the lung. Chronic and tropical abscesses may give few or no symptoms. In the latter the ameba may be found in the stools. The X-rays may show the enlargement of the liver and, if the abscess is near the diaphragmatic surface, a dome-shaped projection. The abscess may break into the peritoneal cavity, one of the hollow viscera, the pleura, the lung, the pericardium, or into the vena cava or portal vein; or it may point externally through the abdominal wall. The diagnosis may be confirmed by aspiration, the needle being inserted in the seventh or eighth intercostal space between the axillary lines, below the costal arch in the right nipple line, or posteriorly in the ninth or tenth interspace vertically below the angle of the scapula. One should be prepared to proceed immediately with operation if pus is found.

The **treatment** is *hepatotomy* by the abdominal or thoracic route, depending upon the situation of the abscess. If the former is chosen, the abdomen is opened, usually by a longitudinal incision, below the costal arch. If the liver is adherent to the abdominal wall, the abscess may be opened without danger of contaminating the peritoneal cavity. In the absence of adhesions the peritoneal cavity must be protected by gauze packing. The abscess is located with a hollow needle, and opened by passing a knife or a cautery blade along the needle. The abscess is irrigated, and drained with a rubber tube, the free portion of the cavity being lightly packed with gauze. After removing the gauze which protects the peritoneal cavity, the liver below the opening of the abscess may be sutured to the abdominal wall. When the abscess is high on the dome of the liver, the transpleural or thoracic operation is indicated. The abscess is located with the needle as directed above, the rib below the needle excised, and, if the pleural cavity is obliterated at this point by adhesions, the abscess opened as previously described. If there are no adhesions, the two layers of the pleura should be stitched together with catgut.

Cysts of the liver arising from dilatation of the lymph spaces are called *simple serous cysts*. They may be single or multiple, large or small, but seldom cause symptoms. *Polycystic disease* of the liver is usually congenital and often associated with cystic disease of the kidneys; almost the whole organ is converted into serous cysts of various sizes. Both these varieties as well as *cystic adenoma* and *dermoids* are very rare. *Hydatid cysts* are considered in the next paragraph.

Hydatid cysts are found more frequently in the liver than in any other portion of the body. The general facts concerning these cysts and the composition of hydatid fluid are given in Chap. XIII.

The **symptoms** develop slowly. The swelling moves with respiration and is seldom painful. When superficial, fluctuation and hydatid fremitus, or thrill, may be obtained; the latter is due to the rubbing together of the daughter cysts. When deeply situated the cyst may be mistaken for a neoplasm. Pressure on the lung causes dyspnea; on the stomach or bowel, vomiting and indigestion; on the blood vessels, ascites and edema of the legs; on the bile ducts, jaundice, which is rare. Hydatid urticaria and toxemia occur most often after rupture into the peritoneal cavity. Examination of the blood reveals eosinophilia. The X-rays may give the same information as in abscess of the liver. Aspiration may be used for diagnostic purposes, but only immediately before operation. The cyst may shrink and the contents become inspissated, or it may enlarge, with or without suppuration, and burst in one of the situations just mentioned under abscess of the liver.

The **treatment** is much like that of abscess. After protecting the abdominal cavity, the cyst is aspirated, opened with the cautery or knife, the daughter cysts removed, and the cavity drained after stitching the edges of the opening to the abdominal wall. Small cysts may be completely excised. Simple aspiration and aspiration followed by injections are not recommended.

Tumors of the liver are usually secondary, hence multiple. Among the primary tumors are carcinoma, sarcoma, endothelioma, angioma, fibroma, adenoma, lipoma, and myxoma. Gummata and thick-walled hydatid cysts may closely simulate neoplasms. In suitable cases the growth may be resected with the knife or thermocautery, after surrounding it with a series of interlocking ligatures of silk or catgut, introduced with a blunt needle. As after rupture of the liver (see contusions of the abdomen) hemostasis may be effected by tamponage with muscle, omentum, or fat, and a transplant of fascia employed to prevent tearing out of the sutures. In certain cases the growth may be secured extraperitoneally by passing pins through the pedicle, and then removed after constricting the pedicle with an elastic ligature, which is left in place.

Hepatoptosis, or floating liver, is generally a part of splanchnoptosis. There may be pain, vomiting, and general weakness, with, in some cases, jaundice and ascites. The prolapsed organ may be outlined by palpation. The *treatment* is that of splanchnoptosis. When other measures fail, the liver may be sutured to the anterior abdominal wall with a blunt needle and silk or catgut (*hepatopexy*). In partial ptosis, or floating lobe, e.g., the result of tight lacing or cholelithiasis (*Riedel's lobe*), the cause should be removed, and the floating lobe supported by suturing the ligamentum teres or gall-bladder to the abdominal wall. Excision of a linguiform projection also has been done.

In **atrophic cirrhosis of the liver** with ascites, attempts have been made to prevent the effusion of fluid into the peritoneal cavity by relieving the venous congestion through an artificial collateral circulation between the portal and the systemic vessels (epiplopexy), or through an anastomosis between the vena cava and the portal (*Eck's fistula*) or superior mesenteric vein, or between the superior mesenteric and ovarian veins; and to drain the effusion into the subcutaneous or retroperitoneal cellular tissue (by leaving an opening in the peritoneum, by suturing the edges of the opening in the peritoneum to the cellular tissues, by placing the omentum in the abdominal wall, by silk threads, wire, tubes), or into the veins by anastomosing the internal saphenous vein with the peritoneum. In *epiplopexy* (*Talma's operation*) the fluid is drawn off by a puncture above the pubes, and the abdomen opened above the umbilicus. The external surface of the liver and the spleen and the apposed parietal peritoneum are scrubbed with gauze, after which the omentum is sutured to the abdominal wall. The wound is then closed, and the freshened intraperitoneal surfaces held together by a tight bandage or adhesive plaster applied to the upper abdomen. About 10 per cent. of the patients thus treated are permanently relieved of the ascites, 20 per cent. temporarily benefited. Direct transference of blood, as in the Eck fistula, aside from its technical difficulties, may cause embolism, alimentary intoxication (because the blood does not flow through the liver), or acute general infection (because the intestinal mucosa does not always oppose a sufficient barrier to microorganisms), hence cannot be recommended. The drainage operations give only transient relief, as the opening is plugged with omentum or closed by cicatrization, the foreign body encapsulated, the vein thrombosed. Our own conclusions are that cirrhosis of the liver cannot be cured by operation; if it could, the operation ought to be performed before the ascites appears. Ascites is a symptom merely. The liver may be large or small in cirrhosis. In all forms of ascites, it may be pushed up or rotated, and give a diminished area of dulness on percussion, or the ascites may be so great that the size of the liver cannot be determined by external examination; hence unless there are contraindications (serious disease of the heart, lungs, kidneys) all cases should be operated upon early, for the purpose of diagnosis, and with the hope that something may be found that is amenable to surgical treatment. If cirrhosis exists epiplopexy may be performed; if gall-stones (which may be the cause or the result of cirrhosis) are found they should be removed; if there is a chronic pancreatitis the gall-bladder may be drained; if the spleen is enlarged (Banti's disease) splenectomy is to be considered. Not infrequently the surgeon will find, instead of hepatic cirrhosis, tuberculous peritonitis, and less often an ovarian papilloma, a tumor in the portal region, or carcinomatosis of the peritoneum. *Biliary cirrhosis* without ascites has been treated by cholecystostomy.

THE BILIARY PASSAGES.

Cholangitis, or inflammation of the biliary ducts, may be acute (catarrhal or suppurative) or chronic. *Acute catarrhal cholangitis* (*catarrhal jaundice*) is usually due to an ascending infection from the duodenum; it is dealt with by the physician and need not be discussed here. *Suppurative or phlegmonous cholangitis* is caused by pyogenic organisms which ascend from the duodenum or are excreted with the bile. Any lesion interfering with biliary drainage predisposes to this condition, and it may be caused by general infections, e.g., pyemia, typhoid fever, influenza, etc. The symptoms are those of septicemia or pyemia, with an enlarged and tender liver and a varying degree of jaundice. The *treatment* is that of pyemia, with the removal, if possible, of any obstruction to the flow of bile, and drainage of the gall-bladder.

Chronic catarrhal cholangitis may follow the acute form, but is usually the result of obstruction of the bile ducts (gall-stones, parasites, tumors, aneurysm, pancreatitis, adhesions, prolapse of the kidney or liver, pseudomembrane, strictures, and inflammatory swelling of the mucosa). In rare instances obstruction is due to congenital absence or atresia of one or more of the ducts. The *symptoms* are persistent jaundice, and in many cases recurring attacks of fever associated with sweats (*Charcot's intermittent fever*). There is usually enlargement and tenderness of the liver with asthenia and emaciation. The complications are suppurative cholangitis, diffuse hepatitis, abscess of the liver, cirrhosis of the liver, pylephlebitis, cholecystitis, perforation of the ducts, pancreatitis, endocarditis, pleurisy, pneumonia, and other septic maladies. The *treatment* is removal of the cause when possible, and drainage of the biliary ducts by one of the operations to be described later.

Cholecystitis, or inflammation of the gall-bladder, may be catarrhal, pseudomembranous, suppurative, or gangrenous. The infection may ascend from the duodenum or descend from the liver. The organisms most frequently found are the colon bacillus, the typhoid bacillus, and the ordinary pyogenic organisms. The causes are those of cholangitis, the most frequent etiological factor being gall-stones. The cystic duct is often blocked, if not by a calculus, by inflammatory swelling or a plug of mucus or membrane; as a consequence the gall-bladder is distended with bile mixed with mucus (catarrhal variety), pus (*empyema of the gall-bladder*), or blood (gangrenous variety). In the severer grades there is always a pericholecystitis, which may result in suppuration or the formation of adhesions. The gall-bladder may perforate into these adhesions, into the stomach or bowel, into the free peritoneal cavity, or rarely through the abdominal wall. As the result of repeated attacks of inflammation, the gall-bladder may be reduced to a fibrous cord (*obliterating cholecystitis*). Prolonged obstruction of the cystic duct, without serious infection, leads to distention of the gall-bladder with mucoid fluid, the bile having disappeared (*hydrops cystidis felleæ*). The *symptoms* are pain and tenderness in the region of the gall-bladder, with, in the more severe forms, fever, rapid pulse, vomiting, rigidity of the abdominal muscles, and leukocytosis. In many instances the distended gall-bladder may be palpated below the edge of the ribs. Jaundice is absent if the gall-bladder alone is involved.

The **treatment** is operation in all cases, with the exception of the non-obstructive catarrhal variety. In this form, especially when arising in the course of some general disease like enteric fever and not associated with severe symptoms, medical treatment is efficacious. Should the symptoms persist, however, or become severe, operation will be indicated. In catarrhal, pseudomembranous, and suppurative cholecytitis, cholecystostomy is the proper treatment, gall-stones being removed if present. In hydrops and gangrene cholecystectomy is demanded.

Cholelithiasis (gall-stones) is said to affect nearly 10 per cent. of all adults, 75 per cent. of the cases being females. It is most common in individuals past forty. Other *predisposing factors* are sedentary habits, tight lacing, abdominal tumors (all of which hinder abdominal respiration, hence the free flow of bile), constipation, excess of carbohydrates in the diet, catarrh of the stomach and duodenum, and lesions which interfere with biliary drainage. The *cause* of gall-stone formation is catarrhal inflammation induced by micro-organisms. The nucleus of the stone is generally a mass of bacteria, rarely a blood clot, particle of mucus, or other foreign body. The stones are composed of cholesterine and calcium salts, and vary in color according to the quantity of bile pigment present. They vary greatly also in number and size, and when multiple are faceted from mutual pressure. The organisms most frequently found are the colon bacillus and the typhoid bacillus, hence in many cases a previous history of typhoid fever may be obtained. The stones are almost always formed in the gall-bladder, rarely in the biliary ducts, although they are often transported to the latter situation. **Symptoms** sufficiently severe to demand treatment are present in about 5 per cent. of the cases, although many of the so-called digestive disturbances are in reality due to gall-stones. The symptoms are caused by the passage of a stone along the ducts, by inflammation, or by obstruction to the flow of bile. When a stone passes along the ducts (*biliary or hepatic colic*), there is in most instances excruciating pain in the region of the gall-bladder which radiates to the epigastrium and right shoulder, and is accompanied by vomiting, sweating, and sometimes collapse. The attack lasts from a few hours to several days; it may be followed by jaundice from obstruction of the common or hepatic duct by the stone or by inflammatory swelling. Jaundice is a symptom of gall-stones in only 20 per cent. of the cases. The calculus may be passed with the feces, but in most instances the colic is unsuccessful, the stone dropping back into the gall-bladder or lodging in one of the ducts. Should a faceted stone be found, the evidence is positive that other stones are present. In the majority of cases there is no typical biliary colic, but the patient complains of indigestion, a dull pain radiating towards the epigastrium and the right shoulder, and tenderness between the ninth costal cartilage and the umbilicus (*Robson's point*, Fig. 373). With these there may be enlargement of the liver and swelling of the gall-bladder. In rare instances crepitus may be obtained by manipulating the gall-bladder. Under favorable conditions the stones may be shown in a skiagraph. The following synopsis concerning the position of the stones and the condition of the biliary apparatus is taken largely from Kehr: 1. Gall-bladder containing stones with free cystic duct and little alteration in the walls.—Symptoms usually wanting, occasionally pains in the stomach due to transitory obstruction of the cysticus. Palpation negative or only slight tenderness in region of gall-bladder. Confusion with gastric ulcer, intestinal colic, movable kidney, and hernia of linea alba frequent. 2. Stones in gall-bladder in which inflammatory processes have already been present resulting in pericystic adhesions.—Severe colic caused by kinking of cystic duct after full meal or complete distention of the gall-bladder; vomiting, tenderness, and palpable gall-bladder. Between attacks there may be complete relief. 3. Acute cholecystitis due to stone in neck of gall-bladder.—Pain, swelling, tenderness in the region of the gall-bladder, and symptoms of general infection; rarely jaundice or expulsion of stone; in the latter event symptoms of acute obstruction of the choledochus arise. Linguiform projection of the anterior edge of the liver over gall-bladder (Riedel's lobe); occasionally mistaken for appendicitis. When the general infection is severe, the condition may be mistaken for malaria, typhoid, or sepsis. 4. Hydrops of the gall-bladder.—Symptoms may be wanting, the tumor being the only sign of disease, although Riedel's lobe and pain may be present. The tumor may be taken for a floating kidney, but is more movable from side to side, and when depressed towards the back immediately returns. 5. Empyema of the gall-bladder.—Symptoms same as cholecystitis. 6. Carcinoma of the stone-containing gall-bladder.—Digestive disturbances at first, later cachexia, and jaundice and ascites from the invasion of portal glands. The tumor is hard, uneven, and only slightly painful. 7. Acute obstruction of common duct by stone.—Typical biliary colic. 8. Chronic obstruction of the common duct.—Jaundice of varying intensity according to degree of obstruction. Intermittent fever, pain and tenderness nearer the middle line; liver and often spleen enlarged. This is in marked contrast to obstruction of the common duct by carcinoma or other tumor, in which there is persistent deep jaundice, no fever, and slight pain. In the latter the gall-bladder is usually distended, in chronic stone obstruction it is shrunken (*Courvoisier's law*), probably because the obstruction is often incomplete or intermittent and the bladder is constantly contracting to empty itself. Robson gives the following list of *complications* of cholelithiasis: "Intestinal obstruction due to localized peritonitis, volvulus, adhesions, or large gall-stones which have ulcerated into the bowel; general hemorrhages the result of chronic jaundice; adhesions causing pain, even after gall-stones have been removed, or dilatation of the stomach; fistula into neighboring viscus or to the surface of the body; stricture of cystic or common duct; abscess (liver, kidney, pericystic, abdominal wall, subphrenic, pancreas); cholangitis, simple or suppurative; septicemia or pyemia; phlegmonous or gangrenous cholecystitis; perforative peritonitis; cancer of the gall-bladder or ducts; pneumonia of the right lung or empyema of the right pleura; acute or chronic pancreatitis; cirrhosis of liver."

The **treatment** of hepatic colic is the application of heat and the subcutaneous administration of morphin and atropin. For the medical treatment of cholelithiasis the reader is referred to a text-book on medicine. Gall-stones are unaffected by drugs and the aim of the physician is to cure the catarrhal inflammation and prevent the formation of other stones. Medical treatment is indicated when the attacks are mild and widely separated, and in cases in which operation would be dangerous because of the presence of some independent affection. In the early stages operation is easy and safe; after the development of complications, both the difficulties and the danger are vastly increased.

Operations on the biliary passages are greatly facilitated by placing a sand bag beneath the spine, in order to push the liver and ducts forward and allow the intestines to fall away from the field of operation. In the presence of chronic jaundice there is great danger of persistent and uncontrollable hemorrhage. In order to avert this catastrophy, Robson gives 30 grains of calcium chlorid daily for several days preceding operation, and 60 grains per rectum for a few days after operation. The same author opens the abdomen through the middle of the right rectus muscle, continuing the incision upwards and inwards along the costal margin as far as the ensiform if more room is desired. Perthes gains a wide exposure, at the same time preserving the nervous supply to the rectus, by making an incision close to the median line from the ensiform nearly to the umbilicus, thence outward at right angles as far as the costal margin. In order to prevent retraction the rectus muscle is fastened to its anterior sheath before division, and the rectangular musculocutaneous flap turned up from the posterior sheath and the peritoneum, which are opened by an oblique incision. After separating any adhesions which may be present and packing off the stomach and intestines, the gall-bladder and cystic duct may be palpated, and a finger passed through the foramen of Winslow, in order to explore the supraduodenal segment of the common duct. The rest of the operation depends upon the conditions found.

Cholecystostomy, or cholecystotomy as it is sometimes called, is indicated in (1) cases in which the gall-bladder is sufficiently large to permit of drainage, after gall-stones have been removed; (2) cases in which, although there are gall-stones in the ducts, the patient is too ill to bear a prolonged operation, the gall-stones being deliberately left for subsequent treatment; (3) empyema of the gall-bladder, if the viscus is not too much disorganized to be permitted to remain; (4) certain cases of chronic catarrh of the gall-bladder or bile ducts; (5) infective and suppurative cholangitis; (6) obstruction of the ducts due to hydatid disease ; (7) dropsy of the gall-bladder after removal of obstruction; (8) rupture or laceration of the gall-bladder or ducts, when cholecystectomy is undesirable; (9) choledochotomy, in order to avoid tension in the sutured duct; (10) certain cases of obstructive jaundice dependent on malignant tumor which is occluding the ducts; (11) phlegmonous cholecystitis when the patient is too ill to bear cholecystectomy; and (12) in chronic pancreatitis, in which both the bile and pancreatic ducts are drained (Robson). The gall-bladder is drawn into the wound, aspirated, an incision made in the fundus, and the stones removed with a scoop. The opening in the gall-bladder is sutured to the transversalis fascia at the upper angle of the wound, and the gall-bladder drained with a rubber tube. A better plan is to suture the rubber tube in the gall-bladder with catgut, invert the edges of the gall-bladder around the tube by depressing it, and apply a purse-string suture to maintain the inversion, thus making a tight joint. It is well also to pass a mattress suture of catgut through the skin around the tube, so as to prevent inversion of the cutaneous margin on which the tube rests (Fig. 425). The tube should be long enough to drain into a receptacle at the side of the bed. When the catgut has been absorbed the tube is ready to be removed. The mortality of cholecystostomy for gall-stones is 1 to 2 per cent. The *biliary fistula* left after removing the tube should close spontaneously. A persistent fistula discharging bile is due to obstruction of the common duct; discharging mucus to blocking of the cystic duct; in either case a secondary operation is required. In former days a biliary fistula sometimes followed suturing of the gall-bladder to the skin.

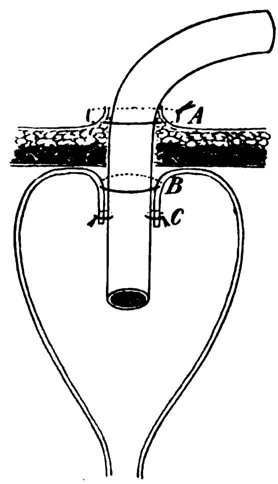


FIG. 425.—A. Mattress suture everting the skin. B. Purse-string suture inverting the edges of the gall-bladder. C. Suture through the tube and the gall-bladder.

Cholecystectomy may be required in (1) wounds of the gall-bladder in which suture is impracticable; (2) stricture of the cystic duct; (3) phlegmonous cholecystitis and gangrene of the gall-bladder; (4) multiple or perforating ulcers; (5) chronic cholecystitis in which the gall-bladder is too small to drain, or in which it is enlarged, thickened, and ulcerated, the common duct being free from obstruction; (6) mucous fistula due to stricture of the cystic duct; (7) hydrops due to stricture of the cystic duct; (8) empyema in which the walls of the gall-bladder are seriously damaged; (9) cancer limited to the gall-bladder or to the immediately adjoining parts; (10) other solid tumors of the gall-bladder, whether inflammatory or neoplastic, and (11) in calcareous gall-bladder (Robson). It is contraindicated when there is obstruction of the common duct. The cystic duct and artery are ligated, the duct grasped with hemostatic forceps between the ligature and the gall-bladder, and severed between the forceps and the ligature, the peritoneal reflection from the liver split on each side of the gall-bladder, and the gall-bladder removed from within outwards by blunt dissection. The peritoneal flaps are then stitched together, any oozing from the liver being checked by sutures or gauze packing. If bleeding is controlled absolutely, drainage may be omitted. If drainage of the biliary apparatus is required, the cystic artery alone should be ligated, and a rubber tube sutured to the end of the open cystic duct with catgut. The mortality of cholecystectomy for gall-stones is 5 per cent. When cholecystectomy is indicated but is impracticable, e.g., because of dense adhesions, the fundus may be amputated and the lining mucous membrane removed (*Mayo's operation*).

Cholecystenterostomy consists in the formation of a fistula between the gall-bladder and duodenum, jejunum, or colon. Robson employs the operation in biliary fistulæ depending on stricture or other permanent occlusion of the common duct; occasionally in cancer of the head of the pancreas or common duct leading to chronic jaundice; and rarely in gall-stone impacted in the ducts, when the common duct cannot be exposed and the patient is in no condition to stand a prolonged operation. The operation is performed by means of the Murphy button or by simple suturing.

Cysticotomy is incision into the cystic duct, usually for the removal of a calculus which cannot be pushed backwards into the gall-bladder. The duct may be sutured with catgut or drained with a rubber tube.

Choledochotomy is incision into the common bile duct, for the removal of a stone (*choledocholithotomy*), or for the purpose of drainage in cholangitis. When the stone lies in the supraduodenal portion of the duct, which is about three-fourths of an inch in length and runs in the right edge of the gastro-hepatic omentum, it is brought forward by a finger in the foramen of Winslow, and the operation completed as in cysticotomy. The portal vein and hepatic artery lie to the left. The sutures may be inserted before the stone, which acts as a guide, is removed. Before tying the sutures, the ducts should be explored with the finger or with the probe. Crushing of the stone without opening the duct (*choledocholithotrity*), or breaking it up by the insertion of a needle, is unsatisfactory because fragments are often left behind. Occasionally a stone in the common duct may be manipulated back into the gall-bladder; it should never be forced towards the duodenum. The retroduodenal portion of the common duct is about two inches in length, runs in or on the pancreas, and cannot be palpated without loosening the duodenum and turning it inwards. Stones in this situation may be removed by an incision in the upper portion of the duct, or when occupying the lower third of the choledochus, especially if impacted in the diverticulum of Vater, the operation of *duodeno-choledochotomy* may be performed. The anterior wall of the duodenum is opened, and the stone removed by enlarging the papilla, or by incising directly down upon it through the posterior wall of the gut. The incision in the anterior wall of the duodenum is then sutured; it is not necessary to place sutures in the posterior wall. The mortality of choledocholithotomy is 10 per cent.

Hepaticotomy, or incision into the hepatic duct, has the same indications as choledochotomy, but is seldom performed.

Hepatico-cholangio-enterostomy consists in anastomosing the intestine to an incision in the liver, when there is an irremovable obstruction in the hepatic duct. *Cholangiostomy* is the establishment of a fistula between the liver and the skin, *choledochostomy* between the common duct and the skin, and *choledocho-enterostomy* between the common duct and the intestine.

After destruction of the common duct by disease or injury the gall-bladder can be made to act as a substitute by performing cholecystenterostomy (vide supra), or, if the gall-bladder is absent, an attempt may be made to build a new duct (**choledochoplasty**) from the omentum, the gastric, duodenal, or abdominal wall. A rubber tube that is taken away when the process of repair is nearly completed, or that is left in place, also has been employed. The last mentioned procedure may lead to perforative peritonitis, cicatricial contraction of the new duct, or to incrustations about the tube. In dogs an artificial common duct has been made by transplanting a piece of artery, vein, or ureter.

THE PANCREAS.

For **injuries of the pancreas** see injuries of the abdomen.

Pancreatitis is due to trauma, general infective diseases, direct extension from neighboring inflammatory lesions, and most frequently to infection by way of the duct, as the result of catarrhal inflammation of the duodenum or cholelithiasis. Obstruction of the duodenal papilla by a stone may cause pancreatic stasis and regurgitation of infected bile, and a stone lodged in the pancreatic segment of the common duct may compress the canal of Wirsung and lead to pancreatic retention, thus predisposing to infection. Although the disease may occur at any age, it is most common during or after middle life. Three forms are described, the acute, the subacute, and the chronic.

Acute or hemorrhagic pancreatitis is characterized by sudden onset and rapid progress. The *symptoms* are violent epigastric pain and tenderness, vomiting, constipation, often slight jaundice, frequently distention of the abdomen, and the usual signs of collapse. Death occurs in from twenty-four hours to one week. The gland is swollen, hyperemic, and often infiltrated with blood. In many cases there are small yellowish-white patches (*fat necrosis*) on the pancreas, in the omentum and mesentery, and occasionally in more remote situations, due to the escape of pancreatic ferments, which split up the fat into glycerin and fatty acids, the former being absorbed, and the latter precipitated with calcium salts. Acute pancreatitis may be mistaken for intestinal obstruction, perforation of the stomach or duodenum, acute cholecystitis (which it may accompany), appendicitis, and acute gastritis the result of swallowing irritant poisons. The urine may contain sugar, leucin and tyrosin, lypolytic substances, or derivatives of glycerin (*Cammidge's test*), but the disease is so rapid that urinary changes are often absent.

The **treatment** is drainage. The abdomen will usually be opened in the median line above the umbilicus for exploration. The pancreas itself may be exposed either above or below the stomach, preferably by the latter route, after tearing through the gastrocolic omentum. A gauze drain may then be inserted into the lesser peritoneal cavity. It is seldom necessary to tie the vessels in the pancreas, as the loss of blood is not the cause of death. The pancreas may be drained also by an incision in the loin, the drain gaining exit below the lower pole of the kidney, preferably the left. Drainage of the gall-bladder also is indicated if there be gall-stones or cholecystitis. A few cases have recovered with this form of treatment.

Subacute pancreatitis is such from the beginning, or follows the acute form if the patient survives, the symptoms at first being much the same but less severe. At a later period suppuration (*suppurative pancreatitis*) or gangrene (*gangrenous pancreatitis*) occurs and septic symptoms develop, viz., chills, fever, sweats, rapid emaciation, and frequently diarrhea with foul smelling or bloody stools. If an abscess forms, the swelling may be detected in the epigastrium or in the loin, or the pus may gravitate to either iliac region. The prognosis is somewhat less gloomy than in the hemorrhagic form. The **treatment** is drainage by one of the routes mentioned above, with the removal of gall-stones and drainage of the biliary passages if there be cholelithiasis.

Chronic pancreatitis is characterized by a marked increase in the connective tissue, which causes the pancreas to become large and hard. The connective tissue may be more marked between the lobules (*interlobular pancreatitis*) or in the lobules (*interacinar pancreatitis*); in the latter form, which is less common than the interlobular variety, the islands of Langerhans are involved and glycosuria is present. The islands of Langerhans are supposed normally to manufacture an internal secretion which prevents glycosuria. The **symptoms** are emaciation, pain after eating, paroxysms of pain and vomiting, and tenderness in the epigastrium. The pain radiates to the interscapular region and towards the left shoulder. The pancreatic *point of Desjardin*, which corresponds with the opening of the canal of Wirsung into the duodenum and which is supposed to be the point of greatest tenderness, is situated from 5 to 7 cm. from the umbilicus on a line running to the right axilla (Fig. 373). Cholelithiasis is frequently present, and there may be jaundice from this cause, or as a result of the pressure of the contracting pancreatic tissue on the common bile duct. Rarely is it possible to outline the pancreas by palpation. The urine may contain sugar (if the islands of Langerhans are involved), fat, glycerin derivatives, or leucin and tyrosin. An excess of fat and muscle fiber may be demonstrated in the feces, which are often clay colored, even when bile is present. When salol is administered by mouth it is not decomposed, and carbolic and salicyluric acids do not appear in the urine (*Sahli's sign*). The **treatment** is removal of gall-stones, if present, and indirect drainage of the pancreas by cholecystostomy. The mortality of operation is about 12 per cent.

Pancreatic calculi are formed much in the same manner as gall-stones, and pancreatic colic is much like gall-stone colic, except that the pain is below and to the inner side of the gall-bladder and may be reflected to the left shoulder. Pancreatic calculi may be associated with gall-stones or with the various forms of pancreatitis, and sometimes cause a retention cyst by damming up the secretion of the gland. In a few instances they have been removed by operation.

Tumors of the pancreas include carcinoma, sarcoma, adenoma, and syphiloma. Primary growths are rare. Carcinoma is the most frequent, and chiefly affects the head of the gland. The symptoms are indigestion, epigastric pain, emaciation, and in the later stages jaundice, painless swelling of the gall-bladder, enlargement of the liver, and the appearance of a tumor. The signs of interference with the functions of the pancreas already mentioned also may be found. The *treatment* is symptomatic, although if detected at any early period, excision would be indicated.

Pancreatic cysts are uncommon, generally arise after middle age, and may be true or false. *True cysts* arise within the gland and include retention cysts (pancreatic ranula), congenital cystic disease, cystadenoma, hydatids, and hemorrhagic cysts. *Pseudocysts* are usually effusions into the lesser peritoneal cavity, the result of injury or inflammation, but may, however, communicate with the pancreas and contain a proteolytic and an emulsifying ferment. The **symptoms** are indigestion, vomiting, and frequently epigastric pain. Other symptoms are due to pressure on environing organs, or to interference with the functions of the pancreas, such as have already been mentioned. The patient usually emaciates and becomes sallow and weak. When of large size the cyst reaches the abdominal wall between the stomach and the colon, although it may be above the stomach or distend the layers of the mesocolon. It is usually immovable and at least partly covered by stomach tympany. The **treatment** in suitable cases is extirpation. In most instances this will be impossible because of adhesions, and it will then be necessary to stitch the cyst to the anterior abdominal wall and drain it.

THE SPLEEN.

For **injuries of the spleen** see contusions of the abdomen.

Splenoptosis (*wandering or movable spleen*) is usually a part of Glénard's disease, or is caused by enlargement of the spleen. The *symptoms* are indigestion, vomiting, dragging pain, absence of normal splenic dulness, and the presence in the abdomen of a movable tumor with a marked notch. The chief danger is twisting of the pedicle, which may lead to gangrene of the organ. The *treatment* is the application of a pad or belt. If this is unsuccessful, the spleen may be removed (see splenectomy), or sutured to the abdominal wall (*splenopexy*). As sutures are apt to cut out and cause profuse bleeding, a better method is to slip the spleen into a pocket formed by separating the parietal peritoneum from the abdominal wall, the peritoneum being sutured to the abdominal wall at the bottom of the pouch (Rydygier's method). Torsion of the pedicle and gangrene require splenectomy.

Abscess may be caused by trauma, extension from neighboring organs, acute infectious diseases, chronic malaria, and pyemia. *Chronic suppuration* may be due to syphilis, tuberculosis, or actinomycosis. The *symptoms* are pain, tenderness, and enlargement of the spleen, with the general symptoms of sepsis. The treatment is the same as for abscess of the liver, or splenectomy if much of the organ is disorganized.

Splenectomy has been performed for (A) local and (B) general indications.

A. (1) *Splenoptosis* and (2) *abscess* are discussed above, (3) *injuries* under contusions of the abdomen. (4) *Spontaneous rupture* may occur in typhoidal and other splenic enlargements, and may demand splenectomy in order to stop the bleeding. (5) *Tumors* are rare, the most frequent being sarcoma. (6) *Aneurysm* of the splenic artery also is rare. (7) *Cysts* may be hemorrhagic, serous, lymphatic, or most frequently hydatid. (8) *Idiopathic splenomegaly*, which is not associated with marked or characteristic blood changes, and (9) *malarial hypertrophy* are indications for splenectomy only when the local discomfort is great; removal of the spleen has no effect on the malaria. (10) *Tuberculosis* of the spleen is almost never primary, hence seldom amenable to surgical treatment.

B. For the discussion of the medical aspects of the diseases mentioned in this group the reader is referred to a text-book on medicine. (1) *Splenic anemia*, in which there is enlargement of the spleen, with diminution in the number of white and red blood cells, and a reduction in the percentage of hemoglobin, responds favorably to splenectomy, a number of apparently permanent recoveries being on record. (2) In *Banti's disease* (splenomegaly with cirrhosis of the liver), which many regard as a later stage of splenic anemia, splenectomy should be considered, although the results are not so good as in splenic anemia. (3) In several cases of *anemia infantum* (*von Jaksch's disease*) removal of the spleen has been followed by marked immediate improvement. (4) *Primary splenomegaly* (Gaucher's disease) has been treated by splenectomy ten times, with eight recoveries and two deaths. (5)

Pernicious anemia has only recently been treated by splenectomy, the first operation having been performed in March, 1913. The mortality is about 25 per cent. Those that recover from the operation show a decided but temporary amelioration in the symptoms. (6) *Hemolytic jaundice* is characterized by anemia, jaundice, and splenomegaly. Two forms are recognized, the *congenital* (*Chauffard-Minkowski*) and the *acquired* (*Hayem-Widal*). In both increased hemolysis is indicated by an excess of urobilin in the urine and the feces, but as the jaundice is non-obstructive there is bile in the stools, and none in the urine (acholuria). The erythrocytes exhibit lessened resistance to hypotonic salt solution, and in the acquired form anto-agglutination. In the congenital type the patients are often more icteric than ill, in the acquired type more anemic than jaundiced. Banti believes he has discovered, in what he calls *splénomégalie hémolytique*, the connecting link between the two varieties outlined above, but his argument is not convincing. In all forms of hemolysis due to "hypersplenism," i.e., increased destruction of the red cells by the spleen, removal of the organ has been followed by excellent results. Perhaps the most important sign, so far as the indications for operation are concerned, is the increased quantity of urobilin in the urine and the feces.

The principal *contraindications* to the splenectomy are leukemia; erythremia (Vaquez's disease), in which there is an enormous increase in the number of erythrocytes, hence possibly due to "hyposplenism;" splenomegaly of the congestive type, resulting from cardiac or pulmonary disease; marked cachexia; and dense universal adhesions.

The *operation*, in many cases in group B, should be preceded by transfusion of blood. A long incision is made in the left semilunar line. If more room is needed the incision may be extended upwards and inwards, along the costal margin, to the ensiform; or upwards and outwards along the eighth intercostal space, the cartilages of the eighth, ninth and tenth ribs being excised, after reflection of the musculocutaneous flap. The phrenosplenic ligament is tied and divided, the spleen delivered through the wound, and each vessel of the pedicle severed between ligatures. The special *complications* are ligation of the tail of the pancreas with the splenic pedicle, an injury that may be followed by fat necrosis; thrombosis of the splenic vein, which may extend into the superior or the inferior mesenteric vein, or give rise to embolism; and gastrointestinal hemorrhage, possibly the result of extension of the thrombosis. The mortality of the operation for all conditions is about 25 per cent.

The *blood changes after splenectomy* vary with the condition of the spleen. In some of the forms of anemia mentioned in group B the blood rapidly regenerates. After removal of a healthy adult spleen, e.g., for injury, there is a reduction in the number of red cells and in the percentage of hemoglobin, an increase in the number of white cells and often enlargement of the lymph glands and the thymus, with tenderness of the bones (the red cells are formed by bone marrow), headache, emaciation, and sometimes rapid pulse, fever, thirst, polyuria, and abdominal uneasiness. These symptoms may last for weeks or months before good health is obtained. The changes may be absent, or at least not so decided, because the compensatory organs (hemolymph glands, thymus, and possibly accessory spleens) at once become active, e.g., in children, or are already doing the work of a spleen whose functions have been destroyed by disease. Extract of spleen, thymus, or red bone marrow, with iron, may be of service in lessening the evil after effects of splenectomy.

ABDOMINAL HERNIA, OR RUPTURE.

The word hernia is sometimes employed in connection with the brain, lung, muscle, or other parts, but when used without qualification means a protrusion of a portion of the contents of the abdomen through a normal or artificial opening in the abdominal wall, the protruded parts being contained in a sac. When the abdominal contents escape through a wound, the condition is called *prolapse* and not hernia.

The **causes** of hernia are congenital and acquired. Among the *congenital causes* are (1) non-obliteration of a normal peritoneal diverticulum, e.g., the funicular process, which precedes the testicle in its descent, and passes along the spermatic cord or, in the female, the round ligament; (2) abnormal congenital apertures, e.g., in the mesentery, diaphragm, linea alba, or linea semilunaris; (3) unusually large normal apertures, e.g., the umbilical, inguinal, and femoral rings; (4) weakness of the abdominal muscles (often inherited); (5) abnormal length of the mesentery or omentum; and (6) imperfectly descended testicles. Among the *acquired causes* are (1) those which weaken the abdominal wall, e.g., prolonged illness, operations, injuries, and intraabdominal tumors and pregnancy, which weaken the walls by stretching; (2) those which increase the intraabdominal pressure, e.g., ascites, intraabdominal tumors, obesity, tight belts, and all conditions which necessitate straining, such as laborious occupations, phimosis, enlarged prostate, constipation, and diseases of the air passages associated with persistent cough; and (3) those which drag on the peritoneum, such as cicatrices and tumors, particularly the subperitoneal lipoma. Hernia is most frequent in the first year of life, 19.6 cases in every 1000 individuals according to Berger; it then decreases in frequency until the minimum is reached in the twentieth to the twenty-fourth year, and gradually increases, owing to degeneration of the muscles, as age advances. Hernia is three times more frequent in males than in females.

In **structure** a hernia consists of (1) a mouth, (2) a sac, (3) the coverings of the sac, and (4) the contents. 1. The **mouth** is the opening in the parietes which is usually called the ring; in certain situations, as in the inguinal region, the opening is more or less canalicular and there are an internal and an external ring. 2. The **sac** is the peritoneal pouch covering the contents of the hernia. In the early stages of an acquired hernia the sac is thin and funnel-shaped; later it becomes larger, thicker, and more globular. It consists of a neck, a body, and a fundus, and is formed by stretching and sliding of the peritoneum, hence when a hernia appears suddenly, excluding actual ruptures of the abdominal muscles (*traumatic hernia*), there must have been a preformed (congenital) sac. As the result of irritation or inflammation, from pressure or injury, the sac may become adherent to the contents, or be divided into two (*hourglass*) or more saccules or diverticula. It is always adherent to its coverings, hence is irreducible, although the contents may be reducible. Occasionally the sac or a saccule becomes completely shut off and filled with fluid (*hydrocele of the sac*). As the sac is merely a peritoneal diverticulum it may participate in any of the affections of the peritoneal cavity,

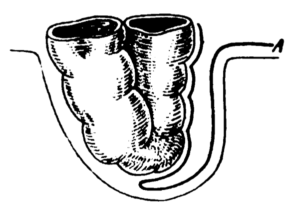


FIG. 426.—Diagram of sliding hernia of the colon. *A*. Peritoneum.

e.g., ascites, carcinomatosis, tuberculosis, acute peritonitis. The *exceptions* to the rule that a hernia must have a peritoneal sac are certain sliding hernias, certain hernias following abdominal operations or injuries, diaphragmatic hernia, and retroperitoneal hernias. *Sliding hernia* is a term applied to hernias of the ascending and descending colon. These structures usually have no mesentery and when they slip down through the inguinal canal the normal arrangement of the peritoneum is preserved, hence the posterior portion of the sac is absent (Fig. 426). 3. The **coverings** of the sac vary with the situation of the hernia and are enumerated with the individual forms. 4. The **contents** may be any abdominal viscus, but only those organs requiring special mention are noted below. The sac usually contains small intestine (*enterocele*), omentum (*epiplocele*), or both (*enteroepiplocele*)). When only a portion of the circumference of the intestine lies within the sac (*partial enterocele, or Richter's hernia*), the hernia is very small, and if strangulation occurs, the symptoms of obstruction are not complete. *Littré's hernia* is a hernia of Meckel's diverticulum. The cecum, with or without the appendix, has been found in even a left femoral hernia (*cecocele*). As it usually has a mesentery, it generally lies within the hernial sac; but when the mesentery is absent, the cecum may be partly within and partly without the hernial sac, the so-called sliding hernia of the cecum. The bladder may be encountered in a direct inguinal hernia (*cystocele*). As a rule, the herniated portion of the bladder is partly covered with peritoneum and partly extraperitoneal, but it may be wholly within or without the sac. The condition may be suspected if the bladder is irritable, if the hernia increases in size when the bladder is filled and lessens in size when it is emptied, and if pressure upon the hernia causes a desire to urinate. The diagnosis may be confirmed by injecting water into the bladder, when the herniated pouch will distend; by cystoscopic examination, when the lateral displacement of the vesical wall can be seen; and possibly by filling the bladder with collargol solution and taking a skiagram. The same diagnostic remarks apply to the rare hernia of a vesical diverticulum, which is devoid of muscular fibres. The *ovary* is normally a pelvic organ, but may be arrested in its descent near the internal inguinal ring, or be raised to this level by enlargement of the uterus (pregnancy, tumors), hence ovarian hernia is most frequent in infants, and in women who have borne children. The swelling is often irreducible, and attempts at reduction cause a sickening pain. The treatment of the conditions mentioned above is considered later. *Loose bodies*, sometimes as large as marbles and probably representing detached appendices epiploicæ, are occasionally found in the sac of a hernia.

The **signs** of an uncomplicated enterocele are (1) a soft *swelling*, (2) which is in the usual *situation* of a hernia, (3) is *inseparable* from the abdominal wall, (4) has an *expansile impulse* on coughing, (5) is *tympanitic* on percussion, (6) *disappears*, often suddenly and with a gurgle, on recumbency or pressure, (7) when the *hernial orifice* may be felt, and (8) which *reappears* when the patient stands or strains. An epiplocele is dull on percussion, feels more doughy, has a less marked impulse, and reduction is more difficult and unaccompanied by a gurgle. The patient may complain of pain, indigestion, and constipation.

The **treatment** may be palliative (trusses) or radical (operation), but such is best considered with the special forms of herniæ.

SPECIAL HERNIÆ.

Inguinal hernia constitutes about 80 per cent. of all herniæ; is much more common in males, because of the larger size of the inguinal canal, the frequency of imperfect closure of the processus vaginalis, and the influence of strenuous occupation; and, owing to the later descent of the right testicle, which keeps the inguinal canal patent for a longer period, is more often encountered on the right side. A classification of the principal forms of inguinal hernia is given in the subjoined table.

I. Indirect or oblique	1. Acquired	a. Incomplete	
		b. Complete (scrotal or labial)	
	2. Congenital	a. Vaginal	
		b. Funicular	
		c. Infantile	
		d. Encysted infantile	
II. Direct (always acquired)			
III. Interstitial (usually congenital)	1. Intraparietal		Intrailiac
			Antevesical
	2. Interparietal		
	3. Extraparietal		

I.—The **indirect or oblique** is called also **external** inguinal hernia, from the fact that it enters the internal ring in the external inguinal fossa, external to the deep epigastric artery. It is more frequent on the right side, for the reason given above, and in about one-third of the cases a similar hernia appears, sooner or later, in the opposite inguinal region.

1. **Acquired indirect inguinal hernia** (Fig. 429), in which the sac is gradually formed from the parietal peritoneum, may (a) distend the inguinal canal only (*incomplete inguinal hernia* or *bubonocele*), or it may (b) pass into the scrotum (*scrotal hernia*) or, in the female, into the labium majus (*labial hernia*), when it constitutes a *complete inguinal hernia* (Fig. 427). The *coverings* of a complete indirect inguinal hernia are the sac, with subperitoneal fat; infundibuliform fascia, derived from the transversalis fascia; cremasteric fascia and muscle, derived from the internal oblique; intercolumnar fascia, derived from the external oblique; deep and superficial fasciæ; and the skin. In old cases the internal ring may lie directly behind the external ring, simulating very closely a direct hernia. The sac always lies in front of the spermatic cord.

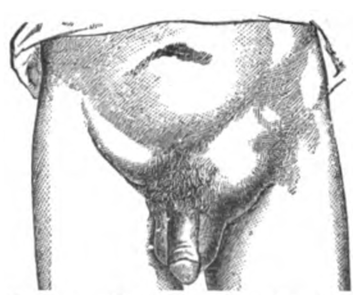


FIG. 427.—Complete oblique hernia on the left, bubonocele on the right.

2. **Congenital indirect inguinal hernia** owes its existence to nonobliteration of the funicular process of peritoneum. It usually appears at or soon after birth, although it is not, as the term congenital implies, always present at this time, but may occur at any period of life as the result of a sudden strain forcing apart the apposed peritoneal layers, indeed, some authors go so far as to attribute practically all hernias to a persistent antenatal sac. It is never gradual in onset but becomes complete at once, and the sac is invariably densely adherent to the cord. Inguinal hernia in the female is almost always congenital, the patent tube of peritoneum (canal

of Nuck) following the round ligament. (a) In the *vaginal form* (Figs. 428 and 430) the bowel passes directly into the tunica vaginalis, surrounding and concealing the testicle. (b) In *funicular hernia* (Fig. 431), which is the most frequent variety of all inguinal hernias, the funicular process remains patent for a variable distance, but is always shut off from the tunica vaginalis. (c) In *infantile hernia* (Fig. 432), which is very rare, the funicular process is closed at its abdominal end only, the hernia (in a special sac) passing downwards behind the process or (d) invaginating it (*encysted infantile hernia*); thus there are three layers of peritoneum in front of the hernia (Fig. 433). Any inguinal hernia, but more particularly the congenital forms, may be associated with a hydrocele of the cord or testicle.

FIG. 428.—Double congenital hernia. (Pennsylvania Hospital.)

II.—**Direct inguinal hernia** (Fig. 434) is always acquired, generally appears late in life, and is bilateral in one-half of the cases. It originates in the internal inguinal fossa, to the inner side of the deep epigastric artery, i.e., in Hesselbach's triangle. The spermatic cord generally lies to the outer side of the hernia, which emerges at the outer side of the conjoined tendon, or splits or pushes that structure before it, thus entering the inguinal canal and appearing at the external ring. When passing to the outer side of the conjoined tendon its coverings are the same as those of indirect

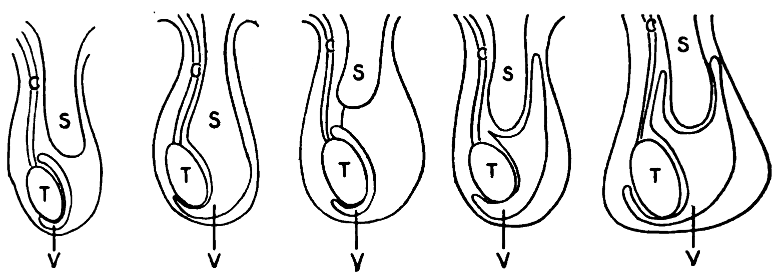


FIG. 429. Acquired inguinal hernia.

FIG. 430. Vaginal form of congenital inguinal hernia.

FIG. 431. Hernia into funicular process.

FIG. 432. Infantile hernia.

FIG. 433. Encysted infantile hernia.

Diagram of herniæ. C. Cord. S. Sac. T. Testicle. V. Tunica vaginalis.

inguinal hernia, except that the transversalis fascia is substituted for the infundibuliform fascia; the conjoined tendon also is added to the coverings when the hernia pushes that structure before it.

III.—**Interstitial hernia,** instead of passing regularly through the inguinal canal, insinuates itself between the layers of the abdominal wall. Over one-half of the cases are cryptorchids. Three forms are described: (1) In *properitoneal* or *intraparietal* hernia, the sac lies between the peritoneum and the transversalis fascia, either extending outwards (*intrailiac*) or inwards (*antevesical*). If there is also a sac in the scrotum the condition is called *hernia en bissac.* (2) In *interparietal hernia* the sac may be between the transversalis muscle and fascia, the external and internal oblique, or between the external oblique and the transversalis fascia, the other muscles having been pushed aside. (3) *Superficial inguinal hernia* (*extraparietal*) is the most frequent form of interstitial hernia. The sac passes through the inguinal canal, thence outwards and upwards along Poupart's ligament, between the external oblique and the skin, or more rarely outwards and downwards beneath the skin of the thigh, thus presenting a superficial resemblance to femoral hernia. In any strangulated interstitial hernia in which the sac is bilocular, the bowel may be pushed from the superficial into the deeper sac, and the symptoms of strangulation persist after apparent reduction; this is the explanation of the so-called *reduction en masse,* or *en bloc,* it being very doubtful whether a hernial sac is ever torn from its attachments and reduced with the contents.

The **signs of an inguinal hernia** are those already mentioned in describing the general features of hernia (p. 560). The swelling increases in size from above downwards and the testicle lies below and behind. In the male the external inguinal ring may be felt by invaginating the skin of the scrotum with the index finger; if it enters, the ring is abnormally large.

FIG. 434.—Direct inguinal hernia.

The **diagnosis** is usually easy, but may be difficult or impossible without operation. In oblique hernia the canal, at least in the beginning, passes upwards and outwards, and in rare instances the deep epigastric artery may be felt to the inner side. Direct hernia occurs in adults, usually stops at the root of the scrotum, has the deep epigastric artery to its outer side, and passes directly backwards through the abdominal wall. The conditions which may be mistaken for inguinal hernia are:

I.—**Reducible swellings** which give (a) an expansile or (b) a nonexpansile (lifting) impulse on coughing.

(a) Reducible swellings with an expansile impulse: (1) In *femoral hernia* the orifice is below Poupart's ligament and to the outer side of the pubic spine; in inguinal hernia above Poupart's ligament and internal to the pubic spine (Fig. 441); in the former the inguinal canal remains empty. In inguinal hernia reduction is effected by pushing upwards, outwards, and backwards, and in femoral hernia, downwards and then upwards and backwards. (2) *Congenital hydrocele* is translucent, and slowly reducible without a gurgle, but is very apt to be associated with a hernia. (3) *Varicocele* feels like a "bag of worms," and reappears from below upwards after compression, even when the finger blocks the inguinal canal. (4.) A psoas or other *chronic abscess* communicating with the abdominal cavity fluctuates, may be on either side of the femoral vessels, and may be associated with other signs indicating its nature, e.g., kyphosis, mass in the iliac region, etc. If it proceeds from bone the X-ray may show the osseous lesion.

(b) Reducible swellings with a nonexpansile impulse: (1) *Subperitoneal lipoma* always has the same shape and consistency; it may, however, be the pilot of a hernial sac. (2.) In *undescended testicle* the scrotum is empty; the swelling is elastic, more or less circumscribed, and gives the testicular sensation on pressure. There is usually, however, a hernia above the testicle. An inflamed or twisted undescended testicle may give symptoms almost identical with those of strangulated hernia.

II.—**Irreducible swellings,** all of which may have a lifting, but never an expansile, impulse: (1) *Enlarged inguinal glands* are lobulated, caused by irritation in the area which they drain, and the inguinal canal is free. (2) *Encysted hydrocele* of the cord is translucent, elastic, circumscribed, and cannot be reduced when traction is made on the cord. (3) In *hydrocele of the testis* the swelling develops slowly, beginning below and spreading upwards; stands out from the abdomen, from which it may be separated by the fingers; is translucent (unless the walls are very thick, or blood or spermatic fluid be the contents), dull on percussion, and not reducible (excepting those which communicate with the abdomen or with a second sac). (4) *Hematocele of the cord* follows injury and is associated with pain and ecchymosis. (5) *Swellings in the lower scrotum*, e.g., spermatocele, hematocele, orchitis, tumors of the testicle, etc., are generally readily differentiated from hernia by the freedom of the cord above, and the absence of a swelling in the inguinal canal.

The **treatment** may be palliative or radical.

Palliative treatment consists in the application of a truss and the removal of all sources of straining. A year or two of this treatment in children will often result in cure. The younger the child, the greater the chances of cure. A truss consists of a pad for the hernia, held in place by a steel spring, which passes backward on the same side, midway between the crest of the ilium and the top of the trochanter, to just behind the anterior superior spine of the opposite side, whence it is continued with a strap, which is fastened to the pad. A second strap passing beneath the thigh may be necessary to hold the truss in place. The measure to be given to an instrument maker is that of the line for the truss just described; the size of the hernia and of the orifice also should be mentioned. The pad may be of vulcanite, rubber, etc., and should rest over the internal ring in oblique hernia, over the external ring in direct hernia. It should rest on the soft tissues only, and should not be so small or so convex as to project into and dilate the opening; the spring should be strong enough to retain the hernia under all strains, but without injurious pressure. In adults the truss is ordinarily worn during the day, being put on before rising and removed after retiring. In young children, in whom there is a chance of cure, the truss should be worn also at night, as a single escape of the hernia, even after months of treatment, will cancel all the good which has been done. In irreducible herniæ cup or bag trusses are sometimes employed. Fig. 435 shows the application of a skein of wool as a truss in the treatment of hernia in children. The wool is changed twice a day or whenever soiled.

FIG. 435.—Wool truss for hernia in children. (Rose and Carless.)

The **radical treatment of inguinal hernia** is recommended in all cases after the age of three, if truss treatment has failed, and up to the age of sixty, providing there is no visceral disease to contraindicate operation. The mortality is less than one per cent., recurrences less than two per cent.; 80 per cent. of the latter occur within the first year. These statements do not apply to enormous herniæ, in which the danger of operation is by no means small, and the chances of recurrence very great. Direct hernias also are prone to recur, because of the flabbiness of the muscles, the large size of the orifice, the absence of a canal, and because the sac is often formed partly by the bladder and therefore cannot be completely removed. While a patient with a reducible hernia and a comfortable truss may be offered operation, one with a hernia which is irreducible, which a truss does not retain, which occasionally becomes incarcerated or inflamed, or which is associated with an undescended testicle or a reducible hydrocele, should be urged to accept radical treatment. Of the many operations that have been advocated for this purpose only two will be described.

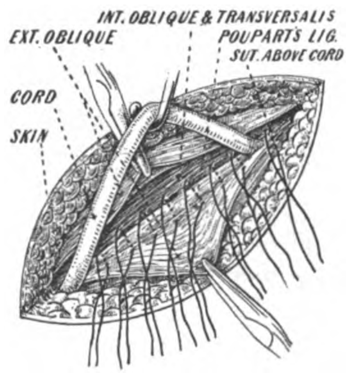


FIG. 436.—Bassini's operation.

Bassini's operation is the one most frequently employed. An incision is made parallel with and one-half inch above Poupart's ligament, from the external to just above the internal ring. The superficial epigastric and the superficial external pudic vessels are secured, and the aponeurosis of the external oblique divided in the direction of its fibres, from the external ring upwards and outwards, the flaps being separated from the subjacent tissues. The sac is now separated from the spermatic cord by blunt dissection, opened to make sure there are no adherent structures, ligated as high as possible, either with silk or catgut, and severed beyond the ligature, the stump retracting into the abdominal cavity. The spermatic cord is separated from its bed, and held aside by a blunt hook or loop of gauze, while the internal oblique and transversalis muscles, as one layer, are sutured to Poupart's ligament beneath the cord. A suture should be placed also above the cord (Fig. 436). The cord is now placed on this suture line and the incision in the external oblique closed. The skin is sutured with silkworm gut, after ligating all bleeding points. Chromicized catgut or kangaroo tendon is used for the buried sutures. In children it is well to seal the wound with collodion before applying the spica of the groin. The scrotum is supported for the first week. The patient remains in bed for two or three weeks, and should undertake no straining efforts for six months. A truss is not needed after operation.

The chief objection to the Bassini operation is that edema of the cord, hydrocele, and orchitis occasionally follow, owing to the handling of the cord and its compression between the layers of the abdominal wall.

The **author's method** combines some of the features of the foregoing and the Ferguson operations, with imbrication of the layers of the abdominal wall in a manner which, although devised independently, is much like that previously suggested by Andrews. After incising the skin and the external oblique the ilioinguinal nerve is retracted, the cremasteric muscle and fascia and the infundibuliform fascia are raised from the cord and divided longitudinally, and the sac, which lies immediately beneath, is isolated by gentle gauze dissection, so as to injure the cord as little as possible, and opened. Adherent omentum is divided between ligatures; adherent intestine gently separated, unless the adhesions are dense, when it is better to leave a portion of the sac, thus preventing the raw surfaces which would otherwise result. A finger is passed into the abdomen and the internal ring of the opposite side palpated; if it is large or a sac found the operation is later repeated on the opposite side. The vicinity of the internal ring on the side of operation is now explored for diverticula, properitoneal hernia, and laxity of the peritoneum to the inner side of the deep epigastric vessels (potential direct hernia). The neck of the sac, which is recognized by following the peritoneum until it expands beneath the parietes, where it is covered with properitoneal fat, and

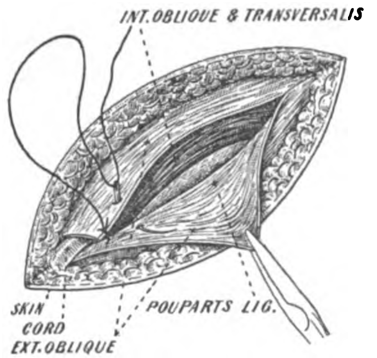


FIG. 437.—The transversalis, internal oblique, and external oblique muscles, as one layer, are sutured to Poupart's ligament.

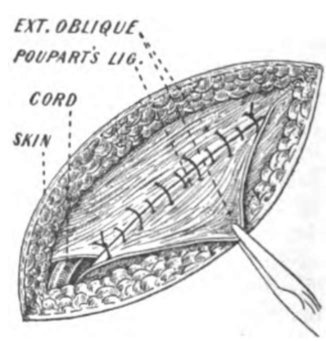


FIG. 438.—Alternate deep and superficial sutures inserted.

by identifying and pushing aside the deep epigastric vessels, is palpated for thickening. If the thickening is soft one should suspect hernia of the bladder or sliding hernia of the colon, conditions in which the affected viscus may readily be injured in ligating the sac. The parietal peritoneum *above the neck of the sac* is now transfixed and ligated with catgut, and the stump transplanted upwards and outwards beneath the transversalis fascia, by carrying the ends of the ligature through the fascia and muscles and tying them. This transplantation is particularly indicated in sliding hernias and in cases in which the peritoneum to the inner side of the epigastric vessels is lax. The internal ring is made snug by passing one or two sutures through the transversalis fascia above the cord. The canal is closed over the cord, by suturing all the structures on the inner side (transversalis, internal oblique, external oblique) to Poupart's ligament, beginning below and extending up as far as the attachment of the muscles to Poupart's ligament (Fig. 437). The fascia of the external oblique thus acts as a splint for the muscular fibres, which, if sutured alone, tend to separate. The needle should be passed, from without inwards, through the structures on the inner side of the canal, then, from within outwards, through Poupart's ligament, while a finger protects the femoral vessels. In order to secure accurate coaptation alternate deep and superficial sutures are employed; this also prevents the tearing apart of the muscular and fascial bundles that sometimes follows when all the sutures are inserted in the same plane (Fig. 438). The lower is now sutured up over the upper flap of the external oblique (Fig. 439) and the skin closed.

Variations in the operations detailed above, which operations apply particularly to the ordinary acquired form of oblique inguinal hernia in the male, may be desirable or necessary under certain circumstances.

In the *female* the round ligament may be treated like the spermatic cord, but as there is some difficulty in dissecting the sac from the ligament, and as removal of the ligament in the inguinal canal permits complete obliteration of the canal, it is better to tie the round ligament and the sac together, transplanting the stump to the inner aspect of the abdominal wall as previously described.

In *congenital hernia* in the male (vaginal form) the entire sac, except the testicular layer of the tunica vaginalis, may be excised, a difficult and tedious proceeding; the upper portion of the sac may be removed, and the opening in the lower portion sutured to form the tunica vaginalis; or, what is more simple, the neck of the sac may be ligated, divided below the ligature, and the sac turned inside out, as in the eversion operation for hydrocele.

Direct hernia is exposed in the same manner as the oblique form, except that instead of incising the infundibuliform fascia over the cord, the transversalis fascia must be divided in Hesselbach's triangle, the fascia subsequently being overlapped by means of sutures. The internal ring is, of course, not concerned in direct hernia, but it should be treated as in oblique hernia if it seems too large. The inguinal canal is closed as already indicated for indirect hernia, most operators preferring transplantation of the cord, as in the Bassini operation, in order to fortify Hesselbach's triangle with a layer of muscle.

Transplantation of periosteum or fascia lata has been employed in cases in which the hernial orifice is large and the muscular structures atrophied. A pedunculated flap may be turned outwards and downwards from the sheath of the rectus muscle and sutured to Poupart's ligament, or the sheath may be incised and the muscular fibres drawn down to the ligament, but as both these procedures weaken the rectus they are not recommended.

In *interstitial hernia*, in addition to tracing carefully the relations of the sac, it will usually be necessary to deal with an undescended testicle (q.v.). In the only case of properitoneal inguinal hernia in which we have operated, the incision was made in the median line, owing to failure to recognize the cause of the obstructive symptoms, and the sac obliterated from within the abdomen.

In *sliding hernia* of the colon (Fig. 426) there are three dangers to be remembered. The extraperitoneal portion of the bowel may be incised for the sac. The peritoneal reflections from the bowel may be mistaken for adhesions, separation of which on the mesial side may result in damage to the nutrient vessels and gangrene of the intestine. When a large hernia of the ordinary variety grows chiefly at the expense of the parietal peritoneum on the outer side of the internal inguinal ring, a small section of the colon, partly covered with peritoneum, may appear in the neck of the sac, and, being regarded as merely a thickening of the tissues at this point, be ligated with the sac. If one suspects a sliding hernia of the colon the sac should never be opened to the outer side or posteriorly, and never without making certain that only the peritoneum is being divided; adhesions and thickenings must always be carefully investigated. After incising the sac well to the inner side, the flap of peritoneum thus formed can be wrapped around the bowel and fastened with a few stitches, so as to form a mesocolon. The bowel may then be reduced, and the remaining opening in the peritoneum closed with sutures. In order to prevent recurrence some surgeons advise suturing the herniated bowel to the anterior abdominal wall (colopexy) through a separate incision. Our own practice is to excise the sac, close the peritoneal opening with a purse-string suture, and transplant the puckered closure in the manner already described for transplantation of the stump of the sac in ordinary oblique hernia, thus displacing the herniated colon upwards and outwards and fixing it to the abdominal wall.

Hernia of the bladder, as pointed out in the general remarks on the structure of hernia, may be diagnosticated before operation. In most instances, however, the condition is not recognized until the bladder is exposed, and, in some instances, incised, an extraperitoneal vesical pouch being mistaken for

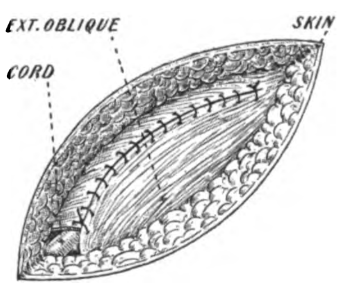


FIG. 439.—Imbrication of the external oblique.

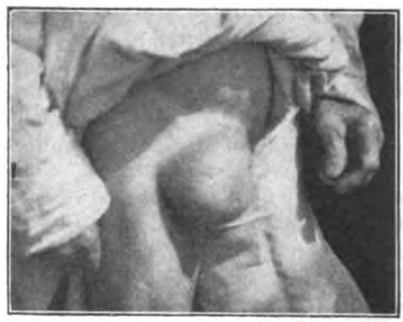


FIG. 440.—Femoral hernia.

the sac. In the event of such an accident the wound should be sutured like a wound in the intestine, and a retention catheter passed into the bladder through the urethra. Ligation of a portion of the bladder with the sac likewise has occurred, urine escaping, after the ligated piece of bladder has sloughed, into the peritoneum or the extraperitoneal cellular tissue. The bladder lies to the inner side of and behind the other contents of the rupture, and is usually covered with a large quantity of fat. If its presence is suspected during an operation, the bladder may be distended or a sound passed into it. As a rule, however, it can be easily recognized by palpation, after opening the sac well to the outer side. The appearance of the muscular fibres is distinctive, but they may be absent in a diverticulum of the bladder. A vesical diverticulum should be excised, but a protrusion consisting of all the coats of the bladder should be reduced, and, after transplanting the neck of the sac upwards and inwards, the inguinal canal closed in the usual manner.

A herniated *ovary, Fallopian tube, uterus* should be reduced if healthy, removed if diseased.

Femoral hernia (Fig. 440) constitutes 10 per cent. of all herniæ, and is more frequent in females owing to the larger size of the crural canal, consequent upon the wider pelvis, but even in females it is less common than the inguinal variety. The hernia passes along the femoral canal and protrudes through the saphenous opening. The internal ring is formed by Poupart's ligament in front, the pectineal line and fascia behind, Gimbernat's ligament on the inside, and the inner septum of the femoral sheath on the outside. The external ring is formed by the saphenous opening. Occasionally the obturator artery arises from the deep epigastric and passes along the edge of Gimbernat's ligament. The *coverings* of a femoral hernia are peritoneum, septum crurale, anterior layer of the femoral sheath, cribriform fascia, deep and superficial fasciæ, and the skin. After the hernia has passed through the saphenous opening, it is bent at an angle, and usually passes upwards and outwards, because of the attachment of the deep layer of the superficial fascia.

The **signs** are those of other herniæ (p. 560). The swelling is seldom large, and is usually more or less lobular. The neck lies to the inside of the femoral vessels, to the outer side of the pubic spine, and below Poupart's ligament (Fig. 441). The *diagnosis* is facilitated by determining the exact situation of the swelling. *Inguinal hernia*, *enlarged glands*, *lipoma*, and *psoas abscess* may be differentiated by considering the points given under the diagnosis of inguinal hernia. An *iliopsoas bursa* limits extension of the hip and appears outside the femoral vessels. *Varix of the saphenous* vein at the saphenous opening may be reduced, but with a thrill instead of a gurgle, and it reappears from below upwards, even when the finger blocks the femoral canal. The veins below are often dilated. *Obturator hernia* lies deep under the adductor muscles and is very rare (vide infra).

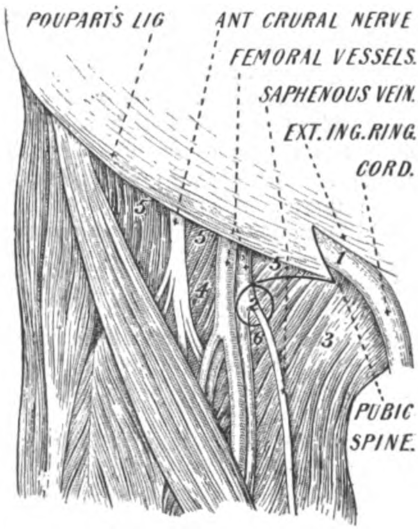


FIG. 441.—Situation of swellings in the groin. (1) Inguinal hernia. (2) Femoral hernia; saphenous opening. (3) Obturator hernia. (4) Iliopsoas bursa. (5, 5, 5) Inguinal lymph glands. (2 and 6) Femoral lymph glands.

The **treatment** may be palliative, a truss somewhat similar to that used for inguinal hernia being employed, except that the pad rests over the femoral canal at the level of Gimbernat's ligament.

The **operative treatment** is simple, safe, and satisfactory. *Bassini's operation* is as follows: An incision, parallel with and below Poupart's ligament, is made over the sac, which is isolated, opened, and ligated as in inguinal hernia. Poupart's ligament is then sutured to the pectineal fascia, to close the internal ring, and the plica falciformis of the fascia lata is sutured to the pectineal fascia, thus closing the canal (Fig. 442). Care should be taken not to injure or compress the femoral vein.

In cases in which there is a coexisting inguinal and femoral hernia, the latter can be dealt with through the inguinal canal. Indeed some operators prefer the *inguinal route* for all cases of femoral hernia, pointing out that, when approached from above, the sac is more certain to be removed in its entirety and the internal femoral ring more effectively sutured. The inguinal canal is opened as for inguinal hernia; the round ligament or spermatic cord retracted upwards; the transversalis fascia in Hesselbach's triangle incised parallel with and close to Poupart's ligament, care being taken not to injure the deep epigastric vessels; the peritoneum opened; the sac drawn from its canal by steady traction, aided, if need be, by snipping the border of Gimbernat's ligament, or, in cases in which the sac is closely adherent beneath the skin, by undermining the lower edge of the cutaneous incision; the sac excised after ligation of its neck; the internal femoral ring obliterated by passing sutures through Cooper's and Poupart's ligaments; the transversalis fascia sutured; and the inguinal sac closed as in the operation for inguinal hernia.

Umbilical hernia represents 5 per cent. of all herniæ. There are three forms:

1. **Congenital umbilical hernia,** or **exomphalos,** is the result of imperfect closure of the abdominal walls, the contents varying from a small loop of bowel to a large part of the viscera (*ectopia viscerum*). The hernia is covered by a transparent membrane composed of peritoneum and tissues of the umbilical cord. The condition is rare, and if overlooked the bowel may be tied with the cord. The *treatment* in small herniæ is an aseptic dressing, with pressure. In larger protusions the contents should be reduced, the sac removed, and the opening closed with sutures, as untreated cases are quickly fatal from sloughing of the sac.

2. **Infantile umbilical hernia** is due to stretching of the umbilical cicatrix. The hernia is usually of small size and tends towards spontaneous recovery. Operation is therefore seldom required, unless the rupture persists after puberty. All sources of straining, e.g., constipation, phimosis, etc., should be removed, and reduction maintained by a flat pad, larger than the ring (a covered penny is often employed), held in place by a broad strap of adhesive plaster.

3. **Umbilical hernia of adults** is caused by stretching or rupture of the tissues in the immediate vicinity of the umbilicus, as the result of increased intraabdominal pressure, hence is most frequent in women who have borne

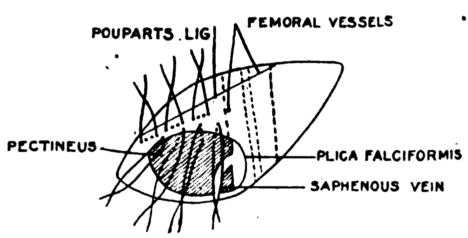


FIG. 442.—Bassini's operation for femoral hernia.

many children. The *coverings* are peritoneum, transversalis fascia, and skin. The hernia often attains a large size, and as it is exposed to various forms of irritation, the contents are prone to become adherent to one another and to the sac. Not infrequently, therefore, the sac is divided into several parts, and the hernia is often irreducible, thus predisposing to strangulation.

The **treatment** should be palliative, unless complications ensue, if, as is often the case, the patient is advanced in years and extremely fat, or the hernia is of large size. A pad truss should be worn, unless the rupture is irreducible, when some form of cup or bag truss may be needed.

The **Mayo operation** is the most satisfactory in cases suitable for radical treatment. The hernia is surrounded by transverse elliptical incisions and the aponeurotic structures about the ring exposed. The sac is opened, and divided at its neck, adherent intestines separated and reduced, and omentum ligated, and removed with the sac and skin. The peritoneum is separated from the edges of the ring and sutured transversely. Mattress sutures of silver wire or chromicized catgut are now introduced an inch or more above the edge of the upper flap, catching the margin of the lower flap *en route*, thus sliding it into the space between the peritoneum and upper flap (Fig. 443). The lower edge of the upper flap is now sutured to the aponeurosis below. König suggests fortifying the line of suture, in operations for umbilical and other forms of hernia, by covering it with a free transplant of fascia or periosteum, which is fixed in place with catgut stitches. Very large hernial orifices have been closed by the implantation of a perforated celluloid plate or a network of silver wire.

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Ventral hernia is a hernia in any portion of the anterior abdominal wall, excepting those mentioned above. It may be median or lateral. Of the **median herniæ** there are two principal forms: 1. *Hernia of the linea alba* forms 1 per cent. of all cases of hernia. It is most frequent about midway between the umbilicus and the ensiform (*epigastric hernia*), at the

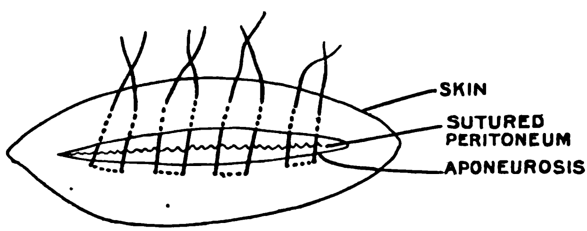

FIG. 443.—Mayo's operation.

point where the middle linea transversa of the rectus joins the median line, because at this point the greatest strain occurs when the recti are brought into action; it is usually preceded by a subperitoneal lipoma, which insinuates itself between the meshes of the linea alba and draws a sac of peritoneum after it. Sometimes a lipoma, with or without a hernial sac, appears just above the umbilicus, at the juncture of the lowest linea transversa with the median line, and occasionally there are several lipomata between the ensiform and the umbilicus. Epigastric hernia is most common in healthy, hard working men, and is frequently insignificant in size, so that it may readily be overlooked. Congenital apertures in the linea alba are very rare. These herniæ often cause epigastric pain, vomiting, and other gastric symptoms. Truss treatment is inapplicable as the hernia is seldom reducible. The lipoma should be excised with the sac, and the opening in the abdominal wall closed with sutures. The stomach and adjacent organs should always be explored at the same time, to make sure that the symptoms are not due to some graver disease. 2. *Diastasis of the recti muscles* is most commonly observed in multipara; it causes a stretching of the linea alba, which encourages a prolapse of all the abdominal viscera. The diagnosis is readily made by having the patient, when lying down, fold the arms and raise the head and shoulders, the whole linea alba bulging forwards in a long mound-like eminence, reaching from the ensiform to the pubes. The treatment is that of Glénard's disease. In some cases marked benefit has been obtained by suturing the recti together, or, better, by overlapping them, with the redundant linea alba. **Lateral ventral hernia** is most frequent in the semilunar line at a point where it is crossed by the omphalo-spinous line, owing to the fact that a branch of the epigastric artery pierces the wall in this situation. It is the result of increased intraabdominal pressure. *Postoperative or postincisional herniæ* may, of course, occur in any portion of the abdomen, and are particularly prone to develop if the wound suppurates or if drainage has been employed. They are treated by separately suturing the individual layers of the abdominal wall or, better, by overlapping these layers.

Among the rarer forms of hernia are the following: **Obturator hernia** passes through the obturator foramen with the obturator vessels, appearing deep in the thigh on the inner side of the femoral vessels (Fig. 441). Eckstein (1912) collected 194 cases. The condition is more common in women (8 to 1) because of the larger size of the foramen. There may be pain in the hip and along the inside of the thigh and knee, due to pressure on the obturator nerve. Bimanual examination may reveal a cord-like mass extending to the foramen. The diagnosis is seldom made; even when the hernia is strangulated, the condition is rarely suspected until after the abdomen has been opened for intestinal obstruction. The sac may be exposed by an incision in the upper and inner angle of Scarpa's triangle, and the constriction relieved by cutting inwards, since the obturator artery usually lies below and to the outer side. The opening may be closed with a flap of muscle or periosteum. The mortality is 70 per cent.

Lumbar hernia occurs in Petit's triangle, and is treated as a ventral hernia.

Sciatic hernia emerges from the pelvis through one of the sciatic foramina, and appears in the gluteal region.

Perineal herniæ are those passing through the pelvic diaphragm, and appearing in the perineum, towards the rectum (*rectal hernia*), vagina (*vaginal hernia*), or in the lower part of the labium (*pudendal hernia*). *Inguinal perineal hernia* is one which follows an aberrant testicle into the perineum.

Diaphragmatic hernia may be congenital or acquired. The acquired form may follow a crush of the thorax or a severe twist of the body, resulting in rupture of the diaphragm, or it may follow a stab or gunshot wound, hence has no sac. It is more frequent on the left side, because the diaphragm is weaker at this point, and because the liver is on the right side. Although any of the abdominal viscera may pass into the thorax, the stomach and transverse colon are the organs usually herniated.

The **symptoms** are abdominal pain, dyspnea, vomiting, sometimes hematemesis, and, in the event of strangulation, those of acute intestinal obstruction. In traumatic cases the history of an injury followed by shock, dyspnea, cyanosis, intense pain, cough, thirst, and hiccough may be obtained. The signs are those of pneumothorax, limited to the lower chest, and displacement of the heart to the right. The tympanitic note is extended and intensified by distending the stomach or the colon with air, and perhaps replaced by dulness when these organs are filled with water. Litten's sign is usually absent.

The X-ray shows the displacement of the heart, an irregular or incomplete diaphragmatic shadow, and a clear area above the line of the diaphragm, through which area the mottled shadow of the lung may be seen. This clear area may be rendered dense by injecting bismuth into the stomach or the colon. With the fluoroscope a paradoxical movement of the diaphragm may be observed, i.e., during inspiration the affected side ascends while the normal side descends, during expiration the affected side descends while the normal side ascends. If, however, the abdominal muscles are strongly contracted during expiration the affected side of the diaphragm is forced upwards. The diagnosis has been made before operation or death is only 15 of the 160 cases reported (Giffin), but if the possibility of diaphragmatic hernia is kept in mind and all suspected cases are carefully studied this condition should be recognized more often in the future. Diaphragmatic hernia may be confused with pneumothorax and elevation of the diaphragm. In *pneumothorax* the tympany usually extends over the whole thorax, and is uninfluenced by distention of the stomach or the colon with air or water. The breath sounds may be amphoric, distant, or absent, while in diaphragmatic hernia the breath sounds and vocal fremitus may be present, and the metallic tinkling coincides with the peristaltic movements of the stomach or intestine rather than with respiration. The coin test is positive more frequently in pneumothorax, and repeated vomiting less apt to occur. A skiagram will show an intact diaphragm and no change in the clear area after a bismuth meal. *Elevation of the diaphragm* is a condition in which one side of the diaphragm is much higher than normal. It may be transient, probably as the result of some temporary affection of the phrenic nerve, or permanent. It is differentiated from diaphragmatic hernia by means of the X-ray. The diaphragmatic shadow, though elevated, is normal in outline, and beneath it are the shadows of the stomach and the colon.

The **treatment** consists, under intratracheal insufflation anesthesia, in opening the lower part of the thorax, possibly by reflecting a section of the eighth and the ninth ribs, reducing the hernia, and suturing the wound in the diaphragm. If the opening is too large to be sutured it may be patched with a free transplant of fascia lata. In most of the cases of diaphragmatic hernia in which the abdomen has been opened in order to deal with an intestinal obstruction of unknown origin the diaphragm has been closed from below. Even in these cases it would perhaps be better, after the diagnosis has been established by abdominal section, to open the thorax, since reduction of the hernia and suture of the orifice are thus facilitated.

Internal or retroperitoneal herniæ are observed in the following situations: 1. **Foramen of Winslow.** 2. **Recessus duodeno-jejunalis**; the margin of this fossa contains the inferior mesenteric vein or colica sinistra artery, a fact to be remembered if, in a case of strangulated hernia in this vicinity, enlargement of the opening is necessary. 3. **Pericecal fossæ,** of which there are three, the *retrocecal,* behind the cecum and external to the mesoappendix; the *superior ileocecal,* in the upper angle formed by the junction of the ileum and cecum; and the *inferior ileocecal,* in the lower angle formed by the ileum and cecum. 4. **Intersigmoid fossa,** at the root of the mesocolon on the left side. 5. **Retrovesical fossa.** Herniæ into these fossæ rarely cause trouble unless they become strangulated, when the symptoms are those of intestinal obstruction. The treatment is laparotomy and reduction of the hernia. Obliteration of the hernial orifice by sutures may be attempted in suitable cases.

ACCIDENTS OF HERNIA.

Irreducible hernia presents all the signs of a reducible one, except that it cannot be replaced within the abdomen and is apt to be more firm in consistence. It is always more prone to become inflamed, obstructed, or strangulated. Irreducibility is most frequent in umbilical hernias (of adults), then in femoral, then in large scrotal hernias. The *causes* are: 1. *Adhesions* (a) between the contents and the sac, (b) among the contents, forming a mass which will not pass through the ring, (c) giving rise to cystic accumulations, or (d) causing thickening of the neck or other portion of the sac. 2. *Excessive deposit of fat*, either in the herniated omentum or mesentery, or within the abdomen; in the latter instance the hernia cannot be returned because of want of room.

The **treatment** in most cases is operation; when this is inadvisable because of the general condition of the patient, the hernia may be supported by a bag truss. When due to fat, the hernia may again become reducible after strict dieting.

An **inflamed hernia** is one in which there is a localized peritonitis, involving the sac and possibly the peritoneal covering of the contained viscera. The causes are external, e.g., blows, badly fitting trusses, and strenuous taxis; and internal, e.g., inflammation, ulceration, or perforation of a herniated appendix or coil of bowel, peritonitis arising within the abdomen and extending to the sac; also incarceration and strangulation, but these are considered in separate classes. The *symptoms* are pain, tenderness, swelling, increased heat, sometimes redness and edema of the skin and occasionally suppuration; in addition there are general fever and often vomiting and constipation. The hernia is likely to be irreducible and hence strangulation is strongly suggested, but in the latter there are shock instead of fever, absence of an impulse on coughing, absolute constipation, and fecal vomiting. The *treatment* of those cases arising from external causes is rest in bed, elevation of the hernia, the application of lead water and laudanum, opium internally, and liquid diet. Suppuration calls for incision. After the inflammation has subsided, the radical operation should be performed. Inflamed hernia arising from internal causes generally demands immediate operation.

Incarcerated or obstructed hernia is an irreducible hernia in which the fecal (not the blood) circulation is interrupted. It is generally due to undigested food or impacted feces. It is most common in umbilical hernias, because of the frequency of adhesions, which interfere with peristalsis, and because of the presence of the transverse colon, which contains solid feces. The *symptoms* are those of an irreducible hernia which becomes tender and painful, harder and larger than usual, and dull on percussion; it may be diminished in size by pressure, and has an impulse on coughing. The abdomen becomes distended and there are vomiting (not fecal), constipation (not absolute), and colicky pain. The hernia may become inflamed or strangulated. The *treatment* is opium, gentle taxis, and the local application of heat or cold. If this treatment is not quickly successful, or if symptoms of strangulation ensue, operation should be performed.

Strangulated hernia is one in which the contents are so firmly constricted that the circulation of blood is cut off. Interference with the fecal circulation is usual but not essential, since the hernia may be an epiplocele or a Richter's hernia.

The *cause* of strangulation is sudden augmentation in the size of the hernia, from the extrusion of additional contents, from congestion or inflammation, or from fecal or gaseous accumulations. The *site of constriction* is usually the hernial orifice, but it may be in the neck of the sac alone, or elsewhere in the sac as the result of adhesions or constrictions. At this point the intestine is furrowed and, if the constriction has lasted long enough, ulcerated. Occasionally this ulcerated area perforates after reduction of the bowel, or by healing causes an annular stricture and intestinal obstruction. The *strangulated loop* is distended with gas, and varies in appearance according to the degree and the duration of the strangulation. In the first stage, in which the venous circulation only is affected, the gut wall is thickened from congestion and edema, dark red in color, smooth and elastic to the touch, and glistening in appearance, although in places small ecchymoses may be seen. The vessels can be emptied by pressure, and refill promptly when the pressure is removed. In this stage relief of the constriction is followed by complete recovery of the gut. Later, owing to the swelling of the hernial contents, the arterial circulation is arrested, and this leads to moist gangrene. The gut becomes sodden, black, lusterless; the vessels are thrombosed and cannot be emptied by pressure; and bacteria escape in large numbers through the intestinal wall. Finally perforation may occur, either spontaneously or as the result of manipulations. The changes in the *bowel above and below* the seat of strangulation are identical with those in other forms of acute obstruction (see intestinal obstruction). Even when obstruction is not complete, e.g., in a Richter's hernia, the bowel may be paralyzed. The *sac* is inflamed, owing to the passage of bacteria through the intestinal walls, and usually contains fluid, which is at first clear, but in the later stages becomes bloody and finally dark brown in color and offensive in odor. Sloughing of the sac is rarely seen; it may be due to the inflammation or to strangulation of the sac. The *parts about the sac* are usually unaffected, but occasionally in unrelieved cases they become inflamed and break down, thus leading in rare instances to spontaneous cure by the formation of an artificial anus. *Retrograde strangulation* is a condition in which the end of a piece of bowel or omentum in a hernia passes back into the abdomen, becoming strangulated at the hernial orifice, the remaining portion of the hernia being uninvolved. Doubtless some of the cases of so-called retrograde strangulation are due to the escape of two coils of intestine (hernia en W), the connecting loop within the abdomen becoming strangulated; to the reduction of a strangulated segment, the sac then filling with healthy bowel or omentum; or to twisting of the end that reenters the abdomen.

The **symptoms** are those of *intestinal obstruction*, viz., shock, abdominal pain and distention, vomiting which finally becomes stercoraceous, increased peristalsis, and absolute constipation. In the final stage the picture is that of generalized peritonitis. In even a strangulated Richter's, Littre's, or omental hernia, there may be symptoms of complete obstruction, possibly from reflex paralysis of the intestine. The *hernia* is irreducible, tense, tender, and painful, and has no impulse on coughing. With the onset of gangrene pain and tenderness disappear, and the hernia becomes softer and sometimes crepitates. Two facts must be emphasized. First, the symptoms may be mild and the cause overlooked, especially in old women who have long had a small irreducible femoral hernia that they deem of no importance and do not mention to the physician. In all doubtful cases one should inquire, or, better, look for hernia. Secondly, gangrene depends, not so much on the duration, as on the tightness of the strangulation, hence may occur in a few hours.

The **treatment** is reduction by taxis or operation.

Taxis, or the manipulations for the reduction of a hernia, should always be gentle, and should rarely be tried for more than five or ten minutes, because of the danger of rupture of the bowel. It should not be employed in the presence of inflammation or gangrene. Reduction is facilitated by having the patient recumbent, the thighs flexed (and that of the affected side adducted in femoral or inguinal hernia), and the pelvis raised. The administration of opium and belladonna and the application of heat or cold also are useful in securing relaxation. One hand is used to steady the neck of the sac, while with the other the hernia is compressed and pushed back into the abdomen. In direct inguinal and umbilical herniæ the pressure is backwards; in oblique inguinal hernia it is upwards, outwards, and backwards; in femoral hernia it is at first downwards and inwards, then upwards and backwards. The successful reduction of bowel is sudden and accompanied by a gurgle; omentum is forced back slowly without gurgling. *The continuance of symptoms after apparent reduction* may be due to (1) incomplete reduction, (2) reduction *en masse* (see interstitial hernia), (3) recurrence of the hernia, (4) the presence of some other form of intestinal obstruction, (5) paralysis of the bowel, (6) peritonitis, (7) reduction of gangrenous or perforated bowel, (8) reduction of bowel which is obstructed by adhesions or through a slit in the omentum, or to (9) the effects of an anesthetic if used. With the exception of the last named condition, the persistence of symptoms after apparent reduction calls for operation.

The **operative treatment, or herniotomy,** consists in reduction of the bowel after division of the constriction. It is indicated as soon as taxis fails, and should be employed instead of taxis, if the strangulation has existed for more than a few hours, or if there is the slightest suspicion of gangrene. If the vomiting is fecal, the stomach should first be washed out, and if the patient is in poor condition, local anesthesia may be employed. When a general anesthetic is administered and the strangulation is recent, taxis may again be tried when the patient is fully relaxed. The sac is exposed by a suitable incision (*vide* radical operations) and opened; it is recognized by its bluish color, the presence of subperitoneal fat, and by its gliding over the contained viscera. The sac almost always contains fluid, hence, as a rule, there is little danger of injuring the bowel in opening it. The contents of the hernia are now examined, and the constriction divided by blunt pointed scissors or a hernia knife (curved blunt-ended bistoury), introduced along the left forefinger, the nail of which is passed into the stricture. The constriction is nicked sufficiently to relieve the strangulation. In inguinal hernia the direction of the nick is directly upwards, in femoral hernia directly inwards. Many surgeons divide the constricting tissues from the surface towards the hernia, so that if any important vessels are cut they may be caught at once and tied. The bowel must be carefully examined to ascertain whether it is viable or not, and it should be withdrawn a little from the abdomen, in order to determine its condition at the point of constriction and to make sure there is no retrograde strangulation or torsion; the omentum should be treated in a like manner. The bowel is viable if it retains its normal luster and elasticity, if the arteries pulsate, if the veins can be emptied by pressure and refill promptly when the pressure is removed, if peristalsis can be induced by pinching, and if the color, although bluish or dark red, improves quickly on the application of hot water. The bowel is gangrenous if it is lusterless, black, sodden; if the arteries do not pulsate; and if the veins are thrombosed. Between these extremes there are numerous gradations, and in some cases even an experienced surgeon is unable to say whether the bowel will live or not. If the hernial contents are healthy, they should be replaced, and the radical operation performed if the patient's condition permits. Any small ulcer at the site of constriction should be inverted with Lembert sutures. If the bowel is gangrenous it should be resected, taking care to go well above and below the apparent limits of the gangrene, else sloughing at the site of anastomosis may follow. In femoral hernia it will usually be necessary to make a second incision above Poupart's ligament for this purpose. If the patient's condition forbids resection, the bowel may be opened and an artificial anus established; this is dealt with at a later period as described elsewhere. If the condition of the bowel is doubtful, it should be resected if the surgeon is skillful and the patient's condition good; under other circumstances it may be surrounded with gauze and the wound left open. Should gangrene or perforation follow, the intestinal contents will be discharged through the wound; if gangrene does not supervene, the bowel may be replaced, and the wound closed at a later period. When the condition of the omentum is doubtful, it should be removed. Sometimes blood appears in the stools after taxis or operation, and although, as a rule, of no serious import, such an occurrence always causes anxiety, since it may be due to thrombosis or deep ulceration.

CHAPTER XXVIII.

RECTUM AND ANUS.

Examination of the anus and rectum may be made in the Sims, knee-chest, lithotomy, or squatting position, or with the patient standing and bending over the back of a chair. A preliminary examination, before the use of laxatives or enemata, will reveal the character of any feces or discharge that may be present (pus, blood, mucus, etc.). The external parts may then be cleansed and the rectum emptied with an enema.

Inspection of the external parts may reveal the orifice of a fistula, external piles, protruding internal piles, fissure, skin diseases, abscess, condylomata, mucous patches, parasites on the anal hairs, anal tumors, and similar conditions. By separating the buttocks and having the patient strain, internal piles, polypi, or a procidentia may appear.

Digital examination permits exploration of the lower four inches of the rectum. A rubber glove should always be worn, and the index finger, lubricated with sterile vaselin (light oil or lubricating fluids cause more pain), introduced gently, first upwards and forwards towards the umbilicus, until the internal sphincter is passed, then backwards in the hollow of the sacrum. The sphincter is twitching and spasmodic in an acute lesion of the anus; hard, unyielding, and hypertrophied in chronic disease; relaxed in exhausting general maladies. The finger may detect an abscess, an ulceration, a foreign body, a tumor, a stricture, indurated internal hemorrhoids, procidentia, or the internal orifice or the tract of a fistula. A growth just beyond the reach of the finger may become palpable if pressure is made on the lower abdomen with the other hand (bimanual examination), or if the patient strains while in the squatting posture. The coccyx, the prostate, the seminal vesicles, the female perineum and pelvic organs also must be investigated, because affections of these parts may be repsonsible for the rectal disorder. The introduction of the hand into the rectum, under general anesthesia, is too dangerous to be recommended.

Instrumental examination of the anal canal and the lower rectum can be made with a short rectal speculum of the cylindric or valvular type (*proctoscope*), but for inspection of the upper rectum and the sigmoid the *sigmoidoscope*, preferably that devised by Tuttle, is needed. Tuttle's instrument is a long hollow cylinder with an electric lamp at the distal end. The patient assumes the knee-chest posture, and, with the obturator in position, the "scope" is introduced through the anus, towards the umbilicus, until the internal sphincter is passed. The obturator is then withdrawn, and if the rectum fails to distend under atmospheric pressure, a plug, containing a glass window, is inserted in the proximal end of the instrument, and the inflation made by means of a hand bulb, which is connected with a small tube running through the plug. The instrument may then be passed to its full extent, fourteen inches, under guidance of the eye. Long applicators, forceps, etc., are made for diagnostic or therapeutic manipulations through the sigmoidoscope. Probing is employed chiefly for the diagnosis of fistulæ.

The size and the shape of the rectum, or of rectal sinuses or diverticula, can be demonstrated with the *X-ray*, after the injection of a bismuth mixture.

Congenital Malformations.—Normally, in the early stages of development the hind-gut communicates in front with the allantois and behind with the neurenteric canal. At a later period the gut and genitourinary canal open externally in a common passage, called the cloaca. By the growth of a posterior and two lateral folds, the perineum is formed, and the gut separated

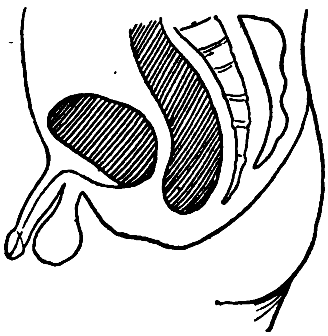

FIG. 444.—Imperforate anus.

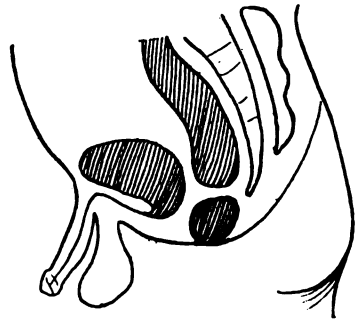

FIG. 445.—Imperforate rectum.

from the genitourinary cavity. A pit called the proctodeum extends inward from the perineum, until finally it meets and communicates with the rectum. According to the extent to which development has progressed, the following malformations may be encountered. **Anal stricture** may be enlarged by cutting backwards towards the coccyx, and the opening maintained by the subsequent passage of bougies. **Imperforate anus** (Fig. 444) is a condition in which the rectum is developed, but there is no proctodeum. When the infant cries, the rectum is felt to bulge at the point where the anal orifice should

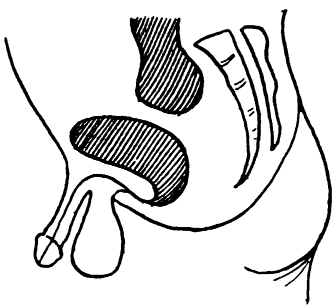

FIG. 446.—Absent rectum.

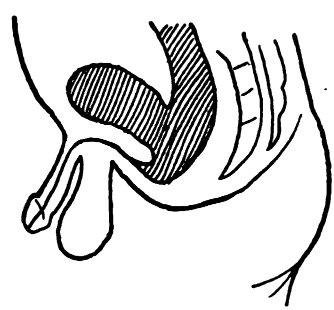

FIG. 447.—Atresia ani vesicalis.

be. **Imperforate rectum** (Fig. 445), in which both the rectum and the proctodeum are developed, but have not united, is the most common malformation, the septum being about an inch above the anus. **Absent rectum** (Fig. 446) is a malformation in which the rectum ends blindly high up, perhaps above the pelvic brim. The proctodeum may or may not be present. When the septum which should divide the cloaca is defective the rectum may open into the bladder (**atresia ani vesicalis,** Fig. 447), urethra (**atresia ani urethralis,** Fig. 448), or vagina (**atresia ani vaginalis,** Fig. 449).

The **treatment** in all cases, except anal stricture (*vide supra*) and atresia ani vaginalis, must be prompt, otherwise the patient dies of intestinal obstruction. If no anus is present, an incision is made in the midline of the perineum and deepened until the rectum is encountered, care being taken not to injure the bladder. One may follow the concavity of the sacrum as high as its promontory, excising, when necessary, the coccyx and lower segment of the sacrum; when the rectum is found, it is pulled down to the external opening, incised, and stitched to the skin. If the rectum cannot be found, the sigmoid may be brought down into the wound or an artificial anus made in the inguinal region. When the anus is present, the septum separating it from the rectum should be incised or excised, the opening thus formed being maintained by the passage of bougies. In atresia ani vaginalis the feces escape without hindrance, hence operation may be postponed until the infant is several years old. The rectum is detached from the vagina and fastened to the perineum, and the opening in the vagina closed with sutures.

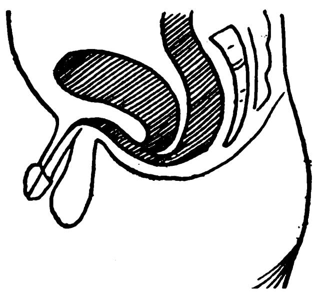

FIG. 448.—Atresia ani urethralis.

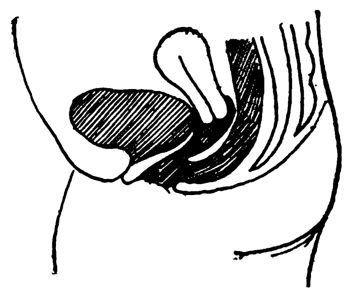

FIG. 449.—Atresia ani vaginalis.

Injuries of the rectum are usually caused by falling on a pointed object, e.g., a spike, by the breaking of a china bedroom utensil, by childbirth (see lacerations of the perineum and rectovaginal fistula), by gunshot or bayonet wounds, by fractures of the pelvis, and by foreign bodies (*vide infra*). The rectum may be wounded during operations, e.g., perineorrhaphy, prostatectomy, perineal section, divulsion of the sphincter, reduction of rectal prolapse, and pelvic operations, also by the passage of a urethral or a rectal bougie, a proctoscope, or an enema nozzle, particularly if the bowel is friable, e.g., from carcinomatous infiltration. The rectum has been ruptured by the colpeurynter, by the injection of compressed air, and by the introduction of the hand for diagnostic purposes. The *symptoms* are pain, hemorrhage, and in most cases shock; the complications sepsis, periproctitis, peritonitis, and secondary hemorrhage; the sequelæ stricture, incontinence, and the various forms of fistula. The *treatment* should be preceded by a careful examination to determine the extent of the wound, bearing in mind the possibility of injury to the urethra, bladder, vagina, and small intestine. Uncomplicated wounds of the rectum should be disinfected with creolin and sutured with catgut. Injuries to adjacent viscera should be repaired as described in the sections dealing with these viscera.

Foreign bodies that have been swallowed, that have formed in, or ulcerated into, the intestine (see foreign bodies in the intestine), or that have been introduced through the anus by degenerates, lunatics, or criminals, may be found in the rectum. The *symptoms* are tenesmus, the passage of blood and mucus (owing to ulceration), and possibly obstruction or suppurative periproctitis. Large foreign bodies may press on the bladder and cause frequent micturition, or on the sacral plexus and cause shooting pains in the lower extremities. The diagnosis may be made with the finger, the speculum, or the X-ray. The *treatment* is extraction with the finger or with forceps. In some cases it may be necessary to give a general anesthetic and split the anal canal backwards towards the coccyx. When the foreign body is impacted up near the sigmoid it may be safer to perform laparotomy and remove it from above.

Pruritus ani, or itching, is a symptom which may be caused by local conditions, such as piles, fissure, fistula, proctitis, worms, pediculi, uncleanliness, herpes, eczema, and diseases of the urethra, bladder, prostate, vagina, uterus, or ovaries, or by general conditions like gout, disorders of digestion, nephritis, diabetes, jaundice, constipation, mental and nervous disorders, and the opium, alcohol, tea, and tobacco habits. The *treatment* is removal of the cause and attention to the general health. The parts should be kept scrupulously clean. The itching may be relieved by lotions or ointments containing carbolic acid (1–15) or menthol (1–30). Painting the skin with silver nitrate (1–10) also is recommended; in the worst cases division of the sensory nerves supplying the part has been practised, or the affected skin excised.

Fissure of the anus is caused by the passage of hardened feces, and not infrequently accompanies hemorrhoids and other diseases. There is often a "sentinel" external pile at its outer extremity. The principal *symptom* is burning pain on defecation, and sometimes on walking or coughing. Constipation is thus encouraged, and when the hardened feces pass, they may be streaked with pus or blood. The ulcer is seen on separating the folds of the anus and the sphincter is found spasmodically contracted. The *treatment* is laxatives and the application of silver nitrate; if this fails, the patient should be anesthetized, and the sphincter stretched with the thumbs, thus causing a paralysis for from five to ten days, during which time the ulcer heals. The same result may be secured by dividing the superficial fibers of the external sphincter through the base of the ulcer. Piles should, of course, be removed at the same time. Large ulcers may be excised.

Proctitis, or inflammation of the rectum, arises from foreign bodies, polypi, piles, parasites, gonorrhea, irritating enemata, dysentery, and other forms of colitis. The *symptoms* are tenesmus, frequent bowel movements, with mucus, pus, or blood, and a sensation of heat and fullness. The bladder also may be irritable. The rectal mucous membrane may prolapse, and in chronic cases there may be ulceration followed by stricture formation. By digital examination the rectum is found to be hot and tender, and by inspection with the proctoscope the red and swollen mucous membrane can be seen. The *treatment* is removal of the cause, rest in bed, liquid diet, suppositories of opium and belladonna, hot sitz baths, and irrigation with very weak solutions of silver nitrate.

Periproctitis (cellulitis) is usually caused by infection from the rectum, as the result of disease (piles, fissure, fistula, cancer, etc.) or injury (hardened feces, swallowed fish bone, etc). It may be caused also by abrasions of the skin and affections of the surrounding tissues, including the bladder, urethra, prostate, and female pelvic organs. The *diffuse* form spreads rapidly, results in extensive sloughing, is usually seen in the old and asthenic, and is very apt to cause death. It is treated by free drainage and vigorous stimulation. In the *circumscribed* variety an abscess forms below (ischiorectal abscess) or above the levator ani (pelvirectal abscess). These abscesses are described in the next section.

Abscesses about the anus and rectum occur chiefly in four situations (Fig. 450), beneath the skin of the anus, beneath the mucous membrane of the rectum, and, as mentioned in the preceding paragraph, in the perirectal cellular tissue below (ischiorectal abscess) or above the levator ani (pelvirectal abscess).

An **anal abscess** is due to infection of a hair follicle or a sebaceous gland (*follicular abscess*, really a furuncle), or to a fissure or a suppurating external hemorrhoid (*marginal abscess*). Follicular abscesses, like boils elsewhere, may be multiple, but seldom give rise to fistulæ. A marginal abscess is generally single and may cause a fistula superficial to the external sphincter. The *symptoms* are itching, and throbbing pain, worse on defecation and walking. As the condition is superficial it is easily recognized. The *treatment* is incision, removal of undermined skin, disinfection, drainage.

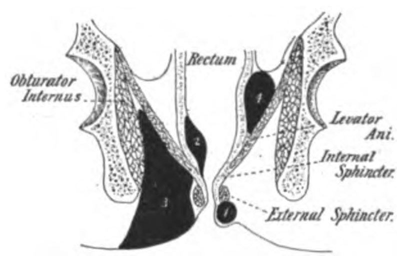

FIG. 450.—Diagram of anorectal abscesses. 1. Anal abscess. 2. Submucous abscess 3. Ischiorectal abscess. 4. Pelvirectal abscess.

If the abscess is due to a fissure or an external pile extending into the anal canal the sphincter should be stretched.

A **submucous abscess,** i.e., between the mucosa and the muscularis, is generally the result of a superficial injury by a foreign body, or of an ulcerated polyp or hemorrhoid. The *symptoms* are those of the preceding variety, and the abscess can be felt by digital examination. The *treatment* is divulsion of the sphincter, incision, removal of undermined mucous membrane, and, later, applications of silver nitrate. Gauze drainage is not needed.

Acute ischiorectal abscess is a form of periproctitis, hence due to the same causes. Left to itself the abscess usually breaks through the weakest portions of its wall, i.e., through the skin alongside of the anus, and through the mucous membrane towards the back of the anal canal (between the sphincters) at the point where the posterior edges of the levatores ani join the anococcygeal ligaments, thus forming a complete fistula. Sometimes it burrows across the median line to the opposite ischiorectal fossa (horseshoe abscess). The *symptoms* are throbbing pain, intensified by coughing, walking, sitting, and defecation, sometimes retention of urine, and always constitutional evidences of sepsis. Between the anus and the ischial tuberosity is a hot, red, tender, brawny, and edematous induration, and on passing the finger into the anal canal a tender, elastic swelling can be felt on the corresponding side. The *treatment* should be prompt, in order to avoid the formation of a fistula. A free incision is made, and the cavity irrigated with creolin solution and packed with iodoform gauze. The pus is fetid and often contains bubbles of gas (colon bacillus); it may be thick and yellow or, from the presence of altered blood clot, dark brown. **Chronic ischiorectal abscess** is usually tuberculous. There is at first a painless induration, which subsequently softens; in the later stages it is often infected with pyogenic organisms, the symptoms then being those of an acute abscess. The *treatment* is that of acute abscess.

A **pelvirectal abscess** is one occurring above the levator ani, between it and the rectum. This space is continuous with the pelvic cellular tissue, hence a pelvirectal abscess is due more often to disease of the urethra, bladder, prostate, or female pelvic organs, than to affections of the rectum. Occasionally a psoas or an appendiceal abscess, or an abscess proceeding from the pelvic bones points in this region, and sometimes the pus perforates the levator ani and appears in the ischiorectal fossa. The *symptoms* are those of the causative lesion, with painful defecation and sepsis. The abscess may be felt bulging into the rectum above the level of the internal sphincter. The *treatment* is that of the cause, with divulsion of the sphincter and evacuation of the abscess.

Fistula in ano means not only, as the term indicates, a fistula opening into the anal canal, but also a fistula running from the perineal skin to the rectum, or a sinus opening into any portion of the anorectal canal or upon the skin in the neighborhood of the anus. Fistulæ connecting the rectum with other viscera (bladder, vagina, etc.), however, are not included under this heading. Excepting punctured wounds, and the rare non-inflammatory fistula, lined by epithelium and possibly due to a small pressure diverticulum, fistula in ano is always caused by the breaking of an abscess through the skin, through the mucous membrane, or in both situations, hence there are three varieties, the blind external, the blind internal, and the complete. These suppurating tracts refuse to heal because of imperfect drainage, continual reinfection, constant motion, and, in the complete variety, because of the escape of gas and feces through the tract. Further, according to some authorities, about one-half of the cases are tuberculous. While phthisis is present in only a small proportion of those submitting to operation, many develop the disease subsequently, hence the conclusion that fistula in ano is often the primary source of tuberculous infection.

The **blind external fistula** (really a sinus) opens externally, but does not communicate with the bowel. It is short, subcutaneous, and close to the anus when due to the breaking of an anal abscess; deep and farther away from the anus when due to the breaking of an ischiorectal abscess (Fig. 451). If the opening is in front of the anus one should suspect a perineal fistula (see stricture of the urethra); if near the tuber ischii, disease of the bone.

The **blind internal fistula** (really a sinus) opens into the bowel, but has no external opening. It is comparatively infrequent, occurring in about 10 per cent. of the cases of anorectal fistula. The submucous form usually opens into the anal canal, the pelvirectal above the internal sphincter. In either case the orifice is generally on the posterior or the lateral wall of the anorectal canal; a sinus opening on the anterior wall may follow the breaking of a prostatic abscess.

The **complete or true fistula** opens both externally and internally. It occurs in about 75 per cent. of the cases and is usually the result of an ischiorectal abscess, the internal opening being between the two sphincters, the external within an inch and a half of the anus. When following a pelvirectal abscess, however, the internal opening may be above the internal sphincter, or when following an anal abscess, outside the external sphincter. A horseshoe fistula is one which extends around the bowel and opens on each side.

The **symptoms** of fistula in ano are pain during defecation, tenesmus, especially when there is an internal opening, a purulent discharge from the anus or the external opening, and in the complete variety the passage of feces and gas through the fistula; recurring abscesses may form, owing to

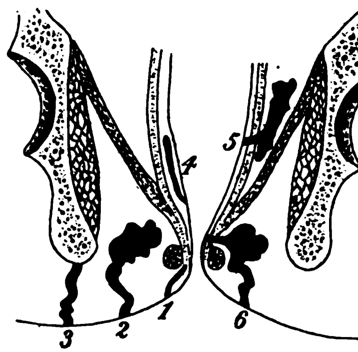

FIG. 451.—Diagram of anorectal fistulæ. Blind external fistulæ following (1) an anal abscess and (2) an ischiorectal abscess. 3. Sinus from disease of the ischium. Blind internal fistulæ following (4) a submucous abscess and (5) a pelvirectal abscess. 6. Complete fistula following an ischiorectal abscess.

healing or blocking of the openings. These abscesses may make new outlets for themselves, thus a blind external or internal fistula may become a complete fistula, and a complete fistula may establish numerous side tracts extending in various directions (Fig. 452). When there is an external opening, the diagnosis is readily made by inspection and the use of a probe. When there is no external opening, it will be necessary to use a speculum in order to expose the orifice. Digital examination will reveal spasm of the sphincters, a cord-like area of induration on one side of the rectum, and possibly the orifice of the fistula. The lungs should always be examined for evidences of phthisis.

The **treatment** is the conversion of the fistula into an open wound, so that it may heal from the bottom. A grooved director is passed through the fistula into the rectum, and the overlying tissues severed with a bistoury. In order to avoid incontinence the external sphincter should be cut but once, and always at right angles to its fibres, and the internal sphincter should never be cut. If the fistula enters the bowel above the internal sphincter the tract should be opened into the bowel at its lower part only. All branching sinuses likewise should be opened, and all fibrous tissue, with undermined skin, cut away with scissors. The bleeding is then checked, and the wound packed with iodoform gauze. If the fistula is lined with mucous membrane it must be completely excised. A blind external or internal fistula may be converted into a complete one and treated as outlined above, or a blind external fistula may be excised and the wound sutured. The bowels are confined for the first three or four days, and the wound dressed after each defecation, being irrigated with creolin and repacked with iodoform gauze.

Hemorrhoids, or piles, are swellings due to varicose veins about the lower end of the rectum. The *causes* are those which induce congestion in this region, such as sedentary habits, rectal disorders, tumors, inflammatory affections in the pelvis, cirrhosis of the liver and other conditions which interfere with the portal circulation, diseases of the heart and lungs, and, most important of all, repeated straining induced by chronic constipation, enlarged prostate, urethral stricture, or vesical calculus. The hemorrhoidal veins run between the mucous membrane and the muscle in a longitudinal

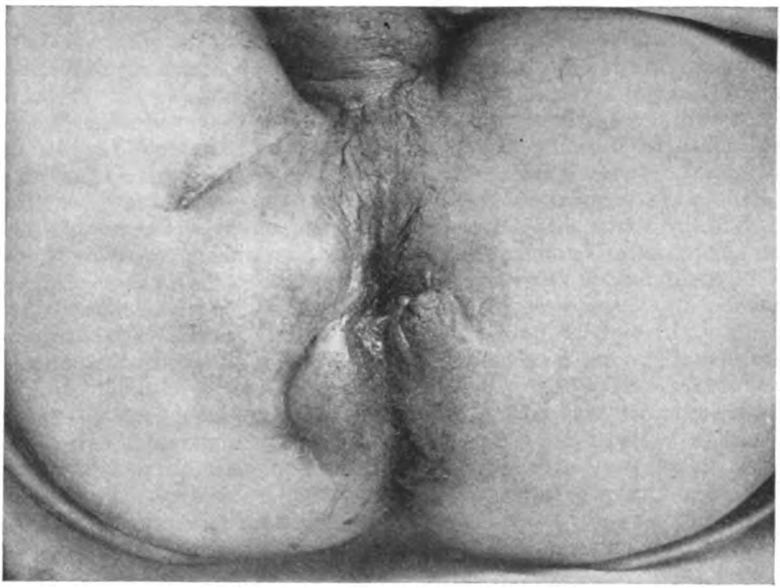

FIG. 452.—Multiple fistulæ in ano. (Pennsylvania Hospital.)

direction, forming a plexus around and above the anus; they have but little support, possess no valves, and form one of the principal communications between the portal and systemic circulations. There are two varieties of hemorrhoids, the external and the internal, which, however, often coexist.

External hemorrhoids occur at the margin of the anus, are covered with skin, originate from the inferior hemorrhoidal plexus, and consist of dilated veins surrounded by fibrocellular tissue. They cause no *symptoms*, except possibly itching or a little irritation, unless they are inflamed, when the veins become thrombosed, painful, and tender, and appear as tense bluish masses which cannot be emptied by pressure. When the attack subsides, the piles are harder and thicker than before. The *treatment* is the relief of constipation, cleanliness, and the use of soft paper or cotton, after defecation. The parts may be washed with a lotion containing witch-hazel. Operation is rarely required unless the piles become inflamed, when they should be incised, the clot turned out, and the cavity filled with iodoform gauze. When operating on internal hemorrhoids it is advisable to remove any coexisting external piles with scissors, the cuts radiating from the anus. If too much skin is removed, however, stenosis may follow.

Internal hemorrhoids are covered with mucous membrane, originate from the superior hemorrhoidal plexus, and consist of dilated veins, arterial twigs, and connective tissue. They cause pain, a sense of fullness, and often bleeding and a mucous discharge. They may protrude through the anus, and in some cases become strangulated from the grip of the sphincter and undergo sloughing. When inflamed (attack of piles), they swell and become intensely painful. Ulceration or suppuration, and occasionally abscess of the liver or pyemia may follow. The diagnosis is easily made with the speculum, but one must examine the whole rectum in order to exclude carcinoma.

The **treatment** is removal of the cause, if such be possible. The bowels should be moved daily, alcohol and spices avoided, and regular exercise taken. The parts should be kept clean, bathed with cold water after defecation, and dried with a soft rag. Ointments or suppositories containing hamamelis and, if there is much pain, opium and belladonna may be used. Adler has the following frequently applied: ex. hamamelis fl., one fluid ounce, ex. hydras. fl., tincture of benzoin comp., each one-half ounce, tincture of belladonna, one dram, ol. olive (carbol. 5 per cent.) q.s. three fluid ounces. Strangulated piles should be reduced after anointing them with oil, or if this is unsuccessful, they should be removed by operation. Operation is indicated also when there is prolapse, ulceration, recurring hemorrhages, attacks of inflammation, or pain requiring the frequent use of opium. The liver should always be examined before operation, as in some cases the bleeding is beneficial rather than harmful. A laxative should be given forty-eight hours before, and an enema the day before operation, thus preventing soiling on the table. Many operators omit shaving. The patient is anesthetized and put in the lithotomy position, and the anus thoroughly stretched. There are three principal methods of operating on hemorrhoids:

Ligation is easy, safe, and sure. The hemorrhoid is picked up with forceps and an incision made through the mucous membrane around the pile; the base is then transfixed with a double silk ligature, which is tied on each side, and the mass cut away.

Operation by the clamp and cautery is favored by many surgeons. The pile is caught with forceps, and a Smith's clamp, the blades of which, in order to prevent burning, are covered with ivory on the side which rests against the mucous membrane, applied to the base of the pile, in the long axis of the rectum. The pile is then removed with scissors, and the base seared with the cautery at a dull red heat, after which the clamp is removed.

Whitehead's operation consists in removal of the entire pile bearing area, and is indicated when there are masses of varicose veins which occupy the whole of this region. A circular incision is made at the junction of the skin and mucous membrane; the tube of mucous membrane containing the varicose veins is then dissected up and amputated, and the divided mucous membrane sutured to the skin. Stricture and incontinence occasionally follow this operation.

After any of these operations bleeding and tenesmus may be prevented, and the painless escape of flatus permitted, by introducing into the rectum a rubber tube surrounded by gauze and transfixed externally by a safety pin. The parts are protected with a sterile gauze pad, and washed each day with creolin solution. The bowels are opened on the third or fourth day. It will often be necessary to catheterize the patient for the first day or two, owing to reflex retention of urine.

Piles have been treated also by *excision* of the individual tumors, preceded by the application of a crushing clamp, or followed by suture of the wound; by *ignipuncture;* and by the injection of carbolic acid, one or two drops of a 10 per cent. solution being injected into each pile at intervals of a week.

Prolapse of the rectum may involve the mucous membrane only (*incomplete prolapse*, or *prolapsus ani*), or the entire rectal wall (*complete prolapse*, or *prolapsus recti*). The *causes* are relaxation of the tissues, such as is seen in the debilitated, and conditions which give rise to repeated and violent straining, e.g., constipation, diarrhea, various forms of rectal irritation, enlarged prostate, urethral strictures, stone in the bladder, and phimosis. In the early stages the prolapse appears as a reducible, red or purplish cuff of mucous membrane. In complete prolapse the mass may be of large size, irreducible, dry, and sometimes ulcerated or even strangulated.

The **treatment** is removal of the cause, and reduction of the prolapse by pressing the finger in the orifice after the parts have been oiled; reduction is maintained by strapping the buttocks together with adhesive plaster, leaving an opening for the passage of feces. In children cure is often thus obtained, if care is taken to prevent constipation. In adults the parts may be kept in place by a T-bandage, and a daily movement of the bowels secured while the patient lies on one side. An enema of cold water containing an astringent, such as tannin or fluid extract of hydrastis, also is useful. When these measures fail in the incomplete variety, longitudinal strips of mucous membrane may be excised and the wounds sutured, or the same result obtained by the use of caustics or the cautery. Paraffin has been injected about the anus in order to narrow the opening. In recurring complete prolapse the rectum or sigmoid may be fastened to the abdominal wall through an incision in the iliac region (*proctopexy or colopexy*). In other cases, particularly when irreducible, the prolapsed gut may be amputated, its continuity being restored by sutures.

Ulcer of the rectum may be simple (due to foreign body, abrasion of feces, etc.), syphilitic, tuberculous, malignant, gonorrheal, dysenteric, or typhoidal. The *symptoms* are those of rectal irritation, with constipation or diarrhea, and the discharge of mucus, pus, or blood. The diagnosis is made by digital examination and the speculum. The nature of the ulcer may be ascertained from the history and the local characteristics, which are much the same here as elsewhere. The *treatment* in non-malignant cases is local applications of silver nitrate, 20 or 30 grains to the ounce, after cleansing the rectum with hot water. Iodoform is useful, particularly in tuberculous cases. Temporary colostomy may be indicated if the ulcer is extensive and recalcitrant. The general health should receive attention, and in syphilitic cases appropriate internal treatment administered.

Stenosis or stricture of the rectum may be caused by pelvic neoplasms or cellulitis, and by the cicatrization of wounds or ulcers of the rectum. It may be also congenital or due to malignant tumors in this region; the latter will be considered separately. The bowel is dilated above the stricture and secondary fistulæ may form. The *symptoms* are pain, discharge (mucus, pus, or blood), constipation, deformity of the stools (ribbon or pipe-stem), occasionally attacks of diarrhea, due to enteritis from the irritation of retained feces, and finally in some cases complete obstruction. The diagnosis is made with the finger and the speculum. The *treatment* in the cicatricial variety is gradual dilatation with bougies. When in the lower part of the rectum, the stricture may be incised posteriorly. In suitable cases the stricture may be excised, and the ends of the bowel united by suture. In extensive and intractable cases colostomy may be the only possible remedy. Any constitutional disease, e.g., syphilis or tuberculosis, should receive treatment.

Tumors of the anus are uncommon. *Epithelioma* in this region presents its usual features, and causes enlargement of the inguinal glands. Cancer of the anus, however, is usually secondary to that of the rectum. The treatment is excision, with the inguinal glands.

Tumors of the Rectum.—Polypus recti is the most common benign tumor, is most frequent in children, and is an adenoma with a long pedicle. The *symptoms* are rectal irritation, the passage of blood or mucus, and occasionally prolapse or intussusception. The *treatment* is removal, after ligating or twisting the pedicle. **Papilloma** is rare, but may occur as a cauliflower mass, the chief symptoms of which are hemorrhage and rectal irritability. The *treatment* is removal by ligature or snare. A microscopic examination should always be made to exclude malignant disease. **Sarcoma** also is rare; it occurs as a large fleshy mass, without primary ulceration. The *symptoms* are the same as those of cancer, but occur at an earlier age. The treatment is extirpation.

Cancer of the rectum is usually of the tubular or cylindrical-celled variety, and is occasionally the result of a malignant change in an adenoma. The disease may begin as an ulcer, or as a nodule beneath the mucous membrane which reaches a large size before ulcerating. In the former instance the growth usually extends annularly around the rectum, in the latter it increases equally in all directions. The consistency varies with the amount of fibrous tissue present; thus the mass may be soft, fungating, and friable, or extremely dense with an ulcerated surface, the margins of which are hard and everted. The softer varieties are the more malignant. Metastases may occur in the lumbar glands, liver, and peritoneum, but are comparatively rare and late. The disease is most common in middle life, but it may occur earlier and has been seen even in childhood. The *symptoms* may be slight or absent, until the disease is far advanced. There may be pain, a sense of fullness in the rectum, tenesmus, and the passage of pus, blood, or mucus. In the later stages the signs of stricture are evident and cachexia develops. Secondary fistulæ into the bladder, vagina, or opening externally may form. The diagnosis is made with the finger and the speculum. If the growth is high up, it may sometimes be detected by having the patient bear down while in the standing position. Death occurs in from one to five years, from exhaustion, obstruction, hemorrhage, or peritonitis.

The **treatment** may be palliative or radical. **Palliative treatment** is indicated when the growth cannot be removed. The rectum is irrigated daily with salt solution, opium given for pain, and colostomy performed at an early period and not postponed until obstructive symptoms supervene, as it diverts the fecal current and thus diminishes pain and retards the progress of the disease.

Radical treatment, or excision of the rectum, is indicated when the growth is movable and metastases are not present. If the sacrum, base of the bladder, or uterus is involved, operation is useless. The mortality of complete excision of the rectum is about 25 per cent., and cure results in about the same proportion. Before any operation the bowels should be thoroughly evacuated, the rectum flushed with salt solution, and the patient fed only on wholly digestible food. Surgeons differ as to the necessity of a preliminary inguinal colostomy. Its chief advantages are that the rectum can be thoroughly irrigated before operation, that the field of operation can be kept clean after operation, and that the limits of the growth above and the presence or absence of abdominal metastases can be determined at the time the artificial anus is made. The chief objections are the additional risk involved in closing the artificial anus, if such be desirable, and the interference with thorough mobilization of the rectum at the time of excision; the latter objection loses its force if the sigmoid is pulled well down at the time of the colostomy. The following are the routes by which the rectum may be excised:

The **vaginal route** is indicated when a small growth exists on the anterior wall. The posterior wall of the vagina is split, the growth excised, and the vagina and rectum sutured.

The **anal route** is indicated when the growth is very low. The anus is dilated, a circular incision made through the rectal wall above the external sphincter, the rectum pulled out through the anus and amputated, and the two ends sutured. If the anus is involved it also must be removed, the primary incision then being made around the anus externally.

The **perineal route** is indicated in growths occupying the lower two or three inches of the rectum, and is much the same as the preceding, except that the incision extends back to the coccyx and, if necessary, as far forward as the scrotum. In some cases the external sphincter may be preserved.

The **sacral route** (*Kraske's operation*) is indicated in higher growths. With the patient on the right side, an incision is made from the posterior margin of the anus, upwards in the middle line, to the second piece of the sacrum. The coccyx is excised, the left side of the sacrum below the third foramen (the third sacral nerve sends a branch to the bladder) removed with the chisel, and the rectum extirpated. If the sphincter is not involved, the upper segment may be sutured to the lower. When this is impossible, the upper segment of bowel may be sutured in the sacral wound, or the end may be closed by sutures, providing, of course, a preliminary colostomy has been made. In the Kraske operation the peritoneum is often opened, subsequently being sutured, or packed with gauze. There are several modifications of this operation, involving more extensive removal of bone or osteoplastic resection.

The abdomino-perineal route is indicated in cases in which the growth extends too high to be removed by any of the preceding methods. In *Quénu's operation* the abdomen is opened in the middle line, both internal iliac arteries tied, the sigmoid divided, the upper segment of the bowel brought out through an incision in the left iliac region, thus making a permanent artificial anus, and the lower segment separated as far down as possible. The abdominal wound is then closed, and the rectum removed through the perineum. In *Weir's operation* the abdomen is opened, the gut divided above the tumor, the upper end of the lower segment invaginated and pulled out through the anus, and the involved segment amputated. The lower end of the upper segment is then drawn through the anus, and united to the lower segment by sutures (Maunsell's method).

CHAPTER XXIX.

URINARY ORGANS.

KIDNEY AND URETER.

Congenital abnormalities of the kidney include (a) absence or atrophy of one organ, the other being hypertrophied (*single kidney*); (b) *fusion of the kidneys* (*solitary kidney*), constituting a disc shaped mass lying in the middle line, or if the lower poles are joined, the horseshoe kidney; (c) *lobulation*, which is normal in fetal life and in some animals; (d) *doubling of the ureter* in whole or in part; (e) *stricture of the ureter;* (f) *two or more renal arteries* for the same organ; and (g) *displacement* of the kidney, which may be freely movable and supplied with a mesonephron (*congenital floating kidney*), or fixed at any point as low as the internal abdominal ring (*ectopic kidney*), to which situation it is probably drawn by the descent of the testicle; (h) *sarcoma*, *hydronephrosis*, and *cystic disease* also may be congenital.

Examination of the Kidney.—(1) To *palpate* the kidney one hand is placed under the loin and the other in front beneath the ribs, while the patient breathes deeply. The patient should be on the back, on the opposite side, or in some cases standing up. The normal kidney descends slightly on deep inspiration but ordinarily cannot be palpated. An enlarged ureter can sometimes be felt through the rectum, vagina, or abdominal wall. (2) The chief value of *percussion* is in determining the relations of a swelling in the loin to the colon; the kidney is always behind the colon. (3) The *X-rays* may show the normal kidney, enlargements of various sorts, tuberculous foci, stones, the ureters (after the passage of styleted catheters, and the renal pelvis (after the injection of collargol 5 to 10 per cent.—*pyelography*, Fig. 453). As food, fecal matter, and gas within the intestines produce confusing shadows, the diet should be limited to liquids for 24 hours before the plate is taken and the bowels cleared by purgation. The patient's back is brought in close contact with the plate by drawing up the knees and raising the shoulders, and the respiratory movements restricted and the thickness of the abdomen reduced by compressing the abdomen with a canvas band or a wooden ring. (4) Of great importance is the *chemical, microscopical, and bacteriological examination* of the urine, with the quantity secreted. (5) *Cystoscopy* allows direct inspection of the ureteral orifice (see examination of the bladder) and catheterization of the ureters (vide infra). (6) The *functional capacity of the kidneys* is considered below. (7) *Exploratory incision* is indicated when all other methods fail to give the desired information, but only in cases in which the symptoms are sufficiently grave to demand operation.

Catheterization of the ureter permits the collection of unmixed urine from each kidney, and is of great value in determining the presence of both kidneys, the location of disease in one or both organs. the patency of the ureter, the size of the pelvis, and like conditions. The technic is given in the section on cystoscopy. In order to overcome the difficulties of ureteral catheterization several forms of *urine segregators* have been devised. The

FIG. 453.—Skiagraph made after injecting collargol (10 per cent.) into the renal pelvis (*pyelography*), showing the size, shape, and position of the renal pelvis and ureter (Jefferson Hospital). Irregularities in the outline of the pelvis may be seen in pyelitis, tumors, tuberculosis, hydronephrosis, and pyonephrosis. The position of the shadow will aid in the differentiation of abdominal tumors, in the detection of solitary, ectopic, and horseshoe kidney, and in the localization of renal calculi (calculi in the cortex will appear distinct from the pelvic shadow). Various forms of ureteral obstruction and dilatation also can be demonstrated. Care must be exercised in making the injection, which should be discontinued if the patient complains of pain. If too much pressure is used the collargol may be forced into the parenchyma of the kidney, or into a ruptured vein, thus causing collargol embolism. Several deaths have occurred after pyelography.

Harris segregator separates the bladder into two compartments by a lever in the rectum or vagina, the urine being drained from each compartment by a small catheter. In another form of instrument (Luys and Cathlin) the bladder is separated into two portions by means of a thin rubber diaphragm which is expanded after it is passed into the bladder; the urine is then withdrawn by separate catheters passed through the instrument into each half of the bladder. Segregation of urine is easier than catheterization of the ureters, but the sources of error are so great that it is rarely or never employed at the present time.

The functional capacity of the kidneys is determined before performing a serious operation on one organ, and it is important to ascertain that the other kidney is not only present and healthy, but also sufficiently active to preserve the patient. The urine from each organ is collected separately and simultaneously, and one or more of the following methods employed.

(1) The *amount* and *composition* of the urine secreted by each kidney in a given time is determined. The normal output of each kidney in twenty-four hours is 500 to 750 cc. of urine, 10 to 15 grams of urea, 5 to 6 grams of chlorids. A decrease of one-third in these quantities indicates that the kidney is incompetent to sustain life.

(2) The *phloridzin test* consists in the subcutaneous administration of 5 milligrams of phloridzin, which is transformed into sugar by the secreting cells of the kidney. If these cells are normal, sugar should appear in the urine in from fifteen to thirty minutes, and continue to be excreted for four hours. Delayed or prolonged elimination points to renal insufficiency.

(3) *Chromocystoscopy* consists in watching the ureteral orifices for the excretion of blue urine, after the intramuscular injection of methylene blue (15 minims of a 5 per cent. solution) or indigocarmin (4 cc. of a 4 per cent. solution). A simpler plan is to insert ureteral catheters and note when the blue urine appears externally. Normally this should occur in from 10 to 20 minutes and continue 24 to 48 hours. If the blue is late in appearing or disappearing the renal parenchyma is diseased. Roundtree and Geraghty have recently suggested the intramuscular injection of 6 milligrams of phenolsulphonephthalein. The urine drains from the catheter into a test-tube containing 1 drop of a 25 per cent. sodium hydroxid solution, which becomes pinkish when the drug appears in the urine. As acid urine shows only a faint orange tinge, it is made decidedly alkaline by adding more sodium hydroxid solution, when it turns to a brilliant red. The sample is now diluted to 1 liter with distilled water, and a small filtered portion compared, by means of a Duboscq colorimeter, with a standard consisting of 3 milligrams of phenolsulphonephthalein and 1 or 2 drops of sodium hydroxid solution (25 per cent.) in 1 liter of water. Normally the drug appears in the urine in from 5 to 10 minutes, 50 per cent. being eliminated during the first hour, 15 to 25 per cent. during the second hour. The quantative estimation of the diastase content of the urine is time consuming and of no greater value than the phthalein test, hence will not be described.

(4) *Cryoscopy* is the determination of the freezing point of the blood and urine. It requires special apparatus and is regarded by most surgeons as untrustworthy. The greater the number of molecules in a fluid, the lower its freezing point, hence if the kidneys are diseased, the urine will contain less solids and will freeze at a high temperature, while the blood will contain more solids and freeze at a low point. The normal freezing point of the blood is -.56 C., of urine -.9 C. When the freezing point of the blood is -.58 C. or lower, and that of the urine is -.8 C. or higher, operations on the kidney are dangerous.

The **presence of two kidneys** may be determined by the cystoscope (presence of two ureteral orifices), by the segregator, by palpation externally (occasionally) or through an incision, and in some instances by the X-ray.

Hematuria, or blood in the urine, may be due to local or general causes. Among the *local causes* are inflammation, congestion, traumatism, embolism, thrombosis, calculus, tumors, ulceration, and parasites in any portion of the urinary tract. The most important parasite is the Bilharzia hematobia, which, in portions of Africa, enters the body with the drinking water and later develops in the veins of the intestine or urinary apparatus. The hemorrhage is caused by the discharge of ova through the mucous membrane. Bleeding may be produced also by the passage of an instrument, and in the female bloody urine may be the result of contamination with the menstrual fluid. Among the *general causes* are certain infectious diseases, e.g., variola, measles, scarlet fever, enteric fever, yellow fever, malaria, plague, and pneumonia; certain blood diseases, e.g., scurvy, leukemia, purpura, and hemophilia; intoxications, such as jaundice or those due to mercury, lead, arsenic, cantharides, turpentine, and quinin; hysteria; and vicarious menstruation. When the cause for the bleeding cannot be found the condition is called essential hematuria (vide infra). The color of the urine varies from red to black. It should be recalled that senna, rhubarb, beet root, and sorrel make the urine red; and carbolic and salicylic acids, brown or black. *Hemoglobinuria* is characterized by the absence of corpuscles. It may be due to any of the causes mentioned above, or to hemolysis, the result of extensive burns, transfusion of blood, infusion of salt solution, paroxysmal hemoglobinuria, or hemolytic poisons, e.g., ether, chloroform, snake-venom, phosphorus, carbolic acid, carbon monoxid. In *renal hematuria* the blood is intimately mixed with the urine, and may contain blood casts of the renal tubules or ureter. By cystoscopic examination blood may be seen issuing from the ureter. In *ureteral hemorrhage* bleeding is often slight and detectable only by microscopic examination. In *vesical* or *prostatic hematuria* the urine is often alkaline, contains clots, and most of the blood is passed at the end of micturition. In *urethral hematuria* blood drips from the urethra independently of micturition, and the final urine passed may be quite clear.

Pyuria, or pus in the urine, may be due to inflammation of, or rupture of an abscess into, any portion of the urinary tract. In renal pyuria the urine is usually acid, and the pus can be washed quickly from the bladder; in vesical pyuria the urine is generally alkaline, and it is difficult to make the washings clear. Pus from the prostate may be expressed into the urethra by pressure through the rectum, and pus from the urethra appears in the first portion of urine passed. The source may often be located with the cytoscope or the urethroscope.

Chyluria may be due to obstruction of the thoracic duct (tumor of the duct, pyloric carcinoma, calcified lymph glands, gravid uterus, dilated right auricle), but is usually caused by filariasis.

Anuria is the condition in which no urine is passed and the bladder is empty. It should not be confused with retention of urine, in which the bladder is distended (see bladder). Anuria may be obstructive or non-obstructive. **Obstructive anuria** may be caused by obstruction of the ureter of the only existing or only functionating kidney, or in rare instances by obstruction of both ureters simultaneously. The causes of ureteral ob-

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struction are given under hydronephrosis. In this variety of anuria uremia may not supervene for a number of days, even though no urine is passed. The *treatment* is nephrotomy upon the obstructed side, in order to allow the urine to escape. The side to be operated upon will usually be indicated by pain, tenderness, muscular rigidity, and possibly by enlargement of the kidney. Removal of the cause of obstruction, unless very easy, should be undertaken at a later date. **Non-obstructive anuria** (*suppression of urine*) may be reflex or due to degenerative changes in the kidneys. Among the *reflex* causes are operations on or injuries to any portion of the genito-urinary apparatus, obstruction to one ureter the other remaining free, hysteria, and extensive burns; in this group also uremia may be postponed for some days. The *treatment* is at first medical, and later nephrotomy upon one or both kidneys.. *Degenerative changes* in the kidneys may be caused by nephritis; acute infectious diseases, including septicemia; poisons, such as phosphorus, turpentine, carbolic acid, cantharides, ether, and chloroform; and by lesions like tumors, tuberculosis, and cystic disease of both kidneys. In these cases uremia accompanies or precedes the anuria. The *treatment* is usually medical, although in a few instances favorable results have followed nephrotomy.

For **rupture of the kidney and ureter** see contusions of the abdomen.

Wounds of the kidney give the same symptoms as ruptures, plus an external wound, from which blood and urine may escape. The treatment is that of ruptures.

Wounds of the ureter may be produced by stabs, bullets, and most frequently by the surgeon during abdominal operations, especially hysterectomy. The result is peritonitis, localized or generalized, and if the patient survive, a urinary fistula. The immediate *treatment* of a lateral wound is suture; of complete division, anastomosis.

Ligation of the ureter, which is sometimes unintentionally performed, particularly during gynecological operations, causes atrophy of the kidney or, owing to ulceration of the ligature through the ureteral walls, an abscess, which on breaking leaves a fistula.

Ureteral fistulæ, in addition to ruptures, wounds, and ligation, may be caused by sloughing following labor, or ulceration the result of conditions like tuberculosis, carcinoma, and calculus. The fistula may open into one of the hollow viscera, the vagina, or on the skin. The *diagnosis* from vesical fistula can be made by injecting colored fluid into the bladder and by cystoscopy. The first step in *treatment* should be the passage of a catheter along the ureter, from the bladder, in order to determine whether the defect is lateral or complete and to make sure the canal below the fistula is pervious. If the defect is lateral and no obstruction exists spontaneous healing may occur. Cutaneous fistulæ in which spontaneous closure is unlikely should be treated by some form of ureteral anastomosis (see operations on the kidney and ureter), vaginal fistulæ as described under vagina.

Movable kidney, or nephroptosis, is to be distinguished from *floating kidney;* in the latter condition, which is said to be always congenital, the kidney passes forward into the abdominal cavity and is completely surrounded by peritoneum, being attached to the posterior abdominal wall by a mesonephron. In movable kidney the organ is excessively mobile behind the peritoneum. Eighty per cent. occur in women, and the right kidney is involved in about the same proportion. It is most common between twenty and forty, but may be seen at any time of life. The adrenal gland remains in place, since it lies in a separate compartment of the perirenal fascia. The *causes* are conditions which render the abdominal walls flaccid, such as pregnancy, emaciation, removal of abdominal tumors, etc.; Glénard's disease; tight lacing; trauma; and conditions which increase the size or weight of the kidney. In many cases, however, no cause can be found, beyond the fact that the patient has a long and slender waist, and this bodily conformation is inherited, hence movable kidney may exist in several members of the same family.

According to the *symptoms* the cases may be divided into four classes. (1) In most cases symptoms are absent. (2) In others there is dragging pain in the loin, with indigestion and nervousness. (3) In this class complications arise. If the ureter becomes kinked or twisted, there is transient hydronephrosis, with violent pain in the kidney and epigastrium, vomiting, collapse, and subsequently elevation of temperature and the discharge of a large quantity of urine (*Dietl's crisis*); if the pedicle becomes twisted gangrene of the kidney may ensue. Dragging on the duodenum or bile ducts may cause gastric and biliary disturbances and even jaundice, and the condition is not infrequently associated with chronic appendicitis or mucous colitis. Albuminuria, pyuria, and occasionally hematuria may occur, from congestion of the kidney or pyelitis. (4) In this group the prolapse is secondary to tuberculosis, tumor, hydronephrosis, or some similar malady, hence presents the same symptoms as the primary trouble. In all cases the symptoms are intensified by exercise or by lying on the sound side, and are usually relieved by lying on the back. The diagnosis is made by feeling the kidney descend below its normal level on deep inspiration. In the severer forms the hands can be approximated above the kidney, and in the worse cases the kidney may be found in the pelvis; percussion over the loin is said to give resonance, but the sign is fallacious. The X-ray may show the position of the kidney and reveal unsuspected conditions, e.g., a calculus.

No **treatment** is required in class 1; above all the patient should not be told that the kidney is movable. The treatment in class 2 is the application of a straight front corset, adjusted while the patient is lying down, forced feeding, tonics, and rest; in class 3, nephorrhaphy; in class 4, that of the cause.

Essential hematuria (*renal hemophilia*) is a condition in which there is constant or intermittent bleeding from one kidney, which on exploration appears to be normal. Even microscopic examination of sections removed at operation may reveal nothing pathologic, although in some instances the tissue shows the changes of a diffuse interstitial nephritis. There may be pain in the loin and sometimes, owing to the passage of clots down the ureter, renal colic. Cystoscopic examination shows blood issuing from the ureter on the affected side. The kidney should be explored for diagnostic purposes and, if no lesion is found, decapsulated. In a surprisingly large number of cases this treatment has been followed by complete recovery.

Hydronephrosis, or uronephrosis, is distention of the pelvis and calices with urine, as the result of gradual or intermittent obstruction of one of the passages below. Sudden and complete obstruction to a ureter results in cessation of the urinary secretion as soon as the back pressure is sufficiently high, and after a time in renal atrophy; if, however, the obstruction is removed within a few weeks restoration of the function of the kidney may follow. The *causes* are congenital and acquired. *Congenital hydronephrosis* is due to atresia of some portion of the urinary passages; *acquired hydrone-*

phrosis to obstruction of the ureter by calculus, blood clot, parasites, plugs of mucus or pus, or stricture; by tumors, abscesses, cysts, pregnant uterus, or other forms of external pressure; by valve formation at the junction of the pelvis and ureter owing to oblique insertion; by kinking, e.g., over an accessory renal artery or from excessive mobility of the kidney; and less commonly to obstructions in the urethra. In the last instance the hydronephrosis may be double. As the result of the accumulation of urine in the pelvis of the kidney the cortex becomes thin and in the final stages disappears, the kidney being converted into a large, thin walled, irregular cyst. At this time the fluid may not contain urea or other urinary solids. Infection and consequent pyonephrosis may occur at any time.

The **symptoms** are combined with those of the causative lesion. Distention of the kidney gives rise to pain and a tumor in the loin, which fluctuates, is dull on percussion, lies behind the colon, and may disappear with the passage of a large amount of urine. Alternating ischuria and polyuria is known as the *flush-tank symptom*. The cystoscope will show absence of urine on the affected side, and the ureteral catheter may reveal the obstruction. If the catheter passes the obstruction the size of the pelvis may be determined by measuring the quantity of water (colored with methylene blue or collargol, 2 per cent.) which can be injected before it escapes from the ureter alongside of the catheter (the normal pelvis holds from 5 to 20 cc.), or by taking a skiagraph after the pelvis is filled with the collargol solution (Fig. 453). Calculi also may be detected with the X-ray. Death occurs from uremia, sepsis, pressure on important organs, or rupture into the peritoneal cavity.

The **treatment** is removal of the cause if possible. *Aspiration* is only a palliative measure. In most instances the kidney is exposed by an exploratory incision, opened, and drained (*nephrotomy*); it is then sometimes possible to find and remove the cause. If the kidney is totally destroyed, or if the obstruction cannot be removed and a permanent sinus follows nephrotomy, *nephrectomy* should be performed if the other kidney is sufficiently active to maintain life.

Pyelitis, or inflammation of the pelvis of the kidney, is caused by the colon bacillus in 75 per cent. of the cases, either alone or mixed with other pyogenic organisms, the most frequent of which are the streptococcus and the staphylococcus. The bacteria reach the renal pelvis by one of five routes. (1) *Ascending infection* travels up the ureter by continuity, or by means of regurgitated urine (*urogenous*). It is the result of obstruction or inflammation in the lower urinary passages (ureter, bladder, urethra). (2) *Hematogenous infection* occurs in acute fevers, such as the exanthemata, typhoid, diphtheria, pyemia; and possibly in those cases depending primarily upon localized forms of irritation, e.g., calculus, parasites (the chief of which is the Bilharzia hematobia), tuberculosis, tumor, contusion, and the excretion of drugs like turpentine and cantharides. It may be stated that ordinarily bacteria excreted by the kidneys produce no evil effects, unless there is some local irritation or some obstruction to the free discharge of urine. Pressure of the gravid uterus on the ureter may thus contribute to the etiology of the pyelitis of pregnancy. (3) *Lymphatic infection* accounts for the frequency of the colon bacillus; the lymph vessels from the ascending and descending colon pass over the renal capsule of the corresponding side, and communicate with the lymph vessels of the kidney. It may be possible also for bacteria to travel from the bladder along the lymphatics of the ureter. (4) *Direct infection* is the consequence of wounds or fistulæ. (5) *Infection by contiguity* is due to inflammation extending from the surrounding structures.

The **symptoms** are pain and tenderness in the kidney, frequent micturition, intermittent pyuria, and fever during the absence of the pus from the urine, which is acid unless there is a coexisting cystitis with decomposition of the urine. Owing to the obstruction to the urinary flow caused by swelling of the mucous membrane or other lesion, a pyonephrosis may develop and extension to the kidney occur (*pyelonephritis*); suppuration may extend also to the surrounding tissues.

The **treatment** is hot fomentations, alkaline waters, diuretics, urinary antiseptics, and, to decrease the number of colon bacilli in the large bowel, laxatives. The external genitals, especially in infants, must be kept clean; circumcision should be performed if there is phimosis; and, in order to lessen the pressure on the ureters, pregnant women may assume the knee-chest position several times daily, and, when sleeping, lie on the side instead of on the back. Recently encouraging results have been obtained with autogenous vaccins. Lavage with a weak solution of one of the silver salts, introduced through a ureteral catheter, is beneficial in some cases. If the condition be caused by an ascending infection, the bladder should receive appropriate treatment. Other causes if evident should be removed. If no cause can be ascertained and the symptoms persist, the kidney should be explored.

Pyelonephritis is pyogenic inflammation of the pelvis of the kidney and of the renal parenchyma, and is due to the same causes as pyelitis. The *symptoms* are chills, fever, pain and tenderness in the kidney, vomiting, headache, and later signs of exhaustion and uremia. The urine is small in amount, usually contains pus, and sometimes blood. The *treatment* is that of pyelitis. If both kidneys are affected the prognosis is extremely grave.

Pyonephrosis, or distention of the pelvis of the kidney with pus, is the result of infection of a hydronephrosis, or retention of pus in pyelitis. The cortex is invaded and the kidney finally represented by a large multilocular pus sac (Fig. 454), surrounded by adhesions, through which the pus may break, establishing a fistulous communication with the bowel or the skin, or setting up a fatal peritonitis. The *symptoms* are those of hydronephrosis, plus those of sepsis. The quantity of pus in the urine depends upon the degree of obstruction. It may be intermittent or entirely absent. Death occurs from sepsis or uremia. The *treatment* in unilateral cases is *nephrotomy*, removal of the cause if possible, and drainage, or if the kidney is hopelessly disorganized, nephrectomy. If both organs are involved treatment is usually hopeless, although double nephrotomy may be employed in suitable cases.

Abscess of the kidney is due to the same causes as pyelitis. Pyemic abscesses are always small and multiple. *Chronic abscesses* are usually tuberculous. The *symptoms* are pain, tenderness, and muscular rigidity on the affected side, and the constitutional symptoms of sepsis. The abscess cannot be detected by palpation unless it is of large size. Pyuria may be present or absent. The *treatment* is *nephrotomy* and drainage, or, if the whole kidney is destroyed, *nephrectomy*.

Perinephritis, or inflammation of the perinephritic fat, may be caused by trauma, infection from the blood, and extension from environing parts (spine, pleura, ribs, liver, intestine), but is usually secondary to suppurative processes in the kidney. The *symptoms* are pain, tenderness, muscular rigidity, and if suppuration occurs, fever, and the presence of a mass in the loin. A **perinephritic abscess** usually points alongside of the erector spinæ, but may descend into the iliac fossa or burst into the pleura, peritoneum, or intestine. The *treatment* of perinephritis in the absence of suppuration is hot fomentations, sedatives, and attention to the general health; a perinephritic abscess should be opened and drained. In all cases the cause should, if possible, be determined and removed.

Ureteritis, or inflammation of the ureter, is practically always secondary to pyelitis or cystitis. Primary ureteritis is possible, e.g., from calculus or injury, but is very rare. In the *acute* variety there is a pyogenic inflammation of the mucosa. *Chronic* ureteritis presents itself in two forms. (1) In the *dilated form* the ureter is dilated and tortuous from obstruction, the muscular coat undergoing hypertrophy and the mucosa cystic changes. (2) In the *fibroid form* the ureter is straight, thickened, shortened, densely adherent, and strictured in numerous places.

The *symptoms* are usually masked by the causative pyelitis or cystitis. Occasionally tenderness can be elicited through the abdominal wall, and the thickened ureter can often be felt through the vagina and sometimes through the rectum. The ureteral orifice, as seen with the cystoscope, is dilated or contracted, retracted or pouting, and almost always rigid (noncontracting) and reddened. Strictures are revealed by the ureteral catheter. The *treatment* is that of the cause.

Tuberculosis of the kidney may be ascending or descending. In the former, which is more frequent in men, the original focus is often in the prostate or epididymis, from which the infection spreads to the bladder, thence ascends the ureter and invades the pelvis and finally the parenchyma, hence both organs are generally affected. In the descending type, which represents about two-thirds of the cases, and which is more common in women (3 to 1), the bacilli are deposited from the blood and the disease is called primary, i.e., it is primary so far as the urinary organs are concerned, but generally secondary to a lesion in some other portion of the body, notably the lungs. This type is usually unilateral, commences in the parenchyma, extends to the pelvis and ureter, and in about half the cases to the bladder and the other kidney. The changes are those of tuberculosis elsewhere. Caseation occurs and the abscesses open into the pelvis or exceptionally through the capsule. In the later stages the kidney is densely adherent from perinephritis, thus rendering nephrectomy difficult and dangerous. The *symptoms* are frequent micturition with dysuria, slight pain or from transient blocking of the ureter severe colic, pyuria, occasionally hematuria, and in the later stages chills, fever, and sweats, due to secondary infection with pyogenic organisms. The kidney is tender and enlarged, but one should not rely on this sign alone, as the larger organ, even though tender, may be the healthy one, greatly hypertrophied because it is doing the work of both. Nodules may be detected in the prostate, epididymis, vas, or seminal vesicle. Tubercle bacilli are sometimes found in the urine. The cystoscope reveals a dilated, rigid (noncontracting), and, owing to the thickening and shortening of the ureter, retracted ureteral orifice, which is often surrounded by ulcers or tubercles (Fig. 462). The thickened ureter can be felt through the vagina and sometimes through the rectum or abdominal wall. The X-ray may show the tuberculous focus, which, owing to calcareous infiltration, sometimes casts a dense shadow closely resembling that of a calculus. The *prognosis* is favorable if all of the disease can be removed; decidedly unfavorable in all other cases, death occurring usually from uremia, sepsis, or generalized tuberculosis. Circumscribed tuberculosis of the bladder due to infection from the kidney may, however, subside after ureteronephrectomy. The *treatment* is medical if both kidneys are involved. Perinephritic abscesses should of course be incised. If the disease is unilateral the kidney should be explored. If the focus is strictly limited, a partial nephrectomy with subsequent suture of the wound may be tried, but in most instances the disease will be found so extensive that the entire organ, with the ureter, will require removal.

Renal calculi (*nephrolithiasis*) are formed by the precipitation of urinary salts, which are then bound together by an albuminoid substance derived from the mucous membrane as the result of a preëxisting inflammation or as the result of the irritation induced by the deposited salts.

The **causes** are general and local. The most important *general* cause is faulty metabolism from overeating, improper diet (excess of nitrogenous food, sugar, and acids, too little water), alcohol, indigestion, neurasthenia, lack of exercise, and debilitating diseases characterized by anemia and wasting. According to the substance which appears in excess in the urine the condition is called the uric acid diathesis (lithemia), oxaluria, phosphaturia, etc. Lithemia and the tendency to the formation of uric acid stones may be inherited. Renal calculi occur at all ages, are more frequent in males, and are bilateral in 30 per cent. of the cases. The endemic nature of nephrolithiasis in certain districts has been attributed to the presence of large quantities of lime in the drinking water, or, owing to a warmer climate, to the increased density of the urine as the result of excessive perspiration; in India, Egypt, China, and other tropical countries, where stone is very prevalent, the Bilharzia hematobia or the filaria sanguinis hominis is held responsible, the ova of the former or the embryos of the latter forming the nuclei for the stones. The chief *local* causes are infection of the kidney or its pelvis and obstruction to the outflow of urine. Here must be mentioned also the possibility of a nucleus, which may be composed of epithelium, bacteria, blood clot, pus cells, a foreign body, or, as mentoined above, animal parasites.

The **appearance** of a renal stone varies with its composition, which, it must be noted, is not always the same throughout. Stones usually consist of uric acid or urates, sometimes of oxalate or phosphate of lime, and very rarely of carbonates, cystin, or xanthin. Uric acid calculi are oval, smooth, brownish, very dense, usually laminated, frequently multiple, and sometimes of large size. Those composed of urates are lighter in color, less dense, and not so distinctly laminated. The oxalate of lime calculus is round or oval, very heavy and hard, distinctly laminated, dark brown or black in color, and spiculated or nodular, hence the name mulberry calculus; it develops very slowly, is seldom of large size, and is usually single. Phosphatic calculi are composed of triple phosphates, are whitish, soft, friable, usually fetid and rarely laminated. They form when the urine becomes alkaline from retention and decomposition or from the drinking of alkaline waters, and may attain a large size. Any stone or foreign body may have a phosphatic coating. Carbonate of lime calculi are round, hard, and white; cystin calculi small, soft, smooth, friable, and waxy in appearance; xanthin calculi reddish-brown in color, small, and hard. Renal calculi may be single or multiple, in the latter event they are often faceted. They vary in size from fine granules (gravel) to a mass almost as large as the kidney itself (Fig. 454). Stones in the parenchyma are usually rounded; in the pelvis often pyramidal, dendritic, or coral-like, in some cases forming a cast of the pelvis; in the ureter oval.

The **symptoms** vary with the situation of the calculus. If it is situated *in the parenchyma* and is smooth there may be no symptoms. As a rule, however, there is pain in the loin, which is increased by jolting, and which may be felt also in the groin, thigh, testicle (sometimes with retraction of this organ), and occasionally along the back of the lower limb as far as the heel. In rare instances it is referred to the other kidney. There may be no urinary changes. Tenderness on pressure can almost always be elicited. Abscess of the kidney may follow. When the stone lies *in the pelvis* of the kidney it usually causes pyelitis (pyuria, hematuria, frequent micturition, etc.). If the stone passes *down the ureter* symptoms of *renal colic* follow, viz., sudden, excruciating, paroxysmal pain, passing from the loin along the ureter to the testicle, which is retracted; vomiting; collapse; strangury; and hematuria, which is often detectable only by the microscope. The pain ceases if the calculus slips back into the pelvis, or if it reaches the bladder. The stone may lodge near the pelvis of the kidney, close to the bladder, or at the brim of the bony pelvis, the point of impaction being excessively tender. Sudden and complete obstruction is followed by suppression of urine on the corresponding side and atrophy of the kidney, or by death if the other kidney is not functionally active. Occasionally the other kidney, even when healthy, suddenly ceases to secrete urine (*reflex anuria*). Incomplete or intermittent obstruction causes hydronephrosis or pyonephrosis. In some cases the stone ulcerates through the wall of the ureter into the abdomen or retroperitoneal tissues. Having passed through the ureter the stone may remain in the bladder as a vesical calculus, be passed with the urine, or, particularly in male children, become impacted in the urethra. A calculus in the lower portion of the ureter may occasionally be palpated through the vagina or rectum. The cystoscope may show edema of, or a stone in, the ureteral meatus, a difference in the urine on the two sides, or absence of the urine on the affected side. As a catheter sometimes passes a stone, Kelly suggests the use of a wax-tipped ureteral bougie, upon which scratches will be made if a calculus is present. The X-rays (Fig. 455) furnish the most reliable

FIG. 454.—Calculous pyonephrosis. (Pennsylvania Hospital.)

means of diagnosis, but are not infallible. They may fail to show very small stones, pure uric acid stones, and stones hidden beneath the twelfth rib. Failure in the last instance may be avoided by taking two plates at different angles. They may apparently show a stone when none exists, the source of error being a defective plate, or shadows cast by phleboliths, atheromatous plates, appendical concretions, gall stones, tuberculous foci, calcified lymph glands, centers of ossification in the pelvic ligaments, dermoids, foreign bodies, and fecal masses (hence the necessity of preliminary purgation). The shadows of ureteral calculi are generally oval, with the long axis in the line of the ureter. In doubtful cases a styleted catheter may be passed into the ureter (Fig. 456) and two plates taken at different

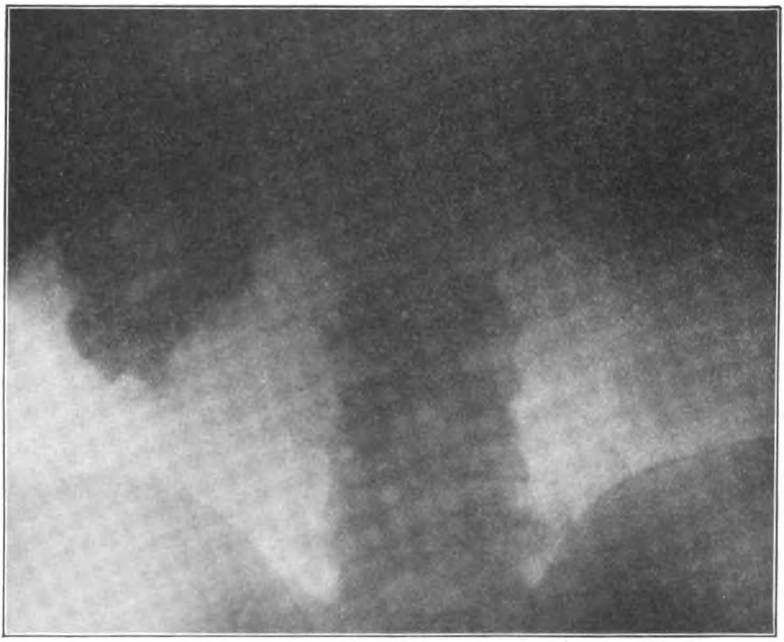


FIG. 455.—Skiagraph of multiple renal calculi. (Pennsylvania Hospital.)

angles. Extraureteral shadows will thus appear out of alignment with the catheter. As calculi are bilateral in 30 per cent. of the cases the skiagraph should always include both kidneys and both ureters.

The **treatment,** if the stone is small, quiescent, and *in the parenchyma,* may be directed to the lithemia, in order to prevent augmentation of the stone or the formation of others; this consists in exercise, regulation of the diet, attention to the bowels, plenty of water, alkaline diuretics, and piperazin. Under even these circumstances, however, the possibility of evil effects is by no means small, and unless there are serious contraindications nephrolithotomy is probably the safer course, an operation which becomes imperative if symptoms or complications arise. A stone *in the pelvis* practically always causes trouble, and, unless minute enough to pass down the ureter, should be removed by pyelolithotomy. A stone moving down the *ureter* causes renal colic, which requires hot fomentations, hot drinks, and the hypodermatic administration of atropin and morphin. If impaction with complete obstruction occurs immediate operation is demanded to save the kidney, or if there is anuria to save life. In impaction with incomplete

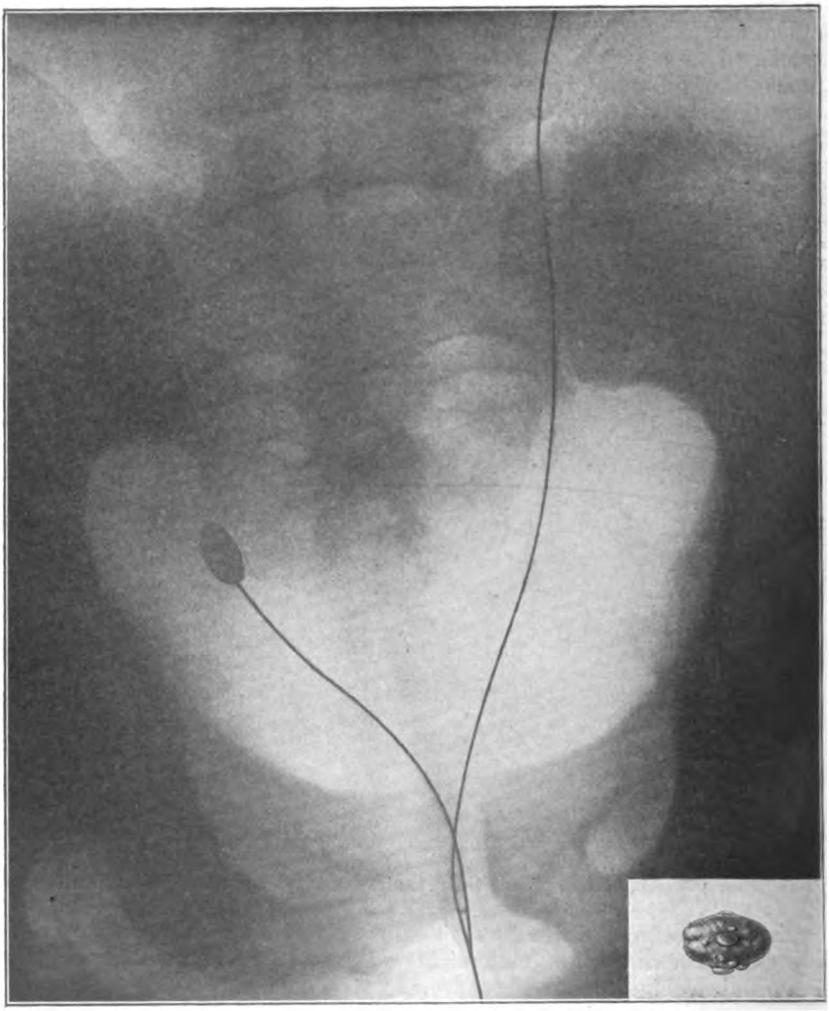


FIG. 456.—Skiagraph of a ureteral calculus impacted near the bladder (Jefferson Hospital). A styleted catheter was passed into each ureter; on the affected side the catheter met with obstruction three-fourths of an inch from the ureteral orifice; on the opposite side the catheter passed up the ureter without difficulty. The stone, which was removed extraperitoneally, through an incision above and parallel with Poupart's ligament, is shown, actual size, in the right lower corner of the illustration.

obstruction large quantities of water by mouth and injections of sweet oil into the ureter through a catheter may be tried. If these fail to dislodge the stone it should be removed by one of the forms of ureterolithotomy or, in some cases, when situated near the kidney, by pyelotomy after it has been pushed back into the pelvis. Nephrectomy is indicated only when the kidney is totally destroyed and the other organ is healthy.

Tumors of the kidney include cancer, sarcoma, and hypernephroma, the last being the most frequent. Sarcomata are most common in childhood. Angioma, papilloma, adenoma, and rarely other benign tumors also have been observed. The *symptoms* are pain, hematuria, and the presence of a growth in the loin, the tumor lying behind the colon, moving slightly with respiration, and having the shape of the kidney. In malignant cases acute varicocele may occur from the pressure of enlarged glands on the root of the spermatic vein, and cachexia sooner or later develops. Pigmentation of the skin indicates invasion of the suprarenal body. Sarcoma, including hypernephroma, may give rise to metastases in the lungs, liver, and bones, indeed the last may be the first sign of trouble. Papilloma of the renal pelvis is very likely to become malignant; it may cause death from hemorrhage, and occasionally some of the villous tufts become detached and appear in the urine. The *treatment* is nephrectomy, unless the growth is benign and small, when it alone should be removed.

Cysts result from interstitial nephritis (small and not treated surgically), from obstruction to one of the ducts, or from hydatid disease. Dermoid cysts also have been observed. When of large size they may be detected by palpation. In hydatid disease the hooklets may sometimes be found in the urine. The *treatment* is *enucleation*, or in the worst cases *nephrectomy*. **Congenital cystic disease** of the kidney is characterized by large multilocular cysts, probably the result of defective development of the Wolffian body. The *symptoms* are the presence of a tumor, and occasionally pain, albuminuria, and hematuria. As both kidneys are usually involved, surgical treatment is, as a rule, contraindicated; one may be forced to operate, however, for complications, viz., suppuration, severe hematuria, hydronephrosis, anuria, intestinal obstruction, painful crises due to displacement. When one organ alone is involved, it may be excised; if both organs are affected the operation must be conservative; nephrotomy, nephropexy, decapsulation with excision or puncture of the cysts.

OPERATIONS ON THE KIDNEY AND URETER.

The kidney may be exposed through the abdomen or through the loin. The **abdominal route** is selected if a very large tumor is to be attacked. The incision is made through the semilunar line, the peritoneal cavity opened, and the organ exposed by an incision through the posterior parietal peritoneum at the outer side of the colon. The **lumbar route** is chosen whenever possible. The patient may be placed upon the sound side with the thighs and knees flexed and a sand bag or air cushion under the loin, or on the abdomen with the air cushion beneath, in order to widen the costoiliac space and push the kidney up into the wound. The incision may be vertical or oblique. The *vertical incision* runs close to the outer border of the erector spinæ, from one-half inch below the last rib to the crest of the ilium. The fibers of the latissimus dorsi are separated, the lumbar fascia incised, and the quadratus lumborum and the erector spinæ retracted inwards. The last thoracic, the iliohypogastric, and the ilioinguinal nerves lie beneath the quadratus and should be drawn aside, or, if severed, sutured at the end of the operation. The kidney is exposed by tearing through the perirenal fat. If more room is needed, the incision may be extended outwards in a transverse direction above the crest of the ilium. The *oblique incision* extends from the outer border of the erector spinæ, one-half inch below the twelfth rib, downwards and outwards towards the anterior spine of the ilium. The latissimus dorsi, external oblique, internal oblique, and the transversalis muscle and fascia are divided.

Nephropexy, or nephrorrhaphy, has been performed in many different ways, but only the most important can mentioned. *Edebohls* delivers the kidney through the wound, excises the fatty capsule, makes an incision through the fibrous capsule along the convex border of the kidney, turns the capsule back towards the pelvis, and passes sutures through the capsule as shown in Fig. 457. The kidney is reduced, and the sutures passed from within outwards through the muscles and tied. The wound is then closed. It has been suggested also to tunnel under the fibrous capsule, and thread the tunnel on the twelfth rib; to throw a free transplant of fascia lata around

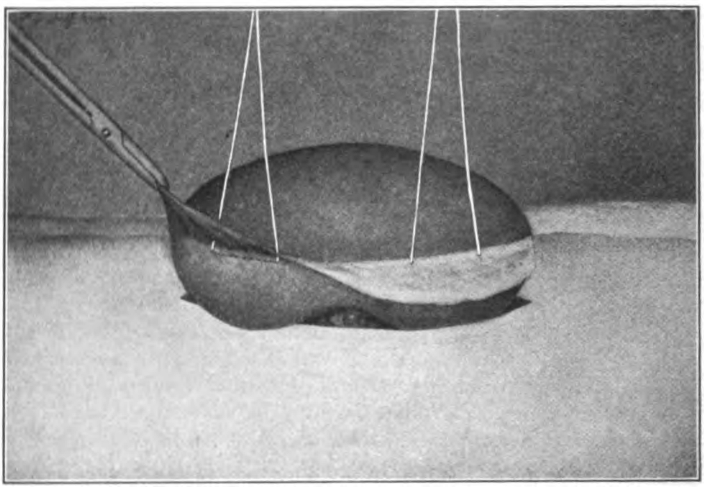


FIG. 457.—Edebohls' operation.

the kidney and suture the sling to the fascia of the back. The passage of sutures through the parenchyma is undesirable. *Da Costa* passes a strip of gauze, composed of two pieces sutured together with catgut, around each pole of the kidney, and ties the strips over additional gauze which fills the wound superficial to the kidney. After the catgut is absorbed the strips are easily removed. The gauze creates a bed of cicatricial tissue which holds the kidney in place.

Nephrotomy, or incision of the kidney, is performed after delivering the kidney through the wound, whenever possible. The length and direction of the incision will vary with the condition to be treated. When done for exploratory purposes, the incision is made along the convex border, just behind the mesial plane, at which place the ventral and dorsal vessels meet and the least bleeding occurs. If necessary the whole kidney may be split and laid open like a book. An assistant should compress the renal vessels during this procedure in order to prevent hemorrhage. Through the incision the interior of the kidney and the pelvis can be explored and bougies passed down the ureter. The wound may be closed with mattress sutures of catgut, which necessarily interrupt the vascular supply to portions of the parenchyma. If bleeding continues tamponage with fat or muscle, as described under rupture of the kidney, should be considered. As a rule the wound cannot be made dry, and drainage must be inserted. We have had several dangerous secondary hemorrhages after nephrotomy, demanding removal of the kidney, hence never employ it unless forced to do so. **Nephrolithotomy** is nephrotomy, plus the removal of stones with the finger or with forceps. The calculi, if not accurately localized by the X-ray, may be found by palpation, or by puncturing the organ with a needle. Drainage will usually be required.

Pyelotomy, or incision of the pelvis of the kidney, is called **pyelolithotomy** when done for stone. The kidney is delivered, the posterior wall of the pelvis opened transversely to avoid the vessels, and the wound subsequently sutured or drained, according to indications. In pyelolithotomy one should disturb the fat over the posterior wall of the pelvis no more than is absolutely necessary; it reinforces the suture line and helps to prevent the escape of urine; in many cases thus treated urine never flows through the wound in the loin. The old belief that urinary fistula is more apt to follow than after nephrotomy has been proved untrue.

Nephrostomy is the making of an opening into the pelvis of the kidney through the parenchyma for the purpose of diverting the urine from the ureter and the bladder. A similar purpose may be served by *pyelostomy*, or, when the bladder alone is to be put at rest, by *ureterostomy* or *ureteroenterostomy*. Watson recommends double nephrostomy, instead of the other operations just mentioned, before total cystectomy, and in cases of inoperable tumor or tuberculosis of the bladder. The ureter is tied close to the renal pelvis, the kidney incised, and a tube inserted. After the fistula is established the urine is collected in a specially constructed reservoir, which is strapped to the back.

Nephrectomy, or removal of the kidney, should not be performed until the presence and, if possible, the functionating capacity of the other kidney have been ascertained. The kidney may be removed through the abdomen or by the lumbar route. The advantages of the abdominal route are that the pedicle can be more easily controlled and the other kidney palpated; the latter maneuver may be accomplished also in the lumbar operation, after incising the peritoneum on the outer side of the colon. The great objection is that the peritoneum is opened, hence it is employed only when the organ is too large to be dealt with through the loin. In either method the kidney is shelled from its bed, and the ureter and renal vessels tied separately. It should be recalled that accessory renal vessels exist in 20 per cent. of the cases. When the operation is done for malignant disease, the fatty capsule also should be removed; if for tuberculosis, the ureter, when involved, likewise should be excised. **Partial nephrectomy** is performed by removing a wedge-shaped portion of the kidney and suturing the wound.

FIG. 458.—(Monod and Vanverts.)

Decapsulation of the kidneys for chronic nephritis consists in exposing the kidneys, peeling off the fibrous capsules, and dropping the kidneys back into place. Improvement follows in some cases, but the exact value of the operation has not yet been determined.

The **ureter** may be palpated through an abdominal incision, but should not be opened by this route because of the danger of peritonitis. The whole ureter may be explored extraperitoneally by the incision shown in Fig. 458. The peritoneum is exposed, and stripped from the parietes until the ureter is reached. The lower end of the ureter may be attacked also through the bladder, vagina, perineum, or by a modified Kraske operation.

Ureteropyelostomy, or anastomosis between the ureter and the pelvis of the kidney, has been performed in cases of hydronephrosis due to impermeable stricture of the upper end of the ureter or kinking of the ureter over the renal vessels. The same result has been obtained by an operation similar to pyloroplasty, or by excising the valve which is sometimes found between the hydronephrotic sac and the ureter.

Ureterolithotomy consists in opening the ureter by a longitudinal incision and removing the calculus, after the ureter has been exposed by one of the routes mentioned above. The wound may be sutured with fine catgut, or drained, and allowed to close at a later period.

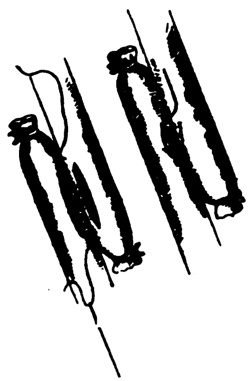


FIG. 459.—(Binnie.)

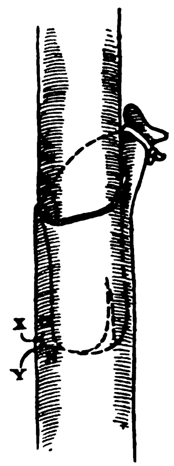


FIG. 460.—(Binnie.)

Ureteral anastomosis may be performed in the same manner as *lateral anastomosis* of the intestine (Fig. 459). *Lateral implantation* (*Van Hook's operation*) is shown in Fig 460. The end of the lower segment of the ureter is ligated, and an opening made below the ligature, into which the lower end of the upper segment is drawn by a catgut suture, the end of the upper segment having been previously split in a longitudinal direction to prevent stenosis. When this operation is not feasible, the ureter may be anastomosed to the bladder (*ureterocystostomy*), to the pelvis (*ureteropyelostomy*), or even to the intestine (*ureteroenterostomy*); the last method, however, is very likely to be followed by peritonitis or infection of the kidney. When a great length of the ureter has been injured or destroyed, it may be necessary to suture the ureter to the skin (*ureterostomy*) or to remove the corresponding kidney. Substitution of a piece of vein for a segment of the ureter has been successfully accomplished in the dog.

THE BLADDER.

Attention has already been called to congenital umbilical and rectal fistulæ communicating with the bladder.

Ectopia vesicæ, or extroversion of the bladder, is a congenital absence of the anterior wall of the bladder, the soft tissues which should overlie it, and of the symphysis pubis. It is most common in males, the upper wall of the urethra also being wanting (*complete epispadias*). The posterior wall of the bladder with the ureteral openings is pressed forwards and becomes inflamed owing to exposure. The urine dribbles away constantly and the inflammation may spread up the ureters to the kidneys. The **treatment** is very unsatisfactory. The patient may wear a urinal or be subjected to operation. Efforts may be made to close the bladder by suturing the mucous edges together, by utilizing flaps from the neighboring skin or a piece of intestine. To facilitate the approximation of a large opening the sacroiliac ligaments have been divided, and the cleft in the symphysis pubis obliterated by forcible compression. The urethra has been patched with a skin flap. A new urethra, opening within the sphincter ani, so as to avoid incontinence, has been made from the skin of the perineum, the wall of the rectum. The rectum has been severed, in order to create a bladder from the distal segment, the lower end of the upper segment being sutured to the skin just behind the anus but within the sphincter ani. A new bladder has been made from the cecum, the appendix acting as the urethra. In order to prevent the urine from flowing over the inflamed vesical mucous membrane the ureters have been implanted in the urethra, vagina, skin of the abdominal wall. The ureters have been anastomosed with the intestine in various ways; probably the best method is that in which the ureters with the trigone are implanted into the sigmoid. The valvular openings of the ureters are thus preserved and bacteria prevented from ascending to the kidney; urine collects in the sigmoid and is voided at intervals.

For **injuries of the bladder** see contusions of the abdomen.

Examination of the bladder may be made by palpation through the hypogastrium, rectum, or in the female through the vagina or even the dilated urethra. Percussion and inspection of the hypogastrium also may give information. The introduction of a sound through the urethra may detect a calculus or tumor. The X-ray is of value chiefly for the detection of stones and foreign bodies. Cystoscopy is described below. In cases in which a diagnosis cannot be reached by the these means, the bladder may be opened above the pubes or through the perineum for exploration.

Cystoscopy is the most important and, indeed, excluding exploratory incision, sometimes the only method for diagnosticating endovesical conditions. It permits inspection also of the prostate and ureteral orifices, the introduction of catheters into the ureters, lavage and medication of these ducts and of the renal pelvis, topical applications to the bladder, and the removal of small intravesical growths, stones, and foreign bodies. It cannot be used when the urethra is too small to admit the instrument, e.g., in stricture and in children, and when the bladder will not hold the requisite amount of fluid; and it is generally contraindicated in acute inflammatory troubles of the urethra, bladder, and prostate; in tuberculosis of the bladder, unless the diagnosis cannot be made by other means; and, because of the danger of suppression of urine, in acute nephritis.

The *cystoscope* consists of a hollow shaft, shaped like a stone sound, with an electric light at the end, and one or more telescopes which slide into the shaft. The lens system in the telescope is so arranged as to enable the examiner to see that part of the bladder toward which the instrument is directed (direct system), or the part at right angles to the instrument (indirect system). In some cystoscopes both systems may be used with the same shaft, which also contains channels for the passage of ureteral catheters and channels for irrigating the bladder. When the indirect system is used for catheterizing the ureters, the catheter is directed towards the ureteral orifice by a lever on the end of the cystoscope, which is raised or lowered by a screw on the external end. A special cystocope is required for endovesical operations. The male cystoscope answers equally well in the female. The cystoscope and ureteral catheters may be sterilized by immersion in a solution of carbolic acid (5 per cent.) or formalin (2 per cent.) for thirty minutes, after which all traces of the antiseptic should be removed with sterile water. For ordinary examinations anesthesia is not required; if the urethra is sensitive, however, about 10 drops of a 5 per cent. solution of cocain may be instilled into its posterior portion by a Keyes-Ultzmann syringe or a catheter;

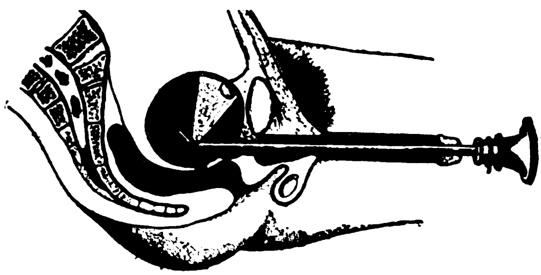


FIG. 461.—Cystoscope in position. (Duplay and Reclus.)

occasionally in nervous patients a general anesthetic must be employed. The buttocks are elevated and brought over the end of the table, the thighs being separated and slightly flexed, the feet resting on chairs; a special table is convenient but not essential. The external genitals are disinfected and washed with sterile water. The light is then turned on for a moment to test the lamp; the instrument lubricated with glycerin or liquid vaselin and passed into the bladder like a sound; the bladder irrigated with cool sterile water until it is clean, adding, however, adrenalin chlorid in the proportion of 1 to 10,000, if there is bleeding; at least 5 ounces of the fluid, but preferably 10 or 12, allowed to remain in the bladder, so as to distend it and prevent burning; the telescope slipped into the sheath; and the light turned on (Fig. 461). If the fluid quickly becomes turbid the examination may be made under continuous irrigation.

If *catheterization of the ureters* is desired the instrument is brought to the middle line and slowly withdrawn until the interureteral bar (which forms the posterior boundary of the trigone) comes into view; this is followed laterally until the slit-like ureteral meatus appears (Fig. 463), which is usually on the summit of a little teat, and may be identified by noting that at intervals, generally varying from 30 to 60 seconds or more, it opens like a fish mouth, ejects a swirl of urine, and closes again. The catheter is protruded from the instrument, gently pressed against the orifice, and then passed up the ureter (Fig. 465). The procedure is next repeated on the opposite side, the light turned off, the fluid allowed to escape from the bladder, and the catheters fed through the cystoscope as it is withdrawn, so as not to pull them from the ureters. Each catheter is passed into a test tube, which is plugged with cotton, and fastened by means of adhesive plaster to the corresponding thigh. It is a good plan to use a catheter of different color for each side so that no confusion as to which is which can arise. As a rule, even with the gentlest manipulation, some blood will be found in the samples, hence it is

FIG. 462.

FIG. 463.

FIG. 464.

FIG. 465.

FIGS. 462 to 465.—Cystoscopic pictures.

FIG. 462.—Dilated, rigid (noncontracting), retracted ureteral meatus, surrounded by ulcers and tubercles, characteristic of renal tuberculosis. FIG. 463.—Normal ureteral meatus. FIG. 464.—Jet of pus coming from ureter. FIG. 465.—Catheter entering ureter.

advisable to collect the urine from each side in two or three tubes, allowing each to remain in position one-half hour or longer, according to the amount of urine excreted. If a catheter does not drain, gentle suction with a syringe should be tried; failing this not more than 2 fluid drams of sterile water may be injected. Urine segregators, the functional capacity of the kidneys, pyelography, and chromocystoscopy are considered under examination of the kidney; the means of measuring the pelvis, under hydronephrosis; the use of styleted catheters, under renal calculi.

Incontinence of urine is the involuntary escape of urine. (1) In *true or passive incontinence* the urine flows out of the bladder as soon as it flows in, and the bladder is never distended. It is seen in conditions like ectopia vesicæ, fistulæ leading into the bladder, and paralysis of the sphincter vesicæ the result of disease or injury of the vesical sphincter or of its center in the spinal cord; it occurs also from propping open of the internal meatus by a growth or calculus. (2) *Active incontinence* is due to exaggeration of the vesical reflex. It is most common in children, occurring, as a rule, only during sleep. It may be *symptomatic*, i.e., due to phimosis, stone, highly acid urine, seat worms, spinal disease, etc., but in most cases it is *idiopathic*, i.e., no cause can be found, except perhaps that the child is neurotic. These cases are treated by removing any existing irritation, administering belladonna and tonics, waking the child at night to pass water, and by sending the patient to bed thirsty. Imperative urination, coming on every few minutes, and due to inflammation or other form of irritation, is sometimes called *false incontinence*. (3) The *incontinence of retention* is the overflow of a distended bladder, due to some obstruction, such as stricture or enlarged prostate, or to paralysis of the detrusor, such as may occur in spinal diseases and injuries.

Retention of urine is distention of the bladder owing to inability to pass urine. The **causes of retention** are: 1. Obstruction, such as phimosis; ligature about the penis; tumor or abscess of the perineum; stricture, calculus, rupture, tumor, abscess, or congenital occlusion of the urethra; inflammation, abscess, tumor, hypertrophy, or calculus of the prostate; and external pressure, such as fecal impaction and uterine tumors. 2. Non-obstructive lesions, such as atony or paralysis of the bladder, reflex inhibition (e.g., after operations on the rectum), hysteria, fevers, shock, and drugs like belladonna, opium, and cantharides. The most common cause in the new born is occlusion of the urethra, in infants phimosis, in children impacted calculus, in youth one of the complications of gonorrhea (male) or hysteria or foreign body in the bladder (female), in men stricture, in women pelvic disease, and in old age prostatic hypertrophy.

The **symptoms** in obstructive cases are pain, intense desire but inability to urinate, and frequent straining efforts. The bladder may be seen and felt above the pubes as a median, symmetrical, pyriform, fluctuating tumor, which is dull on percussion, and pressure upon which increases the desire to urinate. It may be palpated also through the rectum or vagina. The obstruction is encountered on attempting to pass a catheter. The distention increases until some urine is forced through the obstruction, or until the back pressure induces suppression of urine. The bladder does not burst unless injured or ulcerated, although the posterior urethra may give way if the obstruction is lower down. In non-obstructive retention the patient may make no complaint, and as the urine begins to dribble away when the bladder can hold no more, the condition may be mistaken for incontinence. Retention is to be distinguished also from suppression, as in each no urine is voided. In the former the signs of a distended bladder are in evidence, and the introduction of a catheter is impossible, or results in the withdrawal of a large quantity of urine In the latter the bladder is empty and no urine is obtained by the catheter.

The **treatment** of non-obstructive retention following operations is given under surgical technic (Chap. IV), and what is said there applies to most of the other forms of non-obstructive retention. The details of the treatment of obstructive retention vary with its cause. If it is not possible to remove the obstacle to urination at once, and a catheter cannot be passed into the bladder, the patient must be relieved by suprapubic or perineal cystotomy, or by *paracentesis vesicæ*, i.e., the plunging of a fine trocar into the bladder, in the middle line immediately above the pubes.

Atony of the bladder (loss of tone of the muscular walls) is caused by acute or chronic retention, and is physiological in old age. It is to be distinguished from paralysis of the bladder, which is due to some lesion of the nervous system and results in true incontinence. The *symptoms* are difficulty in starting micturition, lessened force of the stream, and dribbling at the completion of the act. There is always some residual urine, which is apt to decompose and set up a cystitis. The *treatment* is removal of any obstruction to the urinary flow, and catheterization to draw off the residual urine. The catheter is to be used once per day for every two ounces of residual urine, thus if there are eight ounces of residual urine, the catheter should be used every six hours. Urinary antiseptics, strychnin, and electricity also may be employed.

Cystitis, or inflammation of the bladder, may be acute or chronic. The morbid anatomy and the varieties are the same as those of inflammation in other mucous membranes. The *causes* are cold, lithemia, injuries, foreign bodies, calculi, gonorrhea, the introduction of filthy instruments, irritating drugs (e.g., turpentine and cantharides), acute infectious fevers, and any condition which, causing obstruction to the urinary flow, results in retention and decomposition of urine. The bacteria usually present are the colon bacillus, staphylococcus, streptocccus, and less commonly the gonococcus, typhoid bacillus, and the tubercle bacillus. These organisms reach the bladder through wounds, through the ureter or urethra, or by the lymph or blood stream. As with the kidney, bacteria may be present in the uriue without inducing inflammation of the bladder, so long as there is no local irritation or obstruction. Even pus may flow through the bladder, on its way from the kidneys, without causing cystitis.

The **symptoms of acute cystitis** are pain in the hypogastrium and perineum, more marked at the end of urination, which is frequent, urgent, and associated with tenesmus; tenderness of the bladder, elicited by hypogastric or rectal palpation; turbid, usually acid urine, containing mucus, pus, and sometimes blood; and fever due to toxemia. Cystoscopic examination is generally contraindicated. Recovery is the rule, but the inflammation may become chronic, or rarely cause death from toxemia, peritonitis, or pyelonephritis.

The **treatment** is removal of the cause, rest in bed with the hips elevated, hot applications to the hypogastrium, hot hip baths, liquid diet, alkaline diuretics, urinary antiseptics such as hexamethylenamine or salol, opium and belladonna suppositories when needed, and daily irrigations of the bladder with boric acid solution or nitrate of silver (1 to 10,000).

Chronic cystitis follows the acute form or is such from the beginning. The *symptoms* are those of the acute form, but much milder in degree. The urine may be acid, but is much more commonly alkaline, ammoniacal, fetid, and turbid with phosphates, mucus, and pus; phosphatic calculi are frequently formed. The general health becomes impaired and there is constant danger of septic pyelonephritis. The bladder walls are thickened and sometimes sacculated. Ulcers may form and occasionally perforation ensues. The diagnosis of chronic cystitis should never be made without cystoscopic examination, as the symptoms of this affection may be due to lesions of the kidney, especially tuberculosis. Further cystitis may exist without subjective symptoms, the only external evidence being the urinary changes.

The **treatment** is conducted on the same lines as in acute cystitis. Confinement to bed is usually unnecessary, and the injections may be stronger. In some cases balsamics, such as sandalwood oil, turpentine, and copaiba, are employed. When the cause cannot be ascertained and no improvement follows treatment like the foregoing, the bladder may be opened through the perineum or suprapubicly, carefully explored, and drained.

Pericystitis, or inflammation of the perivesical cellular tissue, may be due to affections of the bladder, prostate, rectum, uterus, Fallopian tubes (see pelvic cellulitis), pelvic bones, and less frequently to extension from distant parts, e.g., appendix vermiformis, dorsal or lumbar vertebræ. The inflammation may terminate in resolution, the formation of adhesions, or, most frequently, in suppuration, the abscess discharging into the bladder, the bowel, or externally. The *symptoms* are those of the causative lesion, with irritability of the bladder and sepsis. Induration can be detected by external, vaginal, or rectal palpation. The *treatment* is that of the cause, with, if suppuration occurs, drainage of the abscess, either above the pubes or through the perineum.

Tuberculosis of the bladder may be primary, but is usually secondary to tuberculosis of the kidney, prostate, testicle, or lungs. It is more frequent in men than in women. The tubercles break down and form ulcers. The *symptoms* are those of chronic cystitis, gradually become more severe and intractable, until, in the later stages, the bladder is in a state of almost constant spasm, the capacity being reduced to two or three ounces, hence cystoscopic examination is often impossible. The urine is frequently increased in amount, and contains pus, blood, and tubercle bacilli. The prognosis is unfavorable.

The **treatment** is attention to the general health as in tuberculosis elsewhere, and local treatment as in other forms of chronic cystitis. The injection of iodoform emulsion has been advised. Sometimes removal of of the source of infection, e.g., the kidney or the testicle, is followed by amelioration or even complete recovery. When these measures fail the bladder should be opened above the pubes and drained, and perhaps the ulcers curetted, or touched with carbolic acid.

Ulcers of the bladder, apart from tuberculosis and other forms of cystitis, may be due to injury, burning with the cystoscope, or malignant growths. Under the heading *simple ulcer* has been described a solitary ulcer usually situated at the base of the bladder. It is most frequent in anemic women, occasionally perforates, and has been compared to a peptic ulcer. The *symptoms* of ulcer of the bladder are those of chronic cystitis, the diagnosis being made by the cystoscope. The *treatment* is that of chronic cystitis. Ulcers have been curetted and local applications made through an operating cystoscope. In progressing cases the bladder should be opened, the ulcers curetted and cauterized, and drainage established; perforation is treated in the same way as rupture of the bladder.

Tumors of the bladder are uncommon, and are more often encountered in men than in women. The most frequent variety is papilloma; it has projecting fimbriæ, and is apt to undergo carcinomatous degeneration. Carcinoma also is comparatively frequent, and those who work in anilin factories seem to have a special predisposition to this form of growth. Sarcoma, angioma, myoma, and fibroma are very rare. The base of the bladder is the portion usually attacked. The *symptoms* are those of chronic cystitis, with attacks of profuse hematuria, which is most marked at the end of micturition; occasionally a portion of the tumor is passed with the urine. Sudden interruption of the urinary stream may occur from transient blocking of the internal meatus, hydronephrosis from obstruction to the ureter. The diagnosis is made with the cystoscope, the use of which may be difficult on account of hemorrhage. Large tumors may be palpated by bimanual examination, between the hand above the pubes and a finger in the rectum. Malignant growths may often be felt with the sound, particularly if incrustated with phosphatic deposits. The prognosis is bad, even benign growths, if unmolested, may be fatal from bleeding.

The **treatment** of benign tumors by fulguration is recommended by some surgeons. In most tumors of the bladder, however, the best procedure is suprapubic cystotomy. If the growth is pedunculated, it may be removed with the curette and the base cauterized. If it is malignant and of small size, a portion of the bladder wall should be removed and the wound sutured. Partial cystectomy may be done, as suggested by Harrington, through the peritoneal cavity. Removal of the entire bladder, with implantation of the ureters into the vagina or rectum, has been successfully performed. If the growth is found to be inoperable, drainage should be established for palliative purposes.

Foreign bodies usually gain entrance to the bladder through the urethra, being introduced by the patient, or resulting from the breaking of instruments, but they may find their way into the viscus also through ulceration or injury of its walls. The *symptoms* are those of cystitis. If allowed to remain, the foreign body is apt to become the nucleus of a calculus. The diagnosis may be made by means of the sound, the cystoscope, the X-ray, and occasionally by bimanual examination. Foreign bodies should be removed with forceps through the cystoscope, with the lithotrite, with the finger or forceps after dilatation of the urethra (in the female), or by suprapubic or perineal cystotomy.

Vesical calculus, or stone in the bladder, is composed of the same materials and due to the same causes as renal calculus (q.v.), in fact most vesical stones have descended from the kidney and then increased in size. Those originating in the bladder usually consist of phosphates, precipitated as the result of alkaline decomposition of the urine consequent upon chronic cystitis, hence renal stones lodging in the bladder and foreign bodies from other sources generally have a phosphatic coating. Vesical calculi vary greatly in size, but are usually single, and usually spherical, ovoid, or disc-like in shape, although there may be a groove corresponding to the interureteral bar or, when the stone is partly in the urethra, a constriction resembling that of an hour-glass. An elongated concretion is, as a rule, the result of a foreign body, e.g., a hair-pin, a pencil, a fragment of a catheter. Multiple stones are often faceted from mutual pressure. Stone is common in young boys because of the small caliber of the urethra, and in old men because of the frequency of residual urine and cystitis. Women are comparatively free from the affection, as the urethra is short and of large caliber, thus permitting the ready passage of small stones.

The **symptoms** are pain, which is worse just after urination, when the stone is forced down upon the sensitive trigone, and which may be referred to the perineum, back, down the thighs, end especially to the glans penis;

frequent micturition; often hematuria, particularly at the end of micturition; sometimes sudden transient cessation of the flow of urine, caused by the stone falling against the internal meatus; and possibly retention or incontinence of urine, retention from impaction of the stone in the urethra, incontinence from propping open of the internal meatus or, especially in children, from extreme irritability of the bladder. The first three symptoms are intensified by exercise or jolting, and vary in degree according to the size and shape of the stone and the sensitiveness of the mucous membrane. Occasionally the history of "gravel" or of renal colic may be obtained. Cystitis may either precede or follow stone formation. Hernia, hemorrhoids, or prolapse of the rectum may be induced by straining, and priapism is sometimes observed. In children incontinence or constant pulling at the foreskin should always suggest calculus. The diagnosis is made by sounding, by the cystoscope, and by the X-ray, and occasionally a stone may be felt through

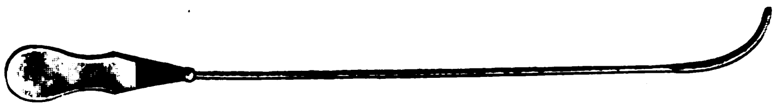


FIG. 466.—Stone sound.

the vagina or the rectum. The sound (Fig. 466) is introduced, as described on p. 625, with the patient in the recumbent posture, the bladder being partly filled with urine or boric solution. The handle should be marked on the side towards which the beak of the instrument projects. The instrument is drawn backwards and forwards, rotated to each side, and finally turned downwards, thus exploring the whole bladder. The stone is detected by a click, which may be felt and sometimes heard. The sound may fail to discover a stone which is encysted in the bladder wall, lies behind a large prostate, or is coated with mucus. The size of the stone can be measured with a lithotrite. A small stone which eludes the sound may be discovered by using a Bigelow evacuator; the suction causes the stone to strike against the end of the instrument. As vesical and renal

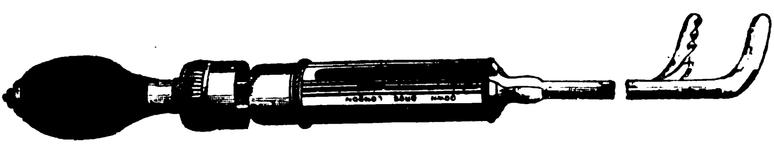


FIG. 467.—Thompson's modification of Civiale's lithotrite.

stones coexist so frequently, the examination should not be regarded as complete until both kidneys and both ureters have been investigated.

The **treatment** is removal of the stone by litholapaxy, or by suprapubic or perineal lithotomy.

Litholapaxy (*Bigelow's operation*) is crushing of the stone and removal of the fragments at the same sitting. *Lithotrity*, which consists in crushing the stone at intervals and allowing the patient to evacuate the fragments through the urethra, has been abandoned. Litholapaxy is to be chosen in all cases in which the following contraindications are not present: Obstructions to the passage of the instrument (e.g., stricture and enlarged prostate), severe cystitis, sacculated bladder, greatly contracted bladder (holding less than four ounces), great irritability of the urethra (as shown by chills after instrumentation), and large (above two inches in diameter), very hard, or encysted calculus. Recurrence is more frequent after this operation than after lithotomy, the nucleus of the new stone being formed by a fragment which has been left behind. The mortality is between three and four per cent. in the hands of the most skilled. The patient is anesthetized, placed on the back with the thighs separated, and the bladder irrigated with boric solution, six ounces of which should be allowed to remain in the viscus. The lithotrite (Fig. 467) is introduced, and the stone caught and crushed between the blades, which are pressed together by screwing the handle. The larger fragments are crushed in the same manner. The crushing is always done in the middle of the bladder, with the blades up, in order to avoid injury to the bladder wall. The evacuator (Fig. 468) is next introduced, and the débris removed by alternate pressure and relaxation of the rubber bulb, the fragments falling into the glass receptacle attached to the apparatus. If fragments remain which are too large to pass, the lithotrite must be reintroduced. Severe bleeding may be checked by the introduction of adrenalin solution 1 to 10,000. If the blades lock, it may become necessary to open the bladder through the perineum or above the pubes. At the completion of the operation the bladder should be inspected with the cystoscope, to make sure that all fragments have been removed. The after treatment consists in rest, warmth, plenty of fluid, and urinary antiseptics. Morphin may be given for pain, quinin for chills, and irrigations for cystitis.

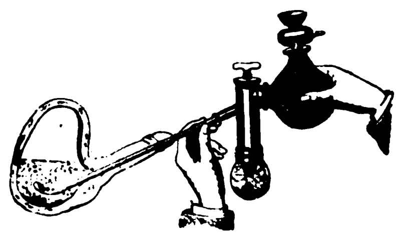


FIG. 468.—Evacuator in position in the bladder. (Rose and Carless.)

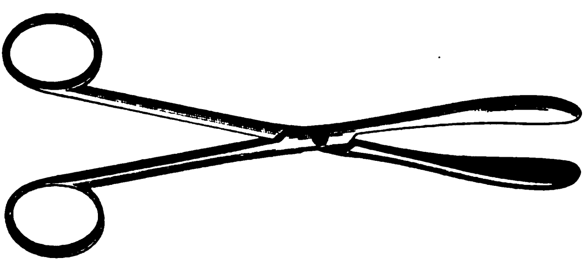


FIG. 469.—Stone forceps.

Suprapubic cystotomy, when performed for the removal of stones, is called **suprapubic lithotomy,** and is the operation of choice when litholapaxy is contraindicated, or when the surgeon lacks the necessary instruments or skill. The patient is prepared as for any abdominal operation, including shaving of the pubes. The capacity of the bladder should have been previously tested, and at the time of operation the bladder should be irrigated and filled with boric acid solution, or, as some surgeons prefer, filled with air. A catheter is tied about the penis, in order to prevent the escape of fluid, and the patient placed in the Trendelenburg position. These maneuvers displace the vesical fold of the peritoneum upwards, and thus permit extraperitoneal exposure of the bladder. The bladder may be pushed upwards against the belly wall by introducing a rubber bag into the rectum and distending it with air or water, but this is unnecessary and sometimes dangerous. A three inch incision is made in the median line from the symphysis pubis upwards, the prevesical fat separated, and the bladder recognized by its longitudinal muscular fibers and its globular form. Two sutures are passed through the bladder wall to act as tractors and a longitudinal incision made between them. Stones may be removed with the finger, forceps (Fig. 469), or scoop (Fig. 470), or if the bladder has been opened for other reasons, the lesion should be dealt with as described elsewhere. If the bladder is not infected, the wound may be closed by two layers of Lembert's sutures of catgut, the incision in the soft parts approximated, leaving space for a small gauze drain running down to the bladder, and a retention catheter passed into the

FIG. 470.—Stone scoop.

bladder through the urethra. If the bladder is infected, the wound in its wall may be sewed to the fascia, or it may be closed with catgut sutures which invert it about a rubber tube, several of the sutures passing through the tube, which should be long enough to syphon the urine to a receptacle beneath the bed. The surgeon must not forget to remove the tube encircling the penis, else strangulation and gangrene may follow.

Perineal cystotomy (*perineal section*) is performed for exploration, drainage, the removal of growths, prostatic enlargement, and the extraction of calculi; in the last instance it is called **perineal lithotomy,** median or lateral, according to the position of the incision. The perineum is shaved and disinfected and the patient placed in the *lithotomy position,* i.e., on the back with the pelvis raised and the thighs flexed on the abdomen. The bladder is irrigated and left partly distended with the solution. In *median lithotomy* a staff with a median groove on its convex side is passed into the bladder, and a median incision made from just behind the scrotum to within one inch of the anus. The membranous urethra is opened on the staff, and the finger passed into the bladder by dilating the prostatic urethra. If more room is required the prostate may be incised in the middle line posteriorly. A calculus may be removed with forceps or scoop, or if too large to be withdrawn whole, it may first be fragmented with the lithotrite. A drainage tube is then introduced into the bladder through the wound. If a rubber tube is employed it should be sutured to the skin; the special metal perineal tube shown in Fig. 471 is fastened in place by tapes. Ordinarily the drainage tube may be removed in forty-eight hours. The wound is covered with dressings, held in place by a T-bandage. *Lateral lithotomy* is rarely performed at the present time, having been displaced by the operations previously described. A staff with a groove on the left side is introduced into the bladder. The incision begins one and one-half inches above the anus, just to the left of the middle line, and extends downwards and outwards to a point just outside of the

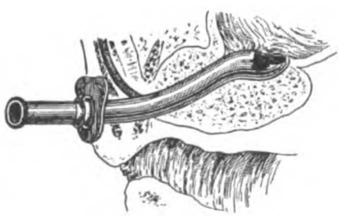


FIG. 471.—Watson's perineal tube.

middle of a line from the anus to the tuber ischii. The knife enters the groove on the staff in front of the prostate and severs the left lobe of that organ. The rest of the operation is much the same as median lithotomy.

Calculus in the female is rare, and is usually due to phosphatic deposits on a foreign body, often introduced by the patient. If small it may be removed by the finger or forceps, after dilating the urethra. If this is injudicious, litholapaxy should be performed. Very large stones may be removed by suprapubic cystotomy. Vaginal cystotomy is inadvisable because of the danger of vesicovaginal fistula.

CHAPTER XXX.

GENITAL ORGANS.

URETHRA AND PENIS.

Congenital Malformations.—Narrow meatus rarely causes symptoms and, as a rule, is brought to the surgeon's attention only when it is desirable to introduce instruments for other reasons. When needed the meatus may be enlarged by cutting downwards with a blunt pointed bistoury (*meatotomy*), the parts being separated each day by a probe in order to prevent union. **Congenital stricture** may occur at the outer end of the fossa navicularis and in the membranous urethra. **Occlusion** of the urethra may be due to a septum, which should be perforated. The urethra may be **absent,** leading to early death unless there is a congenital urinary fistula at the umbilicus or into the rectum or perineum. **Epispadias** (Fig. 472) is a congenital deformity in which the urethra opens on the dorsum of the penis. Complete epispadias, i.e., when the whole urethra is exposed on the dorsum of the penis, is always associated with extroversion of the bladder. The worst feature of the severer cases is incontinence of urine. In *Thiersch's operation* the balanic and penile urethræ are first constructed by lateral flaps (Fig. 473), and at a later period the defect at the foot of the penis and that at the corona are closed as shown in Fig. 474. **Hypospadias,** a congenital condition in which the floor of the urethra is defective, is much more common. There are three types: In the *balanitic*, the urethra opens just behind the glans; in the *penile*, on the under surface of the penis; in the *perineal*, in the perineum, the scrotum being cleft, and the penis rudimentary. In the last form the testicles may remain within the abdomen and the child be mistaken for a female. Hypospadias does not cause incontinence of urine. When the opening is a short distance behind the glans, the urethra may be freed from its surroundings and drawn through a perforation in the glans, where it is sutured (Beck's operation). In other cases the defect may be remedied by an operation similar to that of Thiersch for epispadias. Free venous transplantation for hypospadias is a failure. More promising is the suggestion of Cantas. After diverting the urine through a suprapubic or perineal fistula, a sufficient length of the internal saphenous vein with the overlying skin is dissected from the thigh, remaining attached, however, at its upper end. The lower end of the liberated vein is sutured to the urethral meatus, and at a later

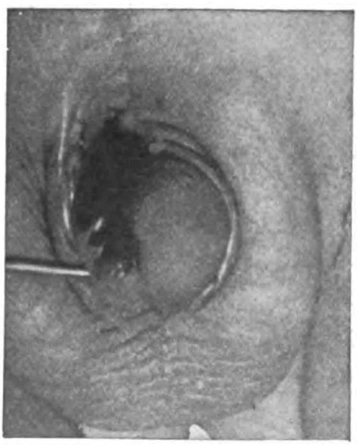


FIG. 472.—Epispadias. (Polyclinic Hospital.)

period the pedicle of the flap is severed, and the skin sutured to the inferior surface of the penis. The fibrous bands which curve the penis downwards should be divided previous to any operation for hypospadias.

Rupture of the urethra usually takes place at the bulb, as the result of falling astride of some hard object. The membranous urethra may be torn in fracture of the pelvis, the penile urethra in fracture of the penis during erection. The urethra may give way also behind a stricture, as the result of ulceration or straining. The rupture may be complete or partial. The **symptoms** are shock, pain, tenderness, bleeding from the urethra, inability to urinate, and swelling caused by blood and urine. At a later period the phenomena of septicemia ensue, owing to the gangrenous cellulitis induced by the extravasated urine. *Extravasation of urine* is

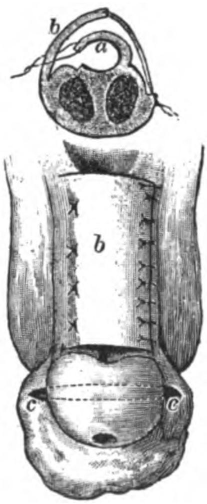


FIG. 473.

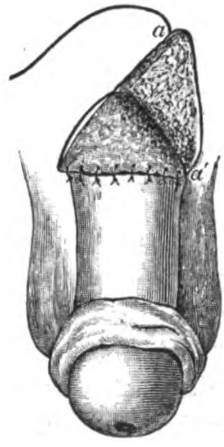


FIG. 474.

FIGS. 473 and 474.—Thiersch's operation. *c c.* (Fig. 473), Incision in prepuce through which glans is thrust (Fig. 474), so that prepuce may be used as flap to close defect between the balanic and penile urethræ. (Esmarch and Kowalzig.)

influenced by the situation of the rupture. When the rupture is above the upper layer of the triangular ligament, the urine extravasates as in extraperitoneal rupture of the bladder; when between the two layers, the urine remains localized and causes an abscess; when below the lower layer, the usual situation, the urine distends the scrotum, penis, and abdominal wall, but does not pass backwards, owing to the attachment of the fascia of Colles. The condition is to be distinguished from contusion, in which extravasation does not occur, and in which urination is usually possible. In severe lacerations a catheter cannot be introduced.

The **treatment** is exposure and suture of the torn urethra, a retention catheter being passed into the bladder through the urethra. The perineal urethra is exposed by an incision identical with that for median lithotomy. The wound should be drained with gauze; additional incisions will be necessary for drainage if the urine has infiltrated the surrounding tissues. Vigorous constitutional treatment will be needed if the parts have become septic.

Traumatic stricture, which is almost inevitable after this injury, should be anticipated by the passage of sounds every second day after the retention catheter has been removed, i.e., at the end of a week. *Contusions* of the urethra are treated by external applications of cold, rest in bed, and urinary antiseptics. The catheter should not be used unless there is retention of urine.

Foreign bodies, such as a portion of a catheter, pencil, etc., when lodged in the urethra, partly or completely obstruct the lumen, and may cause ulceration, periurethral abscess, and extravasation of urine. They may be detected by the sound, the urethroscope, the X-ray, and sometimes by external palpation. Removal is effected by forceps when the foreign body is in the penile urethra, or, when this is not possible, by external incision. In the latter instance the urethral wound should be sutured. A pin which has been pushed into the urethra head-first, may be removed by forcing the point through the floor of the urethra, reversing the direction of the pin, and pushing it out through the meatus. An *impacted calculus* is often expelled after the spasm to which it gives rise has been allayed by a hot bath and an opium and belladonna suppository. If it cannot be expelled it should be treated as a foreign body.

Urethritis may be simple or specific. **Simple urethritis** may be due to any of the pyogenic bacteria, except the gonococcus. It may be induced by injury, e.g., contusions, wounds, foreign bodies, rough instrumentation, and caustic injections; certain substances taken into the stomach, e.g., alcohol in excess, cantharides, turpentine, and potassium iodid; gout or rheumatism; certain skin diseases, e.g., herpes and eczema; urethral chancre or chancroid; highly acid urine; contact with lochial, leukorrheal, or menstrual fluid; infectious diseases; tuberculous ulceration; masturbation; sexual excess; and polypi. The *symptoms* are the same as those of gonorrhea, but usually milder. The *treatment* is removal of the cause, diuretics, urinary antiseptics, and in some cases mild astringent injections.

Specific urethritis, gonorrhea, or clap, is inflammation of the urethra caused by the gonococcus. The gonococcus is a diplococcus looking somewhat like a coffee bean, and occurring both within and without the leukocytes and epithelial cells. It may be stained with methyl or gentian violet, and does not take the Gram stain, a point to be remembered in differentiating it from pseudogonococci. In doubtful cases cultural methods may be necessary to establish a diagnosis. The complement fixation test for gonorrhea, although too recent to be given a fixed status, is becoming more important, especially in the diagnosis of systemic infection. A negative reaction, however, does not exclude the disease. Gonorrhea is acquired by direct contact, but no breach of the mucous surface is necessary. The organism enters the epithelial cells and occasionally the subepithelial tissues, causing a purulent inflammation.

The **symptoms** begin after a period of incubation varying from one to fourteen days. At first there is itching and burning in the fossa navicularis, with gluing together of the lips of the meatus. During the acute stage the meatus is red and swollen, the discharge thick and yellow. There is burning pain on micturition (*ardor urinæ*), which may pass to the groin or perineum. The urinary stream may be forked, owing to the swelling of the mucous membrane, but retention is uncommon. Owing to the infiltration of the corpus spongiosum, erection may be exceedingly painful and the penis markedly curved (*chordee*). After from two to six weeks in a favorable case the discharge becomes serous and finally disappears. In the female the vulva and vagina as well as the urethra are involved, but the symptoms are usually less acute than in the male. Gonorrhea varies in duration and intensity; thus the discharge may persist but a week or ten days (*abortive gonorrhea*), or the manifestations may be comparatively mild (*subacute gonorrhea*), particularly in those who have had previous attacks. In a certain proportion of cases the inflammation extends backwards and involves the membranous and prostatic portions of the urethra (*posterior urethritis*), whence it may spread to the bladder, prostate, seminal vesicles, or testicles. Posterior urethritis is usually announced by frequent and painful micturition and often by perineal pain. If the patient urinates into two glasses, the first, holding about two ounces, will contain the washings of the entire urethra, while the second, if turbid with pus, will indicate posterior urethritis, the pus from which flows back into the bladder. Another test is to wash out the anterior urethra with a catheter, after which purulent urine would point to posterior urethritis.

Chronic gonorrhea may involve the anterior, the posterior, or the whole urethra. In the first and last instances the most important symptom is *gleet*, i.e., a slight mucopurulent discharge, which may be observed only in the morning. If posterior urethritis alone exists, there may be no discharge, but pus or threads (*Tripperfäden*) will be found in the urine. Chronic anterior urethritis is usually perpetuated by a stricture, a suppurating follicle, or a spot of ulceration; posterior urethritis by infection of the prostatic ducts.

The **complications of gonorrhea** are due to (1) *extension by continuity*—balano-posthitis, phimosis, paraphimosis, folliculitis, periurethral abscess, Cowperitis, prostatitis, vesiculitis, epididymitis, cystitis, pyelonephritis (rare), abscess of Bartholin's glands, endometritis, salpingitis, ovaritis, pelvic peritonitis; (2) *extension by contiguity*—cellulitis (rare); (3) *extension by the lymphatics*—lymphangitis, buboes; (4) *transmission of the infection*—proctitis, rhinitis, conjunctivitis (gonorrheal ophthalmia), stomatitis; (5) *extension by the blood*—arthritis (gonorrheal rheumatism), gonorrheal sclerotitis or iritis (independent of gonorrheal ophthalmia), and inflammation of the tendon sheaths, muscles, pleura, pericardium, endocardium, blood vessels, and it is said even of the meninges, nerves, or spinal cord.

The **treatment of acute gonorrhea** is greatly facilitated by keeping the patient as quiet as possible, and in severe cases by rest in bed. The bowels should move regularly and large quantities of water taken. The diet should be plain and unstimulating, alcohol, coffee, tea, and condiments being especially interdicted. The patient should wear a suspensory, and some form of gonorrhea bag to catch the discharge; a piece of cotton held in place by pulling down the foreskin over it, is useful for the latter purpose. Sexual excitement of all forms must be prohibited, and the penis cleansed twice a day by soaking in warm salt solution. A hot hip bath once or twice a day is beneficial. The patient should be warned of the contagiousness of the discharge, and particularly of the danger of gonorrheal ophthalmia; the hands should be kept clean, and all towels used by the patient kept apart from those used by others. The so-called *abortive treatment*, in which strong antiseptic solutions are injected into the urethra, is dangerous. *Internal treatment* usually consists in the administration of urinary antiseptics, e.g., hexamethylenamine (grains 5 t. d.), salol in the same dose, or methylene blue (grains 2 t. d.); alkalies, particularly when ardor urinæ is marked, e.g., carbonate of soda, or potassium citrate or acetate; and balsamics, e.g., oleoresin of copaiba, oleoresin of cubebs, and oil of sandalwood, each of which may be given in from 5 to 10 minim doses t. d. in capsules. The balsamics may upset the stomach and copaiba may cause an urticarial erythema; they are most useful towards the end of an attack or in chronic cases. Bromid of potassium or lupelin, 20 to 40 grains on retiring, is the most effective remedy for chordee; the painful erection itself may be relieved with ice water. Injections may be antiseptic or astringent; the former may be used from the beginning, the latter in the declining stages. Any injection which causes much pain is too strong and must be diluted or discarded. The syringe should be blunt pointed and hold about three or four drams. The injection should be given after each urination, and the fluid held in the urethra for three minutes by compressing the meatus. Of the antiseptic injections may be mentioned argyrol (silver vitellin) 1 to 5 per cent., protargol ½ to 1 per cent., and potassium permanganate from 1 to 10,000 to 1 to 1000. The following are astringent injections; zinc sulphate, grains 10, bismuth subnitrate, powdered acacia, each 1 dram, and water 3 ounces; tincture of catechu, 10 minims to the ounce of water; and liq. plumbi subacetat. dil. *Janet's irrigation method* consists in washing out the urethra by means of a fountain syringe, which is connected with a blunt nozzle to be applied to the meatus. Permanganate of potassium 1 to 4000 or weaker, is used at first, the reservoir being two feet above the penis, and the irrigations given twice a day. Later the strength of the solution is increased, and the irrigations given once a day. The posterior urethra may be irrigated by raising the reservoir to the height of five feet, the fluid entering the bladder, which, when

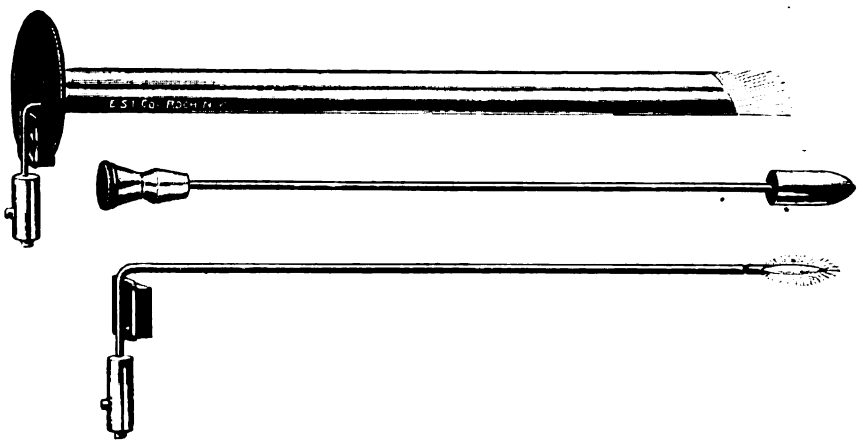


FIG. 475.—Valentine's urethroscope.

full, is emptied by urination. When the acute symptoms subside the irrigations are abandoned and astringent injections employed. The method is highly recommended by some, and condemned by others, who believe that it increases the danger of complications. Gonorrhea in the female is treated on the same principles as in the male (see vulvitis, vaginitis, etc.). Gonorrhea is cured when there are no clinical evidences of the disease for two weeks, and when gonococci cannot be found in the mucus expressed from the prostate, the seminal vesicles, and the urethra.

The **treatment of chronic gonorrhea** involves a careful examination to determine the cause of the persistence of the discharge. Any constitutional malady, particularly gout or rheumatism, should receive appropriate treatment. Localized patches of inflammation will prove to be very sensitive on the introduction of a bulbous bougie, which will detect also any narrowing of the urethra, and will give some information by the character of the discharge which is brought out in front of the bulb. The urethroscope (Fig. 475), which is a cylindrical speculum with a small electric lamp at the end, allows visual inspection of the entire urethra, the walls of the canal prolapsing over the end of the tube as it is withdrawn. Many andrologists prefer a urethroscope which permits dilatation of the urethra with air or water. It is inserted after disinfecting the external genitals and injecting one fluid dram of a 5 per cent. solution of novocain. The prostate and seminal vesicles also should be investigated. Localized patches of inflammation are treated by the application of silver nitrate (½ per cent.), either through the urethroscope or by means of a deep urethral syringe (Fig. 476), every two or three days. Irrigations and injections, as in acute gonorrhea, also are useful. When the discharge depends upon stricture, or some complication like prostatitis, folliculitis, etc., the treatment is that of the complication. Even in the absence of stricture, the passage of a sound once or twice a week is beneficial, in that it is a form of massage which expresses from the follicles any retained secretions. Anti-gonococcal serum and gonococcal bacterin have been

FIG. 476.—Keyes-Ultzman syringe.

employed in the treatment of gonorrhea and its complications, but their value is not yet determined. The dose of the bacterin varies, according to different observers, from 50 to 200 millions dead bacteria every third to every seventh day.

Urethrorrhea is a slight discharge of a non-purulent mucoid fluid from the urethra, most marked in the morning and after straining at stool, and due to hyperactivity of the urethral glands. The discharge stains but does not stiffen linen. The *causes* are sexual excess, masturbation, ungratified sexual desire, and like conditions which induce urethral congestion. It is sometimes accompanied by sexual neurasthenia and false impotence. The *treatment* is tonics and removal of the cause.

Folliculitis, or inflammation of one of the urethral follicles, is caused by urethritis, usually of gonorrheal origin. A tender, painful, shot-like swelling may be felt beneath the skin along the floor of the urethra. If suppuration occurs (*periurethral abscess*), the abscess may discharge into the urethra, through the skin, or in both directions, thus forming a *urinary fistula*. The *treatment* is the application of ichthyol. If pus forms, it may be evacuated through the urethra by means of a fine knife and the urethroscope, or externally if the suppuration is diffuse under the skin. A urinary fistula which refuses to heal should be cauterized, or failing in this, closed by a plastic operation.

Cowperitis, or inflammation of Cowper's gland, is identical in cause and symptoms with folliculitis, except that the swelling is felt in the perineum, to one or the other side of the median raphe. If pus forms, it should be evacuated by a perineal incision.

Stricture of the urethra, or narrowing of the lumen of the canal, may be inflammatory, spasmodic, or organic.

Inflammatory stricture is due to inflammatory swelling of the mucous membrane, which in itself is scarcely ever great enough to interfere seriously with the passage of urine, but which may cause acute retention if engrafted on an organic stricture.

Spasmodic stricture occurs in the membranous urethra as the result of a spasmodic contraction of the compressor urethræ. The causes are organic stricture, particularly after exposure to cold or after drinking alcohol; operations on or injuries of the perineum, rectum, or spermatic cord; and nervous and emotional disturbances. Retention due to spasmodic stricture is treated by a hot sitz bath and an opium suppository, and, if these fail, by the introduction of a large catheter, which, if pressed gently but firmly against the stricture, will, after a time, tire the muscle and slip into the bladder.

Organic stricture may be congenital (see congenital malformations of the urethra) or acquired. **Acquired organic stricture** is due to cicatricial contraction, the result of gonorrhea or other form of urethral inflammation, or injury, such as rupture or laceration of the urethra. Strictures may be single or multiple. The usual situation of gonorrheal stricture is in the bulb, of traumatic stricture in the membranous urethra. Stricture of the prostatic

FIG. 477.—Bougie à boule.

FIG. 478.—Conical.

FIG. 479.—Olivary.

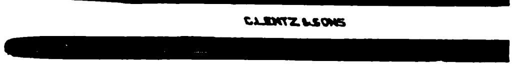


FIG. 480.—Cylindrical.

FIG. 481.—Mercier double elbow (bicoudé).

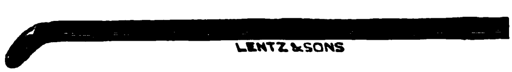


FIG. 482.—Elbow (coudé).

FIGS. 477 to 482.—Flexible catheters.

urethra is extremely rare. According to its shape the stricture may be *annular*, *bridle* (involving only a portion of the circumference), *tubular* (when very long), or *tortuous;* according to its consistency, *fibrous*, *soft*, *cartilaginous*, or *elastic* or *resilient* (rapidly recontracts after dilatation); and according to the degree of narrowing, *impermeable* (does not permit the passage of urine) or *impassable* (when instruments cannot be introduced). A stricture of *small calibre* is one through which a number 15 French sound cannot be passed, a stricture of *large calibre* one which will admit a larger instrument.

The **results** are dilatation of the urethra behind the stricture, with chronic inflammation and sometimes ulceration. If the ulcer extends deeply, a perineal abscess and subsequently *perineal fistulæ* develop; the latter are treated by external urethrotomy, with incision or excision of the tracts. When the obstruction becomes complete the urethra may give way, leading to extravasation of urine. The bladder hypertrophies and ultimately becomes inflamed and sometimes ulcerated, while stone may form owing to the alkaline changes in the urine. In some cases the bladder walls are stretched and thinned instead of thickened. Hydronephrosis, pyonephrosis, and pyelonephritis also may ensue.

The principal **symptom** is gradually increasing difficulty in urination, the stream becoming forked, progressively smaller, and dribbling at the end. Micturition takes more and more time, and finally retention occurs, usually as the result of spasm or congestion following exposure to cold or an alcoholic debauch. The *diagnosis* may be made with the urethroscope or the bougie à boule (Fig. 477); occasionally the induration can be felt through the skin. If the largest bougie which the meatus admits meets with obstruction, there is a stricture, as the meatus is normally the narrowest part of the canal. Smaller sizes should then be used until one finally passes. The exact situation of the stricture may be determined by noting the depth at which a large sound meets with obstruction, and by the catching of the bulb of a smaller instrument upon withdrawal. The patient should be recumbent and the thighs separated. The glans should be cleansed with bichlorid of mercury solution, then with sterile water, the hands disinfected, and the bougie sterilized, and anointed with lubrichondrin or sterile oil. Flexible instruments (Fig. 478 to 482) will sometimes pass an obstruction if a screwing motion is used. Non-flexible (Fig. 483) instruments should be allowed to find their own way along the urethra without the use of force. The penis is

FIG. 483.—Conical steel bougie.

held in one hand and the instrument manipulated with the other. The shank of the instrument is held near the skin of the groin, and the end introduced into the meatus, until the curve disappears within the urethra. The handle is then carried across the abdomen, still close to the skin, to the median line, the penis pulled up on the instrument, and the handle raised to the vertical and finally depressed between the thighs. The pocketing of a small instrument in the lacuna magna may be prevented by carrying the point along the floor of the urethra as far as the perineum, obstruction at the opening of the triangular ligament and at the sinus pocularis by carrying the point along the upper wall of the rest of the urethra. The *dangers* of the introduction of an instrument into the urethra are shock, when the urethra is hypersensitive, a condition which may be prevented by distending the urethra with a 5 per cent. solution of novocain; hemorrhage, which may be avoided by gentleness; false passages; and septic processes, e.g., prostatitis, epididymitis, cystitis, and urinary fever.

The **treatment of stricture** is (1) dilatation, (2) urethrotomy, or (3) urethrectomy. 1. **Dilatation** may be gradual, rapid, or continuous. *Grad-*

ual dilatation is the best treatment for all non-resilient strictures through which an instrument can be passed. The largest sound which the stricture will admit is introduced and allowed to remain a few minutes; this is repeated twice a week with larger instruments, until the stricture is as large as the meatus (from 27 to 32 F.). The patient should take a urinary antiseptic during the treatment, which should always be suspended if there is much irritation. *Rapid dilatation* is less desirable, even though it saves time; it consists in the introduction of larger bougies, one after the other, at the same sitting, until the full size is reached. *Continuous dilatation* is useful in very small strictures. The patient is confined to bed, and a fine bougie introduced and kept in place for a day or two, when it will be found that a larger instrument can be passed. This is continued until a still larger instrument can be passed, when gradual or rapid dilatation may be substituted. Filiform bougies (less than 1 mm. in diameter) are made of whalebone and used for the finest strictures. A filiform bougie is apt to enter one of the crypts in the urethra, in which case it should be partly withdrawn, then pushed onward with a rotary movement. If a filiform fails to enter a stricture, the urethra should be filled with these fine instruments, when it will be found that one will engage in the orifice of the stricture; it may then be left in place for continuous dilatation, or a tunneled sound or catheter (Fig. 484) may be slipped over it. *Forcible dilatation*, or *divulsion*, in which the stricture is torn by means of an instrument working on the same principle as a glove stretcher, is not recommended. After any method of dilatation an instrument should be passed at first once a week, then at increasing intervals, to make sure there is no recontraction.

2. **Urethrotomy,** or cutting of the stricture, may be employed in cases which resist dilatation. **Internal urethrotomy** is indicated in very dense or resilient strictures in the pendulous urethra. Strictures near the meatus may be incised with a blunt pointed bistoury (see meatotomy); in deeper strictures a special instrument is required. Civiale's urethrotome is used by passing

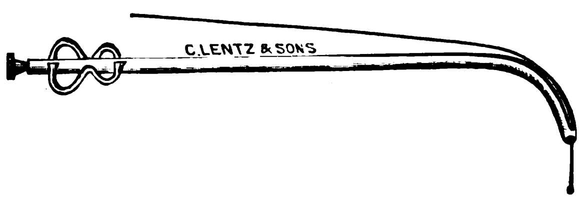


FIG. 484.—Filiform bougie threaded on a Gouley tunneled catheter.

it through the stricture, protruding the blade by a mechanism in the handle, and cutting the stricture, from behind forwards, on the roof of the urethra if in the bulb, on the floor if in the penile portion. Maisonneuve's urethrotome (Fig. 485) cuts from before backwards, and is useful when the stricture is very small, as a filiform bougie screwed to its end acts as a guide to the stricture. The operation may be performed under general anesthesia, or after distending the urethra with a 5 per cent. solution of novocain. The urethra is irrigated previous to operation, and a full sized bougie subsequently passed twice a week, until the tendency to recontraction is overcome.

External urethrotomy has the same indications as internal urethrotomy, when the stricture is in the posterior third of the urethra. (a) **Syme's operation** is performed by introducing a shouldered grooved staff (Fig. 486) into the bladder, and opening the urethra just behind the shoulder of the staff, which corresponds to the stricture, by a median perineal incision. The stricture is then divided, and a large catheter passed into the bladder through the urethra, and fixed there by adhesive plaster, running from the catheter to the penis. The perineal wound is drained. The catheter is washed

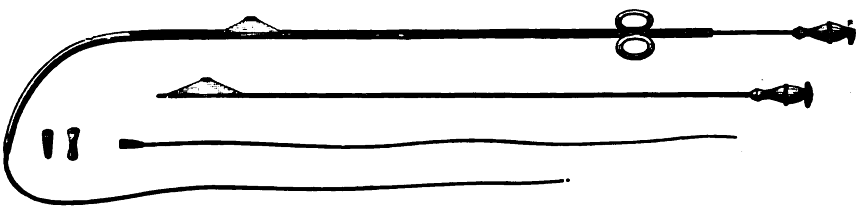


FIG. 485.—Maisonneuve's urethrotome.

daily, and removed at the end of a week, after which sounds are passed twice a week, the perineal wound gradually closing.

(b) **Wheelhouse's operation** is indicated in impassable strictures. A Wheelhouse staff (Fig. 487) is passed down to the stricture, the urethra opened just in front of the stricture by a median perineal incision, and a probe gorget (Fig. 488) pushed through the opening and the stricture divided. The after treatment is that of Syme's operation.

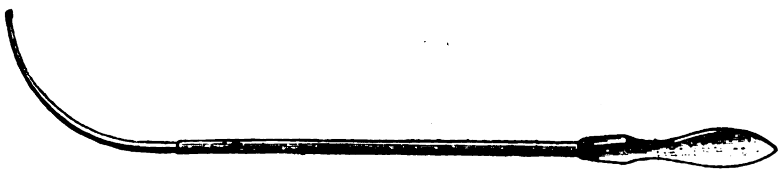


FIG. 486.—Syme's staff.

(c) **Cock's operation** is performed, without a guide, for the relief of retention of urine (Fig. 489). The left index finger is passed into the rectum to the apex of the prostate, and the urethra opened behind the stricture by a median perineal incision. The stricture may be divided at the same time, or the bladder may be drained through the perineum, and the stricture dealt with at a later period.

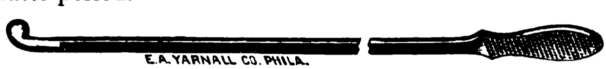


FIG. 487.—Wheelhouse's staff.

3. **Urethrectomy,** or excision of the stricture with subsequent suture of the urethra, has been successfully performed. After the removal of a long segment of the urethra, the appendix has been transplanted to the defect, with, it is said, a good result. Free venous transplantation has always ended in sloughing of the transplant (see hypospadias).

False passages, or channels in the submucous or periurethral tissues, may result from attempts to introduce an instrument into the bladder. The instrument lurches onward with a grating sensation, is deflected from the middle line, and the point cannot be rotated as it should be if it had entered the bladder. No urine flows unless the instrument reenters the urethra or bladder behind the obstruction, and there are pain and hemorrhage. No evil results may follow, but in some cases there will be urinary fever or extravasation of urine and blood. The *treatment* is expectant if the patient can pass urine. If there is acute retention of urine and the stricture is impassable, or if there is leakage of urine into the perineal tissues, external urethrotomy will be mandatory. If an old false passage interferes with catheterization, it may be filled with filiform bougies, when an additional filiform will pass into the bladder.

Urinary, urethral, or catheter fever may be acute or chronic. The *acute* form quickly follows the introduction of an instrument, and is characterized by a chill with a subsequent rise of temperature. It is of nervous or

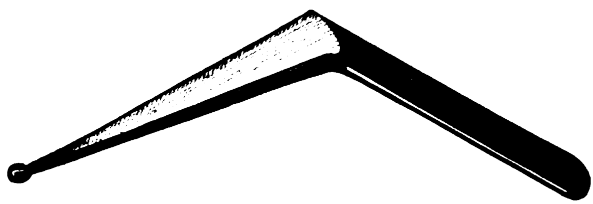


FIG. 488.—Teale's probe gorget.

possibly septic origin, and subsides promptly with the use of opium, quinin, and urinary antiseptics. The *chronic* form is always due to infection, and usually begins several days after the introduction of an instrument. The symptoms are those of septicemia, with in the later stages those of uremia. The pathological findings are those of cystitis and pyelonephritis. The **treatment** is first prevention, i.e., the strictest antiseptic precautions and the greatest gentleness during instrumentation. When once developed the condition is treated on the same principles as septicemia and uremia, with urinary antiseptics, frequent irrigations of the bladder, and in some cases drainage by permanent catheterization, cystotomy, or nephrotomy.

Injuries of the penis may be of any variety, but are of comparatively infrequent occurrence.

Open wounds are treated on general principles. The bleeding, owing to the great vascularity of the part, is often copious. If the urethra is opened it should be sutured and a retention catheter inserted. The possible sequelæ are stricture of the urethra and deformity of the penis from cicatricial contraction, and urinary fistula. If a portion or the whole of penis has been cut or torn away the wound should be treated as described under amputation of the penis. Extensive destruction of the skin alone may be remedied by skin grafting.

Subcutaneous injuries are usually the result of forcible bending of the penis during erection. In the milder cases nothing more serious than the formation of a hematoma occurs. In the so-called *fracture of the penis* the whole organ and the scrotum become greatly swollen from infiltration of blood and, if the urethra is torn, from extravasation of urine. The subsequent scar formation may cause deviation of the penis during erection. The treatment of hematoma and urinary extravasation are described elsewhere.

Strangulation of the penis from the constriction of cords, rings, etc., produces great swelling and eventually gangrene. The urethra is closed and extravasation of urine may follow, leading to the formation of urinary fistulæ. The constricting agent must be removed, with scissors, bone forceps, or file, according to its nature, and the prophylactic treatment for gangrene applied. If sloughs form they should be cut away with scissors, the resulting raw area being subsequently skin grafted.

Chancroid, or soft chancre, is a non-syphilitic sore acquired during coitus, and caused by the *bacillus of Ducrey*. The period of incubation is from one to five days. *Chancroids* are usually found on the glans, the prepuce, or the labia, and very rarely in any extragenital situation. A soft chancre first appears as a red papule, which quickly changes to a vesicle, then a pustule, and finally a painful ulcer with sharp undermined edges and a yellowish base, which secretes a large quantity of highly contagious pus. As a rule there is more than one ulcer, the pus being autoinoculable, and the surrounding parts are inflamed. The inguinal lymph glands are very apt to suppurate (*soft bubo*), but the infection never becomes generalized. If neglected or if occurring in those with poor resistance, chancroid may spread, with or without sloughing, and cause great destruction of tissue (phagedena). For the differential diagnosis between chancre, chancroid, and herpes see chancre. The **treatment** is spraying with peroxid of hydrogen, washing with bichlorid of mercury 1 to 1,000, and dusting the sore with iodoform or thymol iodid. Healing usually takes place within two or three weeks. Phagedena is treated as described under ulceration, while the bubo is dealt with in the same way as other forms of adenitis. If phimosis exists and interferes with cleanliness, the prepuce may be split along the dorsum, and the raw edges touched with carbolic acid; circumcision is generally inadvisable, as the entire wound is apt to become infected.

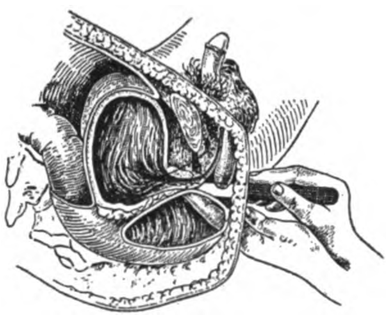


FIG. 489.—Cock's operation.

Venereal warts are papillomatous masses which appear on the genitals as the result of irritating discharges or uncleanliness, and occasionally spontaneously, hence the term venereal is a misnomer. They may be snipped off with scissors and the raw surfaces cauterized with silver nitrate.

Phimosis, or stenosis of the orifice of a long prepuce, is usually congenital in origin, but occasionally results from cicatricial contraction. It interferes with cleanliness, thus predisposing to local inflammatory disorders, and later in life to venereal disease and epithelioma; adhesions may form between the glans and the prepuce, causing retention of smegma or the formation of preputial stones. When of extreme grade it interferes with urination, thus causing straining and predisposing to hernia and prolapsus ani. Retention of urine occasionally occurs, and irritability of the bladder, masturbation, and reflex nervous disorders may be induced. The **treatment** is circumcision, which may be performed by splitting the prepuce up the dorsum, separating adhesions, trimming the flaps flush with the corona glandis, and suturing the skin to the mucous membrane with catgut. The wound is dressed with gauze, which should be changed as often as soiled. When circumcision forceps are used, adhesions are first separated with a probe, the foreskin drawn down, and the forceps applied parallel with the corona, care being taken not to include the glans. The prepuce is then amputated just beyond the forceps, and sutures applied after the forceps have been removed.

Paraphimosis is the condition existing when a narrowed preputial orifice is pushed back over the glans and cannot be replaced. The parts are edematous, sometimes ulcerate at the point of constriction, and occasionally become gangrenous distal to the constriction. The **treatment** is reduction by encircling the penis behind the constriction with the separated index and middle fingers of each hand, and making pressure on the glans with both thumbs, a maneuver which presses the blood from the glans and pulls the foreskin down over it (Fig. 490). Reduction may be facilitated by multiple punctures to relieve the edema, by anointing the parts with sweet oil, and by general anesthesia. When reduction is impossible, the constricting band may be divided on the dorsum of the penis.

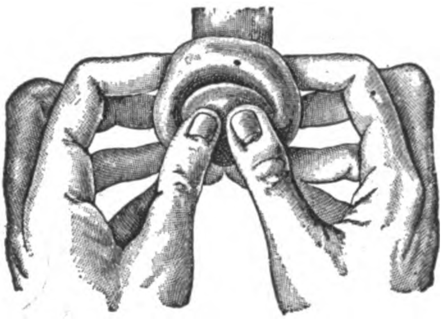


FIG. 490.—Method of reducing paraphimosis. (Hirsch.)

Balanitis, or inflammation of the glans, is usually associated with *posthitis*, or inflammation of the prepuce (*balanoposthitis*). The condition is favored by phimosis, and is usually the result of uncleanliness, or other forms of irritation, such as chancroid, gonorrhea, and diabetes. The prepuce is edematous and a purulent discharge escapes from its orifice. The prepuce may ulcerate and the inguinal glands are often enlarged and tender. The **treatment** is frequent washings with peroxid of hydrogen and bichlorid of mercury 1 to 5,000, the glans being separated from the foreskin, between the washings, by lint moistened with the bichlorid solution. When the prepuce cannot be retracted, it will often be necessary to split it up the dorsum, after which cleanliness may be maintained.

Epithelioma of the penis (Fig. 491) usually begins close to the corona glandis, most frequently in those with long foreskins, hence it may be concealed for a time, the only evidence of its existence being some swelling and a discharge containing blood and pus. The growth has the usual characteristics of cancer elsewhere, and early implicates the inguinal glands. The **treatment** is *amputation of the penis* and removal of the inguinal glands. When the disease is localized to the distal end, the section may be made through the body of the penis. The skin flap may be circular, or a long dorsal and a short ventral flap may be employed. The corpus spongiosum is cut a little longer than the corpora cavernosa, and the end of the urethra sutured to the edges of the flaps, after being split to avoid stricture. The dorsal arteries of the penis and the arteries of the corpora cavernosa will require ligation. *Extirpation of the penis* may be required if the disease is more extensive. With the patient in the lithotomy position, the root of the penis is encircled by an incision which is carried downward along the median raphe of the scrotum to the perineum. The divided scrotum is separated, and the corpus spongiosum severed in front of the triangular ligament, a catheter having been passed down to this point as a guide. The suspensory ligament is then divided, and the crura severed close to the bone. The end of the urethra is split, and sutured to the posterior angle of the perineal incision, and the rest of the wound is closed, with ample provision for drainage.

Priapism is continuous erection of the penis, without sexual desire or seminal emissions. The causes are local irritation from phimosis, adherent prepuce, diabetic urine, venereal warts, herpes, vesical or prostatic stone, stricture, cystitis, urethritis (chordee), prostatitis, sexual excesses, cantharidal poisoning, distended bladder, or diseases of the rectum and anus; inter-

FIG. 491.—Epithelioma of penis.

ference with the venous circulation of the penis from scars, tumors, thrombosis, hematomata; injuries of the spinal cord, myelitis, spinal meningitis, lesions of the pons or middle lobe of the cerebellum, epilepsy, hydrophobia, tetanus, and leukemia. The *symptoms* are pain and sometimes difficulty in urination; in cases depending upon lesions of the central nervous system, however, there may be merely turgescence without pain or rigidity. The *treatment*, aside from that of the underlying cause, is, when pain and rigidity are present, hot or cold applications and the administration of nervous sedatives (bromids, chloral, opium, belladonna, lupulin, hyoscin). Incision and drainage of one or both copora cavernosa, and ligation of the dorsal arteries of the penis have been advised. Incision is particularly indicated in the presence of a hematoma.

Involuntary seminal emissions during sleep (*nocturnal pollutions*) occur normally in the celibate, at intervals varying from one week to a month or longer, according to the temperament, mode of life, and direction of thought of the individual. Excessive pollutions may be the cause or the result of neurasthenia; they may be caused also by masturbation or sexual intemperance, local irritations of various sorts (see priapism), highly acid urine, and most frequently by the youthful imagination. *Treatment* is needed only when the losses recur with great frequency, when they are associated with mental or physical suffering, when they proceed from or lead to atonic impotence, or when on the slightest provocation they occur during the day (*diurnal pollutions*). The cause should, when possible, be removed, the bowels regulated, and the general health improved. As sleeping on the back predisposes to erections, a towel may, before retiring, be tied around the waist with the knot behind. The most useful drugs are the bromides, hyoscin, and lupulin. Lewd companions and novels, erotic plays and pictures must be shunned, and the thoughts diverted from sexual affairs by some useful and absorbing occupation.

True *spermatorrhea*, i.e., a constant escape of semen from the urethra, probably does not exist, most of the cases which have been so diagnosticated being instances of urethorrhea or prostatorrhea in which the discharge has, at the time of examination, contained spermatozoa as the result of a previous emission, or the pressure of fecal masses upon the seminal vesicles during defecation.

Impotence, or inability to perform the sexual act, is usually, but not always, associated with sterility, since in some cases there may be ejaculations of normal semen. Clinically the cases may be divided into two groups:

(1) *Organic impotence* is due to absence, deformity (e.g., epispadias, hypospadias, penile curvature from cicatricial contraction), or disease of the genital organs, especially atrophy of the testes and chronic affections of the prostate, prostatic urethra, and seminal vesicles; to lesions of the spinal cord, notably locomotor ataxia and myelitis; to hypopituitarism or hypothyroidism; or to huge tumors about the genitals, elephantiasis of the scrotum, enormous hernias, and similar conditions that interfere mechanically with sexual intercourse.

(2) *Functional impotence* may be atonic or psychic. *Atonic impotence* is caused by depression or exhaustion of the nervous centers as the result of debilitating general diseases, the prolonged use of certain drugs (e.g., alcohol, arsenic, bromides, chloral, cocain, camphor, opium), sexual excesses or frequent masturbation, or as the result of repeated and protracted episodes of sexual excitement without gratification (mental masturbation). In these cases sexual desire and erections may be absent, or the desire may be strong and the erections feeble, the emissions occurring prematurely and being followed by immediate subsidence of the erection. The diagnosis of atonic impotence should be made only after careful investigation, as in many instances in which no gross lesion can be discovered there exists an old gonorrheal inflammation in the prostatic urethra or seminal vesicles. Further, excessive venery may in itself induce chronic inflammatory changes in these parts, and it is asserted that oxaluria and other irritating conditions of the urine, as well as diseases of the rectum and anus, may induce precipitate ejaculations. *Psychic impotence* is most common in the newly married, as the result of anxiety as to their ability to perform the marital functions. In other cases it may depend upon lack of affinity, disgust, or similar emotions.

The **treatment** consists, when possible, in removing the cause. Pituitary extract is indicated in hypopituitarism, thyroid extract in hypothyroidism. Prolonged sexual rest (including avoidance of obscene books, pictures, and plays), regulation of the bowels, improvement of the general health, cold baths, electricity, and drugs like strychnin, phosphorus, and damiana are of the most benefit in atonic cases. In psychic impotence depending upon fear, reassurance is the principal remedy. Often the patient is convinced, as the result of reading the exaggerated statements of charlatans, that early self-abuse is the cause of his misfortune. He must be told the truth, viz., that such practice, unless carried to excess over a long period, is not followed by evil consequences.

Sterility, or inability to beget children, is not confined to the impotent; it may occur in those who are able to copulate normally, in which event it is the result of aspermia or azoöspermia (see also sterility in the female). *Aspermia* means that no semen is ejaculated during orgasm. It usually depends upon obstruction to some portion of the seminal tract, which obstruction may be congenital or the result of injury or disease, most commonly stricture of the urethra, enlarged prostate, or obliteration of the ejaculatory ducts or vasa deferentia from gonorrheal inflammation. When the semen passes back into the bladder because of stricture of the urethra, or escapes through a defect in the urethra the result of epispadias, hypospadias, or urinary fistula, the condition is sometimes called false aspermia, or malemission. *Azoöspermia*, or absence of spermatozoa from the semen, is due to absence, malformation, or disease of both testicles, or to obliteration of the seminal ducts, the most frequent cause being bilateral gonorrheal epididymitis. Repeated exposures to the X-ray also may cause the spermatozoa to disappear from the semen. The diagnosis of azoöspermia is made by microscopic examination of the semen.

The **treatment** of sterility depending upon remedial lesions, e.g., stricture of the urethra, urinary fistula, is that of the cause. Most cases of obstruction to the seminal ducts are beyond the aid of surgery, although Martin has succeeded in curing sterility due to bilateral epididymitis by anastomosing the vas deferens to that portion of the epididymis on the testicular side of the obstruction. Sterility due to the X-rays may disappear after the exposures have been discontinued.

TESTIS, CORD, AND SEMINAL VESICLES.

The **testicle** may be absent (*anorchism*), fused with its fellow (*synorchism*), undescended (*cryptorchism*), out of place (*ectopia*), or inverted in the scrotum, while at least one case of supernumerary testis (*polyorchism*) has been reported.

Undescended testicle (*cryptorchism*) may be caused by "an unusual length of the mesorchium, which permits so free a movement of the organ that it fails to enter the mouth of the vaginal process, or the mesorchium becomes adherent to adjacent structures; the abnormal persistence of the plica vascularis; certain malformations of the testicle and its component parts, such as a short vas deferens and an abnormally large epididymis; certain forms of hermaphroditism; retraction of the cremaster and absence of the internal fibers of the cremaster before the testicle has entered the inguinal canal; want of development of the inguinal canal, of the superficial abdominal ring, and of the scrotum; and other rare causes, such as the wearing of a truss" (Eccels). The organ may be retained within the abdomen, in the inguinal canal, or just outside of the external ring. An

ectopic testicle may be found in the perineum, Scarpa's triangle, at the root of the penis, or upon the aponeurosis of the external oblique. It is pulled into one of these positions by the gubernaculum or pushed there by a hernia. Imperfectly descended and misplaced testicles are almost always small and soft and do not produce spermatozoa. They are often subject to attacks of inflammation and may undergo cystic or malignant degeneration, while hydrocele and hernia are frequent complications, and gangrene may be induced by torsion of the spermatic cord.

Treatment by massage is dangerous because of the irritation which it produces. If the organ has not descended by the sixth year, the best treatment is *Bevan's operation*. The inguinal canal is opened as in Bassini's operation, and the peritoneal pouch separated from the cord and divided between two ligatures, thus blocking the hernial sac and forming a tunica vaginalis. The cord is lengthened by separating it from the surrounding tissues and peritoneum, and by separating the vas from the spermatic vessels. If this does not produce sufficient lengthening, the spermatic vessels are ligated and divided, the testicle generally being amply nourished by the artery of the vas, although the author has had two cases in which the testicle subsequently became gangrenous. A pocket is then made in the the scrotum by the fingers, the testicle placed therein, and the mouth of the pocket closed by a purse-string suture. The wound is closed as in Bassini's operation, except that the cord is not displaced, but allowed to emerge at the lower angle of the

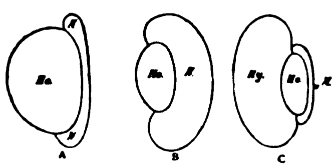


FIG. 492.—Diagrammatic sections of (A) orchitis, (B) epididymitis, and (C) hydrocele of the tunica vaginalis. *Ho*, Testis, *N*, epididymis; *Hy*, hydrocele. (Tillmanns.)

FIG. 493.—Adhesive plaster strapping for testicle. (Heath.)

wound. Castration is advised by many surgeons, but should never be done if the condition is bilateral. for though the patient is even sterile, he may be potent, and removal of both organs has a serious effect upon development, owing to the absence of the internal secretion of the testicle.

Torsion of the spermatic cord may occur during severe exertion if there is a long mesorchium. In about half the cases the testicle is imperfectly descended. The *symptoms* resemble strangulated hernia, in that there are sudden pain, swelling, tenderness, and vomiting. but, unlike strangulated hernia, there is apt to be fever and no intestinal obstruction. In some cases the twisting of the cord and the rotation of the testicle may be made out by palpation. In the severer forms the testicle becomes gangrenous. The **treatment** in recent cases is exploratory incision, with untwisting of the cord and suturing of the testicle to the scrotum. A gangrenous testicle should be removed.

Acute orchitis, or inflammation of the secreting part of the testicle, may be due to injury, gout, rheumatism, mumps, typhoid fever, and less frequently to other infectious diseases; or it may be secondary to epididymitis.

The *symptoms* are sickening pain extending upward along the cord and often to the loin, great tenderness, uniform swelling of the testicle (Fig. 492), fever, redness and edema of the scrotum, and often acute hydrocele. Atrophy commonly follows, but abscess and gangrene are rare. Since in right-sided orchitis or epididymitis there may be pain and tenderness in the right iliac fossa, with vomiting, acute appendicitis may be simulated, especially if the testicular trouble is concealed, as it sometimes is when a youth is examined in the presence of his family.

Acute epididymitis may, in rare instances, be due to the same causes as orchitis, but is almost always the result of infection spreading from the deep urethra, usually arising from gonorrhea, and occasionally from prostatitis, the passage of instruments, or other forms of irritation. The process often extends to the testicle. The *symptoms* usually arise in the latter stages of gonorrhea and are those of orchitis, but the character of the swelling is somewhat different (Fig. 492), the vas is generally swollen and tender, and on rectal examination swelling and tenderness of the corresponding seminal vesicle and lobe of the prostate can often be detected. Acute hydrocele is common, abscess and gangrene rare. In bilateral cases there may be sterility from blocking of the ducts, but sexual potency is retained unless the testicle atrophies, which is not usual.

Chronic orchitis and epididymitis may follow the acute form; those cases which are chronic from the beginning are generally due to syphilis or tuberculosis.

The **treatment** of acute orchitis or epididymitis is rest in bed, elevation of the scrotum, the application of lead-water and laudanum or poultices, and, in the declining stages, pressure by a rubber bandage or by strapping the testicle with adhesive plaster (Fig. 493). Local treatment to the urethra is abandoned; this does not worry the patient as the discharge has probably disappeared with the onset of the inflammation. In acute orchitis with excessive pain or threatened gangrene, the tunica albuginea may be cut subcutaneously with a tenotome. In acute epididymitis Frayser advises epididymotomy through an external incision, whereby it is said the duration of the disease is considerably shortened. *Recurring epididymitis* has been successfully treated by ligation of the vas deferens (Chetwood). *Chronic inflammation* of the testicle is treated by strapping, or by inunctions of ichthyol and mercury and the internal administration of potassium iodid.

Tuberculosis of the testicle usually begins in the globus major of the epididymis, as the result of a deposition of the tubercle bacilli from the blood, or a descending infection from the seminal vesicles or prostate. As in other affections, the left testicle is more frequently involved owing to its more sluggish circulation. The disease is most common between the fifteenth and thirtieth years, in those who are predisposed to tuberculosis, and it is often preceded by inflammation or a slight injury. The process spreads to the body of the testicle and up the vas deferens, affecting the other genitourinary organs, including in many cases the opposite testicle. In favorable cases the tuberculous mass may become encapsulated and calcify, but more often it undergoes caseation, forms abscesses, and later gives rise to fistulæ.

The **symptoms** may be acute, resembling an acute epididymitis which fails to subside and is followed by abscesses. As a rule the onset is insidious, and perhaps the nodular enlargement of the epididymitis is discovered accidentally. At a later period the whole organ is enlarged, effusion into the tunica vaginalis is apt to occur, the vas deferens is thickened and knotty, and finally symptoms referable to the other genitourinary organs appear, while evidences of the disease in the lungs may be detected. Pain and tenderness are not marked until fistulæ of the scrotum form. The sexual power is unimpaired unless both organs are destroyed.

The **treatment** is the wearing of a suspensory, and general treatment as for tuberculosis elsewhere. Injections of iodoform or zinc sulphate are not recommended. If the disease progresses, epididymectomy should be performed, with removal of the vas if it is thickened; this operation does not cause atrophy of the testicle or impotency. When the testicle is extensively diseased, castration should be performed when the process is unilateral; when bilateral, the worse testicle should be removed, and at least a portion of the other preserved. Tuberculosis in other portions of the genitourinary apparatus sometimes subsides after removal of the testicular foci, and should not, therefore, be attacked at the same time.

Syphilis of the testicle during the secondary period appears as a bilateral, painless *epididymitis*, affecting principally the globus major; it is sometimes associated with hydrocele, and disappears with antisyphilitic treatment.

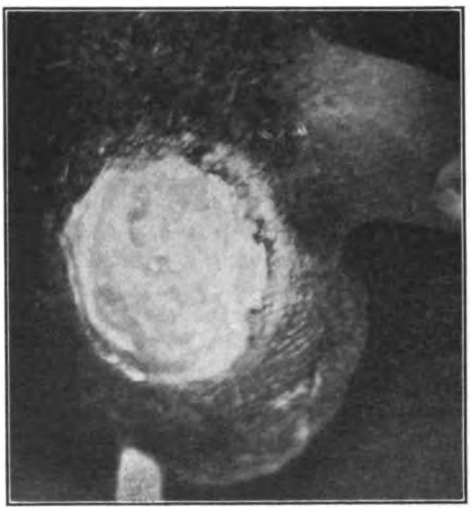


FIG. 494.—Fungus of testicle following gumma.

During the tertiary period *syphilitic orchitis, or sarcocele*, occurs as a diffuse overgrowth of the connective tissue, causing atrophy of the tubules, or as a nodular, gummy degeneration. The *symptoms* appear slowly. The testicle is enlarged, hard, smooth or perhaps nodular, unduly heavy for its size, and neither painful nor tender; hydrocele may occur, and if a gumma opens on the surface, it will present the characteristic features of a syphilitic ulcer. The *treatment* is a suspensory bandage and the internal administration of antisyphilitic remedies. If the testicle is extensively destroyed by ulceration, however, castration should be performed.

Hernia, or fungus of the testicle, is a protrusion of the interior of the testicle or a fungus growth therefrom, through the skin of the scrotum (Fig. 494). It may be due to a wound, malignant disease, abscess, syphilis, or tuberculosis. The *treatment* is that of the cause. In cases following abscess or trauma, the fungus may be cauterized and pressure applied, or amputated and the skin sutured over the stump.

Tumors of the testicle are usually malignant and of a mixed type. The most common non-malignant tumor is *cystic fibroma, or adenoma,* which consists of fibrous tissue with multiple serous cysts; it may, however, contain other forms of tissue, and in the later stages is apt to become malignant. *Dermoid, teratoma, chondroma, osteoma, fibroma,* and *myxoma* also have been observed. Of the malignant tumors *sarcoma* is the more frequent; *carcinoma* is almost always of the medullary variety. Malignant disease may be secondary to benign tumors and is often cystic in character. Both sarcoma and carcinoma spread along the cord, invade the lumbar glands, break through the scrotum, and then involve the inguinal glands.

The **diagnosis** of the exact nature of a neoplasm of the testicle is seldom possible before exploratory incision. The clinician is usually content to distinguish a neoplasm from other lesions not requiring castration. The following table, modified from Keyes, shows the main points in the diagnosis of chronic diseases of the testicle.

	Simple Chronic Epididymitis.	Tuberculosis.	Syphilis.	Tumor.
History	Gonorrhea, stricture, or hypertrophy of prostate.	Tuberculosis, family or personal.	Syphilis inherited or acquired.	Perhaps trauma.
Frequency	Uncommon	Frequent	Frequent	Rare.
Size	Small between attacks.	Does not reach any great size.	Does not reach any great size.	May reach any size.
Tenderness	Yes	Yes	No	No.
Shape	Between attacks testis normal, epididymis nodular.	Epididymis nodular. Testis not involved unless acute or ancient.	Testis evenly enlarged, slightly nodular "clam shell" epididymis.	Testis greatly enlarged, no characteristic involvement of epididymis.
Cord	May be slightly thickened.	Enlarged and nodular.	Free	Free.
Seminal vesicles	Usually distended.	Tuberculous	Uninfluenced	Uninfluenced.
Prostate	Posterior urethra inflamed.	Congested or tuberculous.	Uninfluenced	Uninfluenced.
Urine	Cloudy	Cloudy, may contain bacilli.	Clear	Clear.
Hydrocele	Unusual	Often	Nearly always	Unusual.
Onset	Usually acute.	Usually chronic	Chronic	Chronic.

	Simple Chronic Epididymitis.	Tuberculosis.	Syphilis.	Tumor.
Age	Adult life	Not often after 30.	Middle life	Any age.
Origin	Epididymis	Epididymis	Testicle	Testicle.
Course	Recurring acute attacks.	Chronic	Very chronic	Usually rapid.
Suppuration	Unusual	Common	Rare	None, but fungus common in later stages.
Atrophy of testis	Rare, potency unimpaired.	Rare, potency somewhat impaired.	Common, potency somewhat impaired.	Never, potency unimpaired.
Opposite testicle	Often involved simultaneously.	Usually involved subsequently.	Free	Free.

Malignant disease is the only condition likely to cause enlargement of the iliac, lumbar, and inguinal glands. The aspirator and antisyphilitic remedies may be of value in diagnosis, also the laboratory tests for syphilis, gonorrhea, and tuberculosis. The X-ray might reveal a dermoid, teratoma, chondroma, or osteoma.

The **treatment** of tumors of the testicle is castration.

Castration is best performed through an incision over the external inguinal ring. The cord is isolated, crushed with forceps, tied *en masse*, severed below the ligature, and each vessel secured by an individual ligature. The testicle is next pushed up through the wound, stripped from the scrotum, and removed, any bleeding points being ligated. This incision may be modified to include fistulæ or diseased skin. When the operation is done for *tuberculosis*, the inguinal canal should be opened, and the vas followed until it may be tied and cauterized close to the seminal vesicle. In *malignant disease* too the vessels should be secured as high as possible, and any accessible lymph glands removed. If the scrotum is invaded, the inguinal glands should be excised whether they are enlarged or not.

Neuralgia of the testicle may be caused by ungratified sexual desire, sexual irregularities, incipient inguinal hernia, or by some local or remote disease, e.g., varicocele, prostatic engorgement, and vesical or renal calculus. The *treatment* is removal of the cause.

Hydrocele is a collection of serous fluid in the tunica vaginalis, or in connection with the cord or testicle. **Vaginal hydrocele** (Fig. 495), or a collection of fluid in the tunica vaginalis, may be symptomatic or idiopathic. *Symptomatic hydrocele* (*serous vaginalitis*) is often acute, and may be caused by any disease of the testicle or epididymis. *Idiopathic hydrocele* is always chronic, is most common in the middle aged, and is of unknown origin. The fluid is straw colored, and contains albumin, fibrinogen, inorganic salts, often cholesterin crystals, and occasionally fibrous bodies containing phosphates, carbonates, and fibrin. The tunica vaginalis, in old cases, becomes thickened and fibrous, or even cartilaginous or calcified. Warty growths may arise from the tunic or the testicle.

The **signs** of a vaginal hydrocele are a tense, pear-shaped, fluctuating swelling, which grows from below upward, and which is usually situated in front of the testicle, but occasionally lies behind or envelops this organ. It is flat on percussion, and has no impulse on coughing unless it extends into the inguinal canal. By placing a light on one side of the swelling, translucency will be demonstrated, unless the tunica vaginalis is very thick or the fluid bloody or mucoid. The situation of the testicle may be determined by the light test, and by the peculiar sensation experienced by the patient when the organ is squeezed.

The **treatment** may be palliative or radical. **Palliative treatment** consists in tapping, the needle being entered at the front and lower part of the swelling. The position of the testicle should always be ascertained just before the operation. After the fluid has been withdrawn the puncture should be sealed with collodion. Tapping is often curative in children, and sometimes in symptomatic hydrocele, but practically never in the idiopathic variety, the sac refilling after the lapse of a few months. **Radical treatment** may be carried out by injections or by an open operation. Of the many substances recommended for *injection* pure carbolic acid is the best, from 10 m. to a dram being injected into the sac and diffused by manipulation, after all the fluid has been withdrawn. There is some inflammatory reaction, and retapping may be necessary if there is much effusion. Open operation possesses the advantage of allowing inspection of the testicle, and is always indicated if the sac is thickened. The patient's permission to deal with any testicular lesion which may be present should always be obtained, particularly if the hydrocele has formed rapidly. Open operation may be by incision, excision, or eversion of the sac. *Incision* of the sac, followed by packing it with iodoform gauze, should be obsolete. *Excision* consists in removing the entire parietal layer of the tunica vaginalis. It is indicated in cases in which the wall of the sac is very thick. *Eversion of the sac* is the best operation, when the sac wall is thin. The sac is opened by a small incision, turned inside out, and so held by a few catgut sutures passed through its edges, above the testicle and behind the cord. The testicle is then replaced within the scrotum and the wound closed.

Congenital or reducible hydrocele (Fig. 496) is one which communicates with the peritoneal cavity through an unclosed funicular process, hence is associated with hernia. The *treatment* is that of congenital inguinal hernia. Injections should never be used.

Infantile hydrocele (Fig. 497) is one which distends the tunica vaginalis and the funicular process, the latter, however, not communicating with the peritoneal cavity. The *treatment* is tapping, the walls of the sac being scratched with the end of the needle. If this fails the sac should be excised or everted.

Bilocular or abdominal hydrocele (Fig. 498) is an infantile hydrocele in which the upper end of the funicular process, distended with fluid, lies between the peritoneum and the abdominal wall. The *treatment* is excision.

Inguinal hydrocele is one about a retained testicle; it is dealt with by excision or eversion, and the organ brought down into the scrotum.

Encysted hydrocele of the testis is a cyst, or collection of cysts, occurring in or about the epididymis (*cysts of the epididymis*), or rarely in the testicle. There are two varieties: (1) *Small cysts* occur late in life, rarely contain spermatozoa, and cause little or no disturbance; they are said to be due to senile changes causing a dilatation of the tubules. (2) *Large cysts* occur before middle age and contain a milky fluid filled with spermatozoa (*spermatocele*); they are due to dilatation of the vasa efferentia, or to cystic changes in persisting fetal remains, being in this respect similar to parovarian cysts. The *treatment* is injection or excision.

Diffuse hydrocele of the cord is a smooth boggy enlargement of the cord, which may be due to edema, spermatocele, multilocular encysted hydrocele of the cord, lymphangioma, cysts of fetal remains, or echinococcus cysts. The *treatment*, excepting edema, is excision.

Encysted hydrocele of the cord (Fig. 499) is due to distention of the funicular process which has been closed for a variable distance above and below, or rarely to an accumulation of fluid in an old hernial sac which has

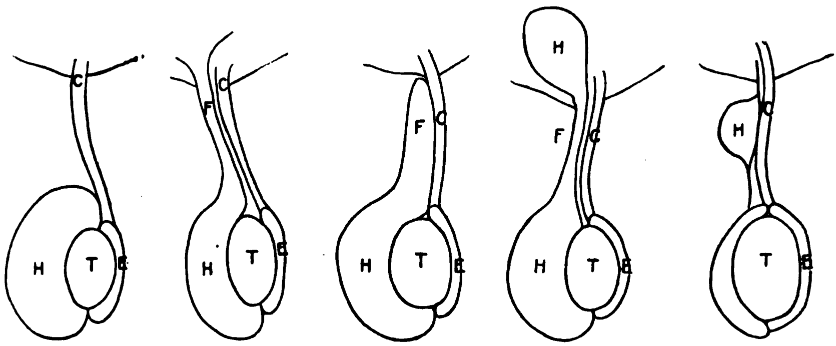


FIG. 495. Vaginal hydrocele. FIG. 496. Congenital hydrocele. FIG. 497. Infantile hydrocele. FIG. 498. Bilocular hydrocele. FIG. 499. Encysted hydrocele of cord.

Diagram of various forms of hydrocele. H, hydrocele; T, testicle; E, epididymis; F, funicular process; C, cord.

been shut off above. In the female the canal of Nuck may be likewise affected, constituting a hydrocele of the round ligament. The condition may be mistaken for hernia, owing to the fact that it may enter the inguinal canal, but if the cord is drawn downwards, the cyst is fixed, and presents the features of a hydrocele elsewhere. The *treatment* is injection or, better, excision.

Chylocele, or chylous hydrocele, is a collection of lymph in the tunica vaginalis, due to the rupture of dilated lymph vessels, and often associated with filariasis. The treatment is that of hematocele, with possibly ligation or excision of the dilated lymph vessels.

Hematocele is a collection of blood in or about the testicle or cord. It follows injury or operations, and occasionally occurs spontaneously, e.g., in malignant disease and hemophilia. According to its situation it may be a *vaginal hematocele*, i.e., in the tunica vaginalis, an *encysted or diffuse hematocele of the cord*, or an *encysted hematocele of the testicle*. The signs are those of hydrocele, except that the swelling is doughy or solid, and not translucent, and there is apt to be ecchymosis of the skin. An old hematocele that has become organized may be mistaken for a neoplasm. The *treatment* is rest and the application of cold, or in the presence of continued bleeding incision and ligation or packing. In old cases in which the blood has not been absorbed, incision and evacuation may be indicated.

Rupture of the vas deferens, as the result of operations or injuries, should be treated by anastomosis in a manner similar to anastomosis of the ureter.

Varicocele is a condition in which the veins of the pampiniform plexus are dilated, thickened, and tortuous. It is very common, and is most frequent in young men. It is almost always on the left side, because the left testicle hangs lower, because the left spermatic vein opens into the renal vein at right angles and has no valves, while that on the right has valves and opens obliquely into the vena cava, and because the left vein lies behind the sigmoid flexure and is apt to be compressed when the latter is distended. The cause is said to be unrelieved sexual desire. It may be due also to the pressure of a truss or abdominal tumors, and is then usually acute, and occurs on either side at any time of life. The condition is readily recognized, the veins feeling like a "bag of earth worms;" it has a slight impulse on coughing, disappears on lying down, and refills from below upwards if pressure is made over the external ring and the patient is asked to stand. The symptoms, when they exist, are neuralgia and hypochondria. The **treatment** is the use of a suspensory bandage, and the application of cold water night and morning. There is no danger of impotence. Operation is indicated when the condition is the source of constant anxiety. Our plan is as follows: The inguinal canal is opened as in the operation for hernia, the testicle pulled up into the wound, and the veins separated from the vas and its vessels and excised, the cremaster muscle being shortened if the cord is very long. Search is always made for a small hernial sac, which may be responsible for the "neuralgia." As the inguinal canal has been dilated by the varicocle, it is obliterated as in the operation for hernia, since removal of the veins leaves an open canal. The subcutaneous operation and injections are not recommended.

Acute seminal vesiculitis is caused by posterior urethritis, usually gonorrheal in nature. The *symptoms* are pain in the perineum, rectum, hip, or back, increased by urination and defecation; frequent micturition; and sometimes priapism and painful, bloody emissions. There is fever, and the distended, tender vesicle can be felt by rectal examination, above and to the outer side of the prostate. The *treatment* is that of acute prostatitis. If suppuration occurs, the abscess should be opened through the perineum.

Chronic seminal vesiculitis follows the acute form, when it constitutes one of the causes of gleet, or it is due to sexual irregularities or prostatic disease. The symptoms are those of the acute form, but much milder in degree. There is sexual feebleness but increased desire, and usually marked depression of the spirits. Recurring epididymitis is common. We have seen several cases in which, because of backache and hematuria, the diagnosis of renal calculus had been made. Chronic seminal vesiculitis has been held responsible for many chronic joint infections. The *treatment* is a hot rectal douche daily, and massage of the vesicles once a week. Massage is performed while the bladder is full and the patient bends over a chair. A finger is inserted into the rectum and the vesicles gently stripped from above downwards. Autogenous vaccins are recommended by some surgeons. The accompanying neurasthenia and posterior urethritis also should receive attention. In inveterate cases collargol (10 per cent.) may be injected into the vesicles by inserting the needle into each vas deferens (vasopuncture), the vesicles may be opened and drained (vesiculotomy) through the perineum, excised (vesiculectomy) by one of the routes mentioned below.

Tuberculosis of the seminal vesicles may be primary, or secondary to the same disease in the prostate or epididymis, the symptoms of which usually bring the patient to the surgeon. On rectal examination the vesicles are found tender and dilated, or even nodular. The bacilli may occasionally be found in the fluid expressed from the vesicles by massage. The *treatment* includes the general measures suitable for tuberculosis elsewhere, with the removal of more accessible foci, e.g., in the epididymis. If the disease continues to progress, the vesicles may be removed through the perineum, by the transsacral route as in Kraske's operation on the rectum, or by a suprapubic or inguinal incision, through which the vesicles are reached extraperitoneally.

PROSTATE GLAND.

Acute prostatitis is caused by posterior urethritis, usually gonorrheal in nature, but occasionally following the passage of instruments or calculi. The *symptoms* are frequent micturition; prostatic shreds or pus in the urine; pain, tenderness, heat, and weight in the perineum, increased by defecation and urination; chills and fever; and sometimes priapism, hematuria, or retention of urine. On rectal examination the prostate feels hot, swollen, tender, and, if suppuration has occurred, boggy or fluctuating. A *prostatic abscess* usually opens into the urethra, sometimes into the rectum or through the perineum, and rarely into the bladder. The **treatment** consists of laxatives, hot rectal douches, opium suppositories, and poultices to the perineum. If suppuration occurs, the abscess may sometimes break into the urethra on the passage of a catheter; if this does not occur, or if the abscess is large, it should be opened by a median perineal incision.

Chronic prostatitis may follow the acute form, but is usually chronic from the beginning. The *symptoms* are enlargement and tenderness of the prostate, pain on urination and defecation, and the discharge from the urethra of a thin, milky fluid containing prostatic casts (*prostatorrhea*), especially after defecation. Prostatorrhea may occur also without prostatitis, and then has the same causes and the same treatment as urethrorrhea. In some of these cases there is atonic impotence and frequent nocturnal emissions. The *treatment* is tonics, gentle massage of the prostate, the passage of a large sound twice a week, and instillations of a few drops of a 5 per cent. solution of silver nitrate into the posterior urethra. Hot rectal douches, suppositories of ichthyol, and counterirritation to the perineum also have been recommended. Should an abscess form, it is treated as described above.

Tuberculosis of the prostate is usually secondary to that of the seminal vesicles and epididymis. The prostate becomes nodular, and later suppuration ensues. The symptoms are painful and frequent micturition, hematuria, pyuria, and pain in the back and perineum. Tubercle bacilli may be found in the urine. The *treatment* is that of tuberculosis elsewhere. In suitable cases the prostate may be removed through the perineum, or abscesses opened, curetted, and packed with iodoform gauze.

Prostatic calculi are caused by the deposition of phosphates or inspissated prostatic secretion. They may cause prostatitis, abscess of the prostate, or retention of urine. They may show on a skiagram, and occasionally they may be felt with a urethral sound or by rectal examination. When producing trouble, they should be removed by a median perineal section.

Hypertrophy of the prostate is a senile enlargement of the gland, the cause of which is not known. It is very rare before fifty, but is said to be present in one-third of all men who have reached the sixtieth year, producing symptoms, however, in only one-half of these. All the elements of the gland hypertrophy, but, according to the tissue which predominates, the growth may be hard and fibrous, or soft and adenomatous. As a rule the changes are more marked in certain portions of the gland, so that the specimen consists of a number of encapsulated tumors, which may be *fibroadenomatous or adenofibromatous*, depending upon which tissue is in excess. In about 20 per cent. of those removed at operation carcinomatous elements are found. Prostatic hypertrophy lengthens the prostatic urethra, and sometimes gives it a tortuous course, owing to the irregular enlargement of different portions of the gland. The outlet of the bladder is always elevated, thus creating a pouch behind the prostate and preventing complete evacuation of the bladder (Fig. 500). In some cases the commissure between the lateral lobes may constitute a bar across the urethra, or a pedunculated growth, the so-called third lobe, which obstructs the internal urinary meatus like a ball-valve. The anterior commissure is rarely involved.

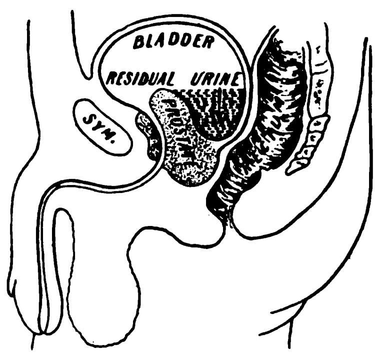


FIG. 500.—Hypertrophy of the prostate. Note retroprostatic pouch and residual urine, the marked anterior curve and increased length of the prostatic urethra.

The **symptoms** are frequent urination, especially at night, and difficulty in urination. The stream is hard to start, has little force, and is terminated by dribbling. The difficulty is increased rather than lessened by straining, which may be so great as to cause hematuria, hernia, or prolapse of the anus. There may be pain and a sense of fulness in the perineum, and priapism sometimes occurs owing to the congestion about the neck of the bladder. These symptoms are insidious in onset and gradually grow worse, the residual urine progressively increasing in amount. At this period indulgence in alcohol or catching cold is apt to increase the congestion and lead to retention of urine, which, unless relieved by the catheter, results in overflow (the incontinence of retention). The patient may have several of these attacks, until finally the bladder remains full all the time, the urine constantly dribbling away. The bladder is now dilated, atonic, and fasciculated, and the back pressure of the urine leads to dilatation of the ureters and of the pelves of the kidneys. Either spontaneously or as the result of instrumentation the bladder and prostate become inflamed, and the urine ammoniacal and purulent, the patient finally dying from an ascending infection of the kidneys. Phosphatic vesical calculi may form, and epididymitis may occur, particularly after the passage of a catheter. The *diagnosis* is confirmed by rectal examination, which is greatly facilitated by making firm pressure over the hypogastrium (bimanual examination), the bladder being empty, the legs flexed, and the mouth open. The finger readily detects the enlarged lateral lobes of the gland. In about 20 per cent. of the cases rectal examination is fallacious, because the chief enlargement is forwards and not backwards. In these cases the obstruction at the neck of the bladder will be appreciated by the passage of a catheter, which may be used to ascertain also the length of the urethra and the amount of residual urine, i.e., the quantity of urine which may be drawn off immediately after the patient has passed water. The bladder should always be searched for stones. In cases in which it can be used, the cystoscope may be employed to outline accurately the nature of the obstruction. The X-ray is of value, not only for the detection of stones, but also, especially if the bladder is distended with air, for showing the size of a hard prostate. "When there are symptoms of prostatic retention without any hypertrophy of the prostate, the essential lesion is a *contracture of the neck of the bladder*" (Keyes). This is usually due to posterior urethritis and is curable by perineal cystotomy.

The **treatment** in the early stages consists in attention to the general health, the drinking of plenty of water, and the avoidance of cold, wet, alcohol, and overeating. When the residual urine amounts to two ounces, the bladder should be catheterized every evening before retiring; each additional two ounces of residual urine will require an additional catheterization, the intervals always being regular. This the patient must be taught to do in a surgically clean manner, laying emphasis upon the ease with which infection occurs, and the great dangers which follow. Hexamethylenamine, grains 5 three times a day, or other urinary antiseptics should be administered, and the bladder irrigated with hot boric acid solution once daily. If the ordinary soft catheter cannot be passed, and this applies equally in cases of acute retention, a soft coudé or bicoudé (Figs. 481 and 482) catheter

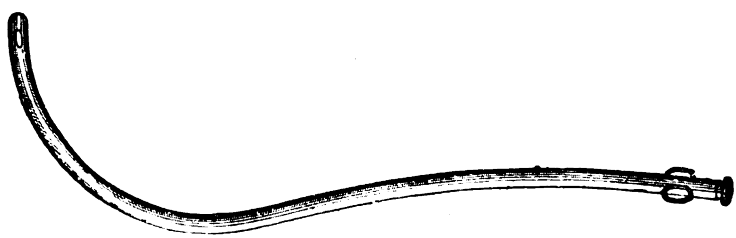


FIG. 501.—Prostatic catheter.

may mount the obstruction and enter the bladder; if these fail, it will be necessary to use a silver prostatic catheter (Fig. 501), which, owing to its greater length and larger curve, may reach the bladder when pressed well down between the thighs. If catheterization is difficult, if there is marked irritability of the bladder, if the residual urine steadily increases in quantity, or if there is stone or persistent cystitis, catheterization should be abandoned and operation advised. Seriously damaged kidneys or the presence of septicemia is an indication that operation has been postponed too long. Operations designed to cause atrophy of the gland by indirect means, such as *ligation of the internal iliac arteries*, *castration*, and *vasectomy*, have been abandoned.

Prostatotomy, or incision of the prostate, may be performed with the knife or the cautery, either through the perineum, or after the bladder has been opened above the pubes, the situation of the cut varying according to which lobe is chiefly enlarged; but these operations are seldom employed. **Bottini's operation,** which consisted in incising the prostatic obstruction with a galvano-cautery introduced through the urethra, has been discarded. Most surgeons think prostatectomy, as complete as possible, to be the operation of choice.

Prostatectomy, or removal of the prostate, may be complete or partial, and effected either through the perineum (intra- or extravesically) or by the suprapubic route. The mortality is from 10 to 20 per cent., but the vast majority of those who recover are cured. The operation may be rendered safer by estimating the functional capacity of the kidneys (q.v.); performing suprapubic cystotomy, under local anesthesia, for drainage; and, after a week, or when the patient's general condition has improved and the renal activity has been restored as much as possible, removing the prostate under nitrous oxid-oxygen anesthesia. Most of the deaths after operation are due to uremia, pneumonia, sepsis, or a combination of these evils. Among the sequelæ are impotence, incontinence of urine, epididymitis, urinary fistula, rectal fistula, and stricture.

Suprapubic prostatectomy is performed by opening the bladder as in suprapubic cystotomy, tearing through the mucous membrane over the prostate with the finger-nail or blunt scissors, and enucleating the gland by working between the true and the false prostatic capsules, while the prostate is pushed upwards by a finger in the rectum. If the lateral lobes are removed separately, the ejaculatory ducts may occasionally be preserved. The hemorrhage is controlled by irrigation with hot water, or temporary gauze packing, and the bladder drained as after suprapubic cystotomy. The operation is easy, quick, requires no special instruments, permits full exploration of the bladder, does not injure the rectum, is rarely followed by a permanent fistula, and does not always destroy the sexual function. The urine begins to pass through the urethra in from one to two weeks, and the suprapubic wound is healed in from two to four weeks.

Perineal prostatectomy may be performed through a curved transverse incision, convexity forward, reaching from one ischial tuberosity to the other, or one of its modifications, but the easiest and simplest is the median incision as in perineal cystotomy. The membranous urethra is opened, and the prostate pulled downwards by a sound passed into the bladder, or by special tractors devised for this purpose, and enucleated after incising its fibrous sheath. The bladder is drained by a tube emerging through the perineum, and the wound packed with gauze. The drain may be removed in a few days, the after treatment being the same as that of perineal cystotomy. Young incises the capsule outside of the seminal ducts, in order to preserve these structures, and removes the rest of the gland. Dittel, Rydygier, and others make a transverse perineal incision, and excise V-shaped portions of the lateral lobes without opening the urethra or bladder (*extravesical prostatectomy*). The perineal operation is more difficult than suprapubic prostatectomy, and has the special danger of injury to the rectum.

If the symptoms are severe, and prostatectomy cannot be practiced because of the poor general condition of the patient, the only operation which promises relief is cystotomy, either suprapubic or perineal, for the purpose of drainage.

Carcinoma of the prostate, as previously mentioned, is found in about 20 per cent. of the glands removed for supposed benign hypertrophy. Sarcoma is rare, and may occur in early life. The *symptoms* of carcinoma are much like those of hypertrophy of the prostate, but the pain is greater, the growth more rapid, hematuria more common, and the gland stony hard and nodular. In the later stages the tumor breaks through the capsule, invades the bladder, urethra, and rectum, causes metastases in the pelvic and inguinal lymphatic glands, and induces cachexia. The *treatment*, if the patient is seen early enough, is removal of the entire prostate, the seminal vesicles, and the anterior two-thirds of the trigone, through the perineum, the bladder being anastomosed with the membranous urethra. Young has performed this operation six times, one patient being well at the end of five years. When excision is out of the question, some relief may be obtained by suprapubic cystotomy.

FEMALE GENITAL ORGANS.

Examination of the female generative organs is usually made with the patient in the dorsal position, the knees being drawn up and the thighs abducted, and the bladder and rectum having previously been emptied. The external genitals should first be inspected. By separating the labia the urethra, the hymen or its remains, and the perineum may be seen, and if the patient strains, a cystocele or rectocele may be detected. For inspecting the inner parts a speculum is necessary, the most serviceable of which is one of the bivalve variety (Fig. 502). The instrument is warmed and

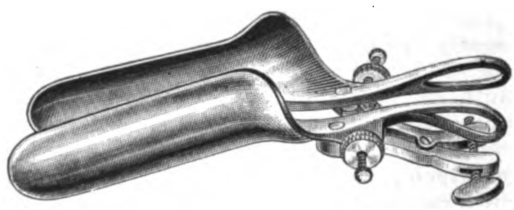


FIG. 502.—Goodell's speculum.

lubricated, and introduced with the blades closed and facing laterally; it is then turned so that the edges are lateral, and the blades separated. The Sims speculum is used with the patient in the *Sims position* (Fig. 503), i.e., lying upon the left side, with the left arm behind the back, the right shoulder near the table, and the hips flexed, the right more than the left. The speculum is introduced, then turned transversely, so as to retract the posterior vaginal wall, the right buttock being lifted with the disengaged hand. The cylindrical speculum of Fergusson, consisting of glass or hard rubber, and having the inner extremity beveled, is seldom employed. By vaginal palpation may be determined the condition of the perineum, whether or not the vulvo-vaginal glands are enlarged, the presence of spasm and tenderness, the amount of heat and moisture, the condition of the vaginal walls, the presence or absence of tumors or masses, and the size, shape, position, mobility, and consistency of the cervix and uterus. Either the index, or the index and middle fingers, according to whether the patient is single or married, are lubricated and passed into the vagina over the perineum; by placing the other hand over the lower abdomen (*bimanual examination*) the uterus, tubes, and ovaries may be palpated between the fingers and their condition determined. The right side of the pelvis is best examined with the right hand internally, the left with the left hand internally. In virgins, instead of a vaginal examination, and often in others as supplemental to a vaginal examination, it is desirable to pass a finger into the rectum and examine the parts bimanually. This examination is facilitated, if at the same time the cervix

FIG. 503.—Sims' position. (Montgomery.)

is drawn downward by volsella forceps (Fig. 504). In order to determine the degree of prolapsus uteri some surgeons examine the patient in the erect posture. The patient stands with the legs apart, while the examiner, kneeling on one knee and facing the patient passes the fingers into the vagina,

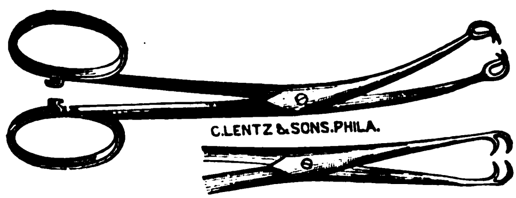


FIG. 504.—Volsella forceps.

supporting his elbow with the other knee. Before or after the internal examination the abdomen should always be examined externally by inspection, palpation, and percussion, and sometimes by auscultation. When these examinations are unsatisfactory, it may be necessary to anesthetize the patient

FIG. 505.—Sims' uterine sound.

in order to secure complete relaxation. The uterine sound (Fig. 505) may be used to determine the length, permeability, and direction of the uterine canal, the presence of growths, the condition of the endometrium, and occasionally to replace a displaced uterus. It is seldom employed, however, because of the dangers of sepsis, perforation, or abortion, and it is absolutely contraindicated in acute inflammatory troubles, in cancer, during the menstrual period, and in cases in which there is the slightest suspicion of pregnancy. The vagina and the sound should be thoroughly sterilized, and the instrument, properly curved, introduced under the guidance of the eye, the position of the uterus having been previously determined. The interior of the uterus may be explored also with the finger, after the cervix has been dilated, or a portion of the endometrium may be removed with a curette for microscopic examination.

THE VULVA.

Any or all parts of the vulva may be absent, rudimentary, or hypertrophied. Enormous hypertrophy of the labia minora is seen in the *Hottentot apron*. Epispadias and hypospadias also occur. True *hermaphrodism* (presence of both ovaries and testicles) does not occur, but *pseudohermaphrodism*, in which the external genitals resemble those of both sexes, is sometimes seen.

The vulva is subject to the same diseases and injuries as other parts covered by skin and mucous membrane, and only a few of these need special description.

Vulvitis is usually gonorrheal in origin, but may be caused by irritating discharges, uncleanliness, diabetic urine, parasites, infectious fevers, traumatism, caustics, pregnancy, and excessive masturbation or coitus. *Follicular vulvitis* is acne. Cellulitis of the vulva is called *phlegmonous vulvitis*. During the acute exanthemata or other debilitating diseases the parts may become gangrenous (*gangrenous vulvitis*, *noma pudendi*), or covered with a false membrane (*croupous vulvitis*); true diphtheria also occurs. The **symptoms** are localized pain and burning, more marked on walking or during micturition. The parts are swollen, reddened, and covered with a mucopurulent discharge. The **treatment** is removal of the cause, and cleanliness. Rest in bed, sitz baths, and local applications of the medicaments recommended for injection in gonorrhea are indicated. In the severer forms tonics and stimulants are needed, while cellulitis will call for incision, and gangrene for excision and cauterization.

Abscess of the vulvovaginal or Bartholin's gland is caused by vulvitis, and presents the usual signs of an abscess. The *treatment* is incision, or excision with partial closure of the wound and drainage. A *cyst* of the vulvovaginal gland caused by occlusion of its duct likewise is treated by excision.

Pruritus vulvæ, or intense itching of the vulva, is a symptom rather than a disease, and may be caused by uncleanliness, local skin diseases, irritating discharges, diabetic urine, parasites, masturbation, rectal diseases, digestive disorders, gout and rheumatism, pregnancy, the menopause, diseases of the internal generative organs, and kraurosis vulvæ. The itching is worse after exercise and at night, and leads to excoriation and trophic changes in the skin; melancholia sometimes follows. The **treatment** is removal of the cause, attention to the general health, and local cleanliness. The itching may be relieved by lead-water and laudanum, carbolic solution (5 per cent.), cocain (5 per cent.), by painting the parts with silver nitrate (10 grains to the ounce) and sometimes by radiotherapy. Excision of the affected skin, or resection of the nerves supplying it with sensation has been performed in inveterate cases.

Kraurosis vulvæ is an atrophic change in the vulvar skin leading to shrinking and thickening of the parts, which become white and smooth. The cause is unknown, and the symptoms are usually pruritus and sometimes intense hyperesthesia. The *treatment* is that of pruritus.

Urethral caruncle is a dark-red tumor growing from the mucous membrane in or near the urethral meatus. The growth is a papilloma, angioma, or adenoma, and is exceedingly sensitive, causing dysuria, pain on walking or intercourse, and marked nervous symptoms. The *treatment* is excision.

THE VAGINA.

The vagina may be *double* owing to failure of union of the lower portions of Müller's ducts, *lateral* if one of the ducts fails to develop, or *absent* or *rudimentary*, in whole or in part (see also atresia ani vaginalis).

Atresia of the vagina (complete closure) occurs at the hymen (*atresia hymenalis*) or at a higher level (*atresia vaginalis*). It may be congenital, or be caused by cicatricial contraction the result of traumatism, operations, caustics, or the severer forms of vaginitis. The **symptoms** are caused by retention of menstrual fluid. At the time of the periods there are all the symptoms of menstruation except the appearance of blood. The vagina becomes distended (*hematocolpos*), and after a time the uterus (*hematometra*), and then the tubes (*hematosalpinx*). When the distention becomes extreme, the blood may burst through any portion of the genital tract, or through the atresia, an accident which is often followed by infection and death.

The **treatment** is puncture or incision of the obstruction, in order to allow the blood, which may be as thick as tar, to escape slowly. The opening is then enlarged, the cavity irrigated with a mild antiseptic solution, and the opening maintained by gauze, or by a rubber or glass plug. If the tubes are distended, they are probably adherent, hence collapse of the uterus and vagina often results in their rupture and peritonitis; the condition of the tubes should therefore be investigated before operating on the atresia, and if distended, they should first be removed by abdominal section. In absence or obliteration of the vagina efforts have been made to construct a canal by flaps from the labia, by skin grafting, by the substitution of a portion of the rectum, and by the transplantation of a segment of the small intestine. We have obtained an almost perfect result by the method last mentioned.

Stenosis of the vagina (incomplete closure) results from the same causes as atresia, and may interfere with intercourse, drainage of the vagina, and labor. The treatment is gradual dilatation with bougies, or a plastic operation.

Injuries of the vagina may be caused in a great variety of ways, e.g., by coitus, bullets, falls astride some sharp object, and rough instrumentation. They are treated on general surgical principles. If the peritoneal cavity has been penetrated by some pointed object, the abdomen should be opened in order to search for wounds of the intestines. By far the most frequent and important injuries are those occurring during labor.

Laceration of the perineum is usually caused by childbirth, rarely by external injuries. According to position the laceration may be *lateral*, the fibers of the levator ani, on one or both sides, being torn; *median;* or *central*, a rare form in which the child is born through a perforation of the perineum, the vulva remaining intact. According to degree the laceration may be *incomplete* or *complete*, the latter passing through the sphincter ani. ***Perineal relaxation*** is a term used for those cases in which there has been a submucous tear of the levator ani fibers.

The **symptoms** are a feeling of insecurity in the parts, dragging pain, and reflex nervous disorders. Incomplete median tears may give no symptoms. When the levator ani is torn, the anus falls backwards, the rectum bulges forward as a tumor (*rectocele*—Fig. 506), causing constipation, and the stretching of the posterior wall leads to retroversion and prolapse of the uterus. These conditions cause congestion, and hence hemorrhoids and endometritis. The anterior vaginal wall also may prolapse from lack of support of the posterior wall, or from descent of the uterus, causing a bulging

FIG. 506.—Laceration of perineum and large rectocele. (Pennsylvania Hospital.)

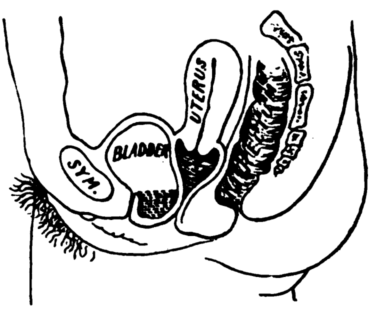


FIG. 507.—Diagram of cystocele and rectocele. Dotted lines represent residual urine. The uterus is displaced downwards and backwards.

downwards and outwards of the bladder (*cystocele*), a condition which may exist likewise without laceration of the perineum, owing to the submucous stripping of the anterior vaginal wall from the underlying parts during labor. A cystocele causes dysuria, and sometimes cystitis from the decomposition of residual urine (Fig. 507). A complete tear causes incontinence of feces and gas. The gaping of the vaginal orifice, the backward displacement of the anus, and the rectocele or cystocele are readily detected by inspection, especially when the patient strains. By palpation with a finger in the vagina and the thumb externally or in the rectum, the gap in the muscles may be felt.

The **treatment** should be immediate repair after labor (*perineorrhaphy, or posterior colporrhaphy*), the divided structures being approximated with silk or twenty-day catgut. Non-chromicized catgut is absorbed very rapidly in these cases and should not be employed. Of the *secondary operations*, i.e., those in which the laceration is repaired after the completion of cicatrization, the most important are described below.

Lateral tears are best repaired by the **Emmet operation.** With the patient in the lithotomy position, guide sutures or tenacula are passed through the apex of the rectocele, and through each labium majus at the lowest carnunculæ myrtiformes. By drawing on the lateral suture and pulling the central suture downward and to the opposite side, the lateral sulcus appears as a triangle with the apex up in the vagina. This triangle is denuded of mucous membrane by cutting off long strips by means of forceps and scissors, or by dissecting the mucous membrane off in one piece. The triangle on the opposite side is treated in the same manner, and the denudation completed by removing the mucous membrane between the bases of the triangles and below the central suture (Fig. 508). Each lateral triangle is closed by interrupted sutures of chromicized catgut or silkworm gut, the latter being shotted. The needle, which should be curved, is entered near the margin of the wound on the outer side, passed deeply to catch the fibers of the levator ani, and brought out at the bottom of the sulcus, at a point nearer the operator; it is then reinserted at the bottom of the sulcus, and passed upwards and backwards in the rectocele, to emerge opposite the point of the original insertion. The opposite triangle is treated in the same manner, which leaves

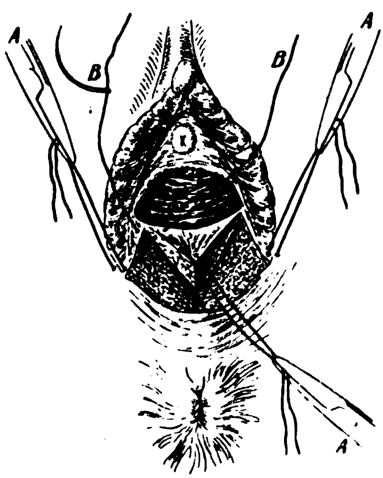


FIG. 508.—Emmet's operation, showing area of denudation. A, A, A, Guide sutures; B, upper suture passed in lateral sulcus.

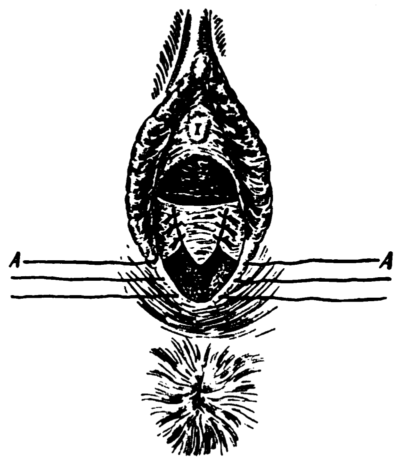


FIG. 509.—Sulci closed. A, Crown stitch.

a small raw area externally to be closed (Fig. 509). The upper or "crown stitch" passes through the skin of the perineum below the lateral guide suture, then through the rectocele below the central guide suture, and finally through the tissues below the opposite guide stitch. As many sutures as may be necessary are inserted below this. If silkworm gut is used, the stitches should be removed on the tenth day. The external genitals are irrigated with weak bichlorid of mercury solution after each urination; catheterization should, if possible, be avoided. The bowels are moved on the second day. Internal douches are not needed unless there be infection. The patient should be kept in bed two weeks, and heavy work and sexual intercourse forbidden for three months.

Hegar's operation (Fig. 510) is indicated in median tears. Lateral guide sutures are placed as in the Emmet operation, and a central guide suture is inserted in the middle line of the posterior vaginal wall as high as may be necessary. The triangle thus outlined is denuded, and the raw surface closed by interrupted sutures passing beneath the entire denuded area, care being taken to catch the transverse perineal muscle.

The **flap-splitting method** may be employed in either lateral or median tears. An incision is made around the lower margin of the vulva, joining the terminations of the nymphæ; the flap separated from the rectum and drawn upwards; the levator ani on each side clearly defined, and the muscular edges united with catgut (Fig. 511); the skin and tissues over the muscles brought together with silkworm gut; and the flap fixed in position with a few catgut sutures.

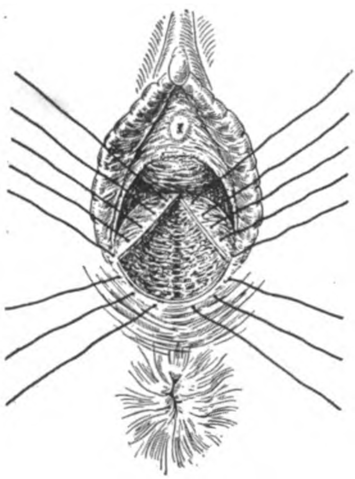


FIG. 510.—Hegar's operation.

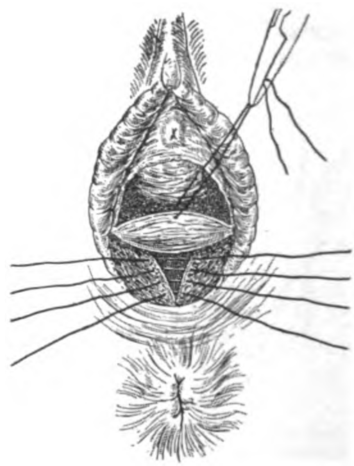


FIG. 511.—Flap-splitting method of perineorrhaphy. Flap elevated and sutures passed through the levator ani on each side.

In the **operation for complete laceration** the rectovaginal septum is split laterally, thus separating the vagina from the rectum for a short distance and thoroughly exposing the ends of the sphincter ani. The wound in the rectum is then closed by two layers of chromicized catgut sutures, one for the mucous membrane and a second for the outer coats. The sphincter ani is approximated by two or three additional catgut sutures. The operation is then completed by any one of the methods just described, the lowest external suture being passed through the sphincter ani. In order to avoid fecal contamination of the wound and the possibility of rectovaginal fistula, Ristine, Watkins, and others make a vaginal flap with the base downwards. The depressions corresponding to the torn ends of the sphincter ani are joined by a curved incision, through the vaginal mucosa, extending a half inch or more above the anal margin. This "apron" is reflected downwards over the anus, and the sphincter ani united without opening the rectum, thus converting a complete into an incomplete tear, which is closed as in the Hegar or, better, as in the flap-splitting operation. The "apron" may be fastened up over the perineal sutures, so as to protect the wound from the rectal discharges.

Anterior colporrhaphy, or the operation for cystocele, consists in removing an elliptical piece of the anterior vaginal wall, extending from just behind the urinary meatus almost to the cervix, the width depending upon the degree of relaxation. The cervix is pulled down with a tenaculum, the cellular space between the bladder and the vagina opened by a short longitudinal incision near the cervix, at which point there is little danger of wounding the bladder, blunt scissors pushed through this incisoin almost to the external meatus, the blades separated and withdrawn, and the space thus created exposed by continuing the longitudinal incision towards the meatus. Each lateral flap is now raised from the bladder by blunt dissection, and resected by a curved incision as far out as may be necessary. The wound is then closed with two or three layers of continuous catgut sutures.

Fistulæ are usually caused by sloughing following a long labor, but are occasionally due to other injuries, and sometimes to disease, such as syphilis, tuberculosis, or cancer. Those due to disease are not, as a rule, suitable for plastic operations. **Urinary fistulæ** may be *urethrovaginal*, *vesicovaginal* (the most common), *vesicouterine*, *ureterovaginal*, or *ureterouterine*. The most common **fecal fistula** is the *rectovaginal*, but occasionally, as a result of a vaginal operation or injury, the vagina communicates with the small bowel (*enterovaginal fistula*). These fistulæ, with the exception of the urethrovaginal, in which leakage occurs only during micturition, cause, according to their character, an involuntary escape of urine, feces, or gas from the vagina, and all give rise to vulvovaginitis as the result of the irritation of the discharges. Urinary fistulæ may be complicated by cystitis, ureteritis, and pyelonephritis. The diagnosis is made by passing a probe or finger through the fistula, or, when the orifice is very small, by injecting a colored fluid into the bladder or rectum and watching for its escape through the fistula. In ureteral fistulæ a small quantity of urine constantly dribbles from the vagina, despite the fact that micturition is normal, and the color and quantity of the fluid escaping from the fistula is not influenced by the injection of a colored solution into the bladder.

The **treatment** of recent small fistulæ is daily irrigation of the vagina with boric acid solution or salt solution, never with strong antiseptics; if spontaneous healing does not occur after three months, operation should be advised. Large or old fistulæ, with the exceptions noted above, always require operation. Often, however, it is first necessary to remove phosphatic deposits, to combat cystitis and ulcerations, and to improve the general health. A *vesicovaginal fistula* may be closed by paring the edges of the orifice, and then uniting them with silkworm gut sutures, which penetrate to, but not through, the bladder mucous membrane. The patient is usually placed in the Sims position during the operation, and a retention catheter remains in the bladder after operation. The sutures are removed in ten days. If the edges do not come together without tension, a longitudinal incision, which is subsequently sutured transversely, may be made on each side of the opening. In some cases it may be necessary to separate the bladder from the vagina for some distance, and suture each cavity separately. Suture of the fistula from above, after the bladder has been opened above the pubes, may be indicated when the fistula is high and difficult to reach through the vagina, when vaginal operations fail, when one suspects that the ureters are close to the orifice. A further advantage is that the bladder is put at rest after operation, by suprapubic drainage. Of thirty-three cases in which the transvesical operation was performed, success followed a single attempt in 60 per cent. (Francey.) In the worst cases which cannot be remedied by other means, the vagina may be closed below the opening (*colpocleisis*), thus converting the bladder and vagina into one cavity. *Urethrovaginal* and *recto vaginal fistulæ* are treated on the same principles as a vesicovaginal fistula. A rectovaginal fistula close to the vulva may be incised like a fistula in ano, and then treated like a complete laceration of the perineum. A *vesicouterine fistula* may be reached by dilating or splitting the cervix. Probably the best operation is to make an incision in front of the cervix, separate the bladder, and close the opening in it with catgut sutures. *Ureteral fistulæ* may be treated by establishing a vesicovaginal fistula alongside the opening in the ureter, and later closing the vesicovaginal fistula, which now includes the ureteral opening, by denuding the vaginal mucous membrane about the orifice of the fistula, and subsequently suturing the raw surfaces. The ureter may be dissected from its bed, either through the vagina or abdomen, and anastomosed with the bladder. Anastomosis with the bowel is not advisable. When all other plans have failed or cannot be used, and the opposite kidney is healthy, the ureter may be tied. When the kidney of the affected side is extensively damaged from an ascending infection, it may be removed. An *enterovaginal fistula* usually demands laparotomy, the intestine being separated from the vagina, and the opening in each closed with sutures.

Vaginitis is usually caused by gonorrhea, but may be due to foreign bodies, or other conditions mentioned under vulvitis. In old age the epithelium is prone to desquamate, leaving ulcers (*senile or ulcerative vaginitis*), which may result in stenosis or atresia. As in vulvitis, gangrenous and croupous inflammation may occur, but cellulitis (*paracolpitis*) is rare. The **symptoms** of the *acute form* are pain and heat in the vagina and pelvis, vesical and rectal irritability, a mucopurulent discharge, and reddening of the mucous membrane, which is frequently studded with enlarged papillæ. *Chronic vaginitis* may have nothing but a leukorrhea to indicate its existence. Gonorrheal vaginitis can be diagnosticated with certainty only by finding the gonococci, although its symptoms are often very acute, and it is more apt to be associated with vulvitis, urethritis, and infection of the vulvo-vaginal glands. Extension to the uterus, tubes, ovaries, and peritoneum also is common.

The **treatment** of acute vaginitis is rest in bed and the general measures advised in the treatment of gonorrhea. Douches of bichlorid of mercury (1 to 5,000) or permanganate of potassium (1 to 10,000) may be given several times a day, while applications of a 5 per cent. argyrol solution may be made through a speculum once daily, and the vagina lightly packed with gauze between treatments. In the later stages, or in chronic cases, the vaginal mucous membrane may be painted with silver nitrate (gr. 30 to the ounce) several times a week, and an astringent douche of zinc sulphate and powdered alum (each half an ounce to a quart of water) may be ordered. Ulcerations are treated by the application of silver nitrate.

Vaginismus is a spasmodic contraction of the perivaginal muscles, preventing coitus and associated with excessive hyperesthesia of the structures about the vulva. It may be caused by a urethral caruncle or other local disease, and is most common in the neurasthenic.

The *treatment* is the correction of any local disease, and gradual dilatation by means of bougies, or forcible dilatation under a general anesthetic. Inveterate cases have been treated by excising the hymen, or by incising the perineum in a longitudinal direction and closing the wound transversely.

THE UTERUS.

Malformations of the Uterus.—The uterus may be *absent* or *rudimentary*, in the latter case existing as a thin band of muscle and connective tissue.

Congenital atrophy of the uterus is a condition in which the uterus is exceedingly small, the size of the cervix being proportionate to that of the body. An **infantile uterus** is small, but the cervix is two or three times longer than the body, a condition which is normally present at birth.

The remaining malformations of the uterus are due to non-union or imperfect fusion of the ducts of Müller. **Uterus septus** is one in which the uterus is divided longitudinally by an antero-posterior septum. **Uterus bicornis** is one in which the uterus is divided into two horns by an antero-posterior groove across the fundus. When this cleft extends to the vagina there are two uteri, each with a tube and ovary (**uterus didelphys**). When one of the canals of Müller develops and the other remains rudimentary, the uterus is deflected to one side (**uterus unicornis**). In the **uterus bipartitus** both horns are rudimentary, but may be hollow and connected with the vagina and with each other by the cervix. Some of these malformations cause sterility, others miscarriages or great difficulty in labor. When

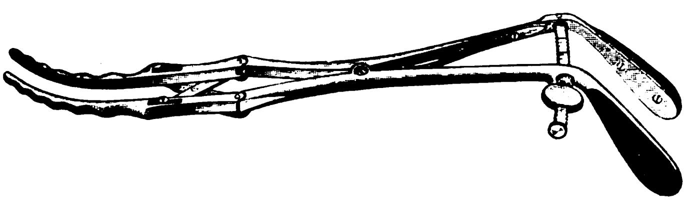


FIG. 512.—Goodell's uterine dilator.

the uterus is so poorly developed that menstruation amounts to agony, the ovaries may be removed. When the uterus is divided by a septum, such may be crushed with forceps, which are left in place until they come away of themselves. When conception takes place in a rudimentary horn, the condition resembles ectopic pregnancy, in that the walls may break and a fatal hemorrhage occur; in such a case the rudimentary horn should be removed. The uterus didelphys has been mistaken for pus tubes and one of the organs removed before the mistake was discovered; excision is the proper procedure if there is a unilateral hematometra or pyometra.

Atresia of the cervix (complete closure) may be congenital, or it may be acquired as the result of tumors of the cervix, or cicatrization following the application of caustics, ulceration due to infectious fevers, injuries of childbirth, or a badly performed trachelorrhaphy. There is retention of menstrual blood (*hematometra*), mucus (*hydrometra*), pus (*pyometra*), or, in cases infected by saprophytes or the gas bacillus, gas (*physometra*). There is amenorrhea with the subjective symptoms of menstruation at the regular periods, except in hydrometra, which usually occurs after the menopause. In pyometra and physometra septic phenomena are in evidence. The uterus is enlarged and cystic in fluid accumulations, tympanitic or crepitating if there is a collection of gas. The **treatment** is puncture or incision of the cervix, irrigation of the uterine cavity with salt solution, and the subsequent passages of bougies to maintain the patency of the canal. The condition of the tubes should be ascertained before operation, and if they also are distended, they should be removed by abdominal section before emptying the uterus, as such is apt to rupture them and cause peritonitis.

Stenosis of the cervix (partial closure) may be due to the same causes as atresia. In the congenital form the cervix is conical and the uterus small and anteflexed. The *symptoms* are dysmenorrhea and sterility, the latter usually being caused by an endocervicitis, which induces also leukorrhea. The *treatment* is dilatation of the cervical canal by a glove-stretcher dilator (Fig. 512), and the subsequent passage of bougies at regular intervals. The operation is performed by seizing the anterior lip of the cervix with a double tenaculum, and gently passing into the uterus a small dilator, the blades of which are separated laterally, and then in other directions, so as not to tear the cervix. A larger and more powerful dilator may then be used if needed. Dilatation by means of tents (sponge, laminaria, tupelo, corn stalk, etc.) which expand by absorbing moisture after their introduction

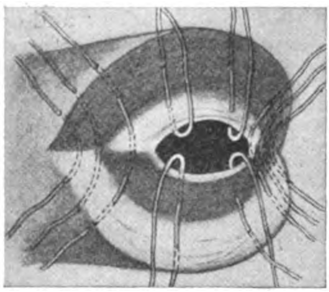


FIG. 513.—(Auvard.)

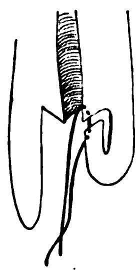


FIG. 514.

into the cervix, is slow, painful, and dangerous because they are difficult to render and keep sterile. Dilatation may be effected also by repeated packings with gauze, or by the Barnes bag; the latter consists of india rubber and is introduced into the cervix collapsed, after which it is slowly distended with air or water. In rare instances it may be necessary to incise the cervix.

Hypertrophy of the cervix may involve the supravaginal or infravaginal portion; the former is associated with prolapse of the uterus and eversion of the vaginal mucous membrane, the latter is congenital and is not associated with displacement of the fundus of the uterus or obliteration of the vaginal fornices. In the congenital variety the os is small and the cervix long and conical. Hypertrophy of the cervix may cause leukorrhea, sterility, and dysmenorrhea, and if the cervix protrudes from the vulva, it may become ulcerated and interfere with locomotion. The **treatment** is *amputation of the cervix*. The anterior and posterior lips of the cervix are seized with double tenacula, the cervix split transversely, each lip amputated by a wedge-shaped incision, and the wound closed by sutures as shown in Fig. 513. Shroeder's method, which is indicated when the cervical mucous membrane is badly diseased, is shown in Fig. 514. The cervix is split as in the previous operation, and each flap amputated in a manner similar to removal of the distal phalanx of the finger when a long palmar flap is used. Chromicized catgut is the best suture material.

Laceration of the cervix is usually the result of childbirth, but occasionally follows attempts at abortion or dilatation of the cervix. The laceration may be *partial* or *complete*, the latter extending through the whole cervix. The line of cleavage is apt to correspond with the right oblique diameter of the pelvis, because the most frequent presentation is the left occipito-anterior. The laceration may be *unilateral*, *bilateral*, or *stellate*, i.e., having more than two branches radiating from the cervical canal. Extensive lacerations may open the cellular tissue of the broad ligaments or even the peritoneum, and be followed by cellulitis or peritonitis. **Symptoms** may be absent, particularly in unilateral lacerations. In a bilateral laceration the lips are separated, exposing the cervical mucous membrane (*ectropion or eversion*), which becomes raw and inflamed (*erosion of the cervix*), and frequently studded with small retention cysts, owing to obstruction of the mouths of the cervical glands (*cysts or ovules of Naboth*). These changes, with the irritation of the cicatrices, lead to subinvolution and chronic inflammation of the uterus, and predispose to its displacement, sterility, abortion, and epithelioma. The most prominent symptoms are usually a feeling of weight and discomfort in the pelvis, menorrhagia, leukorrhea, suboccipital headache, and neurasthenia. The diagnosis is readily made by palpation, and by inspection with the aid of a speculum.

Treatment at the time of laceration is not advisable unless there is excessive hemorrhage, when the laceration should be closed with sutures. After the puerperium erosions may be touched every other day with silver nitrate (grains 20 to the ounce), the cysts of Naboth punctured, tampons saturated with boroglycerid inserted into the vagina every other day, and copious douches of hot water given daily. If this treatment fails to relieve, operation is indicated.

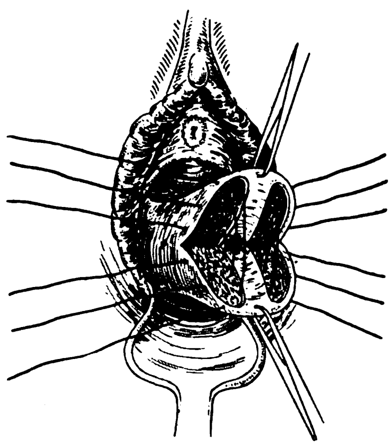


FIG. 515.—Trachelorrhaphy.

Emmet's trachelorrhaphy, or suture of the laceration, is performed as follows: The cervix is exposed by retracting the perineum with a speculum, and each lip caught with a double tenaculum. The edges of the laceration are denuded with scissors or knife, leaving a strip of mucous membrane in the middle for the cervical canal, all the scar tissue excised, and sutures of chromic catgut inserted and tied (Fig. 515). It is usually advisable to precede this operation by curetting the uterus. In stellate tears with much scar formation and hypertrophy of the cervix, amputation is generally the better operation.

Endometritis, or inflammation of the mucous membrane lining the uterus, may be acute or chronic.

Acute endometritis involves both the cervical and corporeal endometrium and extends to the underlying tissues. It is usually caused by infection following labor or abortion, by gonorrhea, or by the use of infected instruments, but it may be due also to acute infectious fevers, and exposure to cold during menstruation. The mucous membrane is swollen, softened, and intensely hyperemic. There may be extravasations of blood into the uterine walls and the formation of abscesses. The **symptoms** in mild cases are a mucopurulent discharge, often bloodstained, pain in the back and pelvis, irritability of the bladder, and a little fever. The uterus is slightly enlarged and tender, the cervix softened, and the os frequently surrounded by an area of erosion. In the severer forms the discharge is very foul, the tenderness more marked, and the general symptoms those of sapremia or septicemia. The infection often spreads to the Fallopian tubes and peritoneum; in other instances it involves the body of the uterus, or causes a phlebitis of the pelvic or other veins; and finally it may spread through the lymphatics and cause a pelvic cellulitis.

The **treatment** is rest in bed, liquid diet, saline laxatives, hot vaginal douches of bichlorid (1 to 5,000) twice daily, and an ice cap to the hypogastrium. In the more severe forms the uterine cavity itself may be irrigated with a solution of bichlorid (1 to 10,000) or normal salt solution. When occurring after labor or abortion, the uterine cavity should be explored with the finger and any decomposing secundines or blood clot removed. Curettage is, as a rule, contraindicated. Septicemia will require appropriate general treatment. In the worst cases, particularly if abscesses form in the uterine wall, hysterectomy may be indicated.

Chronic endometritis may involve the entire endometrium, but is often localized to the cervical or corporeal portion.

Chronic cervical endometritis or catarrh (*endocervicitis*) may be due to any of the conditions producing a vaginitis or endometritis, the inflammation spreading to the cervix from these regions. Lacerations and gonorrhea are the most frequent causes. It may be due also to stenosis of the cervix. The entire cervix, including the epithelium, the glands, and the connective tissue, is involved. The cylindrical epithelium lining the cervix spreads out over the vaginal portion, giving it a raw appearance, which is called an erosion, and sometimes erroneously an ulceration. *True ulceration of the cervix* is seen in chancre, chancroid, tuberculosis, neoplasms, prolapse of the uterus, and after traumatism. In endocervicitis the mucous membrane is often thrown into transverse folds, and the blood vessels may be so dilated as to resemble hemorrhoids. The enlarged glands are often constricted by the increased amount of connective tissue, thus forming retention cysts (ovules of Naboth). The **symptoms** are pain in the back, irregular menstruation, and leukorrhea. The discharge from the cervix is thick and viscid, and this is often sufficient to prevent conception. The cervix is usually enlarged and tender. The changes described above may be made out by palpation and by the use of the speculum.

The **treatment** is attention to the general health, and the use of hot vaginal douches containing sulphate of zinc (one dram to the pint) or corrosive sublimate (1 to 5,000). If stenosed, the cervix should be dilated; if lacerated, sutured. Cysts should be punctured, and the cervix may be scarified if there is much congestion. In some cases it may be necessary to apply tincture of iodin, ichthyol (25 per cent. in lanolin), or silver nitrate (gr. 30 to the ounce) to the cervical canal, following the application by a glycerin tampon. Displacement of the uterus or other complication should of course be corrected. In inveterate cases the uterus should be curetted and packed with gauze, or Schroeder's operation performed.

Chronic corporeal endometritis may follow the acute form, but is more often chronic from the beginning; in the latter instance it is due to the extension of an endocervicitis or vaginitis, or to any condition which induces congestion, e.g., excessive coitus, displacements of the uterus, pelvic tumors, and in fact almost any pelvic disease, as well as tight lacing, and chronic disease of the heart, lungs, liver, or blood. In many of these cases no bacteria can be recovered from the endometrium. According to the tissue more involved the inflammation is designated *glandular* or *interstitial*. When the changes are equally distributed, the mucous membrane is thick, soft, and smooth; when some portions are more involved than others, the surface presents vascular or glandular vegetations (*villous or fungous endometritis*). As in the cervix, the orifices of the glands may be occluded and cysts formed. In *exfoliative endo-*

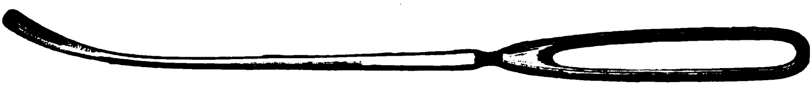


FIG. 516.—Sims' sharp curette.

metritis, or membranous dysmenorrhea, at each menstruation the epithelium is thrown off in shreds, or in one whole piece as a cast of the uterus. The **symptoms** are pain in the pelvis and back, mucopurulent leukorrhea, menorrhagia or metrorrhagia, dysmenorrhea, reflex nervous disturbances, and often sterility or abortions. The uterus is usually enlarged and slightly tender. When the disease occurs after the menopause (*senile endometritis*), the discharge may be retained, giving rise to an offensive odor which suggests malignant disease, a suspicion which may be dispelled by a microscopic examination of the tissue removed by the curette. As in acute endometritis, the inflammation may spread to the extrauterine structures.

The **treatment**, in the absence of acute inflammation in the periuterine structures, is *curettage*. With the patient in the lithotomy position, the anterior lip of the cervix is grasped with tenaculum forceps, and the canal dilated with the glove-stretcher dilator. The curette (Fig. 516) is then introduced and the walls of the cavity systematically gone over several

FIG. 517.—Martin's curette.

times, a grating sensation being imparted to the hand when the mucous membrane has been removed. For curettage of the fundus and cornua the Martin curette (Fig. 517) should be employed. The uterine cavity is irrigated with bichlorid of mercury solution (1 to 10,000) and the vagina filled with sterile gauze. The uterus should not be packed unless there is free bleeding, as the gauze plug interferes with drainage. All gauze should be removed at the end of twenty-four hours, and a daily vaginal douche of bichlorid of mercury (1 to 10,000) given thereafter. The dangers of the operation are perforation of the uterus, inflammation of the adnexa, and peritonitis. The patient should remain in bed one week. The cause of the endometritis, e.g., lacerations, displacements, etc., should, if possible, be removed at the time of the curettage. Strychnin and ergot may be given after operation, in order to encourage contraction of the uterus.

Acute metritis, or inflammation of the uterine muscle, is due to the same causes as acute endometritis, with which it is always associated, and from which it cannot be differentiated clinically. The symptoms and treatment are, therefore, those of acute endometritis.

Chronic metritis, *chronic parenchymatous inflammation of the uterus, diffuse interstitial metritis,* or *subinvolution,* as it is called when following labor, may be due to (a) causes which interfere with normal involution of the puerperal uterus, e.g., retained secundines, cervical laceration, acute endometritis, pelvic inflammation, rising too soon after confinement, nonlactation, and repeated miscarriages; and to (b) causes which produce repeated or protracted congestions, such as chronic endometritis, uterine displacements, pelvic tumors, excessive coitus or masturbation, tight lacing, and chronic disease of the heart, lungs, or liver. At first the uterus is large, soft, tender,

FIG. 518—Anteversion of uterus. (Montgomery.)

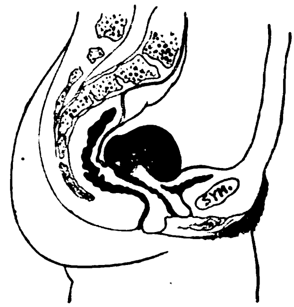


FIG. 519.—Acute anteflexion. (Montgomery.)

and hyperemic, later the connective tissue gradually increases in amount and compresses the blood vessels, rendering the organ hard and anemic. The **symptoms** are those of the complicating chronic endometritis, with a feeling of weight in the pelvis, chronic invalidism, and neurasthenia. The increase in the size, weight, and firmness of the uterus is readily detected by bimanual examination. The cervical canal is dilated and the uterine cavity uniformly enlarged. The complications are displacement of the uterus, chronic endometritis, and extension of the inflammation to the appendages and the peritoneum.

The **treatment** is removal of the cause (displacements, lacerations, tumors, etc.), curettage for the chronic endometritis, copious hot vaginal douches, glycerin tampons, the internal administration of ergot and strychnin, and the general treatment for neurasthenia. The cervix may be scarified, or painted with iodin, or, if it is much enlarged, it may be amputated.

Atrophy of the uterus is normal after the menopause. It may follow destruction or removal of the ovaries, exhausting general diseases, and certain nervous affections. When following labor, it is called ***superinvolution.*** The *symptoms* are amenorrhea, sterility, and reflex nervous disorders. The *treatment* is unsatisfactory. Attention to the general health and electricity locally may be useful.

Displacements of the uterus are pathological when they are more or less permanent and interfere with the normal mobility of the organ. The uterus may be displaced upwards (*ascent*) or downwards (***prolapsus***); it may be tilted (*version*) or bent (*flexion*) forwards (*anteversion or anteflexion*) backwards (*retroversion or retroflexion*), or laterally (*lateroversion or lateroflexion*); it may be turned inside out (*inversion*); and the body may be twisted on the cervix (*torsion of the uterus*). *Dislocation of the uterus* is a displacement of the whole organ, with little or no change in its axis; it may be forwards (*anteposition*), backwards (*retroposition*), or lateral (*lateroposition*). Ascent, lateroversion, lateroflexion, torsion, and dislocation of the uterus are due to exudates or neoplasms which push the uterus, or to adhesions which pull the uterus, into its abnormal position; the treatment is that of the causative lesion.

Anteversion (Fig. 518) may be caused by any condition which increases the weight of the uterus (e.g., metritis and tumors), and by adhesions which draw the fundus forward or the cervix backward. The *symptoms* are those of the causative lesion, with those of pressure on the bladder, i.e., frequent micturition and hypogastric pain. The *treatment* is directed to the condition producing the displacement.

Anteflexion (Fig. 519) is an exaggeration of the normal forward bend in the uterus, with rigidity at the point of flexion. It may be congenital, or the result of metritis, inflammation of the uterosacral ligaments which draws the upper part of the cervix upwards and backwards, irregular involution after labor, or tumors of the fundus. In some cases the uterus falls backwards (*retroversion with anteflexion*). The **symptoms** are dysmenorrhea, sterility, frequent micturition, leukorrhea, and the symptoms of any accompanying inflammation. The cervix is often conical, with a small os, and lies in the axis of the vagina, while the fundus may be felt anteriorly. The condition is differentiated from tumors and exudates in front of the uterus, by definitely locating the fundus by bimanual or rectal examination. The sound should rarely be employed to determine the direction of the canal and the position of the fundus.

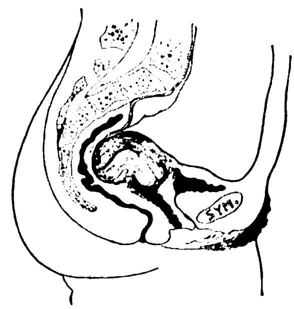


FIG. 520.—Retroversio-flexio. (Montgomery.)

The **treatment** is dilatation of the cervix, curettage of the uterus, and the maintenance of dilatation by the passage of graduated sounds weekly for a month or more. Stem-pessaries and tents are dangerous. Any extrauterine inflammation should of course receive appropriate treatment. *Dudley* splits the posterior lip of the cervix and removes a wedge-shaped piece from each margin of the incision, subsequently uniting the diamond-shaped wound with transverse sutures, thus enlarging the os posteriorly. *Nourse* splits the cervix laterally, and attempts to straighten the uterus by pulling on the posterior lip, which is then sutured in its new position. Others have divided the uterosacral ligaments, or removed a wedge-shaped portion of the posterior wall of the uterus opposite the flexion, the canal being straightened by suturing the incision.

Retroflexion and retroversion are commonly associated, constituting the condition called *retroversio-flexio* (Fig. 520). As a rule the uterus first retroverts, and is later bent backwards by the action of the intraabdominal pressure upon the anterior face of the fundus. The *causes* are subinvolution and relaxation of the ligaments following labor, particularly if the patient gets up too early; violent jars or severe straining; salpingitis, the tubes falling backwards and carrying the fundus with them; pelvic adhesions; tumors of the uterus or tissues in front of it; lacerations of the perineum; and habitually allowing the bladder to become overdistended. Some cases are said to be congenital, the posterior wall of the vagina failing to elongate, thus pulling the uterus backward. The uterus is usually enlarged and congested, and there is practically always a complicating endometritis. **Symptoms,** in the absence of complications, are often absent. In a typical case there is lumbosacral pain, occipital headache, a feeling of weight in the pelvis, leukorrhea, menorrhagia, dysmenorrhea, frequent micturition from pressure of the cervix on the bladder, constipation and hemorrhoids from pressure on the rectum, sterility or abortions, and neurasthenia or hysteria. On examination the uterus is found low in the pelvis, the cervix often pointing forward, and the fundus is found posteriorly. In tumors or exudates in Douglas's *cul de sac,* and in feces in the rectum, the fundus is found anteriorly, a fact which may, if necessary, be verified with the sound. The direction of the cervix is not of much value in differential diagnosis. Feces have a doughy feel and can be identified by passing a finger into the rectum.

The **treatment** varies according to whether the retroversion is acute or chronic, and according to the presence or absence of complications. *Acute retroversion,* i.e., occurring after labor, miscarriage, or an accident, should be treated by replacing the uterus, and the assumption of the knee chest posture (Fig. 521) for five minutes night and morning. When involution is complete (six weeks after labor), a pessary may be inserted and worn for several months. About one-third of the cases are thus cured. If the displacement recurs after the removal of the pessary, the patient should be allowed to choose between an operation and the permanent use of a pessary. A *chronic retroversion* without symptoms or complications requires no treatment. If there are symptoms, the patient may choose between operation and the permanent use of a pessary, if such can be worn with comfort. The pessary in chronic cases is to be regarded as a crutch, as it is very rarely curative. Retroversion with complications (lacerations of the cervix or perineum, endometritis, salpingitis, adhesions, etc.) requires operation primarily for the complications, the uterus being brought forward and held in place by some operative procedure at the same sitting.

FIG. 521.—Genupectoral position. (Montgomery.)

Reposition of a retroverted uterus may be effected by placing the patient in the dorsal position, and pressing the fundus upwards with two fingers in the vagina until it can be caught by the external hand, when the vaginal fingers press backwards on the cervix. If the fundus is caught behind the promontory of the sacrum, the cervix may first be drawn downwards with tenaculum forceps. Another method is to place the patient in the Sims or knee chest posture, and then to press the fundus upwards and forwards with two fingers in the vagina until it passes the sacral promontory, when the vaginal fingers draw the cervix backwards. Reposition by introducing a sound into the cavity of the uterus and using it as a lever is dangerous and should not be employed. When the uterus is fixed by adhesions, abdominal section is the best treatment. If the patient refuses this and the surgeon can assure himself that there are no pus collections, gradual reposition may be tried, the adhesions being stretched by gently pushing the fundus upward, and the posterior vaginal fornix then packed with a tampon. This is repeated every forty-eight hours, and when the fundus has ascended well into the abdomen, the tampon is packed into the anterior fornix, in order to press the cervix backwards. Schultze's method of forcibly breaking up the adhesions under an anesthetic is too dangerous to be recommended.

Pessaries are used to hold the uterus in a forward position after it has been replaced. They should be made of hard rubber, and various sizes will be needed for individual cases. Those most commonly employed are shown in Figs. 522, 523, 524. The advantage of the Smith pessary is the bend of the anterior bar, which prevents pressure on the urethra; the Hodge pessary does not possess this bend, but is more useful in a relaxed vagina; the Thomas pessary possesses a broad posterior bar, which more equally distributes pressure, thus avoiding ulceration. A pessary acts by stretching the posterior vaginal wall and pulling the cervix backwards, and not by supporting the fundus of the uterus. It is contraindicated in the presence of acute inflammation, and should be employed only after the uterus has been replaced. It may be impossible to retain a pessary if the cervix is very short or the perineum extensively torn; in the latter instance the difficulty may be remedied by perineorrhaphy, but it is better to perform an operation for the cure of the retrodisplacement at the same sitting. The length and breadth of the pessary needed may be ascertained by passing two fingers well up into the posterior fornix and separating them. The shape of the pessary may be modified after oiling it and heating it over a lamp; it is then rendered firm by plunging it into cold water. The pessary is introduced as follows, the patient being in the dorsal or the Sims position: It is held by its smaller end and the broader extremity passed into the vagina parallel with the labia, pressure being made downwards against the perineum. It is then turned transversely, the broader extremity curving upwards and the narrow end downwards. The index finger of the disengaged hand is passed beneath the pessary and over its inner end, which is thus guided upwards and backwards behind the cervix. The lower end of the pessary should reach the middle of the urethra, and it should be possible to pass the finger-tip between the pessary and vaginal wall at all points; if the pessary is too large, ulceration may follow. The patient should take a daily douche, and the pessary should be removed, cleansed, and reinserted every month or two.

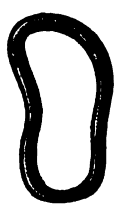


FIG. 522. Hodge pessary.

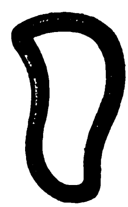


FIG. 523. Smith pessary.

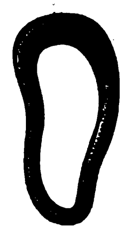


FIG. 524. Thomas pessary.

Operations for retroversion are very numerous and none is ideal. Those which are most frequently employed are Alexander's operation, hysteropexy, and intraabdominal shortening of the round ligaments. **Alexander's operation** consists in opening each inguinal canal as in a hernia operation, and drawing out the round ligaments until the fundus reaches the anterior abdominal wall, the peritoneum being stripped from the ligament as it is pulled outwards. The wounds are closed as in the Bassini operation, the sutures including the round ligament, the excess of which is cut off. The operation is indicated in cases in which the uterus is freely movable, and in which there are no intraabdominal complications. The disadvantages are its limited field, the difficulty sometimes encountered in finding the ligaments, the occasional breaking of a ligament, and the possibility of hernia from the pulling out of a pouch of peritoneum, an accident which can always be avoided.

Hysteropexy, *hysterorrhaphy*, or *ventral suspension*, is performed through a small median abdominal incision or through the *Pfannenstiel incision*. The latter runs in a slight curve, with the convexity downward, within the hair line of the pubes and across the recti muscles. The skin and the anterior sheaths of the recti are dissected up as one layer, the recti separated in the direction of their fibres, the transversalis and the peritoneum opened by a vertical cut. This incision leaves an inconspicuous cicatrix, and is a safeguard against hernia. It is particularly indicated in conservative operations; contraindicated in suppurative lesions, because of the extensive dissection of the cellular tissue. In hysteropexy the uterus is brought forward and the fundus sutured to the lower angle of the wound by two silk sutures, each passing through the peritoneum and subperitoneal connective tissue and the fundus, the first on a line with the Fallopian tubes, and the second about one-third inch posteriorly, thus anteverting the uterus. In time the uterus recedes from the abdominal wall by stretching the bond of union, thus forming an artificial ligament. The operation allows the separation of adhesions and the treatment of other intraabdominal complications, but has the disadvantages of occasionally interfering with labor, and of forming a band, about which intestinal strangulation may occur. *Ventrofixation* is a term applied to the same operation when the sutures fixing the uterus pass through the muscles and aponeurosis of the abdominal wall; it should never be employed unless the ovaries have been removed or the menopause has arrived.

Intraabdominal shortening of the round ligaments possesses the advantages of hysterorrhaphy and the Alexander operation and the disadvantages of neither. Operations which shorten these ligaments by folding them on themselves, by fastening them to the anterior surface of the uterus, or by drawing them through the broad ligament and fastening them together behind the uterus, are objectionable in that the greatest strain is brought to bear upon the weakest portion of the round ligament in the inguinal canal. The *Gilliam-Ferguson* operation utilizes the strongest part of the ligament. After opening the abdomen in the median line a pair of forceps is pushed through the outer edge of the rectus muscle, and the round ligament grasped about two inches from its uterine end; the forceps is withdrawn, and the ligament sutured to the fascia covering the rectus muscle. *Montgomery* has modified the Simpson operation. A silk ligature is passed beneath each round ligament about one and one-half inches from the uterus. The two ends of the ligature are threaded into a pedicle needle, which is introduced between the layers of the broad ligament, and carried forward extraperitoneally until it reaches the outer border of the rectus muscle, through which it is thrust, the round ligament being rendered taut to facilitate this maneuver. The ligature is withdrawn from the needle, and serves to pull the ligament through the abdominal wall, where it is fastened with catgut sutures. As there is some danger of hernia occurring at the point where the round ligament passes through the rectus, we have further modified this operation by carrying the ligament between the rectus and its superficial sheath, to the median line, where it is sutured to its fellow.

Prolapse or descent of the uterus is divided into three degrees, (1) retroversion with sinking of the organ in the pelvis, (2) presentation of the os at the vulva, and (3) prolapse of the uterus between the thighs. The first and second are called *incomplete*, the last *complete prolapse, or procidentia*. The *causes* are (1) lack of support due to relaxation of the uterine ligaments or of the pelvic floor, particularly following laceration of the perineum; (2) increased weight of the uterus, especially subinvolution after labor; and (3) increased intraabdominal pressure, such as is produced by straining, lifting heavy weights, improper clothing, and abdominal tumors. Occasionally prolapse is suddenly produced by a severe injury, such as a crush, or a fall from a height. The **symptoms** in an acute case are severe pain, and possibly internal hemorrhage and peritonitis. In the ordinary chronic form there are first rectocele and cystocele, then retroversion and gradual descent of the uterus, which causes a dragging sensation in the pelvis and back, dysuria, and constipation; in complete prolapse there may be difficulty in walking, and ulceration of the protruding mass is not uncommon. As chronic endometritis is always present the symptoms of this affection are added to those just mentioned. In *pseudoprolapse*, or hypertrophy of the

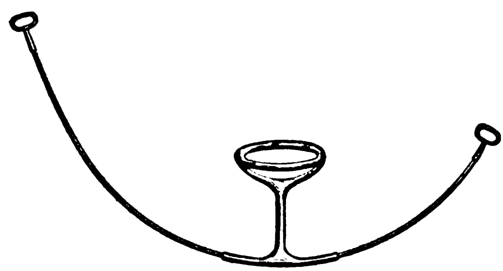


FIG. 525.—Goddard pessary.

cervix, the fundus is found in its normal situation and the vaginal walls are not displaced. *Inversion* of the uterus presents no os, but shows the orifices of the Fallopian tubes; it is smaller above than below, and on bimanual examination a depression is found in the region where the fundus ought to be.

The **treatment** is reduction of the prolapse, and maintenance of the uterus in its normal position by pessaries or by operation. Reduction is occasionally difficult because of edema; strangulation with gangrene of the uterus has occurred in rare cases. If edema prevents reduction, multiple punctures should be made, cold compresses applied, and the foot of the bed elevated for some hours. Pessaries are not curative, but may be employed if the patient refuses operation, or if operation is contraindicated. If the perineum is intact, a retroversion pessary may be tried, or if this fails, a ring pessary. When pessaries of this character cannot be retained, the uterus may be held up by a cup and stem pessary (Fig. 525) which is fastened to an abdominal belt. The *operative treatment* consists in curettage, amputation of the cervix to lessen the weight of the uterus, anterior colporrhaphy and perineorrhaphy to narrow the vagina and support the uterus, and intraabdominal shortening of the round ligaments before, and ventrofixation after, the menopause. If the uterus is badly diseased or contains "fibroids" a supravaginal hysterectomy may be performed and the stump sutured to the abdominal wall. Watkins and Wertheim have recently revived vaginal fixation of the uterus in the treatment of prolapse after the menopause. The anterior vaginal wall is incised longitudinally, the bladder separated from the vagina and the uterus by blunt dissection, and the vesicouterine fold of peritoneum opened. The fundus of the uterus is then brought down into the vagina, the vesical fold of peritoneum sutured to the posterior surface of the uterus near the cervix, and the fundus attached to the vaginal flaps near the urethra. The incision in the vagina is now closed by suturing the flaps together. Thus the uterus, turned upside down, lies between the bladder and the anterior wall of the vagina.

Inversion of the uterus is a condition in which the uterus is partly or completely turned inside out. There are three degrees, (1) the intrauterine, in which the depressed fundus does not protrude from the cervix, (2) the intravaginal, in which the fundus protrudes through the cervix, and (3) the extravaginal, in which the inverted uterus protrudes from the vulva. It arises during the puerperium as the result of traction on the cord, or pressure on the fundus of the uterus (*acute inversion*), or in non-puerperal cases as the result of the dragging of a pedunculated intrauterine tumor (*chronic inversion*). An intussusception is thus formed, the depressed portion being swallowed by the undepressed portion. The tubes and ovaries may or may not lie within the inverted uterus. The **symptoms** of acute inversion are pain, shock, hemorrhage, and the detection of a mass in the vagina. Chronic cases develop gradually and are associated with metrorrhagia, leukorrhea, dragging pains in the pelvis and back, and, from pressure on the bladder and rectum, dysuria and constipation. In intrauterine or *partial inversion* a cupping of the fundus may be felt on bimanual examination, and the depressed portion may be detected by a sound in the uterus. When the inversion is *complete*, the mass is detected in the vagina or outside the vulva, the uterus cannot be found in its normal situation, and the cup-shaped depression may be felt on bimanual examination. A sound, or, better, the finger, may be passed around the tumor, but will enter the cervix for a short distance only, or not at all. The mass is sensitive, bleeds easily, is larger below than above, and may show the orifices of the Fallopian tubes. The condition must be differentiated from prolapse (q.v.) and from polypi. In the latter the uterus is in its normal situation, and a sound cannot be passed all around the base of the tumor, but enters the uterine cavity at one side and reveals it to be of normal or increased depth.

The **treatment** is reduction, usually with the aid of a general anesthetic. Emmet's method consists in passing the fingers around the tumor and into the cervix, in order to press upon the fundus with the palm of the hand while the fingers dilate the cervical ring, counterpressure being made with the other hand through the abdominal wall. Noeggerath pushes on one horn of the uterus with the finger, thus reinverting the fundus and finally the body. Prolonged pressure on the fundus may be employed by gauze packing or an elastic vaginal bag. Special apparatus also has been invented to make pressure on the fundus and pull down the cervix. If these measures fail the posterior lip of the cervix may be cut through in the median line, the uterus reduced, and the cervical wound sutured. Other operations for this condition are stretching of the cervical ring through an abdominal incision, and reduction by traction on the fundus; opening the peritoneal cavity through the mass, followed by dilatation of the cervical ring, suture of the wound, and reposition of the uterus; and vaginal hysterectomy.

Fibromyomata or "fibroids" of the uterus are slow-growing, encapsulated tumors composed of fibrous and muscular tissue, the fibrous tissue being in excess. When the muscular tissue predominates, the term *myofibroma* is applicable. Pure *myomata* are rare, grow rapidly, and are not encapsulated. Fibroids arise during the period of sexual activity, and never before puberty or after the menopause, in fact, subsequent to the climacteric they usually remain stationary or atrophy. They are most frequent in the colored race and in the married, sexual excitement and pregnancy both increasing the rate of growth. Twenty per cent. of all women who have reached the age of thirty-five are said to have fibroids. These tumors are almost always multiple and vary greatly in size. The body of the uterus, particularly the posterior wall, is the favorite situation. According to their relations with the uterine wall, they may be *interstitial*, *submucous*, or *subperitoneal* (Fig. 526); the second and third varieties may be sessile or pedunculated. A pedunculated submucous growth is called a *fibrous polyp*. The uterus is enlarged, and the mucous membrane hypertrophied and sometimes ulcerated. According to the situation of the growth, the uterus may ascend, descend, or be pushed towards one of the walls of the pelvis, while a submucous growth may cause inversion. In 40 per cent. of the cases (Fleck) there is brown atrophy of the heart, a fact accounting for some of the sudden deaths after operation. In 54 per cent. (Tait) there are inflammatory changes in the tubes or ovaries. The changes which may occur in the tumor itself are edema, suppuration, gangrene, calcification, atrophy (especially after castration or the menopause), and fatty, amyloid, myxomatous, cystic, or sarcomatous degeneration (1–2 per cent.). The growth may be associated also with chondroma or osteoma, or carcinoma of the endometrium.

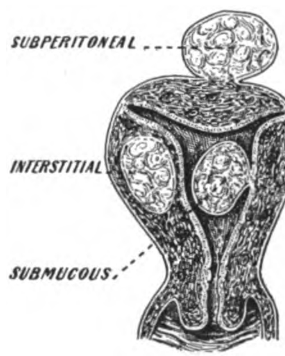


FIG. 526.—Diagram showing the varieties of uterine fibromyomata.

The **symptoms** are (1) hemorrhage (menorrhagia, metrorrhagia, and delayed menopause), especially in the submucous variety; (2) pain due to dysmenorrhea, particularly in submucous growths, or caused by peritonitis or pressure on the pelvic nerves; (3) sterility or miscarriages; and (4) those due to pressure on the urethra or bladder (dysuria, frequent micturition, retention, cystitis), on the ureter (hydronephrosis, pyonephrosis), on the rectum (constipation, tenesmus, obstruction, hemorrhoids), on the pelvic nerves (pain or numbness), on the pelvic veins (varicosities and edema of the leg, phlebitis), and during labor (dystocia). Symptoms may, however, be absent in even large growths. The uterus is irregularly enlarged and often filled with hard masses. A submucous fibroid may be recognized with the sound, or with the finger after dilatation of the cervix. Pregnancy, particularly when associated with bleeding, may be mistaken for a fibroid. In these cases the cervix is softened and the positive signs of pregnancy will sooner or later be detected. It should be remembered that the uterine souffle may often be heard in large fibroids and that intermittent contractions of the uterus can sometimes be felt. Examination with the Röntgen rays may show the fetus after the fourth month of pregnancy. Perhaps Abderhalden's sero-diagnosis for pregnancy may prove of value. In doubtful cases the best diagnostic agent is time. It is not unusual to mistake other tumors or chronic inflammatory troubles of the pelvis for a fibroid. A subperitoneal fibroid with a long pedicle may easily simulate a growth of a neighboring organ.

Treatment is not needed in the absence of symptoms. If symptoms are present the treatment may be palliative or radical. **Palliative treatment** may be indicated if the symptoms are slight, complications absent, and the menopause near. *Drugs* like ergot, hamamelis, hydrastis, thyroid extract, and adrenalin may be given internally for hemorrhage, and such occasionally lessen the size of the growth. *Hygienic treatment* includes rest in bed for a portion of each day, and the avoidance of constipation, coitus, tight corsets, prolonged walking, and, in short, anything which induces pelvic congestion. *Electrical treatment* requires special apparatus, is not free from risk, and should never be used in complicated cases; it is said to reduce the size of the tumor, but is of most value as a hemostatic. The positive pole is attached to a uterine sound, which is passed into the uterus, while the negative pole is placed on the abdomen, the current is then gradually turned on to the point of tolerance and so maintained for five minutes; this may be repeated once or twice a week. *Radiotherapy* (radium, X-rays) has proved of service as a hemostatic agent, and, indeed, according to some enthusiasts, may cause the growth to disappear. *Curettage* followed by packing with iodoform gauze is a valuable measure for controlling hemorrhage. Intrauterine applications of iodin, carbolic acid, and other hemostatics also have been used for the metrorrhagia. *Salpingo-oöphorectomy* checks the bleeding and diminishes the size of the growth, and may be employed in cases in which hysterectomy is contraindicated, because of its difficulty or the general condition of the patient. *Ligation of the uterine arteries* through the vagina is uncertain in its effects and rarely indicated.

Radical treatment is indicated if the tumor is growing rapidly, if the bleeding is severe, or if there are dangerous pressure symptoms or serious complications. Generally speaking, the nearer the menopause, the less the necessity for radical operation. An operation which may be advisable in a working woman who cannot afford to be an invalid, might be postponed or avoided in a woman of means. Radical treatment consists in removal of the growth alone, or the entire uterus, either through the vagina or through the abdomen.

Removal of fibrous polypi when small may be effected with the curette; growths of larger size may be twisted off, or the pedicle may be cut with scissors or with the wire écraseur. Hemorrhage following any of these operations is controlled by gauze packing.

Vaginal enucleation of submucous fibroids may be performed after dilatation or incision of the cervix, the capsule being incised, and the tumor shelled out with the finger or a blunt instrument. If the tumor is too large to be delivered, it may be reduced in size by cutting sections out of it (*morcellement*).

Vaginal hysterectomy is rarely indicated for fibromyomata, as a tumor large enough to demand radical treatment is better dealt with through the abdominal wall. The patient is placed in the lithotomy position, and the cervix exposed by perineal and lateral retractors, and seized with strong tenaculum forceps. The peritoneal cavity is opened by a curved incision behind the cervix and by a curved incision in front of the cervix, care being taken not to injure the bladder. The uterine artery on each side is then ligated, making sure that the ureter is not included in the ligature. The broad ligament between the ligature and the uterus is cut, the uterus drawn further down, and the broad ligament ligated in sections and cut until the uterus is freed. The final ligature is placed to the outer or inner side of the ovary, according to whether it is desirable or not to remove that organ. After separating the cervix from the vagina some operators turn the uterus upside down, thus bringing the fundus into the vagina, and ligate and cut the broad ligament from above downward. Others, instead of ligatures, use clamps which are removed at the end of two or three days; this method facilitates the operation, but increases the danger of secondary hemorrhage. When the uterus is too large to be delivered through the vagina, it may be divided into halves in the median line and each half removed separately, or, if it is still too large, wedge-shaped portions may be excised (*morcellement*) from its center. After removal of the uterus, the peritoneum and vagina may be sutured or the wound filled with gauze.

Abdominal myomectomy consists in exposing the tumor through an abdominal incision, incising its capsule, enucleating the growth, and closing the uterine wound with catgut sutures. The operation is particularly indicated in the young in whom the growths are few and easily accessible. In pedunculated subperitoneal tumors, the pedicle may be ligated if small, or it may be excised by a wedge-shaped incision and the wound in the uterus closed with sutures.

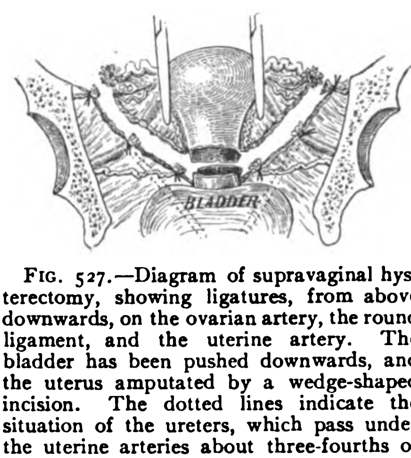


FIG. 527.—Diagram of supravaginal hysterectomy, showing ligatures, from above downwards, on the ovarian artery, the round ligament, and the uterine artery. The bladder has been pushed downwards, and the uterus amputated by a wedge-shaped incision. The dotted lines indicate the situation of the ureters, which pass under the uterine arteries about three-fourths of an inch from the cervix.

Abdominal hysterectomy may be partial or complete. *Partial or supravaginal hysterectomy* is the operation of choice in the majority of cases, particularly in large tumors, in the presence of degenerative changes, and when the tubes or ovaries are diseased. If the ovaries are healthy and the patient young, at least one should be preserved, in order to avoid the nervous symptoms induced by an artificial menopause. A median incision is made below the umbilicus, adhesions separated, the uterus delivered through the wound, the foot of the table raised (Trendelenburg posture), the intestines pushed upwards and held in place with gauze pads, and each broad ligament severed after tying the ovarian artery, the round ligament, and the uterine artery, clamps or ligatures being placed on the uterine edge of the broad ligament to prevent reflux hemorrhage. The ligatures are passed through the broad ligament by an aneurysm or pedicle needle and may be of silk or catgut. The ovarian artery may be tied to the outer or the inner side of the ovary, according to whether this organ is to be removed or retained. In securing the uterine artery, the needle must be passed close to the cervix, in order to avoid the ureter. The two incisions in the broad ligaments are now joined by cutting the peritoneum across the uterus just above the bladder, which is pushed downward with the handle of the knife. A similar incision is made posteriorly, and the uterus amputated at the level of the internal os by a wedge-shaped incision (Fig. 527). The cervix is now closed with catgut sutures, and the peritoneum approximated over the stumps of the arteries and the cervix by a continuous catgut suture. The abdomen is closed without drainage. *Complete hysterectomy*, or *panhysterectomy*, is to be preferred if there is associated malignant disease or infection of the tumor, or fibroid growths in the cervix. The broad ligaments are ligated and divided and the bladder stripped from the cervix, as in the previous operation. An incision is then made into the vagina through Douglas's *cul de sac*, and, aided by a finger passed through this opening into the vagina, the incision is continued all around the cervix and the uterus removed. The opening in the vagina is then closed by sutures, or it may give exit to a gauze drain if such be needed. When there are intraligamentary fibroids, it is often better to sever first the broad ligament on the unaffected side, then to cut through or around the cervix, and ligate and divide the opposite broad ligament from below upwards while the uterus is rolled strongly towards the affected side; by this procedure an intraligamentary growth is turned out of its bed and the danger of injury to the ureter minimized.

Polypi of the uterus are pedunculated tumors springing from the mucous membrane of the body, or more frequently the neck of the uterus. *Fibrous polypi* have been considered above. *Mucous polypi* are soft red growths composed of mucous membrane. *Pedunculated Nabothian follicles* are retention cysts of the cervical glands which have acquired pedicles. *Placental polypi* are undetached portions of the placenta which retain a vascular connection with the uterus. *A papillomatous polypus* may spring from the cervix, and is very apt to become malignant. The **symptoms** are bleeding, leukorrhea, cramp-like pains due to the expulsive efforts of the uterus, dysmenorrhea, and sterility. When the polypus protrudes from the os, it is easily detected with the finger and the speculum. Before this time it may be overlooked, but may be recognized either with the sound, or with the finger after dilatation of the cervix. The **treatment** is removal by seizing the tumor with a pair of forceps, and twisting it until the pedicle gives way, or the pedicle may be cut with scissors, the galvano-cautery, or the wire écraseur. Small soft polypi may be removed with the curette. In all cases the growth should be studied microscopically to exclude malignant disease.

Sarcoma of the uterus is uncommon, is most frequent in the body of the uterus, and is often a degenerative process in a fibromyoma. It is usually of the spindle-celled variety, and has the same tendencies here as elsewhere. The symptoms are pain, uterine hemorrhages, watery leukorrhea, emaciation. a rapidly growing tumor, and in some cases ascites. A fibroid which grows rapidly, continues to increase in size after the menopause, or which recurs after removal, strongly suggests sarcomatous degeneration. The *treatment* is complete hysterectomy.

Carcinoma of the uterus is the most frequent form of malignant disease in the human body. It is most common after the fortieth year, but may arise in early life. The influence of heredity is doubtful, but any local irritation, such as laceration of the cervix, polypus, and chronic endometritis, favors its development. In over 80 per cent. of the cases the disease originates in the cervix. It may be squamous-celled (*epithelioma*) when springing from the vaginal portion of the cervix, or cylindrical-celled (*adenocarcinoma*) when attacking the cervical canal or corporeal endometrium. *Epithelioma of the cervix* begins as a nodule in the vaginal portion of the mucosa, from which, after a time, finger-like projections spring, forming a cauliflower-like mass; or as the result of necrosis, the growth appears as an excavated ulcer with hardened everted edges. Extension is most rapid in the direction of the vagina, and the growth involves the bladder at an early period. *Adenocarcinoma of the cervical endometrium* soon causes enlargement of the cervical canal, either by ulceration, or by pressure from papillary growths. The disease is prone to extend outward into the parametrium along the bases of the broad ligaments, and upward into the body of the uterus, long before it invades the vaginal portion of the cervix; the bladder, and less frequently the rectum, may be involved in the later stages. *Cancer of the fundus* projects into the uterine cavity as a fungous mass, which ulcerates, and extends through the uterine wall to the environing structures. Cancer of the uterus in most instances involves the regional lymph glands, only after it has extended to the parametrium; this is said to be due to the small size of the lymph vessels of the uterus and the large size of the epithelial cells. Metastases to distant portions of the body are therefore comparatively infrequent. Unchecked, the disease is usually fatal in from six months to two years.

The **symptoms,** in the usual order of their appearance, are hemorrhage, offensive discharge, pain, and cachexia. Pain is often absent until the peritoneum or parametrium is involved, while cachexia is often postponed until near the end; consequently to wait for these signs before making a diagnosis is usually to wait until the case is inoperable. Pressure symptoms similar to those induced by fibromyomata (q.v.), and urinary or fecal fistulæ from ulceration involving the bladder or rectum may arise in the final stages. Epithelioma of the vaginal portion of the cervix can be recognized with the finger or speculum, as a friable, fungating, easily bleeding mass. In carcinoma of the cervical canal the cervix is enlarged, firmer than normal, and sometimes infiltrated with nodules, and the growth may be felt by inserting the finger into the cervical canal. Cancer of the fundus causes enlargement of the uterus and may be felt with the sound. In doubtful cases a portion should be removed for microscopic examination, by excision when the disease is in the cervix, and by the curette when in the body of the uterus. Menorrhagia at, or metrorrhagia subsequent to the menopause, is so strongly suggestive of cancer, as to demand a most careful investigation, including microscopic examination of suspected tissue.

The **treatment** is palliative or radical. **Palliative treatment** is indicated in inoperable cases, which, unfortunately, constitute the vast majority of those coming under observation. When the uterus is fixed in the pelvis, indicating invasion of the parametrium, or when the bladder or rectum is involved, radical operation is generally contraindicated, although attempts are sometimes made to remove a portion of all these structures with the uterus. Hemorrhage and discharge are greatly lessened, and life prolonged, by removing as much of the growth as possible with a curette, and cauterizing the raw surfaces with the Paquelin cautery; the cavity is filled with iodoform gauze, which is removed at the end of twenty-four hours, and douches of permanganate of potassium, creolin, or other antiseptic deodorant given daily. Care should be taken not to perforate the uterus during this operation. Instead of, or in addition to the Paquelin cautery, some surgeons insert into the cavity a tampon containing a 50 per cent. solution of chlorid of zinc, which is allowed to remain several days. The vagina should first be coated with an ointment consisting of one part of sodium bicarbonate to three parts of vaselin. Radiotherapy may lessen the discharge, the fetor, and the pain. Nothing short of opium is of value for the excruciating pain in the later stages.

Radical treatment consists in removal of the uterus through the vagina, through the abdomen, or by the combined method. *Vaginal hysterectomy* may be employed when the vagina is large, the uterus small, and the patient very stout. The operation is similar to that already described for fibromyoma, except that any protruding carcinomatous tissue should first be removed with the curette and the cervix closed with sutures, and hemisection of the uterus or morcellation should never be employed. *Complete abdominal hysterectomy* is the operation of choice, as it allows the wide removal of the parametrium and of any enlarged retroperitoneal lymph glands. The operation is identical with that described for fibroids, except that the uterus should first be curetted, packed with gauze, and the cervix closed with sutures, in order to prevent infection of the peritoneum when the vagina is opened, and the uterine arteries should be ligated, not close to the cervix, but to the outer side of the ureters. *Combined vaginal and abdominal hysterectomy* is preferred by some operators. The cervix may be isolated from the vagina and the operation completed through the abdomen; or the broad ligaments may be tied and divided from above, the abdomen closed, and the operation completed through the vagina. The mortality of hysterectomy for carcinoma is from 10 to 20 per cent. The chances of permanent cure are about 5 per cent. in carcinoma of the cervix, and about 75 per cent. in carcinoma of the fundus.

Endothelioma of the uterus is rare and cannot be differentiated clinically from carcinoma. The *treatment* is complete hysterectomy.

Chorio-epithelioma, *deciduoma malignum*, or *syncytioma malignum*, is a malignant growth springing from the chorionic epithelium following pregnancy. The growth resembles placental tissue infiltrated with blood. The *symptoms* usually arise a few weeks or months after a normal labor or an abortion, particularly if there has been a hydatidiform mole. There are metrorrhagia and a foul smelling, watery discharge, and later pain. The os is dilated, and the uterus large and its cavity filled with a friable, purplish mass, which recurs after removal, extends to the surrounding parts, and quickly gives rise to distant metastases. The diagnosis is made with the microscope. The *treatment* is immediate complete hysterectomy.

DISORDERS OF MENSTRUATION.

Amenorrhea, or absence of menstruation, is normal before puberty, after the menopause, and during pregnancy and lactation. The *pathological causes* are atresia of the genital canal (*concealed menstruation*), non-development or atrophy of the generative organs, destruction of the ovaries and tubes by disease or their removal by operation, obesity, emotional disturbances, hysteria, neurasthenia, debilitating diseases, change of climate, catching cold during menstruation, opium and other drug habits, hypothyroidism, hypopituitarism, and most frequently of all chlorosis. The treatment is that of the cause. Suppression of the menses due to cold is treated by hot drinks and hot applications. Emmenagogues are rarely indicated, and should never be employed unless pregnancy can be positively excluded.

Vicarious menstruation is the periodic discharge of blood from some other part of the body than the uterine mucosa. It may occur from any mucous membrane, the skin, or from an ulcer, and is usually associated with amenorrhea or scanty menstruation. Attempts may be made to induce normal menstruation by hot douches, electricity locally, and the internal use of emmenagogues, such as iron, oxalic acid, aloes, apiolin, or the salicylates. Irritating applications to the endometrium are dangerous.

Menorrhagia is prolonged or increased menstrual bleeding. **Metrorrhagia** is bleeding from the uterus between the menstrual periods. Among the *local causes* are inflammatory diseases, displacements, injuries, and neoplasms of the uterus or appendages, foreign bodies in the uterus, pelvic tumors not connected with the uterus, placenta previa, detachment of the placenta, hydatidiform degeneration of the chorion, ectopic pregnancy, abortion, sclerosis of the uterine vessels, and most common of all fungous endometritis. Among the *general causes* are anemia, hemophilia, acute infectious diseases, emotional disturbances, gout, scurvy, malaria, lead poisoning, and diseases of the heart, lungs, and liver. Hyperthyroidism should probably be included among these causes, also, from a theoretic standpoint, hyperpituitarism, although positive evidence of the influence of the latter on the menses is lacking.

The **treatment** is that of the cause. In an emergency the bleeding may be checked by packing the uterus tightly with gauze, while ergot, hydrastis, or suprarenal extract may be given internally. Uncontrollable bleeding at the menopause may demand hysterectomy.

Dysmenorrhea is excessive pain just before, during, or immediately after the menses. Like amenorrhea, menorrhagia, and metrorrhagia, dysmenorrhea is a symptom, not a disease. The following varieties are described:

Neuralgic dysmenorrhea is most frequent in the anemic and nervous, and may or may not be associated with disease of the pelvic organs. The pain is neuralgic in character, and may be referred to the uterus, to the ovaries, or elsewhere. It is apt to be most severe before, and is occasionally relieved by the flow. There may be neuralgia in other parts of the body. The *treatment* is attention to the general health, anemia, gout, rheumatism, or indigestion being relieved by appropriate remedies. Any local disease should be removed, and the pain itself relieved by hot applications and the administration of antineuralgic remedies like acetphenetidin, cannabis indica, and belladonna; elixir of valerianate of ammonium (f℥ ii) or fluid extract of viburnum prunifolium (f℥ i), every three or four hours, is frequently employed. In cases which resist all other forms of treatment, removal of the ovaries may be indicated.

Congestive dysmenorrhea is due to exposure to cold, uterine displacements, pelvic tumors, and inflammations of the uterus, the appendages, or the environing structures. These conditions, excepting the first, cause intermenstrual symptoms and may be recognized by pelvic examination. The symptoms are worst at the beginning of menstruation, and are often relieved by a free flow. The treatment during the attack is hot applications, hot sitz baths, diuretics, and diaphoretics. Between attacks the cause should be removed.

Mechanical or obstructive dysmenorrhea is due to some obstruction to the egress of menstrual fluid, such as stenosis of the cervix, flexions of the uterus, tumors (particularly polyps), and spasmodic contraction of the internal os. There are severe, cramp-like pains (*uterine colic*), followed by a gush of blood or the expulsion of clots, which usually gives relief. Between the periods the passage of a sound may reveal hyperesthesia of the endometrium, particularly about the internal os. The *treatment* is dilatation of the cervical canal if there be stenosis, and curettage of the uterus if there be endometritis. Polypi should, of course, be removed. The treatment of flexions has already been considered. Obstructive dysmenorrhea is often cured by labor, which permanently dilates the cervical canal.

Ovarian dysmenorrhea is associated with disease of the ovaries, the symptoms referable to these organs being intensified during the menstrual period. The *treatment* is that of the causative lesion.

Membranous dysmenorrhea is characterized by the expulsion of a membrane, the decidua menstrualis, either in shreds or as a cast of the uterus. It is differentiated from an early abortion by its regular occurrence, and by the absence of chorionic villi in the membrane. It is a form of endometritis, and is usually associated with sterility. The *treatment* is dilatation and curettage, which may require repetition.

Sterility in the female is normal before puberty, after the menopause, and during lactation, although conception may occur during any of these periods. At other times it may be due to preventive measures, vaginismus, displacements or atrophy of the uterus, laceration of the perineum sufficiently severe to interfere with retention of semen, or to congenital defects, stenosis, atresia, fistulæ, neoplasms, or inflammatory diseases of any portion of the genital tract. Among the general conditions which may be responsible are anemia, debilitating diseases, obesity, gout, syphilis, locomotor ataxia, myelitis, hypothyroidism, hypopituitarism, prolonged use of certain drugs (alcohol, arsenic, bromides, chloral, cocain, camphor, opium), and lack of affinity between the male and female. It should be recalled that in about one-fifth of the cases the fault lies with the male, hence in order to be complete, an investigation for the cause of sterility should include an examination of the male sexual organs, the microscopic examination of the semen for spermatozoa, and an inquiry into the potency of the male. (See impotency and sterility in the male). The *treatment* is that of the cause.

THE FALLOPIAN TUBES.

Congenital Anomalies.—The tubes may be absent or rudimentary, they may have accessory fimbriated extremities, and the tubal ducts may be doubled on one or both sides.

Displacements are usually downwards and backwards as the result of inflammatory trouble. The tubes accompany displacements of the uterus or ovaries, and may be pushed in any direction by tumors.

Salpingitis, or inflammation of the Fallopian tube, is usually the result of extension upwards of an endometritis; its causes, therefore, include those of endometritis, particularly gonorrhea, the use of septic instruments, and sepsis following labor or abortion; occasionally the inflammation extends from the peritoneum or neighboring organs other than the uterus, and infection is sometimes conveyed to the tube by the blood or lymph vessels. The organism most frequently found is the gonococcus, and next, in the order of their frequency, the streptococcus, tubercle bacillus, colon bacillus, staphylococcus, and pneumococcus. In most of the tubes removed at operation, cultures are negative, the organisms having perished. The inflammation first involves the mucous membrane, then spreads through the outer walls to the peritoneum and closes both ends of the tube. The secretions accumulate and distend the tube, particularly the outer two-thirds. The walls may be either thinned or thickened. The tube is distorted, adherent to adjacent structures, and commonly displaced downwards and backwards, although it may remain in its normal situation or be displaced even forwards. *Hydrosalpinx*, or distention of the tube with serum or mucus, is the result of a catarrhal inflammation; such a sac may empty itself intermittently into the uterus (*hydrops tubæ profluens*). *Hematosalpinx* is distention of the tube with blood, as the result of inflammation, tubal pregnancy, torsion of the tube, or atresia of any portion of the genital tract. *Pyosalpinx* is distention of the tube with pus, which may rupture into the bowel, bladder, vagina, or into the peritoneal cavity, in the last instance causing a pelvic abscess or a generalized peritonitis. Leakage of the pus from the abdominal ostium also may occur, and rarely the infection spreads downwards between the layers of the broad ligament, giving rise to pelvic cellulitis or abscess of the broad ligament.

The **symptoms** are pain in the lower abdomen, most marked just above Poupart's ligament, and increased by walking, jolting, or straining; leukorrhea; dysmenorrhea; menorrhagia; sometimes metrorrhagia; usually sterility; and disturbances of the general health. There are often backache, rectal pain intensified at stool, and sometimes pain in distant parts, such as the head, the breast, the epigastrium, or the thighs. In pyosalpinx there may be repeated attacks of pelvic peritonitis with septic symptoms. On bimanual examination, pressure on the uterus, or in the lateral or posterior fornix, causes pain; the uterus is usually retroverted and adherent, and the distended tubes are felt behind or to the sides of the uterus.

The **treatment** may be medical or surgical. *Medical treatment* is indicated during the acute stage, during acute exacerbations of a chronic inflammation, and in chronic cases in the absence of suppuration. In the presence of acute symptoms with fever, the patient should be confined to bed and be given a liquid diet. An ice bag should be applied to the hypogastrium, copious, hot vaginal douches given twice a day, and the bowels thoroughly moved with salts. Depletion may be secured also by scarification of the cervix and glycerin tampons. In severe cases anodynes and stimulants will be required. When the acute symptoms have subsided, absorption of the exudate may be encouraged by the application of iodin to the vaginal fornices, and by the pressure of tampons containing glycerin or ichthyol, which should be removed in forty-eight hours, a copious hot douche taken, and the tampons reinserted. In selected cases curettage of the uterus is beneficial, although it occasionally stirs the chronic inflammation to renewed activity.

The surgical or radical treatment of salpingitis is indicated in the presence of pus, and in cases in which medical treatment fails to give relief; in other words in the large majority of cases. The tubes may be exposed for operative attack through the vagina or through the abdomen. In *vaginal section* the intestines and ureters are more apt to be damaged, bleeding is more difficult to control, secondary hemorrhage is more frequent, the general peritoneal cavity cannot be protected, and disease of environing organs, particularly the appendix, cannot be treated satisfactorily; it is, therefore, seldom indicated. *Abdominal section* is always more or less exploratory in these cases, and the surgeon should secure permission to do that which in his judgment seems best. The abdomen is opened by a median incision below the umbilicus, the table raised to the Trendelenburg posture, and the operative field isolated with gauze. After identifying the fundus of the uterus, two fingers are insinuated downwards along its posterior surface and adhesions separated in the lines of least resistance, the fingers passing outwards and usually unrolling the tube from below upwards. Adhesions may require the use of scissors and the application of ligatures. Should pus appear at any time, it is caught with sponges and the table immediately lowered, while any unavoidable injury to the bowel should be closed at once with sutures. As a rule both tubes and ovaries will be so extensively diseased as to require removal (*salpingo-oöphorectomy*). This may be done by passing a pedicle needle armed with silk or catgut through the broad ligament and below the round ligament (Fig. 528); the loop of the ligature is cut, one-half tied around the tube close to the uterus, and the second beneath the ovary. The ends of one of these ligatures may be left long and again carried around the pedicle and tied, always using a surgeon's knot first and then a single knot. The tube and ovary are then amputated above the ligatures, leaving sufficient tissue to prevent slipping. This method is easy and quick, but may be followed by secondary hemorrhage, as the ligatures are apt to loosen from shrinkage of the stump or to cut through the friable tissues; moreover, the large area left uncovered by peritoneum predisposes to adhesions and intestinal obstruction. A better way is to pass a ligature through the broad ligament to the outer side of the ovary, thus including the infundibulo-pelvic ligament and the ovarian artery. A second ligature is then placed in the angle between the round ligament and the uterus, securing the upper end of the uterine artery (Fig. 528). The tube and ovary are removed by cutting close to them with scissors, the uterine end of the tube being amputated by a wedge-shaped incision. The wound in the uterus and broad ligament is now closed with a continuous catgut suture. When both tubes and ovaries are excised, some operators advise a supravaginal amputation of the uterus, in order to remove all the infected structures, and likewise prevent the adhesions which necessarily form between the intestines and the raw posterior surface of the uterus. If the ovaries are normal they should be allowed to remain, the ligature securing the ovarian artery being placed to the inner side of the ovary. Occasionally only the outer two-thirds of the tube will require removal, the mucous membrane of the remaining portion being sutured to the peritoneum, in order to allow the passage of ova. In cases of sterility due to closure of the abdominal ostium, *salpingostomy* may be performed if the tube is fairly healthy. The outer end of the tube is opened, and its mucous membrane sutured to the peritoneum with catgut. When the tubes are neither seriously altered in structure nor occluded, but simply prolapsed and adherent, the adhesions may be separated, and the tubes retained in their normal position by shortening the infundibulo-pelvic ligaments, or by performing one of the

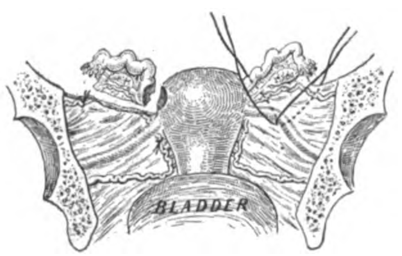


FIG. 528.—Methods of ligation in salpingo-oöphorectomy. On the right mass ligation of the broad ligament. On the left ligation of the individual vessels, with wedge-shaped amputation of the tube; the wound in the uterus and broad ligament is closed with a continuous catgut suture.

operations for retroversion. Drainage is rarely needed after operations for salpingitis, but may be required for continued oozing from adhesions, or in cases in which the infection is active. The best drain for these cases is gauze surrounded by rubber tissue, the drain gaining exit through the abdominal wound, or better, through the posterior vaginal fornix.

Tuberculous salpingitis is the most frequent form of genital tuberculosis; it is usually bilateral and secondary to tuberculosis elsewhere, but may be primary, the bacilli being conveyed to the tubes from the endometrium or peritoneum, or through the blood or lymph vessels. The tubes are usually distended with pus or cheesy material, and give rise to symptoms similar to those of other forms of salpingitis. The condition may be suspected if there is tuberculosis elsewhere in the body, if evidences of other forms of infection are absent, if there is an encysted ascites, and if on bimanual examination the tubes are nodular and only slightly sensitive. Tubercle bacilli have been found in the discharge from the uterus. The *treatment* is salpingo-oöphorectomy.

Neoplasms of the tubes include papilloma, carcinoma, fibromyoma, lipoma, dermoids, lymphangioma, enchondroma, and sarcoma. These growths are rarely recognized until after abdominal section for their removal.

Extrauterine or ectopic pregnancy occurs about once to every 500 intrauterine pregnancies. The *causes* are not clear, but it is supposed to be due to an unusually large ovum, or to conditions which narrow, elongate, or twist the tube, or destroy the cilia of the mucosa, thus interfering with its peristalsis. Among these conditions are salpingitis, peritoneal adhesions, neoplasms, stenosis or atresia, and tubal diverticulum. According to its situation the pregnancy may be (1) **tubal,** usually in the free portion (*tubal proper*), but occasionally in that part embraced by the uterine wall (*tubo-uterine or interstitial*), or between the tube and the ovary (*tubo-ovarian*); (2) **ovarian,** which is very rare; or (3) **abdominal,** the ovum being fertilized and developing in the peritoneal cavity (*primary abdominal pregnancy*), an event which many believe cannot occur, or escaping from one of the previously mentioned situations and continuing its growth in the abdominal cavity (*secondary abdominal pregnancy*). It is possible for an enlarging ovum in the uterine cavity to break through an old scar in the uterus and thus become abdominal.

Pathology.—In tubal pregnancy the walls of the tube at first thicken, and later become thin and weak owing to distention and to the ingrowth of chorionic villi. The abdominal ostium narrows, and finally closes about the eighth week. Prior to this time the ovum may be extruded from the fimbriated extremity, constituting a *tubal abortion*. If this does not occur, the tube usually ruptures, most often between the eighth and twelfth weeks, either into the peritoneal cavity or between the layers of the broad ligament. In the former event the hemorrhage may be quickly fatal, or, if the rupture is small, the bleeding may be checked by the bulging ovum and a new sac be formed, which in turn is ruptured, either causing a fatal hemorrhage, or again forming a new sac. In rupture between the layers of the broad ligament, the bleeding is limited and seldom directly fatal, unless the broad ligament becomes overdistended and also gives way. Hemorrhage is frequently the result of perforation of the tube by developing villi, instead of rupture. In interstitial pregnancy rupture is often postponed until the end of the fourth month, and occasionally takes place into the uterine cavity. The ovum develops normally until the first hemorrhage, when the fetus usually dies; if the patient survives, the ovum may be absorbed or converted into a tubal mole, or it may cause suppuration. Occasionally the fetus survives, and, particularly in extraperitoneal ruptures, may reach even full development. If the fetus dies after it has attained a large size, it may mummify, calcify (*lithopedion*), be converted into adipocere, or suppurate, the resulting abscess breaking into the peritoneal cavity, rectum, vagina, bladder, or through the abdominal wall. It has been asserted that the placenta may continue to develop after the death of the fetus, but this is doubtful. When the ovum is impregnated, the endometrium forms a decidua, which is often expelled at the time of the tubal abortion or rupture. Bilateral ectopic gestation, coincident intra- and extrauterine pregnancy, and twin or triplet extrauterine pregnancy have all been observed.

Symptoms are often absent until the time of rupture. There is frequently a history of sterility or salpingitis, followed by amenorrhea and the early signs of pregnancy. Tubal abortion or rupture is announced by severe, sharp, often excruciating pain, with shock or syncope, and the symptoms of internal hemorrhage. At this time there will likely be metrorrhagia with discharge of the uterine decidua, either in shreds or as a cast of the uterus. If the patient survives, other attacks usually follow. If the gestation goes to term, spurious labor occurs, and the fetus dies and undergoes the changes mentioned above. The uterus is enlarged, the cervix soft, and prior to rupture the tube is slightly distended. Subsequent to rupture the local signs are those of pelvic hematocele or hematoma (q.v.). The conditions which must be differentiated from ectopic gestation may be grouped under four headings: (1) Uterine pregnancy, pregnancy in a bicornate uterus, and spurious pregnancy; (2) any condition giving rise to a pelvic mass; (3) conditions associated with acute pain, such as appendicitis and other acute intraabdominal diseases; and (4) conditions associated with metrorrhagia, especially abortion, which perhaps is the most frequent condition mistaken for ectopic pregnancy by the general practitioner, because both are preceded by amenorrhea, and in each a decidual membrane is discharged. It is too early to make a dogmatic statement as to the value of Abderhalden's sero-diagnosis in differentiating pregnancy, including the ectopic variety, from other conditions.

The **treatment** before rupture is abdominal section and removal of the affected tube, providing the diagnosis can be made at this time. Electricity, injections into the sac, and other measures of like character for the purpose of destroying the embryo should never be employed. If rupture occurs into the peritoneal cavity, the abdomen should be opened immediately, the tube and ovary on the affected side removed as quickly as possible, liquid and clotted blood washed from the abdominal cavity with salt solution, the abdomen closed without drainage, and the patient treated for shock and acute anemia. To allow the effused blood to remain in the peritoneal cavity causes autointoxication, intestinal paresis, adhesions, and predisposes to peritonitis. In interstitial pregnancy it may be necessary to perform hysterectomy in order to control the bleeding. When rupture occurs between the layers of the broad ligament, if the hematoma is small and there are no constitutional symptoms of hemorrhage, the patient should be put in bed, an ice cap applied to the lower abdomen, and expectant treatment adopted, with the hope that absorption will occur. If the hematoma is large, or if constitutional symptoms of hemorrhage are present, operation is indicated. If a hematoma treated expectantly suppurates, it should be opened through the vagina and drained. In *advanced extrauterine pregnancy*, if the fetus is alive, operation may be delayed until just short of term, with the hope of saving the life of the child. The entire fetal sac should be removed if possible; when this is inadvisable, it should be sutured to the skin and drained. The placenta should, however, be removed if such can be done with safety. Often the fear of a fatal hemorrhage will cause the operator to tie the cord close to the placenta and allow it to come away at a later period. In advanced cases in which the child is dead, the entire sac should be removed or drained, according to indications.

THE OVARY.

The ovaries may be absent or rudimentary, and accessory ovaries have occasionally been observed.

The ovary may be displaced by changes in the position of the Fallopian tube or uterus, by tumors, and by peritoneal adhesions. It may be fixed at a high level, thus corresponding to an undescended testicle, or it may be found in the sac of a hernia. The most important displacement is **prolapse of the ovary** downward into Douglas's pouch. It may be caused by relaxation of the ligaments, especially after childbirth, increased intraabdominal pressure, retrodeviations of the uterus, salpingitis, and by any condition which increases the weight of the ovary, e.g., neoplasms and inflammatory affections. The *symptoms* are those of the causative lesion, with those of pressure on the ovary, viz., dyspareunia, painful defecation, and pain on standing or walking. The diagnosis is made by bimanual examination. The treatment is that of the condition which has caused the prolapse. When due simply to relaxation of the ligaments, without serious changes in the ovary, the infundibulo-pelvic ligament may be shortened, or the ovary sutured to a fixed portion of the broad ligament.

Ovaritis, or inflammation of the ovary, may be acute or chronic.

Acute ovaritis may occur in mumps or other acute infectious fevers, and after the ingestion of metallic poisons, such as arsenic and phosphorus, but it is most frequently secondary to salpingitis, hence due to the same causes. The ordinary phenomena of inflammation are present. The disease may terminate in resolution or in abscess formation, or it may become chronic. The *symptoms* are those of the salpingitis with which it is usually associated; pain, however, is much more intense. Pelvic peritonitis and the constitutional symptoms of sepsis are present in the severer forms. Occasionally the enlarged ovary may be mapped out on bimanual examination, but as a rule all that can be felt is a sensitive mass behind or to the side of the uterus, consisting of tube, ovary, and pelvic exudate. The *treatment* is that of acute salpingitis.

Chronic ovaritis may follow the acute form, or it may be caused by repeated or continued congestion the result of excessive venery, menstrual suppression, displacements of the uterus, pelvic tumors, or inflammatory affections of adjacent organs. In the early stages the ovaries are enlarged and firm (*hyperplastic ovaritis*) and are apt to prolapse behind the uterus. At a later period rupture of the Graafian follicles is hindered by the thickened tunica albuginea and the ovary is filled with small cysts (*cystic ovaries*). In the final stages the connective tissue contracts and renders the ovary small, hard, and fissured (*cirrhosis of the ovaries*). The *symptoms* are pain in the region of the ovary, increased by walking, defecation, coitus, or jolting, and worse at the menstrual periods, which are apt to be profuse and prolonged. Sterility is common, and when the ovaries become cirrhotic, there may be amenorrhea. Hysteria, neurasthenia, and various reflex neuroses are frequent complications. The diagnosis is made by bimanual examination, which is often rendered easier by descent of the ovaries.

The **treatment** is removal of the cause of congestion if possible, attention to the general health, the application of iodin to the vaginal vaults, support of the ovary with a tampon, and hot vaginal douches. If these measures fail to give relief, the ovaries should be removed. Excision of the most diseased portion of the ovary by a wedge-shaped incision followed by suture, puncturing of cysts, and shortening of the infundibulo-pelvic ligament may be beneficial, but such measures are uncertain.

Tuberculosis of the ovary is almost always secondary to tuberculosis of the Fallopian tube or peritoneum, and the infected ovary should be removed when the disease in these situations is attacked.

Atrophy of the ovary prior to the menopause may be caused by the pressure of tumors, chronic inflammation, ovarian hemorrhage, varicocele of the broad ligament, superinvolution of the uterus, obesity, diabetes, myxedema, hypopituitarism, and by certain neuroses and exhausting diseases. There is amenorrhea with sterility. The *treatment* is directed to the cause.

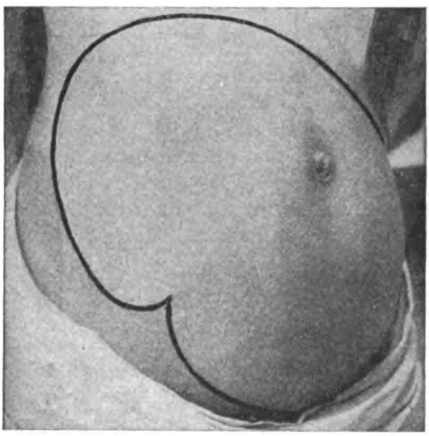


FIG. 529.—Showing outline of sarcoma of right ovary. (Polyclinic Hospital.)

Ovarian hemorrhage may take place into the follicles or stroma of the ovary, as the result of congestion or inflammation, and is called *ovarian apoplexy*. When the hemorrhage is diffuse, the whole organ may be converted into a blood sac (*hematoma of the ovary*), which may rupture into the peritoneal cavity, resulting in the formation of a hematocele, or occasionally causing death from hemorrhage. These cases are usually mistaken for ectopic pregnancy. Small hemorrhages are of little importance, but profuse bleeding demands abdominal section and removal of the ovary.

Tumors of the ovary include the fibroma, myoma, fibromyoma, sarcoma, papilloma, carcinoma, and endothelioma. All of these growths are comparatively rare, and the malignant are more frequent than the benign varieties. Carcinoma is usually secondary, but may be primary, and is commonly of the medullary variety. Sarcoma (Fig. 529) is the most frequent neoplasm, is usually of the spindle-celled variety, and may occur in childhood. The ovary rapidly enlarges, sometimes reaching an enormous size, but retains its shape and presents a smooth surface. Ascites is common and the other ovary is usually involved. The symptoms of tumors are those of cysts of the ovary. Rapid growth and ascites always suggest malignancy. The *treatment* is removal of the ovary; the opposite organ should always be excised in sarcoma, as it, too, is generally sarcomatous.

Cysts of the ovary and parovarium may be found at any time of life, but are most frequent between the ages of twenty and fifty. The etiology is obscure; some are undoubtedly the result of inflammation. Fig. 530 shows the areas in and about the ovary in which cysts develop. The *hydatid of Morgagni*, representing the closed extremity of Müller's canal, is a small cyst which may be regarded as normal.

Cysts of the oöphoron, or egg bearing portion of the ovary, are of several varieties. *Simple or follicular cysts* (*hydrops folliculorum*) are dilated Graafian follicles; they are unilocular, multiple, and usually bilateral and of small size, but occasionally may be as large as, or larger, than a man's head. The cyst replaces the ovary, and has a thin wall and serous contents. *Cysts of the corpus luteum* are unilocular and rarely larger than an orange. Microscopic ex-

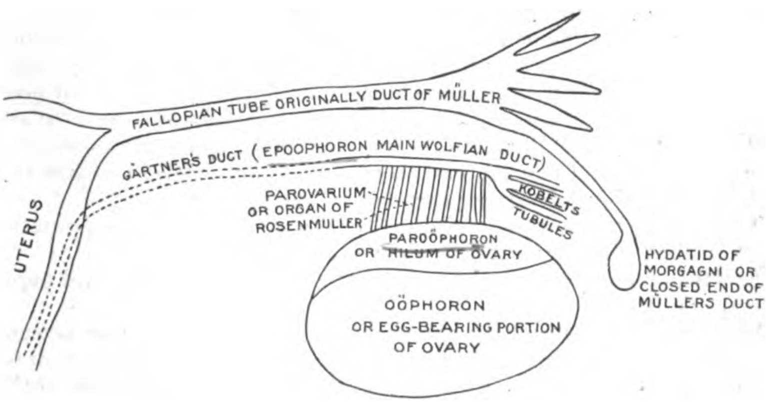


FIG. 530.—Diagram showing structures from which cysts arise.

amination of the wall demonstrates the bud-like papillæ characteristic of the corpus luteum. *Cystadenoma* (*glandular proliferating cyst*) springs from the parenchyma of the ovary and may attain an enormous size. It is always multilocular, and sometimes resembles a honeycomb on section, the walls being made up of altered glandular tissue. Unilocular cysts of this variety are due to absorption of the partition walls. The contents may be thin or gelatinous, and light yellow, green, purple, or black in color; the contents of the different loculi in the same cyst usually vary in color and consistency. Occasionally the cysts contain papillary growths. *Dermoids* containing epiblastic derivatives, such as hair, teeth, etc., occur in the ovaries, as well as *teratomata*, which contain tissues from all the blastodermic layers. Dermoids have dense walls, and, because of their weight, are more prone to rotate on the pedicle than other cysts. Rupture or aspiration of a dermoid may result in peritonitis, owing to the irritating character of its contents.

Cysts of the paroöphoron, or hilum of the ovary, which consists of connective tissue and blood vessels, are usually unilocular, do not affect the shape of the ovary unless of large size, burrow between the layers of the mesosalpinx and broad ligament, and generally contain papillomatous masses (*proliferating papillary cysts*), which may spread to and infect the peritoneum, causing ascites and the growth of papillomata all over the abdominal cavity.

Cysts of the parovarium arising in the *vertical tubes* are generally unilocular, filled with a clear fluid of low specific gravity, and burrow between the layers of the broad ligament. They neither contract adhesions nor suppurate, and never occur before puberty. The ovary is attached to one side of the cyst, over which is stretched the Fallopian tube. *Cysts of Gärtner's duct* may project down into the vagina. *Cysts of Kobelt's tubes* are small, pedunculated, and of no clinical importance.

Tubo-ovarian cysts are retort-shaped and due to fusion of the tube with an ovarian cyst, or to the communication of the tube with an abnormal peritoneal investment of the ovary (*ovarian hydrocele*). In some of these cases the fluid is evacuated through the tube into the uterus.

The **symptoms of ovarian cysts** are mainly those of pressure, such as have been listed under fibromyomata of the uterus, and those due to accidental complications. Menstruation may be unaffected, or there may be amenorrhea from destruction of the ovaries, or menorrhagia from pressure on the pelvic veins. When the tumor is very large it interferes with respiration, presses on the stomach and intestines, causing emaciation and a peculiar facial expression (*facies ovariana*), and leads to umbilical hernia, dilated superficial veins, and to the formation of lineæ albicantes. Sometimes the breasts enlarge, become pigmented and painful, and secrete colostrum. Death is usually the result of exhaustion, uremia, or some complication.

The **complications** are ascites, inflammation (adhesions, suppuration), torsion of the pedicle (hemorrhage, gangrene), and rupture.

Ascites is most frequent in malignant growths, fibromata, and papillomatous cysts.

Inflammation, causing symptoms of localized peritonitis, may be caused by tapping, or by infection derived from the tubes, bladder, intestines, or from the blood or lymph vessels. Circumscribed or universal *adhesions* are thus formed between the cyst wall and adjacent structures, which may be vascular enough to keep the cyst alive, even after it has been separated from its pedicle. *Suppuration* is most frequent in dermoids, and is manifested by the signs of a severe localized peritonitis, with the constitutional symptoms of sepsis. The treatment of these cases is immediate removal of the cyst, or, when this is impossible, suture of the cyst to the abdominal wall and drainage. Left to itself the abscess may rupture into the peritoneal cavity, into one of the hollow viscera, into the vagina, or externally through the abdominal wall.

Torsion of the pedicle is most apt to occur when the pedicle is long, when the tumor is small and heavy, e.g., dermoids, and during pregnancy. If the twist takes place slowly, the cyst may be gradually separated from its pedicle and be nourished by adhesions. When the torsion is acute and tight, strangulation ensues, the cyst increasing in size from effusion of blood and later becoming *gangrenous*. There are severe pain, shock, rigidity of the abdominal muscles, and symptoms of internal hemorrhage if there is much loss of blood. Intracystic *hemorrhage*, causing sudden enlargement of the tumor, may follow also injury or tapping, or it may arise spontaneously from dilated veins or papillomatous masses. Torsion of the pedicle calls for immediate removal of the cyst.

Rupture of the cyst may follow traumatism of any character, twisting of the pedicle, or simple overdistention. It is most prone to occur in the thin-walled parovarian cyst. The swelling suddenly diminishes in size or disappears, and free fluid is found in the abdomen. This may be rapidly absorbed, leading to free sweating and the passage of large quantities of urine. In rare instances symptoms of intraabdominal hemorrhage appear. The passage of serous fluids into the peritoneal cavity does no harm unless the cyst is inflamed. Rupture of a dermoid is generally followed by peritonitis; if the cyst be papillomatous, these growths may be widely implanted throughout the abdominal cavity. Immediate operation is not imperative for rupture of the cyst, unless it be dermoid or papillary in nature, or unless there be symptoms of internal hemorrhage or peritonitis.

The **diagnosis** of small cysts is made by bimanual examination. *Inflammatory masses* are fixed, more painful, intimately connected with the uterus,

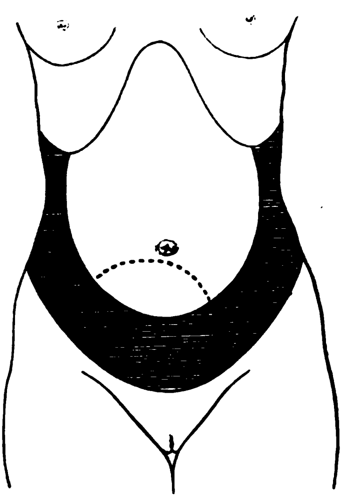


FIG. 531.

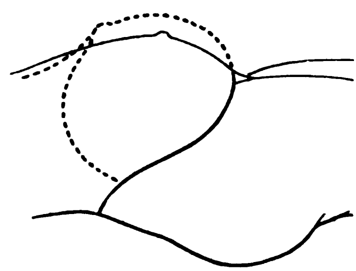


FIG. 532.

FIG. 531.—Area of dulness in ascites (shaded) and in ovarian cyst (dotted line) when the patient is recumbent. Note that the former is symmetric, with a concave upper border; that the latter is asymmetric and convex. The shape of the dull area in ascites changes with the position of the patient, that of a cyst is always the same.

FIG. 532.—Lateral view of abdomen in ascites. Dotted line indicates ovarian cyst and its effect on the profile of the abdomen. Note that in ascites the greatest circumference is at, in ovarian cyst below, the umbilicus.

and are preceded by a history of infection. *Solid tumors* are much harder, are often accompanied by ascites, and grow rapidly if malignant. The presence or absence of fluctuation depends upon the thickness of the cyst wall, the number of loculi, and the contents of the cyst. *Dermoids* have a doughy feel and the X-ray may show the presence of bone. A large cyst ascends into the abdomen, pushes the uterus to one side, and elongates the vagina; it may be mistaken for conditions like ascites, pregnancy, hematometra, hydramnios, and distended bladder. In *ascites*, when the patient is recumbent, the flanks bulge and are dull on percussion, while the central portion of the abdomen is tympanitic (Fig. 531); when the pelvis is elevated the area of dulness in the loins is increased; when the patient turns on one side the upper flank is tympanitic; the greatest circumference of the abdomen is at the umbilicus, not below as in ovarian cyst (Fig. 532); the fluctuation wave is very distinct and extends all over the abdomen; the vagina is not lengthened, indeed may be shortened from descent of the uterus and bulging of the fornices; the uterus is in the midline and freely movable; and disease of the heart, liver, or kidneys may be found. In ovarian cyst the patient may have noticed that the swelling was at first unilateral. In *localized peritoneal effusions*, such as are most often seen in connection with tuberculous peritonitis, the diagnosis may be impossible without exploratory incision. A *pregnant uterus* is more central, less fluctuating, and is associated with softening of the cervix, amenorrhea, and the positive signs of pregnancy; the parts of the fetus may be recognized, and the growth is more rapid than ovarian cyst. X-ray examination may show the fetus after the fourth month of pregnancy. Abderhalden's sero-diagnosis of pregnancy also may be considered. In *hematometra* the menses are absent, atresia of the genital canal is present, the tumor is central and formed by the uterus, and the menstrual molimina appear each month. *Hydramnios* will show the signs of pregnancy. A *distended bladder* will collapse upon the introduction of a catheter.

The **treatment** is ovariotomy, or removal of the cyst. Tapping is never indicated, unless the patient's condition forbids abdominal section. A coexisting pregnancy is not a contraindication to operation, indeed, as complications are likely to arise at this time and during labor, it makes operation more urgent. **Ovariotomy** is performed through a median abdominal incision below the umbilicus. A hand is introduced into the abdomen and any light adhesions broken, care being taken not to mistake the peritoneum for the cyst wall. The cyst is punctured with a trocar to which a rubber tube is attached, the contents draining into a bucket at the side of the table. An assistant makes pressure on the abdominal wall to keep it closely applied to the cyst, which is seized with forceps and drawn from the abdomen as it collapses. Adhesions to the deeper parts, if present, may now be separated, or tied and cut, according to their nature, oozing from large raw surfaces being controlled by pads soaked in hot water, or by sutures or gauze packing. The pedicle, consisting of the broad ligament, the ovarian ligament, and the Fallopian tube, and containing the anastomosis between the ovarian and uterine arteries, is transfixed and ligated as in salpingo-oöphorectomy, and divided about one-half inch beyond the ligature. The other ovary should be removed if it is diseased, if the woman is near the menopause, or if the ovarian growth is malignant or papillomatous. In dermoids, papillomatous cysts, and in cysts which are inflamed or suppurating, the growth should be removed without tapping whenever possible. Intraligamentary cysts are enucleated after incising the layers of the broad ligament, and usually after tying the ovarian and occasionally the uterine artery. The raw cavity left is closed by sutures, and sometimes drained through the vagina. The abdominal wound is closed in the usual manner. When adhesions are dense and universal, particularly if the condition of the patient is poor, the cyst may be sutured to the abdominal wound and drained (*marsupialization*). The mortality of uncomplicated ovariotomy is about 5 per cent.

PELVIC PERITONEUM AND CONNECTIVE TISSUE.

Pelvic peritonitis is usually secondary to salpingitis, but may follow inflammation or perforation of any of the pelvic organs, or the leakage, through the tube into the peritoneal cavity, of fluid which has been injected into the uterus. It may be caused also by the irritation of pelvic tumors, and is a part of a generalized peritonitis caused by lesions of any of the abdominal viscera. The **symptoms** are pain and tenderness in the lower part of the abdomen, rigidity of the overlying muscles, constipation, tympany, vomiting, irritability of the bladder, fever, and a rapid, wiry pulse. The patient lies on the back with the knees drawn up. The vagina is hot and dry, the vaginal fornices exceedingly tender, and the pelvis, particularly the pouch of Douglas, filled with exudate (Fig. 533), which may be hard or soft, according to the presence or absence of pus.

The **treatment** of acute pelvic peritonitis due to salpingitis is rest in bed, fluid diet, an ice bag to the lower abdomen, saline purgatives, hot vaginal douches, sedatives for pain, and stimulants if needed. If suppuration occurs and fluctuation can be detected in Douglas's pouch, the abscess should be opened in this situation and a drainage tube inserted, particularly if the condition of the patient is poor. Even after an abscess has been drained through the vagina, it will usually be necessary to remove the tubes and ovaries at a later period, when the condition of the patient has improved. In all other cases abdominal section with removal of the cause of trouble is the proper treatment.

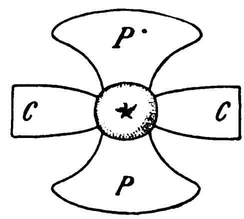


FIG. 533.—PP, Induration from pelvic peritonitis; CC, induration from pelvic cellulitis.

Chronic pelvic peritonitis is adhesions and organizing exudate following the acute form, and results in displacements of the uterus and appendages. Its *treatment* has been considered with these subjects and with salpingitis.

Pelvic cellulitis is inflammation of the connective tissue of the pelvis, and may exist about the bladder, uterus, vagina, or rectum, or in any of the pelvic ligaments. It is comparatively rare, and almost always associated with pelvic peritonitis. *Parametritis* is that form involving the connective tissue of the broad ligaments. It is usually of puerperal origin, the infection entering through lacerations or abrasions of the endometrium, cervix, or vagina, but it may be caused also by inflammation of, or operations on, any of the pelvic organs. The pathology is that of cellulitis elsewhere. Suppuration is the common result, the abscess rupturing into the vagina, rectum, or bladder, or through the abdominal wall above Poupart's ligament, through one of the hernial canals, or through the sciatic or obturator foramen; occasionally it opens into the peritoneal cavity. The exudate may be wholly absorbed, or it may organize and result in chronic pelvic congestion, displacements of the uterus, or stricture of the rectum.

The **symptoms** in the mildest cases are those of the causative salpingitis or endometritis. In the severe form there are chills, fever, and the general symptoms of septicemia. Locally there are pain, metrorrhagia, and often irritability of the bladder or bowel, when the connective tissue about these structures is involved. Digital examination reveals the exudate in the broad ligaments, more commonly on the left side, and possibly about the rectum, bladder, or above Poupart's ligament, if the inflammation spreads so far. If suppuration occurs, the septic symptoms continue and the mass softens. Pelvic cellulitis can seldom be differentiated from pelvic peritonitis, indeed, the two are commonly associated. Cellulitis, however, when existing alone, is less painful, more often unilateral, and more prone to suppurate, and it bulges into the vagina, displaces the uterus laterally, and presents no exudate in the peritoneal pouches in front of and behind the uterus (Fig. 533).

The **treatment** is that of pelvic peritonitis. If suppuration occurs, the abscess should be incised either through the vagina or above Poupart's ligament, according to its situation. In doubtful cases the abdomen may be opened in the median line, the relations of the mass determined, and in the absence of disease of the appendages the abdomen closed and the abscess opened through the vagina. Organized exudate is treated by hot sitz baths, hot vaginal douches, pressure by boro-glycerid tampons in the vagina and shot bags on the lower abdomen, and by the internal administration of potassium iodid and tonics.

Pelvic hematocele is an effusion of blood into the cavity of the pelvic peritoneum. It is almost always due to a ruptured ectopic pregnancy or a tubal abortion, but may be caused also by rupture of an ovarian hematoma, excessive bleeding following rupture of a Graafian follicle, rupture of peritoneal adhesions from traumatism, regurgitation of blood in atresia of the genital canal, malignant tumors of the pelvis, and by operations on, or injuries of, any of the abdominal viscera. The blood gravitates into the pouch of Douglas, where, after a time, it coagulates and becomes encapsulated by adhesions. Finally it may undergo absorption, organization, or suppuration. The **symptoms** are sudden sharp pain, followed by evidences of internal bleeding if there be much loss of blood. When the blood coagulates, there may be signs of pressure on any of the pelvic organs. At first there is only an indefinite fulness in the posterior fornix, but as the blood clots, this becomes firmer and may crepitate on pressure.

Pelvic hematoma is an extraperitoneal effusion of blood, usually between the folds of the broad ligament. It is generally due to the rupture of an ectopic pregnancy, but may be caused also by spontaneous or traumatic rupture of any of the pelvic vessels, especially varices of the broad ligament. The **symptoms** are similar to those of hematocele, though fatal hemorrhage is less common and coagulation occurs more quickly. The hematoma is felt to the side of and behind the cervix, displacing the uterus forward and to one side, and may be detected above Poupart's ligament when of large size. It may rupture into the peritoneal cavity, vagina, or rectum, and, like hematocele, it may undergo absorption, organization, or suppuration.

The **treatment of hematocele and hematoma,** the result of ectopic pregnancy, has already been given. When due to other causes, the patient should be confined to bed and ice applied to the lower abdomen. If the mass steadily increases in size, or is accompanied by symptoms of internal bleeding, the abdomen should be opened and the hemorrhage controlled. If suppuration occurs, the abscess should be opened through the vagina.

Varicocele of the broad ligament is usually the result of displacements, tumors, or chronic inflammation of the pelvic organs, or other conditions producing chronic congestion, such as constipation, sedentary life, and chronic diseases of the heart, lungs, or liver. As in the male, the left side is more frequently affected. The *symptoms* are those of the causative lesion, with dull aching pelvic pain, which is worse on standing and relieved by the recumbent posture. The *treatment* is removal of the cause and attention to the general health. When the abdomen is opened for other reasons, the veins, as well as any calcified thrombi (*phleboliths*), may be excised.

Neoplasms of the pelvic connective tissue require no special description. When intraligamentary they may be removed in the same way as parovarian cysts or intraligamentary fibroids of the uterus.

CHAPTER XXXI.

EXTREMITIES.

Congenital elevation of the scapula (*Sprengel's deformity*) is rare. The scapula is elevated, and its lower angle rotated towards the spine. It may be associated with scoliosis, and asymmetry of the head. The suprascapular muscles are shortened and sometimes ossified. When seen early in life the contracted muscles should be divided.

Scapulum alatum, or winged scapula, was formerly supposed to be due to slipping of the lower angle of the bone from beneath the fibers of the latissimus dorsi, hence the term *dislocation of the lower angle of the scapula;* it is now known to be due to paralysis of the serratus magnus following poliomyelitis, or neuritis, rupture, or contusion of the long thoracic nerve. The *treatment* is electricity, massage, strychnin, and in some cases a brace. Suture of the divided nerve, or its anastomosis to the posterior cord of the brachial plexus, may be considered in cases depending upon section of the nerve. Tubby transplants the lower portion of the pectoralis major to the digitations of the serratus magnus, after splitting it to correspond to these serrations. When bilateral the scapulæ may be sutured together (von Eiselberg). Duval sutures the inner border of the scapula to the sixth and seventh ribs.

Subdeltoid (subacromial) bursitis may be due to trauma, gout, rheumatism, syphilis, tuberculosis. Codman describes three forms. In the acute form there is pain on voluntary, but not on passive, abduction of the arm. The pain is referred to the insertion of the deltoid, and sometimes runs up into the neck, or down the arm, even to the hand. The pain is worse at night, and the patient may be unable to sleep on the affected side. When the arm is voluntarily abducted or rotated externally, the motion is at first free, then the scapula is locked by spasm and accompanies the humerus. The tenderness is located on the point of the shoulder, just below the acromion and outside the bicipital groove, and, owing to the bursa becoming entirely subacromial when the arm is abducted, may disappear when the limb assumes this position. This sign is almost pathognomonic. The swelling may or may not be apparent. With proper treatment recovery occurs in a few weeks. In the subacute form there are adhesions within the bursa, hence a mechanical obstacle to abduction and external rotation, and persistence of the tender point when the arm is abducted. These symptoms may persist for a year or two. In the chronic form the bursa is irregularly thickened. Motion may be free, but at some point in abduction there is pain, which disappears when the tuberosity of the humerus passes beneath the acromion, only to recur when the arm is lowered again. In some of the chronic cases the symptoms are intermittent, disappearing and reappearing irregularly.

The **diagnosis** from inflammation of the sheath of the biceps tendon is made by accurately localizing the seat of the tenderness, and by noting that in this condition abduction is painful from the start. In paralysis of the deltoid (circumflex nerve) the deltoid is atrophied and does not contract. Acromio-calvicular arthritis causes thickening of the joint, over which the tenderness is situated. A deep axillary abscess may cause fixation of the shoulder, but should be detected by careful examination. Fractures about the shoulder and tuberculosis of the head of the humerus may be excluded by the X-ray.

The general **treatment** is attention to any existing diathesis. In the acute form rest may be obtained by keeping the arm abducted on a table or, at night, on a pillow; this relaxes the deltoid and the short rotators, and prevents the tender point at the base of the bursa from coming in contact with the tip of the acromion. Local applications of ichthyol, iodin, etc., may be of some use. Passive motions should be made from time to time to prevent the formation of adhesions. Subacute cases may be treated by massage, passive and active motions, baking, rupture of the adhesions under an anesthetic, incision and division of the adhesions, excision of the subdeltoid portion of the bursa. If the bursa is to be opened or excised, the elbow is flexed to a right angle, the humerus placed at the side midway between internal and external rotation, and a vertical incision, two or three inches in length, made over the external lip of the bicipital groove. The fibres of the deltoid are separated, the bursa opened, and, after strong downward traction is made on the arm, a finger introduced into the cavity between the tuberosity and the acromion. Adhesions may be ruptured or cut, exostoses removed, or the lower part of the bursa excised. The arm is dressed in abduction, and passive motion begun early.

Volkmann's contracture (*ischemic myositis*) is a claw-like contraction of the interphalangeal joints of the fingers, the metacarpophalangeal articu-

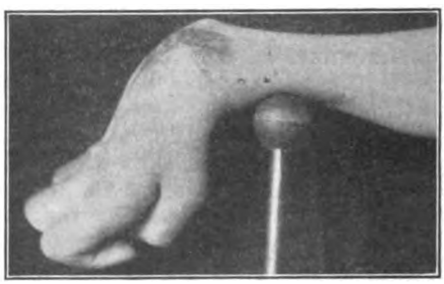


FIG. 534.—Volkmann's contracture, from the pressure of a splint; treated by tendon lengthening.

lations remaining straight. In the milder forms the fingers can be straightened when the wrist is bent; in the worst cases the wrist also is strongly flexed (Fig. 534). The forearm is pronated and slightly flexed. The condition is usually due to the compression of a splint or a bandage, applied for the treatment of a fracture, but has followed also a simple contusion without the application of a bandage. Other rare causes are the Esmarch band, and embolism, thrombosis, or ligation of the brachial artery. The flexor and pronator muscles on the anterior aspect of the forearm are shortened, atrophied, hard, anemic (grayish in color), and friable. In rapid or old cases the nerves and the vessels are enveloped in a fibrous mass, and even the bones are softened and atrophied. The reason for these changes is ischemia, followed by infiltration of blood between the muscular fibres, and later by degeneration of the muscles. Neuritis, which some hold responsible for the ischemic myositis, is, when present, always secondary. In all the reported cases the age of the patient was between three and fifteen years (Berger). Pain and edema of the bandaged forearm generally, but not invariably, precede the development of the deformity. The contraction may be apparent when the splint is removed, or it may not appear for weeks. The hardened muscles can be palpated, splint sores are often present, and if there is neuritis, the symptoms of this affection are in evidence.

The **diagnosis** is rarely difficult. In cicatricial contraction involving the tendons in the palm the fingers cannot be extended when the wrist is flexed. Hemiplegic and post-paralytic contractures yield under general anesthesia. In deformities due to ankylosis of the fingers or wrist the joints are rigid.

Prophylaxis, after a fracture of the forearm or elbow, consists in avoiding tight bandages, indeed if there is much swelling reduction of the fracture and dressing may be postponed for a day or two, unless it is thought that the displaced fragment is contributing to the edema. The Jones position likewise should not be employed immediately after the accident. If the cyanosis and edema continue when the forearm is elevated and extended Murphy advises subcutaneous incision of the fascia on the antero-ulnar side of the forearm, for a distance of several inches. This, he states, must be done within 36 hours if a good result is to be obtained.

The **treatment** is nonoperative or operative. The nonoperative treatment consists in gradually and daily stretching the contracted tissues, manually or by specially constructed splints. Electricity, massage, and baking in the hot air apparatus are useful adjuncts. This treatment must be continued for months or years. The operations that have been employed are neurolysis, elongation of the tendons, and, in order to shorten the arm, resection of a portion of the radius and ulna. The last is sometimes followed by pseudarthrosis, hence the fragments should be fastened together by wire or other means. Berger advises, in order to avoid fusion of the callus from the two bones, resection of the radius at its upper part, of the ulna at its lower part; a further advantage of this proceeding is the small calibre of the bones at these points.

Club-hand may be palmar, dorsal, radial, or ulnar, depending on the direction of the deviation. In *congenital absence of the radius* there is a pronounced radial club-hand. The mildest cases may be remedied by massage and passive motion; in others tenotomy will be required. When the bones are much altered, osteotomy of one of the bones of the forearm or removal of one or more of the carpal bones, according to the type of deformity, may be needed.

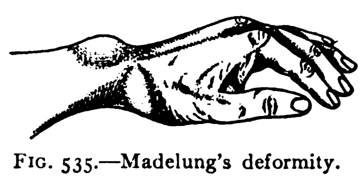


FIG. 535.—Madelung's deformity.

Madelung's deformity (Fig. 535) is a progressive forward (rarely backward) subluxation of the radiocarpal joint, due to relaxation of the ligaments or to disturbance in the growth of the radial epiphysis. Eighty per cent. of the cases occur in girls during adolescence. The lower end of the ulna is prominent, the radius often curved, and the hand usually adducted but occasionally abducted. Extension and sometimes flexion of the wrist are impaired. The *treatment* in the early stages is a retentive apparatus, e.g., a leather cuff. At a later period tenotomy, reduction through an incision, or cuneiform osteotomy of the radius may be indicated.

Polydactylism, or supernumerary fingers or toes, requires amputation of the accessory digits if they are useless or troublesome. **Macrodactylism,** or congenital hypertrophy of one or more fingers or toes, also may require amputation. **Ectrodactylism** is the absence of one or more digits. **Syndactylism,** or webbed fingers, is treated by incising the web in such a way as to form a flap which is used to cover the raw surface between the roots of the fingers, or by raising two flaps of skin by an incision along the middle of the palmar surface of one finger and another along the middle of the dorsal surface of the other finger, the flaps being wrapped around the digits after they have been separated.

Congenital contraction of the fingers corresponds to congenital hammer-toe, with which it is sometimes associated. The little finger is the one usually affected. The first phalanx is hyperextended and the second and third flexed, thus differing from Dupuytren's contraction, in which the first and second phalanges are flexed and the third extended. In the former the middle, and in the latter the lateral digital processes of the palmar fascia are shortened. The *treatment* is forcible correction and the application of a splint, or division of the contracted fascia.

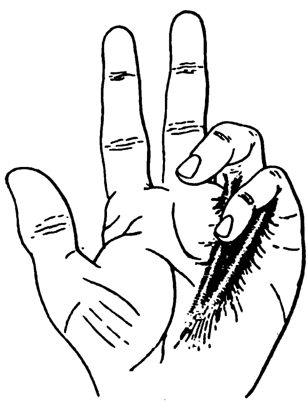


FIG. 536.—Dupuytren's contraction.

Snap- or trigger-finger is an acquired deformity in which one or possibly two fingers can be extended only by great effort or by using the other hand, when the finger flies out like the blade of a penknife. Over 90 per cent. of the cases are caused by some condition that offers a limited obstruction to the play of the tendon in its sheath, e.g., contraction of the sheath, enlarged sesamoid, ganglion, a growth on the tendon, or, most frequently, a localized fibroid thickening of the tendon, as the result of repeated contusions, or a partial tear, of the tendon, the lesion usually being situated over the metacarpophalangeal joint, at which point the "tendon callus" can often be felt. In less than 10 per cent. of the cases the trouble is due to an alteration in the relations of the joint surfaces the result of injury or disease. The *treatment* is removal of the obstruction. In the usual variety it is necessary only to incise the theca over the fusiform enlargement of the tendon.

Baseball finger is the result of a blow of a baseball on the palmar surface or, more frequently, on the end of the finger. The injuries may be divided into two groups. In the first, one of the interphalangeal joints is tender and swollen, and a fusiform enlargement persists long after the injury. The lesion may be a sprain or a dislocation, but in many instances there is a fissured fracture of the end of one of the phalanges, hence a skiagram should always be taken. The treatment is the reduction of any deformity that may be present, a palmar splint for three weeks, and later massage. In the second group (mallet finger) the extensor tendon is stretched or torn, as described in the next paragraph.

Mallet finger is a drooping of the distal phalanx as the result of rupture or overstretching of the end of the extensor tendon, such as may be caused by sudden and violent hyperflexion of the end of the finger. In the early stages it is treated by the application of a splint. If the deformity persists, the tendon may be sutured to the periosteum.

Dupuytren's contraction (Fig. 536) is a shortening of the palmar fascia the result of a chronic cirrhotic inflammation, which begins as an induration in the palm, and, as it progresses, gradually puckers the skin and causes a permanent flexion of the little and ring fingers, and less frequently of the remaining fingers. It is most common in middle aged men and may be bilateral. Occasionally it follows long continued pressure, such as is necessitated by the use of certain tools, and a gouty or rheumatic history is often obtainable. On seeing his first case, the student feels the tense bands of fascia and almost invariably makes a diagnosis of contracted tendon, a condition which may readily be differentiated by noting that the finger can be extended when the wrist is flexed. The **treatment** is excision of the contracted fascia, either through longitudinal incisions, or after dissecting off the skin in the form of a flap. Removal of the puckered skin with the fascia, the raw surface being subsequently covered if small, with a Wolf graft, or, if large, with a pedunculated flap from the forearm or abdomen, is probably a better operation. Subcutaneous section of the tense bands is unsatisfactory. Injections of thiosinamin (fibrolysin) are recommended by some therapeutists.

Foreign bodies in the palm, especially needles, are often difficult to find, because they may lodge in a ligament, a tendon, or because they are moved before operation by muscular contractions or preliminary scrubbing, or during operation by the manipulations of the surgeon. If a needle is in a tendon it can be seen to move with the fluoroscope when the tendon moves. The foreign body should be localized accurately with the X-ray, and removed at once, before it has had time to migrate. If it is not found quickly, one should stop, and have another X-ray examination made, as extensive mutilation may do more harm than the foreign body.

Felon, whitlow, or pyogenic infection of the tissues on the palmar aspect of the finger occurs in four forms.

1. The **subcuticular,** or blister-like, is a collection of pus under the epidermis, due to infection of a sweat gland or possibly a superficial lobule of fat, the pus in the latter instance perforating the true skin. The raised epidermis should be removed with forceps and scissors, and if a perforation in the skin is found communicating with a deeper collection, the perforation should be enlarged.

2. The **subcutaneous** form is a cellulitis, usually located over the distal phalanx, and preceded by a contusion or a wound. There are tense swelling, great tenderness, and severe throbbing pain, especially when the hand is dependent. Fluctuation is rarely detected unless the abscess is about to break. The process occasionally spreads to the cellular tissue over the middle phalanx, and thence to the tendon sheath (which is absent over the distal phalanx), but is more likely, owing to the perpendicular arrangement of the trabeculæ of the pulp, to extend to the bone. Painless and destructive felons may occur in certain nervous maladies, notably syringomyelia. The *treatment* is incision along the side of the pulp of the finger (Fig. 537 A), continued, if the process be extensive, around the end and then along the opposite side, thus raising the soft parts from the bone in the form of a flap (Fig. 537 B). A median scar is unsightly, and is subjected to pressure whenever the finger is used; further if made over the middle or the proximal phalanx a median incision may open the tendon sheath, thus inaugurating a dis-

astrous tenosynovitis. The wound is kept open with gauze impregnated with vaselin, and the finger dressed with hot antiseptic fomentations.

3. The **subperiosteal,** or bone felon, may be primary, but is often secondary to the subcutaneous variety, or to paronychia, the base of the nail being in intimate relation with the bone. The symptoms are those of subcutaneous felon, with possibly a greater amount of pain. The treatment is cleavage of the end of the finger, as described in the preceding paragraph, and incision of the periosteum. After the acute symptoms have subsided the flap may be allowed to fall back against the bone. Later the amount of bone devitalized may be shown by the X-ray. If only a thin scale is necrotic, it will soon separate and be discharged. If a large portion or the whole of the diaphysis has perished one may wait until it becomes loose, a matter of four or

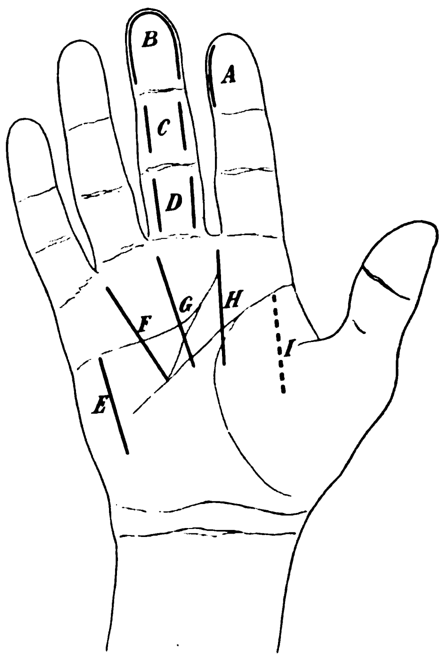


FIG. 537.—Incisions for cellulitis of the hand. A. Lateral. B. curved. C.D. Bilateral. E. Hypothenar space. F.G. Midpalmar space. H. Thenar space. I. Dorsal incision for thenar space.

five weeks, and then remove it; or, perhaps better, in that it shortens convalescence, proceed with the sequestrotomy as soon as the sequestrum is well defined. The epiphysis, into which the tendons are inserted, is seldom implicated, hence great care should be taken not to injure it. Occasionally, however, the entire distal phalanx, the joint, and a portion of the second phalanx are destroyed. In these cases one may fill the defect, after healing has occurred, by transplanting a portion of the crest of the tibia, or in order to secure a joint, the bones of a toe.

4. The **synovial,** or **thecal** form, is a suppurative tenosynovitis. It may be associated with the variety just described or follow a cellulitis, in which

event, if prompt drainage has been established, it is possible for the infection to localize itself to a segment of the sheath. In most instances, however, and especially in those due to a streptococcic infection following a puncture wound of the sheath, e.g., from a pin, the entire synovial sac of the affected finger is invaded. It may be recalled that the synovial sheath of the thumb and each finger extends distally to the base of the terminal phalanx. Proximally the sheath of the index, the middle, and the ring finger each reaches the neck of the corresponding metacarpal bone, or, roughly estimated, the level of the great transverse flexion crease of the palm. The sheath of the thumb communicates with the external (radial) palmar sac, which envelops the flexor longus pollicis only. The sheath of the little finger is continuous with the internal (ulnar) palmar sac, which widens in the palm and envelops also the tendons of the ring, the middle, and the index fingers, the first to a considerable extent, the second less, the last only a little. As there are two layers of tendons to be enveloped, there are three culs de sac, the pre-, the inter-, and the retrotendinous; the first is the smallest, the last the largest, consequently pus accumulates easiest under both layers of tendon. The internal and the external palmar sacs converge in the carpal canal, being separated by cellular tissue, in which lies the median nerve; in this situation they are in close relationship with the carpal articulations, which are not infrequently invaded by infection from the palm. The sacs both extend into the forearm, the internal to a point about one inch and a quarter, the external to a point about one inch and a half, above the annular ligament (Fig. 538). There are, however, frequent anomalies. The tendon sheath of the little finger or the thumb may be separated from the corresponding palmar sac, hence infection of the sheaths of these digits is not invariably followed by palmar synovitis. The two palmar sacs often communicate, either directly, or by a median sac, usually annexed to the deep flexor tendon of the index finger; and the digital sacs of the first three fingers may communicate with the internal palmar sac, so that it is possibe to have a total palmar synovitis following infection of the thumb or any of the fingers. Excluding these variations, we may, for the purpose of description, take suppurative synovitis of the first three fingers as the type of digital thecal infection, reserving that of the thumb and the little finger for discussion with palmar abscess.

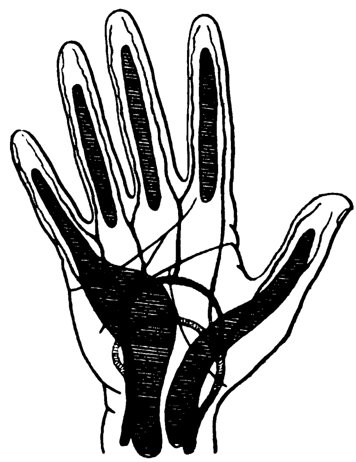


FIG. 538.—Diagram showing the usual arrangement of the tendon sheaths of the hand (shaded) and the relations of the palmar arches (in red) to the lines of the palm. Note also the position of the digital arteries.

The *symptoms* of suppurative thecitis of the index, the middle, or the ring finger are, when the sheath alone is infected, only slight redness of the skin; moderate swelling, most marked on the dorsum of the finger; great pain on moving the finger, which is held in a flexed position; and acute deep tenderness sharply localized to the sheath, perhaps most intense over the upper end and beneath the digitopalmar pad. This line of tenderness can be mapped out by making pressure with a probe. Cellulitis may, of course, precede or follow thecitis. The general symptoms are, as a rule, more severe than those of other forms of infection.

The *treatment* should be prompt, in order to save the tendon, and to prevent rupture of the sheath and diffusion of the pus into the cellular tissue of the palm. In view of the difficulty sometimes experienced in differentiating cellulitis over the theca from thecitis with cellulitis, the operation should be of an exploratory nature, to permit which the patient should be anesthetized and the part rendered bloodless. An incision is then made alongside of the tendon, between the flexion creases of the finger, in the region of the primary infection (Fig. 539 D). If the sheath is reddened, edematous, distended, it

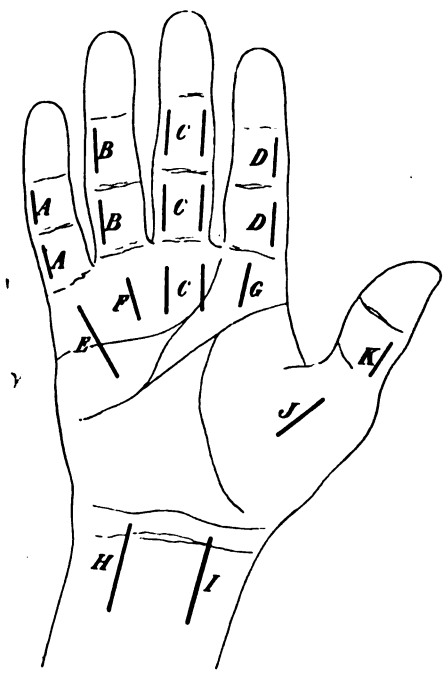


FIG. 539.—Incisions for synovitis of the hand. Lateral for little finger (A.A.), ring finger (B.B.), index finger (D.D.), and thumb (K). Median for upper end of distal sheath (F.G.). Bilateral (C.C.C.). Internal palmar sac (E). Upper end of internal sac (H), of external sac (I). External sac (J).

contains pus; if there is any doubt as to the contents of the sheath it may be explored with a hypodermic needle. If infected the sheath is opened. A similar incision must then be made over the other phalanx (the distal phalanx is not concerned, unless the seat of the primary infection), and a third incision, in the axis of the finger, through the digitopalmar pad, as far as the great transverse crease of the palm (Fig. 539 G). Bilateral incisions, as shown in Fig. 539 C, may be employed if freer drainage is thought desirable. The incisions should never cross the joints, otherwise, particularly with a long median incision, the tendon is dislocated from its sheath, and assumes, in its relation to the flexed finger, the position of the string to a bow. Instruments must not be thrust beneath the tendon, for fear of injuring the mesotendon (vinculum), through which the blood vessels run. The wounds are drained with vaselinized gauze, which should extend to, but not into, the sheath, a warm, moist, antiseptic dressing applied, and the hand put on a splint. Many surgeons advise Bier's treatment, but we believe prolonged daily soaking in hot salt solution to be quite as efficient and without the disadvantages of passive hyperemia. If incision has been delayed for several days the tendon sloughs and, after three or four weeks, is discharged.

Palmar abscess superficial to the palmar fascia requires no special description. Deep palmar abscess follows the superficial variety, a wound of the palm, or an infected finger, the lesion being a suppurative synovitis or cellulitis, or both. The general symptoms of sepsis are marked in both varieties; the local signs and the treatment differ.

Palmar synovitis may be divided in that of the internal and that of the external sac, although the two forms are often combined.

Suppuration of the *internal* (*ulnar*) *sac* following a thecitis of the little finger gives the signs of digital thecitis mentioned above, with swelling and tenderness along the ulnar side of the palm, and above the annular ligament to the ulnar side of the palmaris longus. The dorsum of the hand is little affected. The *treatment* is incision of the digital theca over the middle and the proximal phalanx, as already described (or at the point of infection in the palm, if the trouble started in the palm), when it will be found that pus can be forced through the upper wound by pressure on the inner side of the palm. The palmar sac is now opened by an incision (Fig. 539 E) running from the middle of the digitopalmar pad of the little finger, up towards the radial styloid, to a line crossing the palm at the level of the web of the thumb, which line overlies the superficial palmar arch. Pressure over the sac above the annular ligament will cause pus to flow through the wound, hence another incision must be made. The line of this incision is parallel and just external to that for the ulnar artery; it commences close to the crease of the wrist and extends upwards for about one and a half inches (Fig. 539 H). The flexor carpi ulnaris and ulnar vessels are drawn inwards, the other flexors outwards, and the sac found deeply under the latter.

Suppuration of the *external* (*radial*) *sac* due to a thecitis of the thumb also gives the signs of digital thecitis, but with swelling and tenderness along the inner side of the thenar muscles, and above the annular ligament to the radial side of the palmaris longus. The *treatment* proceeds as in suppuration of the internal sac. A lateral incision is made over the proximal phalanx of the thumb. The second incision runs from the base of the thumb, on a line to the ulnar styloid, for about one inch (Fig. 539 J). The short flexor of the thumb is cut, and the sac identified by moving the thumb. In the upper part of the wound the thenar branches of the median nerve must be avoided. The third incision is above the annular ligament, parallel and just within the line of the radial vessels, which must be drawn aside. The incision runs from the crease of the wrist upwards for one and one half inches. A few operators, in severe cases, advise severing the annular ligament over the radial or ulnar bursa, or over both bursæ, according to the location and the extent of the infection, thus making the palmar and the forearm incisions continuous.

Palmar cellulitis causes great swelling of the dorsum of the hand, and, owing to the resistance of the palmar fascia, only slight tumefaction of the palm. The point of greatest tenderness, however, is in the palm, and it is by this, and not the situation of the maximum edema, that one should be guided. The motion of the fingers is not restricted, because the synovial sheaths are not involved. The subfacial cellular tissue of the palm surrounds the tendon sheaths, and extends through the interdigital spaces to the digitopalmar pads and to the dorsum of the hand, and through the carpal canal, between the synovial sacs, to the forearm. According to Kanavel, pus is likely to accumulate in one of the following spaces. The hypothenar space lies beneath the hypothenar muscles. The thenar space occupies the area of the thenar eminence, as far as the flexion and adduction crease of the thumb, but does not extend to the ulnar side of the middle metacarpal. It lies deep in the palm just above the adductor transversus. The middle palmar space is limited by the middle metacarpal on the radial side, is overlapped by the ulnar bursa on the ulnar side, and is separated from the thenar space by a partition which is firm everywhere except at the proximal end. Below it has three diverticula, which extend along the lumbrical muscles. Abscess of the hypothenar space is relatively infrequent, and is opened by an incision parallel and internal to the fifth metacarpal bone (Fig. 537 E) The thenar space is often invaded by infection from the thumb or the index finger, occasionally from the middle finger. This space may be opened by a dorsal incision parallel to the metacarpal bone of the index finger, and to the radial side of the bellies of the interossei muscles of the finger (Fig. 537 I). Blunt forceps are pushed across the palmar surface of the metacarpal bone of the index finger into the space. This incision does not scar the palm or endanger the palmar arch. Intertendinous palmar incisions may be indicated when the original infection enters through the palm. Picqué incises between the tendons of the index and the middle fingers and ties the superficial palmar arch (Fig. 537 H). The midpalmar space may suppurate as the result of infection of the middle, the ring or the little finger. It is opened by an incision starting between the digitopalmar pads of the ring and the little fingers, and extending upward toward the heel of the hand as far as the superficial arch (Fig. 537 F). The flexor tendons and ulnar bursa are drawn outward, the hypothenar muscles inward, and the cellular space beneath the tendons drained. It may be drained likewise through the lumbrical space between the middle and ring finger, by an incision between the digitopalmar pads of these fingers. If the thenar space also is involved a drain may be passed beneath the flexor tendons and out through the incision which has been made into the thenar space. Occasionally, e.g., after a compound fracture of the metacarpus, the dorsal subaponeurotic space is involved, and it becomes necessary to push a pair of forceps between the bones and between the extensor tendons to the skin, which is opened, and through-and-through drainage established.

If pain and fever persist after free drainage of palmar infections it may be due to septicemia, lymphangitis, or lymphadenitis, which are treated as described under these headings, or to septic arthritis of the carpal joints or cellulitis of the forearm. Septic arthritis of the wrist demands drainage and frequently resection. Cellulitis of the forearm may be superficial, but is often deep, the infection coming through the carpal canal. In the latter instance incisions are made close to the volar border of the radius and the ulna, in the lower third of the forearm, the tendons, the vessels, and the nerves lifted forward, and through-and-through drainage established. Similar incisions may be needed also in the upper third of the forearm.

In all forms of palmar abscess the drainage material should be vaselinized gauze, rather than rubber tubes, which may induce necrosis. Rubber tissue is employed by some surgeons, but is more apt to slip into the cavity than gauze. Dry gauze acts as a plug, and causes pain and bleeding at each removal. The hand should be covered with a warm, moist, antiseptic dressing and be put on a splint. The dressing should be changed at least once a day, and the hand submerged for thirty minutes or longer in a warm salt solution bath. After the acute symptoms subside the fingers should be moved at each dressing, in order to prevent adhesions about the tendons. If a tendon sloughs, attempts may be made, after the wounds have healed, to repair the loss by transplanting a segment of the palmaris longus tendon, or a twisted strip of the fascia lata.

Jumping, springing, or snapping hip (*hanche à ressort, schnappende Hüfte*) is characterized by a sudden jump at the level of the great trochanter, on flexion, and sometimes on extension, of the thigh, which jump is accompanied by a noise, expressed onomatopoically as "cloc." This condition has been ascribed to voluntary subluxation of the hip, inflammation or absence of the bursa, osteoma, voluntary or spasmodic contraction of the gluteus maximus or tensor vaginæ femoris, and to relaxation of the ligaments or muscles. It seems probable, however, that in all cases, even in those complicated by subluxation, which is not common, the jump and snap are due to slipping of the anterior border of the gluteus maximus over the trochanter, for at the time of the snap a cord-like structure can be seen and felt to glide over the trochanter, forwards during flexion, backwards during extension, and the snap may be prevented by fixing the cord with the hand. Clinically there are two varieties, the congenital and the acquired. The congenital form, which is often bilateral, is not associated with pain or limping, and, according to Heully, is due to a low insertion of the gluteus maximus on the femur. The acquired form usually follows an injury to the hip, and is the result of tearing of the upper part of the attachment of the gluteus maximus from the linea aspera, thus allowing the anterior border of the muscle, with its attached fascia, to slip suddenly over the trochanter. In these cases there may be pain and lameness, and, to avoid the "cloc," the patient may keep the hip extended, or walk bent over towards the well side, thus causing secondary scoliosis, adduction of the affected limb, elevation of the anterior superior spine on the same side, and apparent projection of the trochanter. *Treatment* is needed only when the trouble seriously handicaps the patient. The anterior edge of the gluteus maximus may be sutured to the periosteum of the trochanter (Bayer) and, in addition, to the femoral aponeurosis and vastus externus (Heully).

Coxa vara is a downward bending of the neck of the femur, which may form an angle of 90° or even less with the shaft of the bone. It may affect one or both sides and is frequent in young males, although it may occur in either sex and at any period of life; indeed it is physiological in old age and may be congenital. Diseases which soften the osseous tissue, such as rickets, osteomalacia, ostitis deformans, and chronic inflammatory affections of bone, as well as fracture of the neck of the femur, may result in coxa vara. The symptoms are pain and lameness. The limb is shortened, the trochanter above Nélaton's line, and abduction limited. The foot may be everted and internal rotation restricted, if the neck is twisted backwards, and less commonly inverted with the restriction of external rotation, if the neck is twisted forward. Careful examination, with a radiogram, will usually permit easy differentiation from coxalgia or congenital dislocation. The **treatment** in the developing stages is rest in bed with extension, or the use of some form of hip splint, for a number of months, in order to prevent further deformity, the nutrition of the limb being maintained by massage and electricity. Persistent deformity when disabling may be corrected by osteotomy, either linear or cuneiform (Fig. 540).

Coxa valga is an increase in the angle between the neck and shaft of the femur. As in coxa vara the neck may be twisted forwards or backwards. The limb is lengthened, the trochanter below Nélaton's line, and adduction restricted. It has been found associated with diseases like those mentioned under coxa vara. Osteotomy and correction of the deformity may possibly be indicated in some cases.

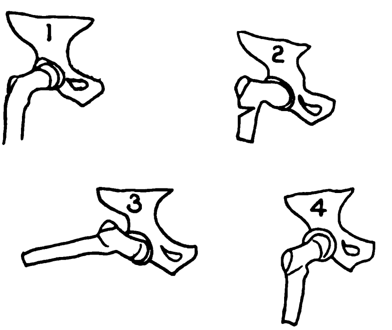


FIG. 540.—1. Normal femur. 2. Coxa vara—cuneiform osteotomy. 3. Abduction of limb fixes the upper fragment against rim of acetabulum and closes opening in bone. 4. Replacement of limb after union is complete elevates the neck to its former position. (Whitman.)

Genu valgum, or knock-knee, is an abnormal outward deflection of the leg, the feet being separated when the knees are together in the extended position. One or both limbs may be affected. According to the cause, the cases may be grouped in three classes: 1. *Genu valgum rhachiticum* appears soon after the child begins to walk, the normal angle between the thigh and the leg being exaggerated as the result of lengthening of the internal condyle, or bending of the femur above, or the tibia below, the knee. The internal lateral ligament is stretched, and the joint is often abnormally movable in all directions (*loose knees*). 2. *Genu valgum staticum* is most common during adolescence in those of poor physique, or in those who are compelled to stand much or to carry heavy weights. It is supposed by some to be due to a latent form of rickets. Owing to the normal obliquity of the femur, most of the weight of the body is transmitted to the tibia through the external condyle of the femur, and knock-knee is prevented by the action of the muscles on the inner side of the limb. In the weak or overworked these muscles tire and the individual assumes an attitude of rest with the feet separated and the knees extended, thus relaxing the muscles, stretching the internal lateral ligament, and ultimately causing atrophy of the external condyle and hypertrophy of the internal condyle. The patella passes externally, the tissues on the outside of the limb are contracted, and the tibia is usually rotated outwards. The patient has a rolling gait, and scoliosis may follow in unilateral cases. As the enlargement of the internal condyle is chiefly in the vertical and transverse directions, the deformity disappears when the knee is flexed to a right angle, unless the tibia is curved. 3. *Other causes* of knock-knee are infantile or other forms of paralysis, fracture or dislocation of the knee, and destructive inflammatory affections of the joint or neighboring bones. Flat-foot may be either the cause or the result of knock-knee.

The **treatment** during the early stages consists in keeping the patient off the feet and employing massage and daily *corrective manipulations*, the knee being pressed outward and the tibia inward. Constitutional measures for rickets, or in static cases for the feeble general health, should be employed. At a later period *braces* consisting of an outside steel rod running from the trochanter to the foot, and supplied with straps for pulling the knee outward, are indicated. When the bones have become thoroughly ossified (at the age of three or four in children), cure can be obtained only by *operative treatment*. **Macewen's osteotomy** is the usual operation. The outer side of the knee is placed on a sand bag, and a small longitudinal incision made on the inner side just above the adductor tubercle. Through this an osteotome, which differs from a chisel in being beveled on both sides (Fig. 219), is passed down to the bone, turned transversely, and driven three-fourths of the way through the bone. It is then withdrawn, the remaining portion of the bone broken, the wound sutured, and the limb put up in plaster in a corrected position. Rarely, and only in the worst cases, is it necessary to remove a wedge of bone (*cuneiform osteotomy*). The cast is removed in six weeks and the patient allowed to walk at the end of two months.

Genu varum, or bow-leg, is the reverse of genu valgum, the extended knees being separated when the feet are together. It is almost always due to rickets, which permits the tibiæ to bend outward. Occasionally the deformity is produced by a bending of the femur or an enlargement of the external condyle. *Anterior bow-leg* is a forward curve of the tibia, usually near one extremity of the bone, and generally associated with some lateral deviation, thus differing from the *sabre blade deformity* of syphilis, which is due to a hyperplasia rather than a bending of the bone, and which is generally regular and without a twist. *Posterior bow-leg* or *genu recurvatum*, is the reverse of anterior bow-leg. The **treatment** is correction by daily manipulations or the use of braces, up to the age of three or four, after which operative treatment offers the only hope of success. **Osteotomy of the tibia** is performed at the point of greatest curvature, in the same manner as osteotomy for knock-knee, the fibula being broken manually. The cast is removed in four weeks and the patient allowed to walk at the end of six weeks. *Osteoclasis*, or fracture of the bone by a special apparatus, the osteoclast, is preferred by some surgeons, but should not be employed when the curve is near a joint or the bone very strong.

Rupture of the plantaris (*tennis leg*) may occur during climbing, jumping, boxing, tennis, and similar exercises. There is a sharp pain in the calf like the sting of a whip (*coup de fouet*), tenderness, swelling, and, after a day or two, ecchymosis along the posterior surface of the leg; identical symptoms are produced by the rupture of a deep varix. The *treatment* is rest of the leg for one week, ichthyol, and a firm bandage. Later the patient may walk, but should not rise on the toes for several weeks.

Talipes, or club-foot, is an abnormal and permanent deviation of the foot in the direction of extension (T. equinus), flexion (T. calcaneus), adduction (T. varus), or abduction (T. valgus). Combinations of these forms occur, such as T. equino-valgus or varus, and T. calcaneo-valgus or varus.

The **causes** are congenital and acquired. **Congenital club-foot** may be due to abnormal intrauterine pressure, to defective development of the bones of the leg, or to some nerve lesion, e.g., when associated with spina bifida. It is often bilateral, sometimes hereditary, and usually not associated with the wasting, trophic changes, and impaired electrical reactions observed in the acquired paralytic form. **Acquired club-foot** may arise from paralysis from any cause, but particularly that form following anterior poliomyelitis (*paralytic talipes*), from spasmodic affections of certain groups of muscles (*spastic talipes*), cicatricial contraction of the soft parts following injury or disease, rupture of tendons or muscles, fractures about the ankle (*traumatic talipes*), and epiphysitis. Shortening of the lower extremity from any cause is often followed by a compensatory talipes equinus, while prolonged fixation of the foot in any position may lead to deformity, e.g., the pointed foot following prolonged confinement to bed (*talipes decubitus*), or the improper application of a plaster cast. The *anatomical changes* vary with the degree and type of deformity. The midtarsal joint (os calcis with cuboid, and astragalus with scaphoid) is the one most frequently and most extensively involved, the ankle joint being most affected in equinus and calcaneus. In severe cases the bones are altered in shape, the tendons run in abnormal directions, the weak or paralyzed muscles are stretched or atrophied while their opponents are shortened, the ligaments and fasciæ are contracted or stretched, and the skin is thickened, perhaps with corns or ulcers, at the points where the foot rests on the ground. Abnormal bursæ also may form.

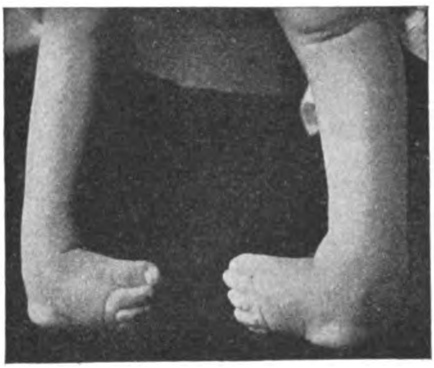


FIG. 541.—Talipes equino-varus. (Pennsylvania Hospital.)

The **treatment** is (1) mechanical, i.e., manipulation, plaster-of-Paris bandages, and braces, or (2) operative, i.e., tenotomy, tendon lengthening, shortening, or transplantation, syndesmotomy or fasciotomy, myotomy (rare), *brisement forcé*, open incision, tarsotomy or tarsectomy, bone transplantation, nerve transplantation, arthrodesis, and in the worst cases amputation. **Manipulation** consists in holding the foot in a corrected position for a few minutes several times daily; it is indicated in recent cases of mild degree. An extension of this method is the application of *plaster-of-Paris* bandages, after the deformity has been corrected as much as possible. When the cast becomes loose, further correction is made and a second bandage applied, and so on, until the foot returns to its normal position. *Braces* and shoes are employed, not so much for correction, as for the maintenance of the normal position after the deformity has been reduced by other means.

Operative treatment of some form is required in all but the mildest cases, and varies with the type of deformity. **Talipes equino-varus** (Fig. 541) is the commonest form of club-foot, and when bilateral is called *reel-feet*, owing to the fact that the feet are lifted one over the other when the patient walks. The heel is drawn up and the foot twisted and folded on itself, so that the toes point inwards and the patient walks on the outer border or dorsum. When the measures mentioned above have failed or are inadvisable, the varus may be corrected after *tenotomy* of the tibialis anticus, tibialis posticus, and plantar fascia (*fasciotomy*), and the equinus may then be overcome by section or lengthening of the tendo Achillis. Division of the contracted ligaments on the inner side of the foot (*syndesmotomy*) also may be needed. In any operation for club-foot the deformity should be overcorrected and the foot and leg put up in plaster, which should not be disturbed for two or three months. After the plaster has been removed, braces will be needed until there is no longer any tendency towards recurrence, usually a matter of some years. In paralytic cases a permanent brace may be required. *Brisement forcé* is immediate forcible correction by the hands or by instruments (Fig. 542). *Open incision*, or Phelps' operation, consists in dividing all the tissues on the inner side of the foot, down to the bone, by an incision extending from the internal malleolus to one-fourth of the distance across the sole of the foot. The wound is packed with gauze, and the foot put up in plaster in an overcorrected position. Jones raises a triangular flap, thus lessening the gap after correction of the deformity. When the bones are so altered in shape as to prevent reduction, the osseous tissue itself must be attacked. According to the situation of the obstruction, *osteotomy* may be performed upon the neck of the astragalus through an incision below the internal malleolus, upon the head of the os calcis through an incision below the external malleolus, or upon the scaphoid through an incision in the sole; osteotomy of the tibia and fibula above the ankle is seldom employed. *Tarsectomy* has been performed in various ways, one or more of the tarsal bones being removed, according to different operators. Perhaps the best plan is to remove a wedge of bone with the base outwards and of sufficient size to correct the deformity. An incision is made over the most prominent portion of the tarsus, the tendons and soft parts retracted, and the bone removed with a chisel, without respect to the individual bones or joints. *Bone transplantation* has been employed with success. The scaphoid is split into anterior and posterior halves, and a wedge of bone taken from the tibia or the cuboid forced into the split. In paralytic cases *tendon or nerve transplantation* may be indicated. "The outer half of the tendo Achillis may be inserted into the distal end of both peronei. The extensor longus hallucis or the outer half of the tibialis anticus may be passed across the foot under the other tendons to be fastened to the periosteum of the cuboid bone" (Le Breton). The anterior tibial nerve and the branches to the tibialis anticus may be transplanted into the musculo-cutaneous. *Arthrodesis* of the calcaneo-cuboid joint also may be used in these cases.

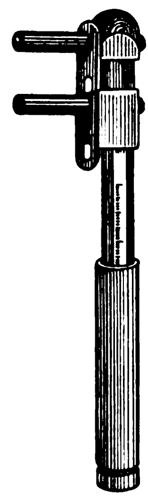


FIG. 542. Thomas club-foot wrench.

Talipes equinus is usually the result of paralysis of the extensor muscles, and is rare as a congenital deformity; the patient walks on the toes, and in the worst cases on the dorsum of the foot. The tendo Achillis and the tissues of the sole of the foot are shortened. The operative measures for its correction are division or lengthening of the tendo Achillis, or in more severe cases removal of the astragalus or a wedge-shaped section of the tarsus. Nerve transplantation as for equino-varus, or the transplantation of a portion of the tendo Achillis to the tibialis anticus or extensor communis digitorum may be employed. After correction arthrodesis of the ankle joint may be performed.

Talipes calcaneus may be congenital or acquired. The foot is drawn upwards and the patient walks on the heel. It may require division of the extensor tendons, shortening of the tendo Achillis, transplantation of the peronei into the os calcis, astragalectomy, or arthrodesis of the ankle joint.

Talipes valgus (Fig. 543) is an abduction and eversion of the foot with flattening of the sole. It may be combined with equinus or calcaneus.

The acquired form is synonymous with flat-foot, under which the treatment will be discussed.

Talipes varus (Fig. 544), or adduction and inversion of the foot, is treated as equino-varus, excepting the division of the tendo Achillis.

Flat-foot, or pes planus (*splay-foot, acquired or spurious valgus*), is a flattening of the arch, usually with abduction and eversion of the foot. The *causes* include all those conditions which induce a disproportion between the weight of the body and the strength of the muscular and ligamentous tissues controlling the foot, and diseases or injuries which alter the relation or shape of the bones. Among these conditions are improperly fitting shoes,

FIG. 543.—Talipes valgus. (Gould.)

FIG. 544.—Talipes varus. (Gould.)

prolonged standing, rapid increase in weight, general ill health, prolonged disuse of the foot resulting in muscular weakness, infantile or other form of paralysis, rickets, injury (particularly Pott's fracture), and arthritis, especially of gonorrheal origin.

Symptoms may be absent in a well-marked case, severe in a case in which the deformity is slight or absent. Pain, particularly after using the foot, is most marked in the sole and the midtarsal joint, but occurs also in other portions of the foot, occasionally being reflected up the limb even to the lumbar region, and sometimes associated with muscular spasm. The foot loses its normal flexibility, and tenderness exists over the points of the ligamentous attachments. The gait is shuffling and there may be

FIG. 545.—Flat-foot plate.

some swelling, which frequently leads to an incorrect diagnosis of rheumatism. The deformity (Fig. 543) is quite obvious in well-marked cases and is accentuated when the patient stands. The inner border of the foot is lengthened and rests on the ground, and the internal malleolus and head of the astragalus are more prominent than usual. The plantar ligaments and muscles are stretched, the tibialis posticus weakened, and the peronei contracted. An impression of the weight bearing portion of the sole may be obtained by having the patient step on cardboard covered with lamp black.

The **treatment** in static cases, i.e., those due to disproportionate weight, is the application of a flat-foot plate (Fig. 545), and, to strengthen the muscles, massage, electricity, and exercises, such as rising on the toes, and walking with the foot in a varus position. When the symptoms have disappeared the plate should be gradually discontinued. When the foot is too tender for the use of a plate, the patient may rest in bed or have a plaster cast applied. In some cases the eversion is so marked as to require a steel bar running up the outer side of the leg, and supplied with a strap, which passes around the internal malleolus and pulls the ankle out. Plates and supports are generally useless unless the deformity can be corrected. When the foot is fixed in deformity, the patient should be anesthetized, the deformity overcorrected with the hands or the club-foot wrench, and a plaster cast applied, a support being used when the pain has disappeared. In paralytic cases nerves may be transplanted as in equino-varus. The peroneus brevis may be passed under the tendo Achillis and attached to the scaphoid, while the peroneus tertius may be attached to the same point after being passed beneath the anterior tendons. The extensor longus pollicis or the tibialis anticus may be passed through a hole bored in the scaphoid and turned back and sutured to the periosteum. The peroneus longus has been transplanted to the tibialis posticus. When the obstacle to reduction is osseous, a wedge of bone may be removed from the inner side of the tarsus. Other bone operations are osteotomy of the neck of the os calcis and astragalus, removal of the scaphoid, supramalleolar osteotomy, longitudinal section of the os calcis with displacement downwards of the posterior fragment, and bone transplantation, a wedge-shaped piece of the scaphoid being excised, thus shortening the inner side of the foot, and driven into an osteotomy wound in the forward part of the os calcis, thus lengthening the outer border of the foot.

FIG. 546.—Pes cavus. (Gould.)

Pes cavus, or hollow foot (Fig. 546), is the reverse of flat-foot. It is rarely congenital, being usually the result of anterior poliomyelitis or the wearing of short or ill fitting shoes. The most marked cases occur in Chinese women, from bandaging. The treatment is the use of a properly fitting shoe, with a flat steel plate in the sole and a strap running over the arch of the foot. The severer forms require division of the plantar fascia.

Metatarsalgia, or Morton's disease, is severe neuralgic pain beginning on either side of the distal end of the fourth metatarsal bone and passing up the foot and often up the leg. It is caused by a pinching of the digital nerves between the heads of the third and fourth, or fourth and fifth metatarsal bones, which have become displaced as the result of badly fitting shoes. The transverse arch formed by the distal ends of the metatarsal bones is flattened and the foot broadened; there may or may not be flat-foot. The pain usually comes on when walking and is often so severe that the patient immediately removes the shoe and rubs the foot; it can often be induced by rolling the metatarsal bones one over the other. The *treatment* is the application of a flat-foot brace, if such is needed, and the use of properly fitting shoes; the pain may often be relieved by a pad to brace up the transverse arch of the metatarsus, or by the application of a tight bandage to the anterior segment of the foot. Intractable cases can be cured only by resection of the head of the fourth metatarsal bone, or by excision of the superficial branch of the external plantar nerve.

Hallux valgus is an outward deviation of the great toe produced by short, tight, or pointed shoes and stockings. It exists in a slight degree in most civilized people and the most severe forms are commonly seen in later life. The head of the first metatarsal is uncovered, and often becomes enlarged as the result of chronic periostitis. A bursa may form in this situation (*bunion*), which may become inflamed; should suppuration occur the joint may be invaded and disorganized. The **treatment** in early cases is the application to the inner side of the foot of a hard rubber splint, to which the toe is bandaged, or the use of a metal partition attached to the sole of the shoe and projecting between the first and second toes. An inflamed bunion is treated like acute bursitis; a bunion plaster, i.e., a pad with a central opening, may be applied to relieve pressure. Permanent relief is obtained by excision of the bursa, and correction of the hallux valgus, which in advanced cases can be accomplished only by operation. This may be an osteotomy of the metatarsal bone, an excision of the metatarso-phalangeal joint, or a shaving off of the exostosis on the inner side of the head of the metatarsal bone. In addition to the last procedure, Weir divides the outer portion of the capsular ligament and transfers the dorsal tendon to the periosteum on the inner side of the base of the first phalanx (Fig. 547). After excising the joint and the exostosis, Mayo swings a flap consisting of the subcutaneous tissues and the bursa, into the defect between the bones, thus re-establishing the joint. A similar result may be obtained, if the bursa must be excised, by filling the new joint with fat.

Hallux rigidus is an arthritis of the metatarso-phalangeal articulation, the result of flat-foot, defective shoes, or injury, and terminating in ankylosis. The *treatment* is removal of the cause, with local applications as for arthritis. In old cases, particularly if ankylosis occurs in a vicious position, arthroplasty may be performed.

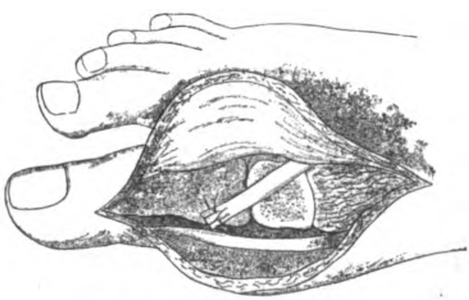


FIG. 547.—(Weir, "Annals of Surgery.")

Hammer-toe is a permanent hyperextension of the first, and flexion of the second and third phalanges. The congenital form is probably due to shortening of the lateral digital processes of the plantar fascia. It may be caused by short shoes or be associated with hallux valgus, talipes equinus, or pes cavus. It also follows paralysis of the interossei and lumbricales, corresponding to a similar deformity of the fingers after ulnar paralysis. Corns or bursæ may form over the points exposed to pressure, and walking becomes painful and difficult. The **treatment** in the mildest form is the application of a splint, preceded, if necessary, by division of the contracted fascia and forcible correction. When more severe, it will be necessary to excise the distal end of the first phalanx and divide the extensor tendon. In the worst cases amputation will be required.

Achillodynia is a term which has been applied to two separate conditions. (1.) **Post-calcaneal bursitis, or Albert's disease,** causes a tender swelling between the os calcis and tendo Achillis, and may follow an injury, a strain, or prolonged walking or skating. Some cases are due to an exostosis of the os calcis. The *treatment* is rest of the foot and the use of the measures indicated in bursitis. Operation may be required for an exostosis. (2.) **Synovitis of the tendo Achillis** may follow the same conditions, or arise spontaneously in the gouty or rheumatic. Pain and swelling are most marked at the level of the top of the shoe, and soft crepitus may sometimes be obtained on flexing or extending the foot. The *treatment* is that of tenosynovitis, with the use of the salicylates in the rheumatic.

Painful heel (*policeman's heel*) is characterized by pain and tenderness on the under surface of the heel. It may be caused by strain, periostitis, flat-foot, inflammation of the bursa beneath the os calcis, or an exostosis, hence the necessity for a radiograph in all doubtful cases. The *treatment* necessarily varies with the cause.

Aside from superficial obvious lesions, e.g., corns, wounds, ulcers, etc., and in addition to the various conditions mentioned above, **painful feet** may be caused by gout, rheumatism, cardiac or renal disease, neurasthenia, neuritis, neuroma or other tumors, inflammatory affections of the bones, and diseases of the ovary, prostate, or rectum. *Non-deforming club-foot* causes pain in the foot, leg, and ankle, and is supposed to be due to an alteration in the articular surfaces, the result of injury, arthritis, habitual malposition, or anterior poliomyelitis. The foot cannot be flexed beyond a right angle. *Erythromelalgia* is a curious nervous disorder in which there are redness, swelling, and burning pain, increased by heat and immediately relieved by cold.

Perforating ulcer of the foot (*mal perforant*) is most frequently seen beneath the head of the first or fifth metatarsal bone. As a rule a corn or callosity first appears, suppuration takes place beneath this, and a sinus results, the opening being surrounded by thickened epidermis; the sinus deepens, and if allowed to progress unchecked, the bones and joints may be destroyed. The discharge is scanty and pain frequently slight or absent. The cause of perforating ulcer is usually anesthesia of the sole of the foot, which permits repeated or long continued irritation without the individual's knowledge. It may be found in many diseases, conspicuous among which are leprosy, tabes dorsalis, and peripheral neuritis the result of alcohol, syphilis, or diabetes; it may result also from injury of the spinal cord or nerves. In rare instances it may follow epithelioma, a neglected corn, or other purely local lesion, and in these cases pain may be severe.

The **treatment** is relief of pressure by confining the patient to a chair, removal of the thickened epidermis after poulticing or soaking the foot in warm water, and disinfection and drainage of the sinus; the wound may then be stimulated by balsam of Peru, or weak solutions of silver nitrate or copper sulphate. Good results have followed stretching of the tibial or the plantar nerves. In recalcitrant cases the ulcer should be excised and necrotic bone removed. When the foot is extensively involved amputation may be necessary. The cause of the condition should, of course, be removed if possible.

AMPUTATIONS.

Amputation as applied to the extremities signifies the removal in continuity of the whole or a portion of a limb. If through a joint it is known as a *disarticulation*.

The **indications** for amputation are (1) to save life, e.g., in extensive crushes, virulent infections, gangrene, septic diseases of bone, tumors, and aneurysms; and (2) to provide for the fitting of useful artificial supports when the limb is functionless from disease or deformity. To amputate or not to amputate is a question which often taxes the surgeon's judgment to the utmost, as absolute rules cannot be formulated. The age and general condition of the patient may be such as to necessitate amputation, which under other circumstances would be inadvisable. Furthermore, a laborer who must support a large family can often be more quickly and better prepared to meet life's responsibilities with an artificial limb than with a badly crippled extremity, which to his more fortunate brother is an inconvenience only. In injuries the principal questions to be answered are: (1) Will the blood supply be adequate to prevent gangrene; (2) is the injury to the nerves and muscles so great that a useful limb cannot be obtained; (3) can infection be prevented or kept under control? 1. Laceration of the main artery or vein alone is not an indication for amputation, as either, indeed both, may be sutured or even tied without gangrene following, providing the collateral vessels are intact. If both artery and vein require ligation, however, and the collateral vessels also are damaged, amputation must be performed. Moszkowitz tests the efficiency of the circulation by elevating the limb, applying a tourniquet, then lowering the limb and after five minutes removing the constrictor. If the circulation is active, the whole limb becomes hyperemic in a few seconds. Parts which remain anemic are devitalized, those which improve in color very slowly will probably become gangrenous. Matas, in order to ascertain the condition of the collateral circulation, maintains the pressure on the artery after removing the tourniquet. Sandrock scrubs the limb vigorously, thus inducing hyperemia if the part is adequately nourished. If the limb is of normal color below the wound, if the peripheral ends of the artery and the vein bleed, and if congestion can be produced by compressing the main vein, the collateral circulation is capable of supporting the life of the limb. 2. Nerves and muscles may be sutured in suitable cases, but they are often so extensively damaged that they either cannot be approximated or repair cannot be expected. Extensive loss of skin in itself is rarely an indication for amputation. 3. Infection is practically never an indication for *primary amputation;* a finger may, however, be amputated immediately after a bite by a venomous snake or after a known infection with very virulent organisms. Unless amputation is positively demanded, e.g., in pulpification of the whole limb or a segment thereof, one is always justified in making an effort to preserve the part by careful disinfection and free drainage. If gangrene or extensive cellulitis follow within a few days, the limb may then be removed (*intermediate amputation*). *Secondary amputation*, i.e., after a number of days, may be required for secondary hemorrhage, osteomyelitis, chronic sepsis, exhaustion, or amyloid disease, or to remove a useless limb after healing has occurred.

As a rule, in accident cases, **operation** should be postponed until shock has subsided, the hemorrhage being temporarily stayed by applying a tourniquet as close as possible to the point at which the muscles and bone are crushed. The tissues thus compressed are already so devitalized that they would, in any event, be removed with the limb, hence the tourniquet is harmless and should remain in place until after the amputation, a second one being adjusted at a higher level to control bleeding during the operation. Disinfection, in these cases, can be thoroughly performed only after the induction of anesthesia. The operator stands to the right of the limb, which is brought to the edge of the table and held by an extra assistant.

Preliminary control of hemorrhage is secured by elevating the limb for several minutes, in order to allow the blood to drain into the vessels of the body, and applying an Esmarch band (Fig. 125) or other form of tourniquet

(Fig. 126) above the site of amputation. In certain regions (hip and shoulder) slipping downwards may be prevented by long pins thrust through the tissues below the band, by sutures, or by a bandage passing beneath the band and around the trunk. When elastic constriction is inadvisable (atheroma, etc.) or inapplicable (interscapulo-thoracic amputation, etc.), the main vessels may be occluded by digital pressure, or exposed by a preliminary incision and clamped or tied.

Division of the tissues must be so made that there will be sufficient periosteum to cover the bone, enough muscle to cover the periosteum, and ample skin to cover the muscles, the scar being so situated as not to be exposed to pressure. As the tissues subsequently contract, flaps which fit snugly are too short. Formerly made by entering a long knife close to the bone and cutting from within outwards (*transfixion*), flaps, at the present time, are dissected from without inwards, as anesthesia has removed the necessity for great haste, and it is important to divide the vessels and nerves transversely rather than obliquely. The manner in which the flaps are shaped is described

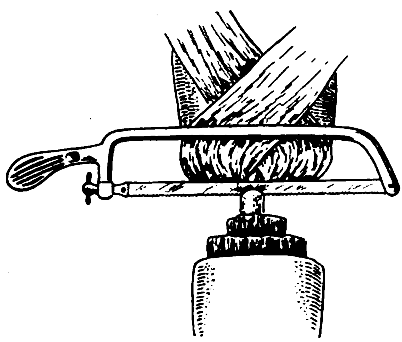


FIG. 548.—Circular amputation, showing application of two-tailed muslin retractor.

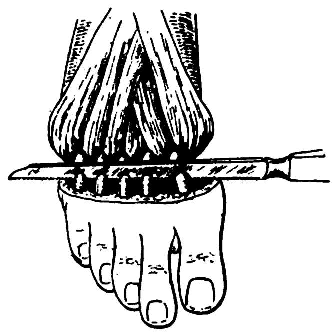


FIG. 549.—Amputation through metatarsus, showing application of six-tailed muslin retractor.

below. After retracting the soft parts the *periosteum* is incised circularly around the bone, at the level of the attached muscles, and pushed back with the raspatory for a distance equal to one-half the diameter of the bone, thus the periosteum retains its connections with the muscles, an important matter from the standpoint of its future nutrition. If, as is sometimes the case especially with thin bones, this cuff-like reflection of the periosteum is difficult, a longitudinal incision may be made through the deeper muscles and the periosteum on each side, from the circular cut to the proposed saw-line, so as to form musculo-periosteal flaps. The soft parts, including the periosteum, are now drawn out of harm's way by means of a piece of muslin with a slit in it (or with two or more slits in it if there are two or more bones, Figs. 548, 549), and the *bone* sawed transversely. The nail of the left thumb is pressed against the bone just above the saw-line and the blade of the saw steadied by the knuckle of the thumb. The saw is then lightly drawn from heel to point several times, so as to form a groove, after which, as there is less danger of injury to the soft parts from slipping of the saw, a to-and-fro motion is employed, but never with great force. When the section is nearly completed the strokes should become short and very light. Any spicules or bony irregularities are removed with rongeur forceps. *Nerves* and *tendons* are drawn out a little way and cut off short, thus preventing their inclusion in the cicatrix. In order to avoid the formation of neuromata, each large nerve may be exsected by a V-shaped incision, followed by suture of the neural flaps; the end of each nerve may be turned back and sutured to the trunk; the ends of the nerves may be sutured together or covered with fat; or, as mentioned above, the nerves may be cut at a high level and allowed to retract. If the amputation has been performed skillfully there will be little need for trimming away tags or shreds of muscle and fascia. The principles recited above are considered sound by most, but not all, surgeons. A few believe that retention of the deep fascia is liable to cause sloughing. Others fashion the flaps without muscular tissue, because it subsequently atrophies. Some do not cover the end of the bone with periosteum, indeed Bunge removes a cuff of this membrane above the saw-line and scrapes out the medullary cavity (*aperiosteal amputation*), claiming that this practice is less apt to be followed by a painful stump due to bony outgrowths. It is a curious fact that many of those who condemn the use of periosteal flaps are enthusiastic in their advocacy of osteoplastic amputation, which means a little bone added to the periosteum (see amputations of the leg). It has been suggested also that, in order to avoid callus, the end of the bone be covered by suturing the tendons over it, or by a free transplant of fascia lata.

Permanent control of hemorrhage is attained by isolating the large vessels, and tying each with silk or, better, chromicized catgut. The tourniquet is then removed, and the smaller vessels caught, and ligated with catgut. Capillary oozing may be controlled by pressure with gauze, or by very hot water; bleeding from the bone which persists after the use of these expedients may be arrested with bone wax.

Closure of the wound should obliterate all dead spaces. The periosteum and the muscles are stitched with catgut, the skin with silkworm gut. *Drainage* is not required if the wound is dry and clean. If oozing continues, gauze or a rubber tube may be inserted between the lips of the most dependent part of the wound, through which a suture is passed but not tied. After 24 or 48 hours the drain is removed and the suture tied. Drainage for infection must be maintained until the healing process is almost completed. After applying the *dressing*, the stump is firmly bandaged in such a way as not to drag on the flaps; then bound to a splint which projects beyond the end of the stump, thus protecting it from injury; elevated on a pillow in order to minimize oozing; and covered with a cradle, which supports the bed clothing. The *sutures* are removed at the end of ten days, after which tension on the line of union is relieved by means of strips of sterilized adhesive plaster.

The fundamental **types of amputation,** designated according to the shape of the incision in the soft parts, are the circular, the oval, the racquet, and the flap methods.

In the **circular amputation** the skin and the subcutaneous tissues are divided around the whole circumference of the limb, at a distance below the level of the intended saw-line, equal to three-fourths of the diameter of the limb at the saw-line. The skin and superficial fascia are dissected back like a cuff, the superficial muscles divided at the level of the retracted skin, and the deep muscles divided at the edge of the retracted superficial muscles, so that the cut surfaces resemble a funnel (Fig. 550). The periosteum, the deep muscles, the superficial muscles, and the skin are, in turn, sutured, either transversely or anteroposteriorly, the scar being situated on the end of the stump. The method may be employed when the bone is evenly surrounded by muscles, e.g., in the arm and the thigh. It is simple, quick, sacrifices less of the soft parts than other methods, supplies a thick covering for the bone, and does not endanger the blood supply to this covering, but it has a limited range of applicability, produces a funneled wound that may render exposure of the bone at the saw-line difficult, and, owing to the retraction of the muscles, is sometimes followed by a conical stump.

In the **oval method** an elliptical incision is made around the limb, through the skin and the subcutaneous tissues, the upper end of the ellipse being just above the saw-line, and the lower end at a distance below the saw-

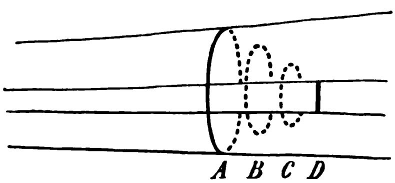


FIG. 550.—Circular amputation. A, level of skin incision; B, level of section of superficial muscles; C, of deep muscles; D, saw line.

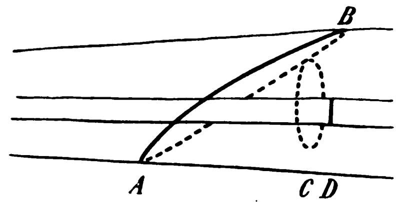


FIG. 551.—Oval amputation. AB, skin incision; C, level of section of muscles; D, saw-line. At the completion of the operation A is sutured to B.

line equal to one and one-half diameters of the limb at the saw-line. The distal portion of the ellipse is dissected up, and the muscles divided circularly a little below the proximal end of the skin incision, or the muscles underlying the distal half of the ellipse may be divided in the plane of the oval and those on the opposite side of the limb divided circularly just below the level of the saw-line. The operation is completed by suturing the free convex border of the cutaneous incision to the upper concave margin (Fig. 551), consequently the scar is on the side of the stump. This method is

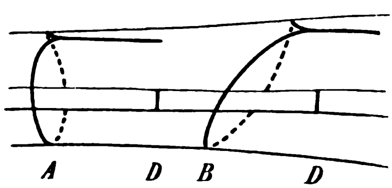


FIG. 552.—Racquet amputations. A, transverse racquet incision; B, oblique racquet incision; D, saw-line.

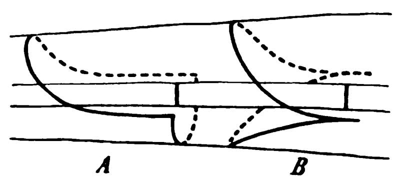


FIG. 553.—Flap amputations. A, single long flap; B, double equal flaps.

employed chiefly for disarticulation of the elbow or the wrist. It has the advantages and disadvantages of amputation by a long single flap.

The **racquet method** (Fig. 552) consists of a straight incision in the axis of the limb, joining a circular or oval incision around the limb, the angles formed by the junction of the incisions being rounded. The muscles beneath the straight incision are divided or separated down to the bone, and those beneath the circular or the oval incision divided at the level of the retracted skin. The wound is closed in its long axis, so that the scar runs across the end of the stump and up one side. The racquet method is often employed for disarticulations. If desirable the parts may be explored through the longitudinal incision before deciding on amputation, and through the same incision the main vessels can be secured before removing the limb.

Lateral or anteroposterior flaps may consist merely of skin and subcutaneous tissue, or of all the tissues, the muscles being cut obliquely

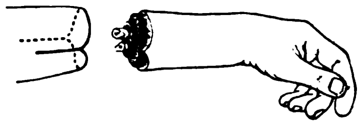


FIG. 554.—Modified flap and circular amputation of the forearm.

from the line of the retracted cutaneous incision, to a point on the bone at a distance below the saw-line equal to a little more than the diameter of the bone at the saw-line, which is exposed by pushing back the musculoperiosteal covering in the usual manner. The flaps may be single or double (Fig. 553), and of various sizes and shapes, according to the exigencies of the case, but their bases should be half the circumference of the limb in width, and the length of single flaps, or the combined length of double flaps, should be one and one-half diameters of the limb at the saw-line. The scar is situated to the side of the stump after an amputation by a single flap, on the end and the sides after an amputation by equal flaps, and, according to the degree of inequality, on the side, or partly on the side and partly on the end, after an amputation by unequal flaps. The flap method may be employed in any region, permits easy exposure of the bone at the saw-line, and gives a more shapely stump than the circular amputation, but it sacrifices more of the limb, produces a larger wound, with the muscles and the vessels cut obliquely, and may not adequately provide for the nourishment of the flaps if they are long. Hence many surgeons, in order to combine the merits of the flap and the circular amputations employ, when possible, the ***modified flap and circular method***, which consists of two rectangular flaps, with rounded corners, made on opposite sides of the limb. The skin and the subcutaneous tissues are reflected, and the muscles divided as in the circular amputation (Fig. 554). *Osteoplastic flaps* are described under amputations of the leg.

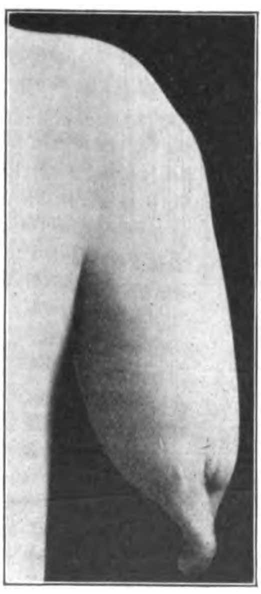


FIG. 555.—Conical stump from continued growth of bone. Reamputation.

A **stump** when healed should be firm, symmetric, well covered, freely movable, and painless. The scar should not be adherent to the bone, or on that portion of the stump which is subjected to pressure, e.g., on the palmar surface of the hand or plantar surface of the foot. The most favorable situation for a scar after higher amputations is mentioned in the paragraph on artificial limbs. All of the tissues of a stump necessarily atrophy. The end of the bone becomes smooth, and the medullary cavity is often closed by osseous tissue. *Necrosis* of the end of the bone may be caused by stripping up of the periosteum, especially when followed by infection.

Diffuse septic osteomyelitis and *secondary hemorrhage* (q.v.) are uncommon complications at the present time. *Sloughing of the flaps* results from amputating too close to the lesion, too thin flaps, arterial disease (atheroma), or from some debilitating constitutional malady, especially diabetes. If extensive, reamputation may be needed. *Conical stump* is caused by too short flaps, cicatricial contraction following septic processes, and, in the young, from continued growth of the bone (Fig. 555). In the worst cases the end of the bone is exposed. The treatment is reamputation. *Painful stump*, apart from ulceration (vide infra), is caused by disease of the bone or the nerves. Periostitis, ostitis, and exostoses, formerly thought to be of secondary importance, have, since the advent of the X-ray, been proved to be responsible for most sensitive stumps. If relief is not obtained by the ordinary treatment for inflammatory disease of bone, reamputation, with careful suturing of the periosteal flaps, or, according to Bunge, by the aperiosteal method, should be performed. *Neuralgia of a stump* is due to encarceration of a nerve in the cicatrix, to adhesions about a nerve at a higher level, or to the formation of a neuroma. A cicatrix or a neuroma may be excised, adhesions separated, the nerve cut at a higher level, or reamputation performed. Recurrence may be prevented as already indicated in the paragraph on division of the tissues. *Spasmodic stump* may complicate neuralgia, and is then curable by the same treatment. When of central origin, relief is usually not obtained. *Ulceration* of the scar is prone to develop if it is thin and adherent or exposed to pressure, although it may depend upon some constitutional disease (syphilis, etc.). The worst cases require reamputation. Occasionally *epithelioma* develops.

Artificial limbs are adjusted after the stump has shrunken and become solid and resistant. In order to hasten this process the stump should, as soon as the wound is healed, be bandaged firmly, or a leather "stump corset" worn, after several weeks of which treatment measurements can be made for the new limb. While waiting for the new limb massage and active motions should be practised, in order to maintain the nutrition of the part, and prevent fixation of the neighboring joint at an inconvenient angle. Slight shrinkage of the stump after the limb is applied can be compensated by wearing a thicker stocking; marked shrinkage will necessitate a new socket. As the end of a stump in the upper extremity, exclusive of the hand, is not subjected to pressure, even by an artificial arm, which is hollow and takes its support from the sides of the limb, the best place for the cicatrix is on the face of the stump. In the lower extremity, if the patient is to wear a modern artificial leg, which is constructed in the same manner as an artificial arm, the most favorable site for the scar is on the end of the stump. If the patient is to wear a "poor man's leg," i.e., a solid one which receives the weight of the body through the end of the stump, the scar should, if possible, be placed on the side of the stump, and the stump should, as soon as healed, be prepared for weight bearing by pressing it, several times daily, for gradually increasing periods, against a bran bag, and, later, against a board, after which practice with the peg-leg should be started.

SPECIAL AMPUTATIONS.

In many cases, particularly after injuries, no set amputation is applicable; one must remove the devitalized or diseased tissues and fashion impromptu flaps from that which remains, hence the following methods must be regarded as suggestive only.

In **amputations of the fingers and hand** the principal objects to be kept in mind are usefulness, symmetry, and the avoidance of a palmar scar. **Disarticulation of the distal phalanx** should be performed, when possible, by opening the joint transversely on the dorsal aspect, dividing the lateral

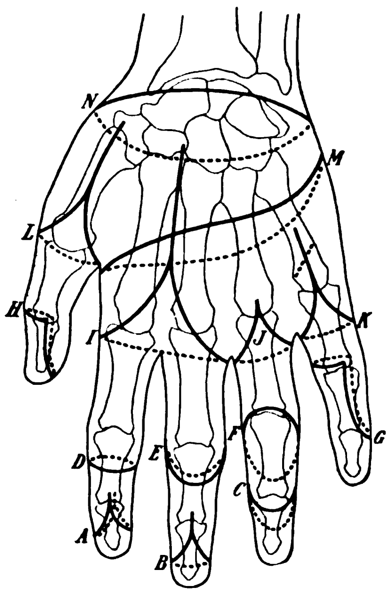


FIG. 556.—Dorsal surface of hand. Disarticulation at second interphalangeal joint (A) by equal lateral flaps, (B) by racquet incision, (C) by short posterior and long anterior flap. Disarticulation at first interphalangeal joint (D) by circular incision, (E) by equal anterior and posterior flaps, (F) by oval incision, (G) by single lateral flap. Removal (H) of distal phalanx of thumb by single palmar flap, (I) of index and middle fingers at carpometacarpal joints by racquet incision, (J) of ring finger at metacarpophalangeal joint by racquet incision, (K) of little finger by racquet incision with beveling of metacarpal bone for symmetry as indicated by dotted line across bone, (L) of thumb and metacarpal bone by racquet incision, (M) of the four fingers and their metacarpal bones by unequal flaps. (N) Disarticulation at wrist by oval incision.

ligaments, and cutting a long palmar flap from the pulp of the finger. The incision outlining this flap passes from the joint-line downwards along the middle of the side of the finger, thus avoiding the palmar digital artery, which runs nearer the palmar surface. The incision then curves across the palmar surface at a distance below the joint-line equivalent to one and one-half diameters of the finger at the articulation, and passes upwards along the middle of the opposite side of the finger to the joint-line. There is no theca over the distal phalanx. In amputating through the lower half of **the middle phalanx** the deep flexor will be severed, and should be sutured to the orifice of the theca, which is closed at the same time. In amputating through the middle phalanx above this level or through the **proximal phalanx** both flexors are severed, and should be treated in the same way. Each bone of the thumb, however, is supplied with different tendons. The various methods of amputation are shown in Fig. 556. If in doubt as to the necessity of amputation of the fingers, do not amputate; the reverse is true of the toes. When amputating through a phalanx the section should be made, not with cutting forceps, which are apt to splinter the bone, but with a Gigli saw. In a traumatic amputation through a phalanx, one may, in suitable cases, cover the raw surface with a Wolf graft, or a pedunculated flap from the abdomen or other part, instead of sacrificing more bone in order to secure flaps. A lost finger has been replaced by a toe, transplanted by the Italian method.

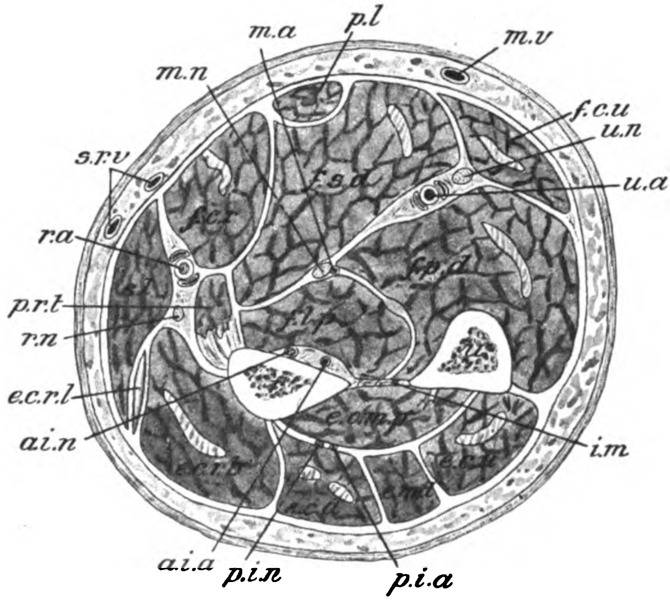


FIG. 557.—Section through the forearm above the middle. (After Braune, and Esmarch and Kowalzig.) *r.* Radius. *u.* Ulna. *i.m.* Interosseous membrane. Muscles: *s.l.* Supinator longus. *p.r.t.* Pronator radii teres. *e.c.r.l.* Extensor carpi radialis longior. *e.c.r.b.* Extensor carpi radialis brevior. *e.c.d.* Extensor communis digitorum. *e.o.m.p.* Extensor ossis metacarpi pollicis. *e.m.d.* Extensor minimi digiti. *e.c.u.* Extensor carpi ulnaris. *f.l.p.* Flexor longus pollicis. *f.p.d.* Flexor profundus digitorum. *f.s.d.* Flexor sublimis digitorum. *f.c.u.* Flexor carpi ulnaris. *p.l.* Palmaris longus. *f.c.r.* Flexor carpi radialis. Vessels: *r.a.* Radial artery and venæ comites. *u.a.* Ulnar artery. *m.a.* Median artery. *a.i.a.* Anterior interosseous artery. *p.i.a.* Posterior interosseous artery. *s.r.v.* Superficial radial vein. *m.v.* Median vein. Nerves: *m.n.* Median nerve. *u.n.* Ulnar nerve. *a.i.n.* Anterior interosseous nerve. *p.i.n.* Posterior interosseous nerve. *r.n.* Radial nerve. (Walsham.)

Amputation at the metacarpo-phalangeal joint is best done by a racquet shaped incision, which starts over the knuckle and is carried obliquely around the phalanx at the level of the web of the finger (Fig. 556). The articulation is opened from the dorsal side. Lateral flaps taken from the outer side may be used in amputations of the thumb, index, and little fingers. While removal of the head of the metacarpal bone increases symmetry by allowing the adjoining fingers to fall together, it impairs the strength of the hand, hence is contraindicated in a laboring man. The metacarpal bone can be removed by extending the incision corresponding to the handle of the racquet upwards (Fig. 556).

Amputation at the wrist joint may be performed by an *elliptical* incision (Fig. 556), which is one-half inch below the articulation on the dorsal side, and two inches lower on the palmar side; it passes between the pisiform and the base of the fifth metacarpal on the ulnar, and crosses the carpometacarpal joint on the radial side. The joint is opened from the

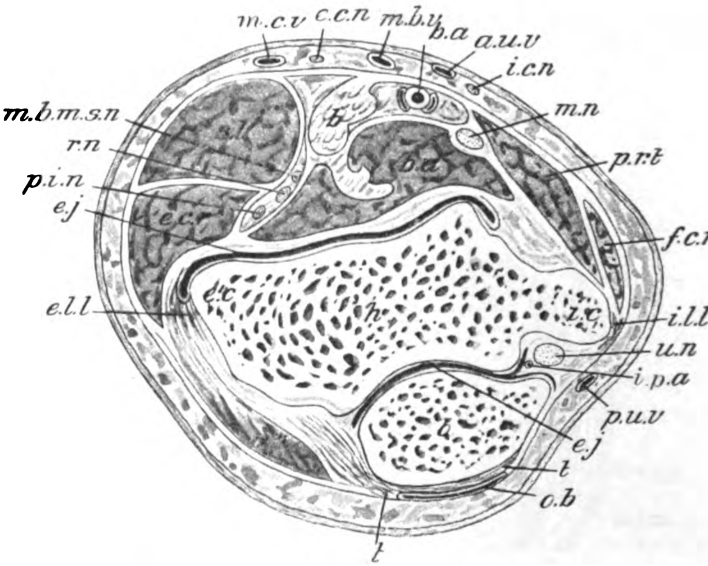


FIG. 558.—Section through the elbow joint. (After Braune, and Esmarch and Kowalzig.) Bones, ligaments, and synovial membrane: *h.* Humerus. *e.c.*, *i.c.* External and internal condyle. *o.* Olecranon. *ej.*, *ej.* Elbow joint. *o.b.* Olecranon bursa. *e.l.l.*, *i.l.l.* External and internal lateral ligament. Muscles: *s.l.* Supinator longus. *e.c.r.* Extensor carpi radialis. *a.n.* Anconeus. *t.* Triceps. *f.c.r.* Flexor carpi radialis. *p.r.t.* Pronator radii teres. *b.a.* Brachialis anticus. *b.* Biceps. Vessels: *b.a.* Brachial artery with venæ comites. *i.p.a.* Inferior profunda artery. *m.c.v.* Median cephalic vein. *m.b.v.* Median basilic vein. *a.u.v.* Anterior ulnar vein. *p.u.v.* Posterior ulnar vein. Nerves: *m.n.* Median nerve. *u.n.* Ulnar nerve. *r.n.* Radial nerve. *p.i.n.* Posterior interosseous nerve. *m.b.m.s.n.* Muscular branch of the musculo-spiral nerve. *i.c.n.* Internal cutaneous nerve. (Walsham.)

dorsal surface. *An external lateral flap* (*Dubreuil's method*) may be made by an incision which starts on the dorsal surface at the junction of the middle and outer third of the wrist, curves downward to the head of the metacarpal bone of the thumb, and then passes upward on the palmar surface to a point immediately opposite its commencement. Some of the muscular tissue of the thenar eminence should be included in the flap. The ends of the flap are connected by a circular incision on the ulnar side and the wrist disarticulated. A *long palmar flap* reaching to the middle of the metacarpal bones may be similarly employed.

Amputation through the forearm (Figs. 554, 557) may be effected by any of the flap methods. The muscles should be divided circularly, the interosseous membrane severed, a three-tailed muslin retractor applied, and both bones sawed through at the same time, after making a guiding groove in the radius.

Cinematic amputation (*Vanghetti's operation*) has been employed in the forearm. The tendons are cut longer than the bones, and loops formed by suturing the ends together or by turning the tendons back upon themselves, or knobs made by tying the ends in knots or by chiseling off the bony insertion. The loops or knobs are enveloped in skin flaps, so that after healing takes place they may be attached to hooks or strings and thus convey movement to an artificial limb.

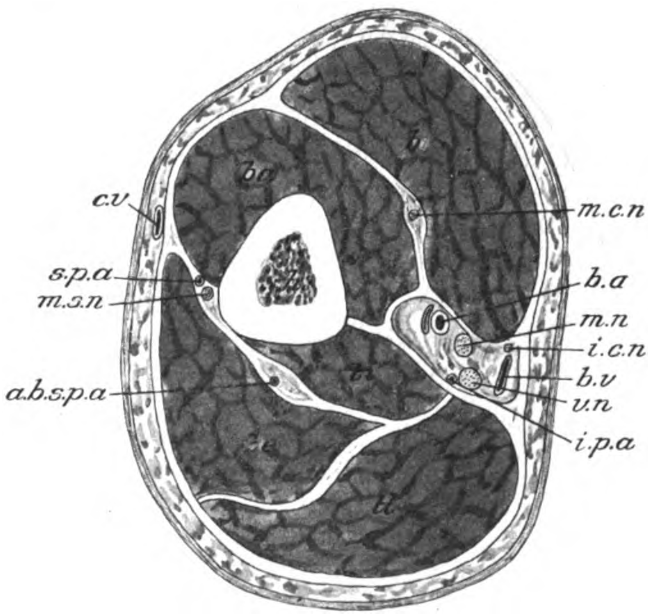


FIG. 559.—Section through the arm below the middle. (After Braune, and Esmarch and Kowalzig.) Muscles: *b.* Biceps. *ba.* Brachialis anticus. *te.* External head of triceps. *tl.* Long head of triceps. *ti.* Inner head of triceps. Vessels: *b.a.* Brachial artery with vena comites. *i.p.a.* Inferior profunda artery. *s.p.a.* Superior profunda artery. *a.b.s.p.a.* Articular branch of the superior profunda artery. *b.v.* Basilic vein. *c.v.* Cephalic vein. Nerves: *m.n.* Median nerve. *i.c.n.* Internal cutaneous nerve. *u.n.* Ulnar nerve. *m.c.n.* Musculo-cutaneous nerve. *m.s.n.* Musculo-spiral nerve. (Walsham.)

Disarticulation at the elbow joint (Fig. 558) is unsatisfactory, amputation above or below the joint being preferable. When undertaken, the elliptical or long anterior flap method should be used.

Amputation through the arm (Figs, 559, 560) may be accomplished by any of the methods as indicated by the conditions.

Amputation at the shoulder joint may be performed while the subclavian vessels are controlled by direct pressure, or the axillary vessels may be ligated as a preliminary step. Elastic constriction by Wyeth's method (see amputation of hip) has the objection that hemorrhage may occur when the bone is removed. The posterior pin enters at the middle of the lower margin of the posterior axillary fold, and emerges just behind and one inch within the acromion process. The anterior pin is introduced at the middle of the lower margin of the anterior axillary fold and emerges one inch to the inner side of the acromion. The constricting band is applied above the pins. The classical operations are those of Spence, Larry, and Dupuytren.

Spence's operation (anterior racquet, Fig. 561) is begun by making an incision down to the bone, from midway between the coracoid and acromion processes, downwards and outwards for three or four inches;

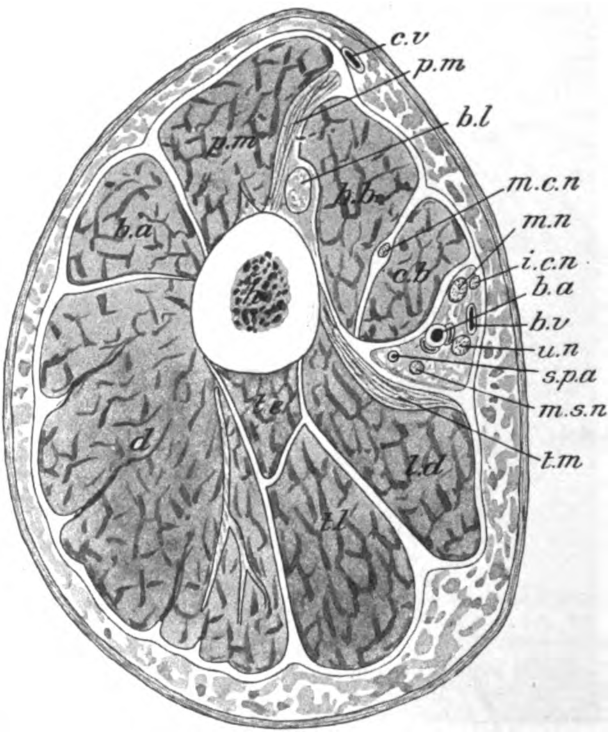


FIG. 560.—Section above the middle of the arm. (After Braune, and Esmarch and Kowalzig.) Muscles: *p.m.* Pectoralis major. *b.a.* Brachialis anticus. *d.* Deltoid. *t.e.* External head of triceps. *t.l.* Long head of triceps. *l.d.* Latissimus dorsi. *t.m.* Teres. major. *c.b.* Coraco-brachialis. *b.b.* Short head of biceps. *b.l.* Long head of biceps. Vessels: *b.a.* Brachial artery with venæ comites. *s.p.a.* Superior profunda artery. *b.v.* Basilic vein. *c.v.* Cephalic vein. Nerves: *m.n.* Median nerve. *u.n.* Ulnar nerve. *m.s.n.* Musculo-spiral nerve. *i.c.n.* Internal cutaneous nerve. *m.c.n.* Musculo-cutaneous nerves (Walsham.)

if desirable the joint may be opened at once for examination. The knife is then carried downwards and inwards across the axillary fold and around the arm to the end of the primary incision. The skin is reflected for an inch or more and the muscles on the inner aspect divided obliquely, thus exposing the axillary vessels, which are ligated and divided. The soft parts on the outer side are separated from the bone, the inner half of the capsule and the subscapularis divided, the head of the humerus drawn outwards, the division of the capsule completed, and the remaining tissues cut by carrying the knife downwards close to the inner side of the bone, to avoid injury to the posterior trunk of the circumflex artery.

Larry's operation is an external racquet amputation (Fig. 562). A six inch vertical incision is made from the tip of the acromion down the outer side of the arm. The oval incision begins at the center of the vertical and is carried obliquely around the arm. The flaps are reflected from the outer aspect of the joint and the extremity removed as in the Spence operation.

Dupuytren's amputation consists of a U-shaped flap extending from the coracoid to the root of the acromion, the lowest point reaching to the insertion of the deltoid (Fig. 562). The inner flap is made by an incision joining the ends of the former and extending two inches below the axilla. Disarticulation is accomplished as in other methods.

Interscapulo-thoracic amputation is the removal of the entire upper extremity, arm, scapula, and the whole or a portion of the clavicle. An

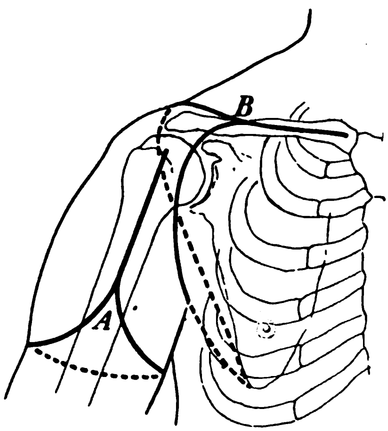


FIG. 561.—A. Spence's amputation. B. Interscapulothoracic amputation.

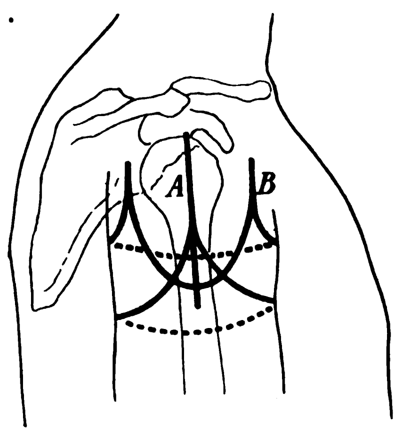


FIG. 562.—A. Larry's amputation. B. Dupuytren's amputation.

incision is made along the clavicle, and the preliminary control of hemorrhage secured by ligation of the subclavian vessels, after resecting the middle third of the clavicle (Berger), or after disarticulating its sternal end (Le Conte), care being taken not to open the pleura. The anterior flap is outlined by carrying the knife from the center of the clavicular incision downwards and outwards across the anterior axillary fold and backwards to the lower angle of the scapula (Fig. 561). The muscles are severed, thus exposing the brachial nerves, which are cut on the same level as the subclavian vessels. The limb is then carried across the chest, and a posterior flap made by joining the ends of the two previous incisions. The scapular muscles are detached and the whole extremity removed.

Amputations of the toes, excepting the great toe, are never made except at the metatarso-phalangeal articulation, the operation then being identical with that described for the fingers, remembering, however, that the joint is the same distance behind, as the tip of the toe is in front of the web.

Disarticulation at the tarso-metatarsal joint (*Lisfranc amputation*) is performed by making a curved incision from the base of the first metatarsal across the dorsum of the foot to the base of the fifth (Fig. 563). The plantar flap curves convexly to the root of the toes, and includes all the tissues of the foot to the bones. To disarticulate (Fig. 564), the knife is passed behind the projecting end of the fifth metatarsal and directed toward the base of the great toe; the fourth metatarsal is separated by cutting toward the middle of the fifth metatarsal, and the third by cutting towards its base; the knife then glides over the second metatarsal, and enters the joint of the first metatarsal. The second metatarsal is separated by incising

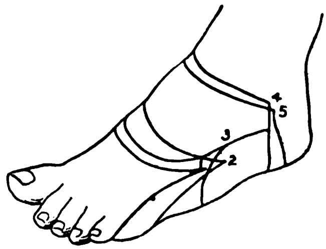


FIG. 563.—Incisions for (1) Lisfranc's, (2) Chopart's, (3) Subastragaloid, (4) Pirogoff's, and (5) Syme's amputations.

its dorsal ligament transversely and then cutting upwards between the first and second metatarsals. By strongly depressing the foot any remaining attachments may be severed and the disarticulation completed. *In the Hey operation* the difficulty of disarticulating the second metatarsal is overcome by sawing through the projecting internal cuneiform. In *Skey's method* the second metatarsal is sawn through at its base. *Baudens* advised disarticulating the first metatarsal and sawing through the remaining ones at the same level.

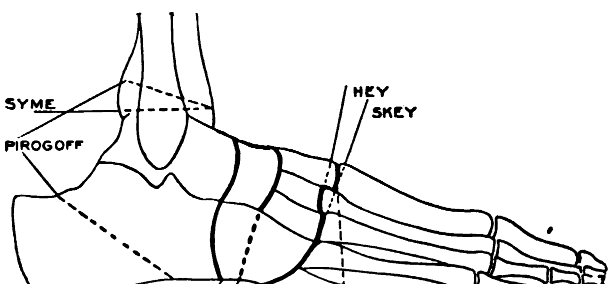


FIG. 564.—Diagram of amputations of foot.

Disarticulation at the Mid-tarsal Joint (*Chopart's Amputation*, Figs. 563, 564).—The long plantar incision begins on the inner side at the tubercle of the scaphoid, curves forward to within one inch of the ends of the metatarsal bones, and terminates on the outer side at a point midway between the malleolus and base of the fifth metatarsal. The dorsal incision curves slightly forward and unites the ends of the plantar. The astragalo-scaphoid and the calcaneo-cuboid articulations are opened from the dorsal side. The muscles and tendons of the flaps should be sutured together,

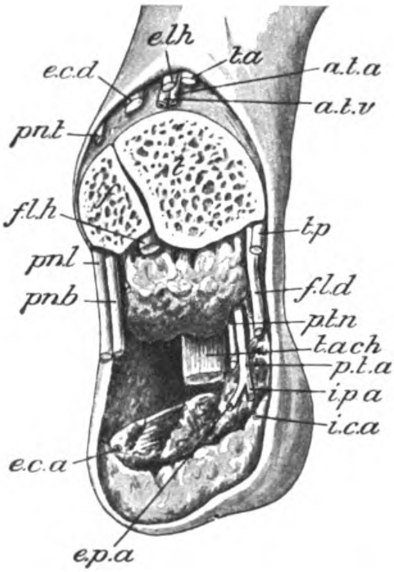


FIG. 565.—Syme's amputation, showing the structures divided. *f.* Fibula. *t.* Tibia. *t.a.* Tibialis anticus tendon. *e.l.h.* Extensor longus hallucis. *a.t.a.* Anterior tibial artery. *a.t.v.* Anterior tibial vein. *e.c.d.* Extensor communis digitorum. *pn.l.* Peroneus longus. *pn. b.* Peroneus brevis. *f.l.h.* Flexor longus hallucis. *t.* Ach. Tendo Achillis, beneath which is a bolster of fat. *t.p.* Tibialis posticus. *f.l.d.* Flexor longus digitorum. *p.t.a.* Posterior tibial artery dividing into *e.p.a.* and *i.p.a.* external and internal plantar artery. *e.c.a.* and *i.c.a.* External and internal calcaneal branches forming the blood supply of the thick heel-flap. (Walsham.)

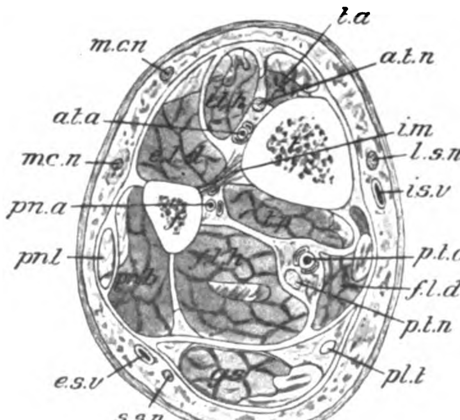


FIG. 566.—Section through the lower third of the leg. (After Braune, and Esmarch and Kowalzig.) *f.* Fibula. *t.* Tibia. *i.m.* Interosseous membrane. Muscles and tendons: *t.a* Tibialis anticus. *e.l.h.* Extensor longus hallucis. *e.l.d.* Extensor longus digitorum. *pn.l.* Peroneus longus. *pn.b.* Peroneus brevis. *t.p.* Tibialis posticus. *f.l.h.* Flexor longus hallucis. *g. s.* Gastrocnemius and soleus forming the tendo Achillis. *pl.t.* Plantaris tendon. *f.l.d.* Flexor longus digitorum. Vessels: *a.t.a.* Anterior tibial artery. *pn.a.* Peroneal artery. *p.t.a.* Posterior tibial artery. *i.s.v.* Internal saphenous vein. *e.s.v.* External saphenous vein. Nerves: *a.t.n.* Anterior tibial nerve. *m.c.n.* Musculo-cutaneous nerves. *p.t.n.* Posterior tibial nerve. *s.s.n.* Short saphenous nerve. *l.s.n.* Long saphenous nerve. (Walsham.)

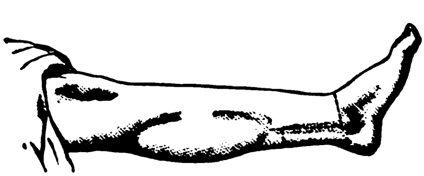
taking particular care to secure the extensor tendons and the tibialis anticus, in order to oppose the tendency towards retraction of the heel by the calf muscles. Despite this precaution, however, the os calcis is often drawn upwards subsequently because of the removal of the anterior part of the arch of the foot, which leaves the posterior without any support. As a result the limb is lengthened, and the patient walks on the astragalus, thereby causing considerable pain and perhaps ulceration. *Forbes* separated the cuneiform bones from the scaphoid and sawed through the cuboid.

Subastragaloid amputation of the foot makes a useful stump covered by the skin of the heel. A racquet-shaped incision (Fig. 563) is made, commencing at the insertion of the tendon of Achillis, and extending along the outer side of the foot to a point just above the base of the fifth metatarsal, where it encircles the foot. The dorsal flap is reflected, the tendon of Achillis divided, the astragalo-scaphoid joint opened, the foot twisted inwards, and the astragalus separated from the os calcis, which is then cleared and the foot removed.

Amputation at the ankle joint by Syme's or Pirogoff's method gives a clumsy stump, but one which is covered by the resistant tissues of the heel and capable of weight-bearing. *Syme's amputation* (Figs. 563, 564, 565) is a disarticulation at the ankle joint, with removal of the malleoli and the articular surface of the tibia. An incision is made down to the bone at the tip of the external malleolus, and is carried under the heel to a point one-half inch below and behind the inner malleolus. This flap is dissected from the os calcis, keeping close to the bone to avoid the calcaneal vessels. The dorsal incision unites the ends of the first and is slightly convex downward. The ankle joint is then opened from the dorsal aspect, the posterior ligaments and the tendon of Achillis divided, and the lower ends of the tibia and fibula removed with the saw.

Pirogoff's amputation differs from Syme's in that the posterior portion of the os calcis is sawn off and approximated to the sawn ends of the tibia and fibula, the plantar incision, forming a right angle with the dorsal, being carried obliquely forward instead of vertically downwards (Fig. 563). The lower ends of the tibia and fibula are sawn obliquely and almost parallel with the sawn surface of the os calcis (Fig. 564). The bones are then approximated and held in place by wire, or by catgut sutures passing through the periosteum. *LeFort* modifies this operation by sawing the tibia and os calcis horizontally. *Ferguson* allowed the malleoli to remain and brought the fragment of the os calcis up between the two.

Amputation through the leg should never be performed within three inches of the upper end of the tibia, as the stump is too short to provide the leverage necessary for manipulating an artificial limb, and is apt to become permanently flexed as the result of contraction of the ham-string muscles. Amputation just above the ankle, although occasionally performed, likewise is objectionable in that the stump, which consists merely of skin, bone, and tendon, is often badly nourished, hence predisposed to ulceration. The point of election for amputation through the leg, so far as subsequent prosthesis is concerned, is at the junction of the middle and lower thirds. The fibula should always be divided at a higher level than the tibia, the sharp anterior edge of which should be beveled. As in the forearm, a three-tailed retractor will be needed to keep the soft parts out of harm's way when the saw is used. In the *lower third* (Fig. 566) lateral flaps of equal length are perhaps the best. *Osteoplastic flaps* (Moschcowitz) may be obtained from the malleoli and made to cover the ends of the two bones; they should be on the same plane as the articular cartilage of the tibia. *Teal's method* (Figs. 567, 568) consists of two rectangular flaps including all the structures down to the bone. The length and breadth of the long flap, which is taken



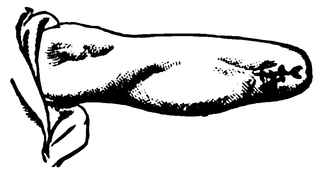


Fig. 567. Fig. 568.

Teale's amputation. (Moullin.)

from the surface where the bone is most superficial, should be equal to one-half the circumference of the leg at the proposed site of amputation. The short flap, containing the main blood vessels, is one-quarter the length of the long flap. In the *middle and upper thirds* likewise (Fig. 569), two lateral flaps

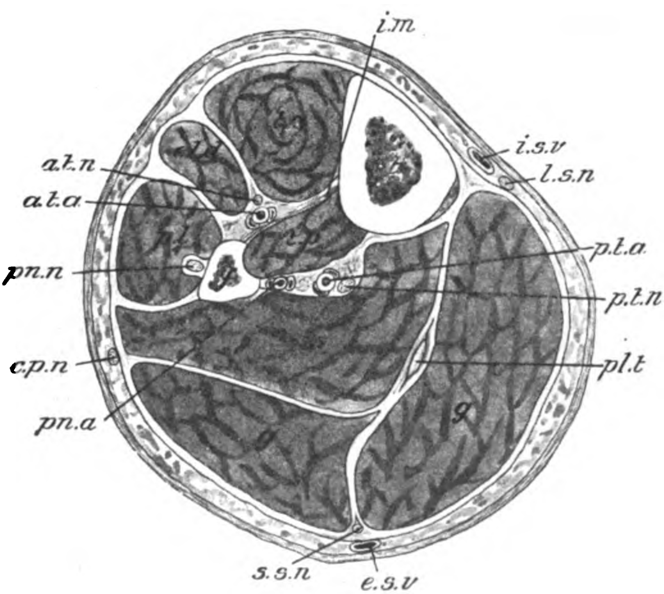


Fig. 569.—Section through the middle of the leg. (After Braune, and Esmarch and Kowalzig.) *f.* Fibula. *t.* Tibia. *i.m.* Interosseous membrane. Muscles: *t.a.* Tibialis anticus. *e.l.d.* Extensor longus digitorum. *p.l.* Peroneus longus. *t.p.* Tibialis posticus. *s.* Soleus. *g.g.* Gastrocnemius. *pl.t.* Plantaris. Vessels: *a.t.a.* Anterior tibial artery with venæ comites. *p.t.a.* Posterior tibial artery. *pn.a.* Peroneal artery. *i.s.v.*, *e.s.v.* Internal and external saphenous vein. Nerves: *a.t.n.* Anterior tibial nerve. *pn.n.* Peroneal nerve. *p.t.n.* Posterior tibial nerve. *l.s.n.* Long saphenous nerve. *s.s.n.* Short saphenous nerve. (Walsham.)

of equal length are satisfactory, or the external flap may be long and the internal short. In the latter operation care should be taken to cut the anterior tibial artery long, and not to injure it in separating the interosseous membrane. An oblong *osteoplastic flap* (Bier) may be sawn from the anterior portion of

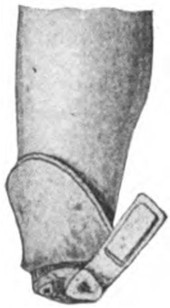


Fig. 570. Fig. 571.
Bier's osteoplastic amputation of leg. (Esmarch and Kowalzig.)

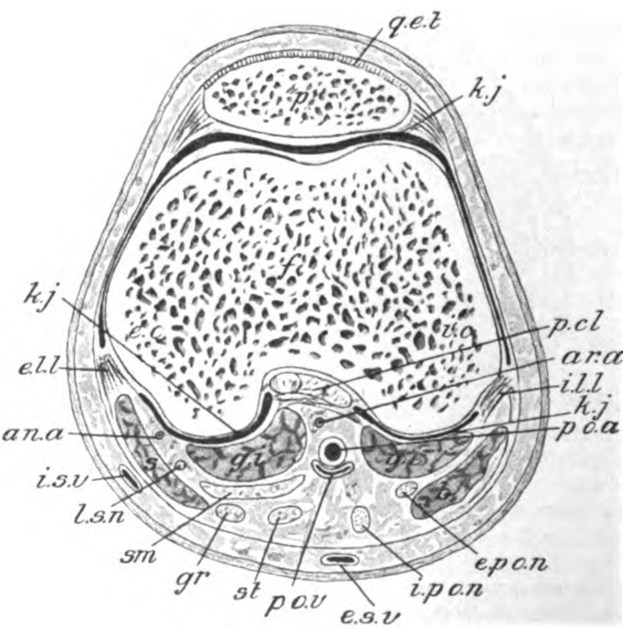


Fig. 572.—Section through the condyles of the femur, to show the relations of the structures. (After Braune, and Esmarch and Kowalzig.) *f.* Femur. *p.* Patella. Muscles: *g.i.*, *g.e.* External and internal head of the gastrocnemius. *s.* Sartorius. *sm.* Semimembranosus, *gr.* Gracilis. *st.* Semi-tendinosus. *b.* Biceps. *k.j.* Knee joint. *i.l.l.*, *e.l.l.* Internal and external lateral ligament. *p.c.l.* Posterior and crucial ligaments. Vessels: *po.a.* Popliteal artery. *ar.a.* Articular branch. *an.a.* Anastomotic artery. *po.v.* Popliteal vein. *i.s.v.* Internal saphenous vein. *e.s.v.* External saphenous vein. Nerves: *e.po.n.* External popliteal nerve. *i.po.n.* Internal popliteal nerve. *l.s.n.* Long saphenous nerve. (Walsham.)

the tibia, and turned upward by fracturing its upper border; the periosteum forming the hinge of the flap is then separated from the tibia for a short distance, the tibia and fibula divided on a level with the base of the hinge, and the flap sutured over the ends of the bones with chromicized catgut sutures passing through the periosteum (Figs. 570, 571). The advantages claimed are the closure and protection of the medullary canal, increased stability of the bone, and a movable skin flap. Binnie simplifies this operation by using a free transplant of bone covered with periosteum. Another method (Bier), which can be employed in any region, is to remove a wedge of bone a short distance above the line of amputation, and close the wedge at the completion of the operation, thus changing the position of the scar and closing the medul-

FIG. 573.

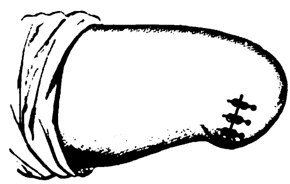


FIG. 574.

Carden's amputation. (Moullin.)

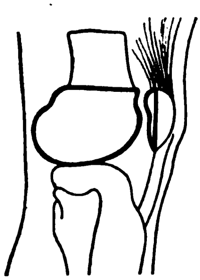


FIG. 575.

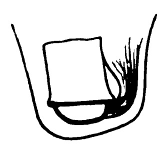


FIG. 576.

Gritti's amputation.

lary cavity. Osteoplastic amputations are tedious, and are contraindicated in the presence of infection, and in most traumatic cases.

Disarticulation at the knee joint (see Fig. 572 for relations) may be effected after making bilateral flaps. Two semilunar incisions, starting at a point just below the tibial tubercle, curve around each side of the leg, meeting again posteriorly in the midline on a level with the joint. As the internal condyle is the larger, the inner flap should be longer. The ligamentum patellæ is divided and the joint opened and disarticulated. *A long anterior flap* may be made by an incision from one condyle to the other, and extending to a point five inches below the patella; a short curved incision unites the ends of the former. The patella should be removed, or fastened between the condyles. The stump is ungainly in appearance but capable of bearing weight.

Supracondyloid Amputation of the Femur (Carden's Method).— An anterior semilunar flap of skin and subcutaneous tissues is outlined by an incision passing from one condyle to the other, and reaching downward to

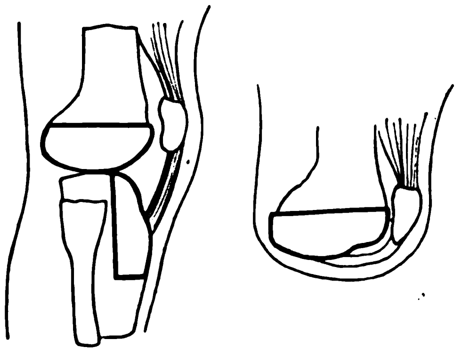


FIG. 577. FIG. 578.
Sabanejeff's amputation.

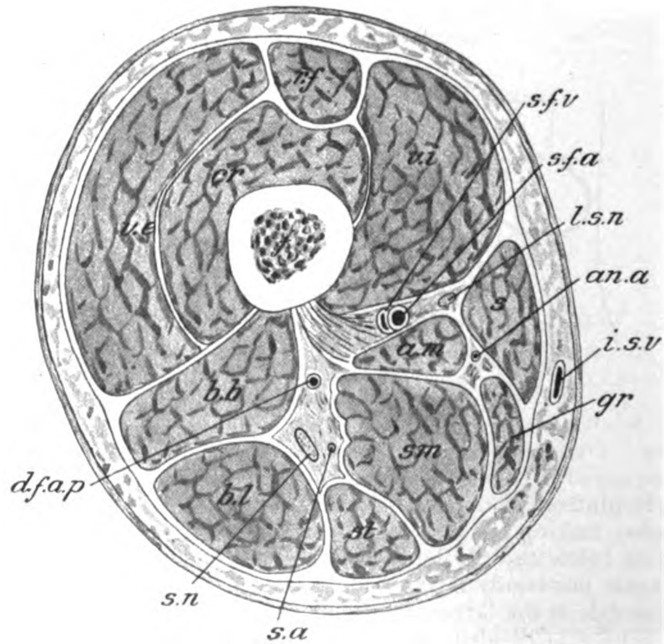


FIG. 579.—Section of the thigh at the junction of the middle and lower third. (After Braune, and Esmarch and Kowalzig.) *f.* Femur. Muscles: *v.i.* Vastus internus. *r.f.* Rectus femoris. *cr.* Crureus. *v.e.* Vastus externus. *b.b.*, *b.l.* Short and long head of the biceps. *st.* Semi-tendinosus. *sm.* Semi-membranosus. *gr.* Gracilis. *s.* Sartorius. *a.m.* Adductor magnus, artery about to pass through. Vessels: *s.f.a.* Superficial femoral artery. *an.a.* Anastomotic artery. *d.f.a.p.* Deep femoral artery perforating. *s.a.* Sciatic artery. *s.f.v.* Superficial femoral vein. *i.s.v.* Internal saphenous vein. Nerves: *s.n.* Sciatic nerve. *l.s.n.* Long saphenous nerve. (Walsham.)

two inches below the patella; the posterior flap is made by an incision connecting the ends of the anterior and passing through all the soft tissues (Figs. 573, 574). The condyles are divided just below the epiphyseal line. *Gritti's osteoplastic method.*—An anterior semilunar flap extends from the condyles of the femur to the tibial tubercle and includes the quadriceps extensor tendon and the patella; the posterior is made by an incision connecting the ends of the anterior. The condyles of the femur are divided just above the articulation. The posterior surface of the patella is then removed with a fine saw, and the remaining portion sutured to the sawn surface of the femur with catgut passing through the periosteum, or with wire (Figs. 575, 576).

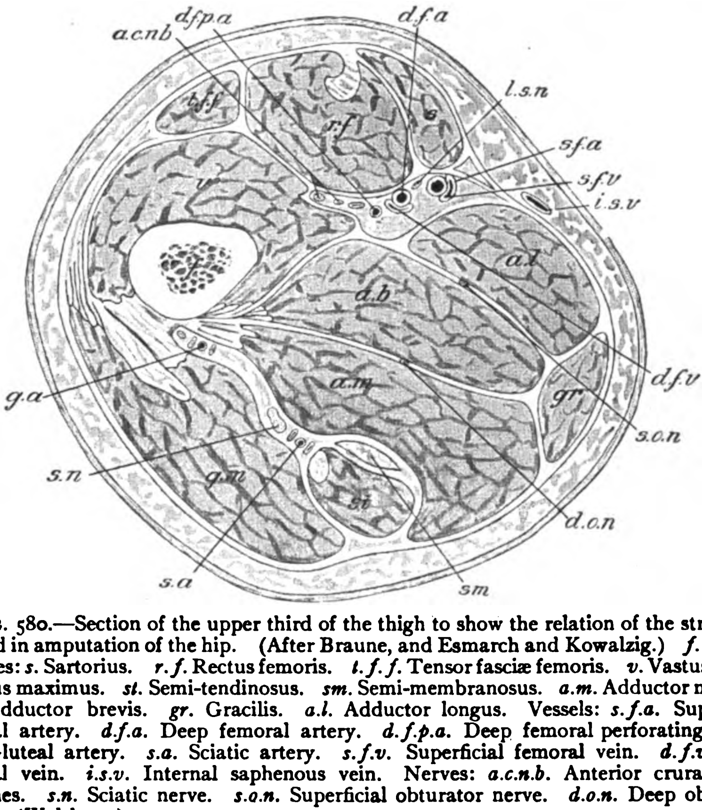


FIG. 580.—Section of the upper third of the thigh to show the relation of the structures divided in amputation of the hip. (After Braune, and Esmarch and Kowalzig.) *f.* Femur. Muscles: *s.* Sartorius. *r.f.* Rectus femoris. *t.f.f.* Tensor fasciæ femoris. *v.* Vastus. *g.m.* Gluteus maximus. *st.* Semi-tendinosus. *sm.* Semi-membranosus. *a.m.* Adductor magnus. *a.b.* Adductor brevis. *gr.* Gracilis. *a.l.* Adductor longus. Vessels: *s.f.a.* Superficial femoral artery. *d.f.a.* Deep femoral artery. *d.f.p.a.* Deep femoral perforating artery. *g.a.* Gluteal artery. *s.a.* Sciatic artery. *s.f.v.* Superficial femoral vein. *d.f.v.* Deep femoral vein. *i.s.v.* Internal saphenous vein. Nerves: *a.c.n.b.* Anterior crural nerve branches. *s.n.* Sciatic nerve. *s.o.n.* Superficial obturator nerve. *d.o.n.* Deep obturator nerve. (Walsham.)

Sabanejeff covers the end of the femur with a bone flap from the tibia (Figs. 577, 578).

Amputation through the thigh (Fig. 579) may be performed by any of the usual methods, the modified flap and circular being perhaps the best. The most favorable site for section of the femur is at the junction of the middle and lower thirds. Amputation close to the lower end gives a stump which is too long for a mechanical knee-joint, amputation within five inches of the crotch gives a stump which is too short for wielding a false limb.

Amputation at the hip joint (Fig. 580) is accompanied by unusual risks from hemorrhage, shock, and sepsis. Hemorrhage may be controlled by (1) preliminary exposure and ligation of the femoral vessels, with subsequent clamping of the smaller ones as they are divided (the best method); (2) pressure upon the aorta by various forms of tourniquets (dangerous); (3) pressure upon the external iliac vessels with Davy's rectal lever (dangerous); (4) direct digital pressure on these vessels through an abdominal incision (McBurney); or (5) by a rubber tourniquet held close to the brim of the pelvis by two long steel pins (Wyeth), by sutures, or by a loop passing around the abdomen. In Wyeth's bloodless method, "after exsanguinating the limb one pin is introduced one-fourth of an inch below and within the anterior superior spine of the ilium, and after traversing the muscles and fascia on the outer side of the hip, emerges on a level with the point of entrance. The point of the second pin is thrust through the skin and tendon of the origin of the adductor longus muscle one-half inch below the crotch, the point emerging one inch below the tuber ischii. The points should be shielded at once with corks to prevent injury to the hands of the operator. No vessels are endangered by these skewers. A piece of strong white rubber tubing, one-half inch in diameter when unstretched, and long enough when in position to go five or six times around the thigh, is now wound tightly around above the fixation needles." The thigh is amputated by an external racquet incision, the external portion of which extends from the rubber band downwards for six inches, then being completed by a circular incision around the thigh. The skin and subcutaneous tissues are reflected to the lesser trochanter and the muscles cut at this level. The capsule of the joint is opened and the thigh carried upward, inward, and forward, thus forcing the head of the bone from the socket. The round ligament is then severed and the limb removed. *Senn* perforates the thigh close to the head of the femur with a double rubber tube, one-half of which is tied in front and the other half behind. *Esmarch* divides the femur at the level of the circular incision, ties all blood vessels, removes the constrictor, and then enucleates the upper end of the femur. Perhaps the best method, when applicable, is the *anterior racquet amputation* without the use of a constrictor. A longitudinal incision is made from the middle of Poupart's ligament downwards for three inches. The common femoral vessels are divided between ligatures, and the incision continued downwards and inwards across the inner side of the thigh about four inches below the crotch, thence continuing around the thigh to join the primary incision. The outer flap, including the muscles, is separated from the femur, any bleeding vessels being caught and tied as they are encountered. The limb is then rotated outwards and the process repeated on the inner side. The capsule is now opened, the head of the bone disarticulated forward, the ligamentum teres divided, and the tissues on the posterior surface severed by carrying the knife downwards and outwards behind the bone.

Interilio-abdominal amputation, in which the entire lower extremity, including the whole or a portion of the innominate bone, is removed, has been performed thirty-four times with ten recoveries (Ransohoff).

INDEX.

N. B. The most important reference is placed first.