MINOR SURGERY

INCLUDING

BANDAGING

BY

HENRY R. Edward WHARTON, M.D.

CONSULTING SURGEON TO THE PRESBYTERIAN HOSPITAL, CHILDREN'S HOSPITAL, ST. CHRISTOPHER'S HOSPITAL, THE BRYN MAWR HOSPITAL AND GIRARD COLLEGE; FELLOW OF THE AMERICAN SURGICAL ASSOCIATION

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PREFACE TO THE NINTH EDITION.

In the preparation of this edition the attempt has been made to make the book conform strictly to its title. Major operative procedures, demanding a large special experience in surgery, have been excluded as not properly germane to this work. They require a fuller discussion and description than could be allotted to them.

Space has thus been obtained for the presentation of recent additions to our resources which are of general utility, such as the simpler methods of transfusion of blood, the indications and essentials of débridement, the chlorine antiseptics and the Dakin-Carrel method of treatment of wounds. Increased recognition is given to local anesthesia for minor surgery, and the chapter on surgical bacteriology and immunology has been modernized.

Many smaller changes and additions have been made throughout, to cover recent improvements in practice, and it is hoped that the book will continue to meet with the same cordial approval of student and practitioner as the previous editions.

The author wishes gratefully to acknowledge the invaluable assistance of Dr. Damon B. Pfeiffer, who made many helpful suggestions, and who read the proof and supervised the passage of the book through the press.

H. R. W.

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PART I.

BANDAGING.

Bandages.—These constitute one of the most widely used and important surgical dressings; they are employed to hold dressings in contact with the surface of the body, to make pressure, to hold splints in place in the treatment of fractures and dislocations, and to maintain in their natural position parts which may have become displaced.

Bandages may be prepared of various materials, such as linen, crinoline, flannel, gauze or cheese-cloth, rubber-sheeting, or muslin, bleached or unbleached; the latter material is the most commonly employed, by reason of its cheapness; flannel, from its elasticity, is sometimes used, but its employment for bandages is now generally limited to its use in dressings for operative work in connection with the eye and abdomen, and for a primary roller in the application of plaster-of-Paris dressings.

Bandages are either *simple*, when composed of one piece of material, such as the ordinary roller-bandage, or *compound*, when prepared of one or more pieces adapted by size and shape to particular objects.

The importance of being familiar with the general rules of bandaging and proficient in the application of the roller-bandage cannot be overestimated, and both the student and the general practitioner will never have cause to regret the time occupied in learning to apply neatly this form of surgical dressing.

A well-applied bandage adds to the security of the dressing and the comfort of the patient, and the method of application often secures for the physician the confidence both of the patient and of his friends; while, on the other hand, a badly applied bandage is apt to be uncomfortable and insecure, and to meet with their adverse criticism.

The Roller-bandage.—The roller-bandage consists of a strip of woven material, prepared from some one of the materials previously mentioned, of variable length and width according to the portion of the body to which it is

Fig. 1.

Bandage-winder.

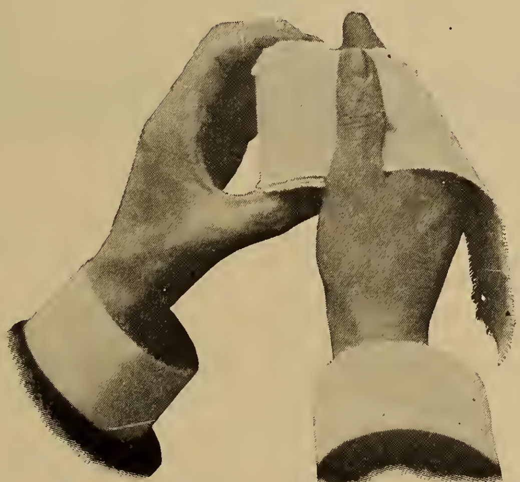
to be applied; this, for ease of application, is rolled into a cylindrical form.

The material commonly employed for the roller-bandage is unbleached muslin, although, for special purposes, linen, flannel, rubber-sheeting, crinoline, gauze or cheesecloth may be used. It is important that the roller-bandage should consist of one piece, free from seams and selvage, for if made of a number of pieces sewed together, or if it contains creases or selvage, it cannot be so neatly applied, and it is not so comfortable to the patient, as it is apt to leave creases upon the skin.

In preparing the ordinary muslin bandage, the material is torn in strips varying in length and width according to the part of the body to which it is to be applied, and it is then rolled into a cylinder, either by the hand or by a machine constructed for the purpose (Fig. 1).

It is important that every student and practitioner should be able to roll a bandage by hand, for in practice the medical attendant may at any moment be called upon to prepare a bandage, in order to apply a dressing, and the art of preparing a bandage is easily acquired by a little

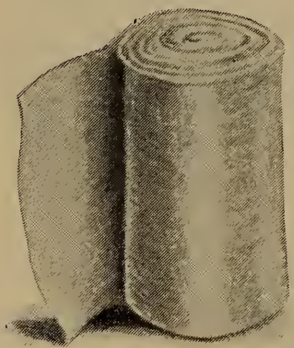
Fig. 2.



Rolling a bandage by hand.

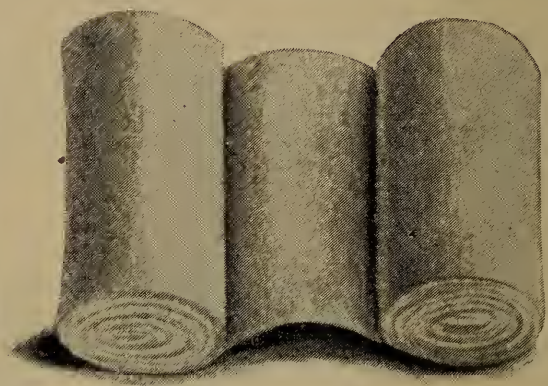
practice. To roll a bandage by hand, the strip of muslin should be folded at one extremity several times until a small cylinder is formed; this is then grasped by its extremities by the thumb and index finger of the left hand; the free extremity of the strip is then grasped between the thumb and index finger of the right hand, and by alternate pronation and supination of the right hand the cylinder is revolved and the roller is formed; the firmness of the roller will depend upon the amount of tension which is kept upon the free extremity of the strip during the revolution of the cylinder (Fig. 2). A bandage rolled in the form of a cylinder is called a *single* or *single-headed* roller (Fig. 3); if rolled from each extremity toward the centre, so that two cylinders are formed joined by the

Fig. 3.



Single roller.

Fig. 4.



Double roller.

central portion of the strip, the *double* or *double-headed* roller is formed (Fig. 4).

Double rollers are not much used, and in practice the single roller will be found to be amply sufficient for the application of almost all the bandages employed in surgical dressings.

The free end of the roller-bandage is called the *initial extremity;* the end which is enclosed in the centre of the cylinder is its *terminal extremity;* and the portion between the extremities *the body;* a roller has also two surfaces, *external* and *internal.*

Dimensions of Bandages.—Bandages vary in length and width according to the purposes for which they are employed, and in practice it will be found that a small variety of bandages will be amply sufficient for the application of the ordinary surgical dressings.

The following list, comprising those most frequently used, will show their dimensions:

Bandages *one* inch wide, *three* yards in length, for bandages for the hand, fingers, and toes.

Bandages *two* inches wide, *six* yards in length, for head-bandages and for the extremities in children.

Bandages *two and a half* inches wide, *seven* yards in length, for bandages of the extremities in adults; a roller of this size is the one most generally used.

Bandages *three* inches wide, *nine* yards in length, for bandages of the thigh, groin, and trunk.

Bandages *four* inches wide, *ten* yards in length, for bandages of the trunk.

General Rules for Bandaging.—In applying a roller-bandage, the operator should place the external surface of the free extremity of the roller upon the part, holding it in position with the fingers of the left hand until fixed by a few turns of the roller, the cylinder being held in the right hand by the thumb and fingers; for thus as the bandage is unwound it rolls into the operator's hand, thereby giving him more control of it; care should also be taken that the turns are applied smoothly to the surface, and that the pressure exerted by each turn is uniform.

When a bandage is applied to a limb, the surgeon should see that the part is in the position it is to occupy as regards flexion and extension when the dressing is completed, for a bandage applied when the limb is flexed will exert too much pressure when the limb is extended, and then may, by the pressure it exerts, become a matter of discomfort or even of danger to the patient, or if applied to an extended limb it will become uncomfortable upon flexion.

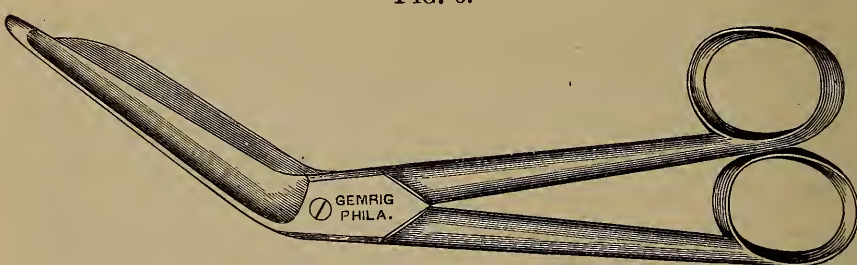
My experience has been that, as a rule, those who have had little experience with the application of the roller-bandage are apt to apply the bandages too tightly, and this may lead to disastrous consequences, gangrene of the extremities having resulted from the too tight application of bandages, especially in the dressing of fractures. Professor Ashhurst, in his clinical teaching, advised students to make use of a larger number of turns of a bandage in securing fracture-dressings rather than to depend upon a few turns too firmly applied—advice which certainly conduces to the safety and comfort of the patient. When the bandage has been completed, the terminal extremity should be secured by a pin or safety-pin applied transversely to the bandage, and if a pin be used its point should be

FIG. 5.

Method of removing a bandage.

buried in the folds of the bandage; if the bandage be a narrow one, the end may be split and the two tails resulting secured around the part by tying.

FIG. 6.



Bandage-scissors.

Removal of Bandages.—In removing a bandage, the folds should be carefully gathered up in a loose mass as the bandage is unwound, the mass being transferred rapidly from one hand to the other, thus facilitating its removal and preventing the part from becoming entangled in its loops (Fig. 5). If it is desirable to cut the bandage to remove it, the use of scissors made for this purpose will be found most satisfactory (Fig. 6).

VARIETIES OF BANDAGES.

Circular Bandage.—This bandage consists of a few circular turns around a part, each turn covering accurately the preceding turn. This variety of bandage may be used to retain a dressing to a limited portion of the head, neck, or limbs, to make compression upon the veins of the arm before performing venesection, or to secure a compress to control venous hemorrhage (Fig. 11).

Oblique Bandage.—In this form of bandage the turns are carried obliquely over the part, leaving uncovered spaces between the successive turns (Fig. 7). It cannot

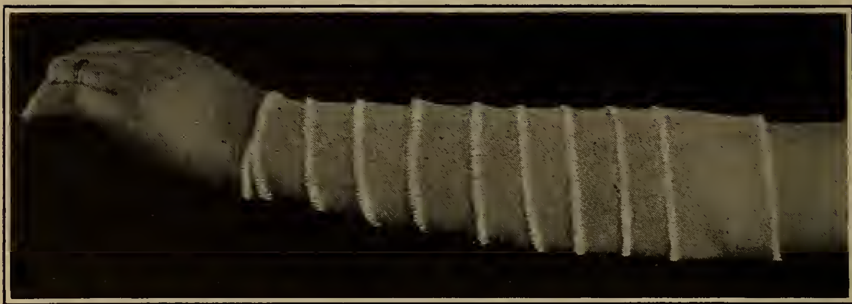
Fig. 7.

Oblique bandage.

be applied with much firmness on account of the swelling of the uncovered portions of skin between the turns of the bandage, and its principal use is for the application of temporary dressings, such as wet dressings which may require frequent removal.

Spiral Bandage.—In this bandage the turns are carried around the part in a spiral direction, each turn overlapping a portion of the preceding one, usually one-third or one-half; it may be applied as an ascending spiral (Fig. 8)

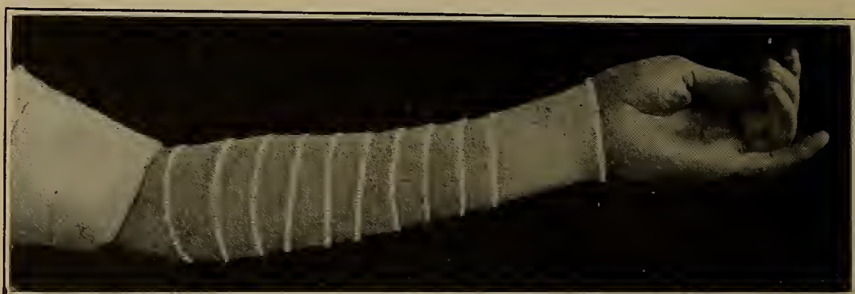
FIG. 8.



Ascending spiral bandage.

or as a descending spiral (Fig. 9). This bandage may be used to cover a part which does not increase rapidly in diameter; for instance, the abdomen, chest, or arm.

FIG. 9.



Descending spiral bandage.

Spiral Reversed Bandage.—This bandage is a spiral bandage, but differs from the ordinary spiral bandage in having its turns folded back or reversed as it ascends a part the diameter of which gradually increases. By its use, it is possible to cover by spiral turns a part conical in shape, so as to make equable pressure upon all parts of the surface. The reverses are made as follows: After name from the turns being applied so as to form a figure-of-eight. This method of application is made use of in the Barton's bandage, the bandages of the knee and elbow, and many other bandages.

FIG. 13.

Recurrent bandage.

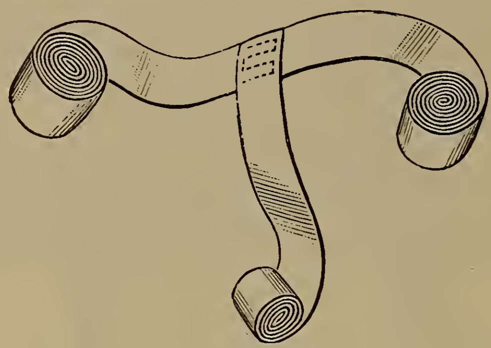
Recurrent Bandage.—This bandage derives its name from the fact that the roller after covering a certain part of the surface is reflected and brought back to the point of starting; it is then reversed and carried toward the opposite point, and this manipulation is continued until the part is covered by these recurrent turns, which are then secured by a few circular turns (Fig. 13). This is the bandage usually employed in the dressing of stumps after amputation.

Compound Bandages.

These bandages are usually formed of several pieces of muslin or other material, sewed or pinned together, and are employed to fulfil some special indication in the application of dressings to particular parts of the body. The most useful of the compound bandages are the T-bandages and the many-tailed bandages.

T-bandage.—The single T-bandage consists of a horizontal band to which is attached, about its middle, another having a vertical direction ; the horizontal piece should be about twice the length of the vertical piece (Fig. 14). The

FIG. 14.



Single T-bandage.

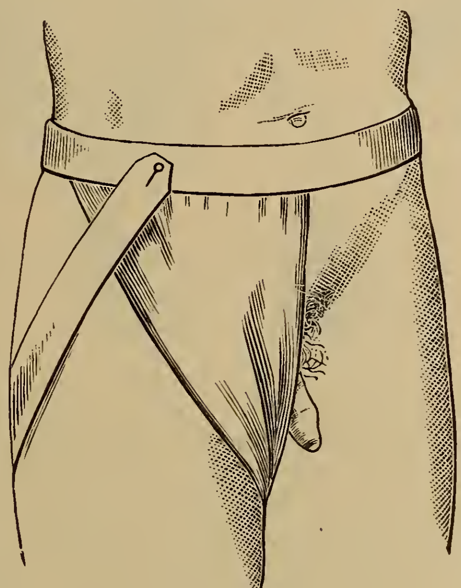
single T-bandage may be used to retain dressings to the head, the horizontal piece being passed around the head from the occiput to the forehead, the vertical piece being

FIG. 15.

Single T-bandage for chest.

passed over the head and secured to the horizontal piece, the shape and width of the two pieces being varied according to the indications. In applying dressings to the anal region or perineum, or in securing a catheter in a perineal wound, the single T-bandage will be found most useful. In applying a T-bandage for this purpose, the body of the bandage is placed over the spine, just above the pelvis, and the horizontal portion is tied around the abdomen. The free extremity is split into two tails for about two-thirds of its length, and is carried over the anal region and brought up between the thighs, the terminal strips passing one on each side of the scrotum and being secured to the horizontal strip in front. The single T-bandage may be

Fig. 16.

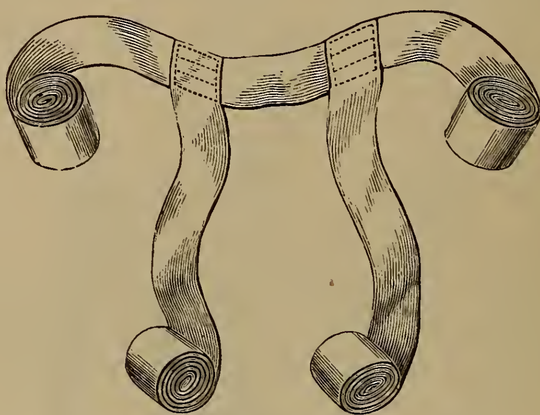


T-bandage of groin.

variously modified according to the indications which are to be met; for instance, in applying a dressing to the breasts the horizontal strip passing around the chest may be made ten or twelve inches in width; the vertical strip, two inches in width, passes from the back over the shoulder and is secured to the horizontal strip in front (Fig. 15). For the groin, a piece of muslin six inches wide at its base and thirty inches long is sewed to a horizontal strip of muslin one and a half yards long and two inches in width. It may be applied as in Fig. 16 to hold a dressing to this part.

Double T-bandage.—The double T-bandage differs from the single bandage in having two vertical strips attached to the horizontal strip, and it may be used for much the same purposes as the single T-bandage (Fig. 17).

Fig. 17.



Double T-bandage.

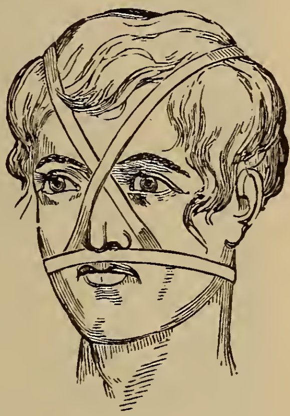
It may be conveniently used for retaining dressings to the chest, breast, or abdomen; when used for this purpose the horizontal portion should be from eight to twelve inches wide and long enough to pass one and a quarter times about the chest; two vertical strips, two inches wide and twenty inches long, should be attached to the horizontal strip a short distance apart near its middle. In applying this bandage to the chest, the horizontal strip is placed around the chest so that the vertical strips occupy a position on either side of the spine; the overlapping end of the horizontal portion is secured by pins or safety-pins, and the vertical strips are next carried one over either shoulder and secured to the other portion of the bandage in front of the chest (Fig. 18).

The double T-bandage may also be used to secure dressings to the nose, in which event the strips should be quite narrow, about one inch in width, and should be applied as shown in Fig. 19.

Fig. 18.

Double T-bandage of chest.

Fig. 19.



Double T-bandage of nose.

Many-tailed Bandages or Slings.—These bandages are prepared from pieces of muslin of various lengths and breadths, which are split at each extremity into two, three, or more tails up to within a few inches of their centres, their width and length being regulated by the part of the body to which they are to be applied.

The *four-tailed* bandage may be found useful as a temporary dressing in cases of fracture of the jaw, or to hold dressings to the chin. It may be prepared by taking a portion of a roller-bandage three inches wide and one yard in length, and splitting each extremity up to within two inches of the centre; it is then applied as seen in Fig. 20.

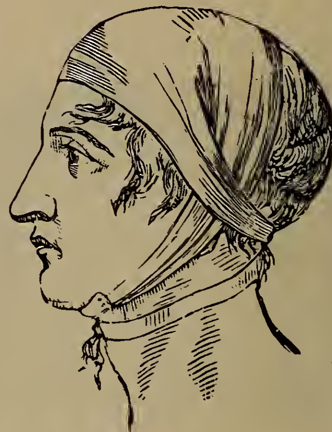
The four-tailed bandage may also be used to retain dressings to the scalp, and may be prepared by taking a piece of muslin one yard and a quarter long and six or eight inches in width, splitting it at each extremity into two tails within six inches of the centre; it may then be applied as seen in Fig. 21.

The four-tailed bandage may also be used in the temporary dressing of fractures of the clavicle, the body of the bandage being placed upon the elbow of the injured

Fig. 20.

Four-tailed bandage of chin.

Fig. 21.



Four-tailed bandage of head.

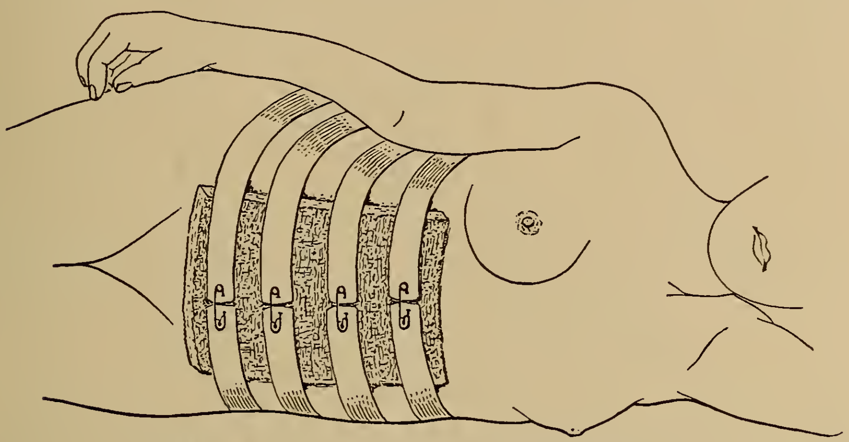
side, two tails passing around the body, fixing the arm to the side, and two tails passing over the sound shoulder.

Fig. 22.

Many-tailed bandage of abdomen.

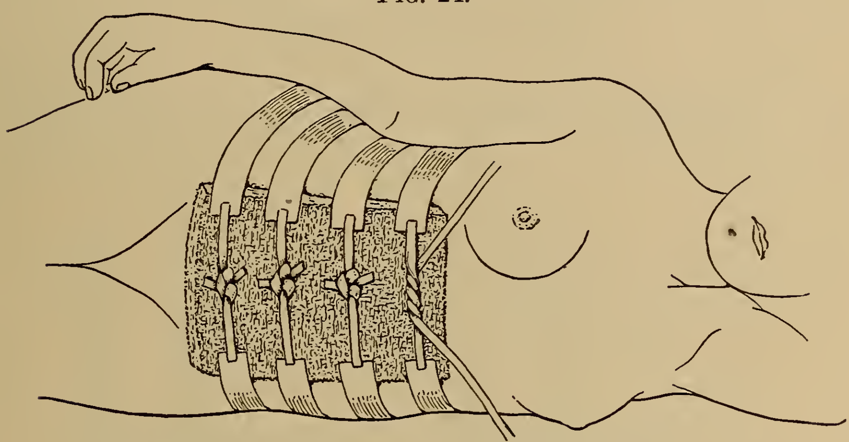
Many-tailed Bandage of Abdomen.—This bandage may also be used for holding dressings in contact with the abdomen or trunk, and is the bandage which most surgeons employ to hold the dressings to a laparotomy wound, and to give support to the abdominal walls after this operation. In preparing this bandage, a strip of muslin or

Fig. 23.



Dressing secured by strips of plaster and safety-pins.

Fig. 24.



Dressing for laparatomy wound held by strips of plaster and tapes.

flannel, one and a half yards in length and eighteen to twenty inches in width, is required; the extremities may be split on each side to within six inches of the centre so as to form a four- or six-tailed bandage. In applying this bandage to the abdomen, the body is placed upon the patient's back and the tails are brought around the abdomen and overlap each other, and when sufficiently firmly drawn to make the desired amount of pressure they are secured by means of safety-pins (Fig. 22).

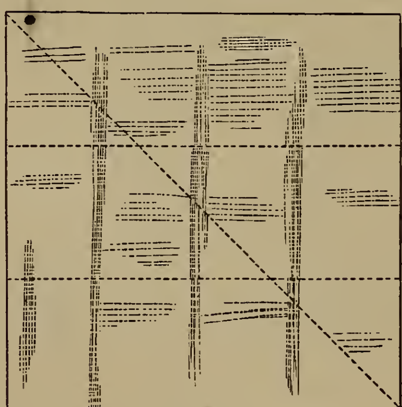
Many surgeons prefer to hold the dressings to a laparotomy wound in place by three or four broad straps of adhesive plaster passing from the back across the abdomen. These are cut in the centre at the first dressing, and the ends turned back to remove the dressings. When the new dressing is applied, it is secured in place by holding together the cut ends of the straps by safety-pins (Fig. 23).

When the dressing of a laparotomy wound requires frequent changing, it will be found convenient to hold the dressing in place by straps of adhesive plaster nine inches in length and two inches in width. Three or four such strips are attached to the back on each side of the abdomen, and to the free end of each strap is attached a short piece of tape. When the dressing is applied to the wound, the ends of the corresponding tapes are tied together and the dressing is secured in place (Fig. 24).

Handkerchief-bandages.

The use of handkerchiefs or square pieces of muslin for the temporary or permanent dressing of wounds, fractures, or dislocations was advocated many years ago by M.

Fig. 25.



The square.

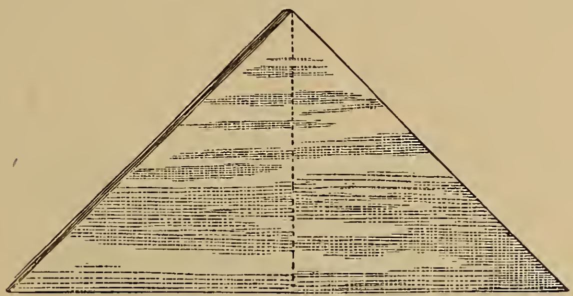
Fig. 26.

The oblong.

Mayor, a Swiss surgeon, who wrote an extensive work upon this subject, in which he reduced their application to a system. He employed a handkerchief or a square piece of muslin, and by various modifications in the application of these developed a number of very ingenious bandages.

The various forms which the handkerchief or *square* (Fig. 25) is made to assume are as follows: The *oblong*,

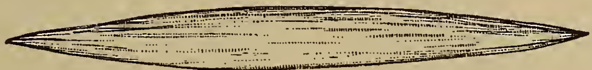
FIG. 27.



The triangle.

made by folding the square once or twice on itself (Fig. 26). The *triangle*, made by bringing together the diagonal angles of the square (Fig. 27). The line of the fold-

FIG. 28.



The cravat.

ing is known as the base, the angle opposite the base the apex, and the other angles the extremities.

The *cravat* is prepared from the triangle by bringing the

FIG. 29.

The cord.

apex to its base, and folding it a number of times upon itself until the desired width is obtained (Fig. 28).

The *cord* is formed from the cravat twisted upon itself (Fig. 29). The names of the various handkerchief-bandages are derived from the shape of the handkerchiefs used and the parts to which they are applied; the names serve as guides in their application. It is to be remembered that the base of the triangle or the body of the cravat is to be placed upon the portion, the designation of which forms the first portion of the name of the bandage ; thus, in the *occipito-frontal triangle*, the shape of the handkerchief is given, and we know that the base of the triangle is to be applied to the occiput and the apex carried to the forehead. In using the cravats the same rule applies ; thus, in the *bis-axillary cravat* the body of the cravat is to be placed in the axilla of the affected side, the extremities crossed over the corresponding shoulder and carried over the chest, one before, the other behind, to the axilla of the opposite side, where they are secured.

Fig. 30.

Occipito-frontal triangle.

Fig. 31.

Mento-vertico-occipital cravat.

The Occipito-frontal Triangle.—To apply this handkerchief, place the base of the triangle upon or a little below the occiput, and bring the apex forward over the head, allowing it to drop over the forehead ; next bring the extremities of the handkerchief forward and tie them in a knot over the forehead ; finally turn up the apex over the knotted ends and pin it to the body of the handkerchief (Fig. 30).

The Mento-vertico-occipital Cravat.—To apply this handkerchief, the middle of the base of the cravat is placed under the chin; the extremities are then carried in front of the ear on each side to the vertex of the skull, and are crossed at that point; the ends are then carried downward over the parietal region to the occiput, and are secured by a knot at this point (Fig. 31). Another method of applying this handkerchief consists in placing the base of the

FIG. 32.

Mento-vertico-occipital cravat (modified).

cravat under the chin and carrying the extremities over the vertex of the skull, crossing them at that point; then carrying them downward to the occiput, and crossing them again here and passing them forward around the chin, and finally securing the ends by a knot (Fig. 32). The turns of the latter handkerchief correspond exactly to the turns of the Barton's bandage of the head.

These handkerchief-bandages may be used to secure dressings to the chin or scalp, or may be employed as temporary dressings to secure fixation of the parts in cases of fracture or dislocation of the jaw.

The Bis-axillary Cravat.—To apply this handkerchief, the body of the cravat is placed in the axilla, and the ends are brought up, one in front of, the other behind, the axilla, and are made to cross over the top of the shoulder; the extremities are then carried across the back and chest respectively to the opposite axilla, where they are secured by tying (Fig. 33). This handkerchief may be employed to secure dressings in the axilla, or to hold dressings in contact with the shoulder.

FIG. 33.

Bis-axillary cravat.

The Dorso-axillary Cravat.—This handkerchief is applied by placing the body of the cravat over the spine between the scapulæ, and then carrying one extremity over the shoulder and through the axilla backward to meet the other extremity, which has been carried through the axilla and over the other shoulder to the back, where the ends are secured by a knot (Fig. 34). This handkerchief may be used to hold dressings to the axilla or upper portion of the back of the chest.

The Compound Dorso-bis-axillary Cravat.—To apply this handkerchief, two cravats are required. The base of one cravat is placed over the front of one shoulder, and the ends are passed, one over the top of the shoulder, the other through the axilla, and they are then secured by a single knot over the scapula; the ends are next secured by tying them in a loop. The second cravat is next placed in front of the shoulder on the opposite side, and the ends

Fig. 34.

Dorso-axillary cravat.

are respectively carried over the shoulder and through the axilla to the back, where they are secured by a single knot; the ends of the handkerchief are then passed through the loop of the first handkerchief and secured by a knot (Fig. 35). This handkerchief may be used to draw the shoulders backward in cases of dislocation or fracture of the clavicle.

Triangular Cap or Suspensory of the Breast.—To apply this handkerchief, the base of the triangle is placed under the affected breast, and one extremity is carried beneath the axilla of the same side, and the other extremity is carried around the opposite side of the neck, and they are secured together upon the back by a knot; the apex should then be brought up over the breast and shoulder of the affected side, and pinned to the bandage over the scapula (Fig. 36). This handkerchief may be employed to sling the breast in nursing-women, or to hold a dressing to the breast.

Fig. 35.

Compound dorso-bis-axillary cravat.

The Gluteo-femoral Triangle.—In applying this handkerchief, a cravat is first fastened around the waist, and a second handkerchief folded into a triangle has its base placed in the gluteo-femoral fold, and its extremities carried around the thigh and secured in front by a knot; the apex of the handkerchief is then carried upward and passed beneath the cravat around the waist, and is turned down and pinned to the body of the triangle (Fig. 37). This handkerchief may be used to retain dressings to the region of the buttock or hip; by unpinning the apex and turning it downward, ready access can be had to the parts beneath.

Gluteo-inguinal Cravat.—In applying this handkerchief, the base of the cravat is placed just over the gluteofemoral fold, and the extremities are carried forward, one

Fig. 36.

Triangular cap or suspensory of the breast.

around the inner, the other around the outer portion of the thigh, and they are made to cross in the groin; the ends are next passed around the pelvis and secured together upon the back by a knot (Fig. 38). This handkerchief may be employed to hold dressings to the region of the groin.

By employing two cravats, a double gluteo-inguinal cravat may be applied, which may be used to hold dressings to both groins. The turns of these cravats correspond to the turns of the single and double spica-bandages of the groin.

I have described a few of the many ingenious bandages devised by Mayor to substitute the use of the roller-bandage, which will give the student some idea of their

FIG. 37.

Gluteo-femoral triangle.

FIG. 38.

Gluteo-inguinal cravat.

design and application. It is well to bear in mind this system of dressing, for the occasion might occur in which the ordinary means of bandaging could not be obtained, and the use of handkerchiefs might answer a useful purpose as temporary dressings. I think their principal use is for temporary dressings, and I do not believe they will ever take the place of the roller-bandage, which can be applied with greater nicety and exactness, and certainly presents a much neater appearance.

BANDAGES OF THE HEAD.

Barton's Bandage. *Roller Two Inches in Width, Six Yards in Length.*—The initial extremity of the roller should be placed on the head just behind the mastoid process, and the bandage should then be carried under the occipital protuberance obliquely upward under and in front of the parietal eminence across the vertex of the skull, then downward over the zygomatic arch, under the chin, thence upward over the opposite zygomatic arch and over the top of the head, crossing the first turn which was made, as nearly as possible in the median line of the skull, and carrying the turns of the roller under the parietal eminence to the point of commencement. The bandage is then passed obliquely around under the occipital protuberance and forward under the ear to the front of the chin, thence back to the point from which the roller started. These figure-of-eight turns over the head and the circular turns from the occiput to the chin should be repeated, each turn exactly overlapping the preceding one until the bandage is exhausted (Fig. 39). The extremity should then be secured by a pin ; and pins should be introduced at the points where the turns cross each other, to give additional fixation to the bandage. In applying the bandage, care should be taken to see that the turns overlap each other exactly, and that the turns passing over the vertex cross as nearly as possible in the median line of the skull (Fig. 40).

Modified Barton's Bandage.—To obtain additional security in the application of the Barton's bandage, a turn of the bandage passing from the occiput to the forehead may be made, this turn being interposed between the turns of the bandage as ordinarily applied (Fig. 41). In applying this bandage, after the first set of turns has been completed—that is, after the bandage has been brought back to the occiput—the bandage is carried forward upon the head just over the ear, around the forehead and backward above the ear on the opposite side to the occiput; this being done, the ordinary figure-of-eight and circular

FIG. 39.

Barton's bandage.

FIG. 40.

Barton's bandage, showing crossing of turns at vertex.

turns are made, and when these have been completed another occipito-frontal turn may be made as described above, and this may be repeated as often as is desired until the bandage is exhausted, when the extremity is fastened with a pin, and pins are introduced also at all points at which the turns cross.

Use.—This bandage is one of the most useful of the bandages of the head, being employed to secure fixation of the jaw in cases of fracture or dislocation, and for the application of dressings to the chin. I have also employed it in place of the head-gear in slinging patients for the application of the plaster-of-Paris jacket in cases of disease of the spine, a stout cord or a piece of bandage about three inches wide and one yard long being passed under the turns crossing over the vertex; this cord is then secured to the cross-bar of the extension apparatus (Fig. 42). This will be found quite as comfortable to the patient as

FIG. 41,

Modified Barton's bandage.

the ordinary head-gear employed, and much less likely to slip out of place and interfere with the breathing of the patient.

A firmly applied Barton's bandage holds the jaws so closely together that care should be taken in applying it to patients who are under the influence of an anæsthetic, for if vomiting occurs the material may not escape from the mouth, and suffocation might occur unless the bandage were promptly removed. This accident I once saw occur, and the patient's condition was alarming until the bandage was cut, allowing the jaw to be opened and the contents of the mouth to escape.

Gibson's Bandage. *Roller Two Inches in Width, Six Yards in Length.*—The initial extremity of the roller should be placed upon the vertex of the skull in a line with the anterior portion of the ear; the bandage is then carried downward in front of the ear to the chin, and passed under the chin, and is carried upward on the same line until it reaches the point of starting. The turns are repeated until three complete turns have been made; the bandage is then continued until it reaches a point just above the ear, when it is reversed and is carried backward around the occiput, and is continued around the head and forehead until it reaches its point of origin; these circular turns are applied until three have been made. When the bandage reaches the occiput, having completed the third turn, it is allowed to drop down to the base of the skull, and it is then carried forward below the ear and around the chin, being brought back upon the opposite side of the head and neck to the point of origin; these turns are repeated until three complete turns have been made, and upon the completion of the third turn the bandage is reversed and carried forward over the occiput and vertex to the forehead, and its extremity is here secured with a pin. Pins should also

Fig. 42.

Barton's head-bandage, employed for suspension.

be applied at the points where the turns of the bandage cross each other (Fig. 43).

Use.—This bandage may be used to fix the lower jaw in cases of fracture or dislocation of the jaw, but is very apt to change its position, and is, therefore, not so satisfactory as the Barton's bandage for this purpose.

FIG. 43.

Gibson's bandage.

Oblique Bandage of the Angle of the Jaw. *Roller Two Inches in Width, Six Yards in Length.*—The initial extremity of the roller is placed just in front of and above the left ear, and if the left angle of the lower jaw is to be covered in, the bandage is then carried from left to right, making two complete turns around the cranium from the occiput to the forehead; if, however, the right angle of the lower jaw is to be covered in, the turns should be made in the opposite direction. Having made two turns from the occiput to the forehead, the bandage is allowed to drop down upon the neck, and is carried forward under the ear and under the chin to the angle of the jaw; it is next carried upward close to the edge of the orbit, and obliquely over the vertex of the skull, then down behind the right ear, continuing this oblique turn under the chin to the left angle of the jaw, where it ascends in the same direction as the previous turn. Three or four of these oblique turns are made, each turn overlapping the preceding one and passing from the edge of the orbit toward the ear until the space is covered in; the bandage is then carried to a point just above the ear on the opposite side, is reversed, and finished with one or two circular turns from the occiput to the forehead, the extremity being secured by a pin (Fig. 44).

Fig. 44.

Oblique bandage of the angle of the jaw.

Use.—This will be found one of the most useful of the head-bandages; it may be used with a compress in treating fractures of the angle of the lower jaw, for holding dressings to the lower part of the chin and to the vault of the cranium, and is especially useful in retaining dressings to the sides of the face and the parotid region. As before stated, it may be applied to cover either the right or left side of the face, and, by reason of the oblique turns, holds its position most securely, having little tendency to become displaced.

Recurrent Bandage of the Head. *Roller Two Inches in Width, Six Yards in Length.*—The initial extremity of the roller is placed upon the lower part of the forehead and the bandage is carried twice around the head from the forehead to the occiput to secure it. When the bandage is brought back to the median line of the forehead it is reversed, and the reversed turn is held by the finger of the left hand while the roller is carried over the top of the head along the sagittal suture to a point just below the occipital protuberance; here it is reversed again, and the reverse is held by an assistant while the roller is carried back to the forehead in an elliptical course, each turn covering in two-thirds of the preceding turn. These turns are repeated with successive reverses at the forehead and occiput until one side of the head is completely covered in, and when this is accomplished a circular turn is made from the forehead to the occiput to hold the reverses in place.

The opposite side of the head is next covered in by elliptical reversed turns made in the same manner, and when this has been accomplished two or three circular turns are carried around the head from the forehead to the occiput, to fix the preceding turns. Pins should be applied at the

Fig. 45.

Recurrent bandage of the head.

forehead and occiput at the points where the reversed turns concentrate (Fig. 45).

Use.—This bandage when well applied is one of the neatest of the head-bandages, and it will be found useful to retain dressings to the vault of the cranium in the treatment of wounds of the scalp in this region. It will also be found of service in holding dressings to fractures of the cranium and to wounds after the operation of trephining. In restless patients it will sometimes become displaced, and it may be rendered more secure by pinning a strip of bandage to the circular turn in front of the ear and carrying it down under the chin and up to a corresponding point on the opposite side, where it is pinned to the circular turn; or one or two oblique turns passing from the circular turn over the vertex of the skull downward behind the ear, under the chin and up to the circular turn in front of the ear, may be applied. The course of these turns is the same as those employed in the *oblique bandage of the angle of the jaw*, the extremity being secured by a pin.

Transverse Recurrent Bandage of the Head. *Roller Two Inches in Width, Six Yards in Length.*—The initial extremity of the roller is placed upon the lower part of the forehead and the bandage is carried twice around the head from the forehead to the occiput to secure it. The head is then covered in by transverse turns of the bandage; the first turn, starting from a point behind the ear on one side, is carried below the occiput to a corresponding point behind the opposite ear, and ascending transverse turns are then made and carried over the head, each turn covering in about two-thirds of the preceding turn, until the forehead is reached, and when this has been reached two or three circular turns are carried around the head from the forehead to the occiput to fix the recurrent turns. Pins should be applied at the points of starting and finishing of the reversed turns behind the ears, and at the occiput and forehead (Fig. 46).

FIG. 46.

Transverse recurrent bandage of the head.

Use.—This bandage may be employed to secure dressings to the scalp in cases of wounds or in injuries to the skull, and is used for the same purposes as the recurrent bandage of the head.

V-bandage of the Head. *Roller Two Inches in Width, Four Yards in Length.*—The initial extremity of the roller is secured by two turns of the bandage around the cranium from the forehead to the occiput, and when the roller reaches the occipital protuberance it is allowed to drop a little below this, and is carried forward below the ear around the front of the chin and lower lip, then backward to the point of starting. These turns passing from the occiput to the forehead and from the occiput to the chin are alternately made until a sufficient number have been applied, and the extremity is secured by a pin over the occiput (Fig. 47).

FIG. 47.

V-bandage of the head.

FIG. 48.

Head-and-neck bandage.

This bandage may be modified by carrying the turns from the occiput forward under the ear and around the upper lip and back to the occiput, and alternating these turns with the occipito-frontal turns; if employed in this way, a bandage of one and one-half inches in width should be used.

Use.—This bandage may be employed to hold dressings to the front of the chin, to the upper and lower lips in cases of wounds, or to give support to these parts after plastic operations.

Head-and-neck Bandage. *Roller Two Inches in Width, Four Yards in Length.*—The initial extremity of the roller is placed upon the forehead and carried backward just above the ear to the occiput, and is then brought forward around the opposite side of the head to the point of starting. Two of these circular turns are made to fix the bandage, and when it is carried back to the occiput it is allowed to drop down slightly upon the neck, and is then carried around the neck, the turns around the head alternating with the neck-turns until a sufficient number of these have been applied, when the extremity of the bandage is secured by a pin at the point of crossing of the turns at the back of the head (Fig. 48).

Use.—This bandage may be found useful in securing dressings to the anterior or posterior portion of the neck or to the region of the occiput. Care should be taken to apply it in such a manner that too much pressure is not made by the turns around the neck, which would be uncomfortable to the patient, and might seriously interfere with respiration.

Crossed Bandage of One Eye. *Roller Two Inches in Width, Four Yards in Length.*—The initial extremity of the bandage is placed upon the forehead and fixed by two circular turns passing around the head from the occiput to the forehead; the roller is then carried back to the occiput and passed around this and brought forward below the ear, and passing over the outer portion of the cheek is carried upward to the junction of the nose with the forehead, and is then conducted over the parietal eminence downward to the occiput; a circular fronto-occipital turn is next made, and when the bandage is brought back to the occiput it is brought forward again to the cheek. It should then ascend to the forehead, covering in two-thirds of the preceding turn, and again be conducted back to the occiput; these turns are repeated, the oblique turns covering the eye alternating with circu-

Fig. 49.

Crossed bandage of one eye.

lar turns around the head until the eye is completely enclosed (Fig. 49), and the bandage is finished by making a circular turn about the head and introducing a pin to secure its extremity. It will be found more comfortable to the patient to include in the turns of the bandage the ear on the same side on which the eye is covered.

Use.—This bandage will be found useful in retaining dressings to one eye. It will be more comfortable to the patient if a flannel roller be used to apply this bandage, as well as the bandage which includes both eyes.

Crossed Bandage of Both Eyes. *Roller Two Inches in Width, Six Yards in Length.*—The initial extremity of the roller is placed upon the forehead and secured by two circular turns of the bandage passing around the head from the forehead to the occiput; the roller is then carried downward behind the occiput and brought forward below the ear to the upper portion of the cheek; it is then carried upward to the junction of the nose with the forehead and conducted over the parietal eminence to the occiput; a circular turn is now made around the head from the occiput to the forehead, and the roller is carried from the occiput over the parietal eminence of the opposite side forward to the junction of the nose with the forehead, then downward over the eye and outer portion of the cheek below the ear and back to the occiput; a circular turn around the head is next made, and this is followed by a repetition of the previous turns, ascending over one eye, descending over the other eye, each turn alternating with a circular turn around the head. These turns are repeated until both eyes are covered in, and the bandage is finished by making a circular turn around the head, the extremity being secured by a pin (Fig. 50). In this bandage both ears may be covered in or left uncovered.

Fig. 50.

Crossed bandage of both eyes.

Use.—This bandage may be used to apply dressings to both eyes, and both of these bandages covering the eyes are used where it is desired to make pressure; but for the simple application of a light dressing or of a bandage for the exclusion of light, the Liebreich's bandage (Fig. 101) will be found more comfortable to the patient.

Occipito-facial Bandage. *Roller Two Inches in Width, Four Yards in Length.*—The initial extremity of the roller is placed upon the vertex of the head and the bandage is carried downward in front of the ear, under the jaw, and upward upon the opposite side in the same line to the vertex; two or three of these turns are made, one turn accurately covering in the other. A reverse should be made just above and in front of the ear, and two or three turns are then made around the head from the occiput to the forehead, which completes the bandage (Fig. 51). Pins should be inserted at the points where the turns of the bandage cross each other.

Use.—This bandage is employed to secure dressings to the vertex, temporal, occipital, or frontal region.

Fig. 51.

Occipito-facial bandage.

Fig. 52.

Oblique bandage of the head.

Oblique Bandage of the Head. *Roller Two Inches in Width, Six Yards in Length.*—The initial extremity of the bandage is placed upon the forehead, and is secured by two circular turns passing around the head from the forehead to the occiput. From the occiput the bandage is carried obliquely over the highest part of the lateral aspect of the head, which is to be covered in, and is passed over the forehead and back to the occiput. It is then carried to the forehead by a circular turn, which is conducted obliquely over the other side of the head and back to the occiput. A circular turn from the occiput to the forehead should be made between the oblique turns. These turns are repeated, so that each succeeding turn covers in three-fourths of the preceding turn until the sides of the head are covered in by descending turns, and the bandage is completed by a circular turn passing around the head from the forehead to the occiput (Fig. 52). This bandage may be applied with descending or ascending turns.

Use.—This bandage is employed to make pressure upon or to hold a dressing to the lateral aspects of the head.

Fig. 53.

Occipito-frontal bandage.

Occipito-frontal Bandage. *Roller Two Inches in Width, Four Yards in Length.*—The initial extremity of the roller is placed upon the forehead, and a circular turn is made around the forehead and occiput to fix it. A circular turn is then made, passing around the head from a point below the occiput to a point just above the forehead; the next circular turn is made around the head ascending posteriorly and descending anteriorly, and after a sufficient number of these turns have been made to cover in the front and back of the head the end of the bandage is secured with a pin (Fig. 53).

Use.—This bandage will be found useful in securing dressings to the forehead and anterior and posterior portions of the scalp.

BANDAGES OF THE UPPER EXTREMITY.

Spiral Bandage of the Finger. *Roller One Inch in Width, One and a Half Yards in Length*—The initial ex-

Fig. 54.

Spiral bandage of the finger.

Fig. 55.

Spiral reversed bandage of fingers.

tremity of the roller is secured by two or three turns around the wrist; the bandage is then carried obliquely across the back of the hand to the base of the finger to be covered in, then to its tip by oblique turns; a circular turn is next made, and the finger is covered by ascending spiral or spiral reversed turns until its base is reached; the bandage is then carried obliquely across the back of the hand and finished by one or two circular turns around the wrist; the extremity may be pinned or may be split into two tails which are tied around the wrist (Fig. 54).

Use.—This bandage is employed to retain dressings to injuries or wounds upon the finger, and to secure splints in the treatment of fractures or dislocations of the phalanges.

Spiral Reversed Bandage of Fingers. *Roller One and a Half Inches in Width, One and a Half Yards in Length.*—The initial extremity of the roller may be secured by two or three turns around the wrist; the bandage is then carried obliquely across the back of the hand to the base of the fingers to be covered in, then to their tips by oblique turns; a circular turn is next made and the fingers are covered in spiral reversed turns until their bases are reached; the bandage is then carried obliquely across the back of the hand and finished by one or two circular turns around the wrist; the end of the bandage may be secured by a pin or split into two tails which are tied around the wrist (Fig. 55).

This bandage may also be applied so as to cover the fingers alone by making one or two circular turns around the base of the fingers and then carrying the bandage obliquely down to the tips of the fingers, there making a circular turn and then conducting it back to the base of the fingers by spiral reversed turns, and at this point it is secured by a pin or by tying. This bandage does not hold its position as securely as the one first described.

Use.—This bandage is employed to secure dressings to two or more fingers or to retain a splint in contact with them.

Gauntlet Bandage. *Roller One Inch in Width, Three Yards in Length.*—The initial extremity of the roller is fixed at the wrist by one or two circular turns of the bandage; it is then carried down to the tip of the thumb by an oblique turn of the roller, and this is covered in by spiral or spiral reversed turns to the metacarpo-phalangeal articulations; the roller is then carried back to the wrist and a circular turn is made around it. The bandage is then carried down to the tip of the index finger by an oblique turn, which is covered in the same manner. When all the fingers have been covered in, the bandage is finished by circular turns around the hand and wrist (Fig. 56).

Use.—This bandage may be employed to apply dressings to the fingers and hand in cases of wounds or fractures. It was formerly much employed in the treatment of burns of the fingers to prevent the opposed ulcerated surfaces from adhering, but its use for this purpose has been supplanted by wrapping each finger in a separate dressing and applying a bandage over all the fingers and the hand with a few recurrent and spiral turns of a wide roller, the application of this dressing being much less painful to the patient,

Fig. 56.

Gauntlet bandage.

Fig. 57.

Demi-gauntlet bandage.

and being at the same time equally satisfactory in its results.

Demi-gauntlet Bandage. *Roller One Inch in Width, Four Yards in Length.*—The initial extremity of the bandage should be placed upon the wrist and fixed by two circular turns passing from the radial to the ulnar side; then carry the roller obliquely across the back of the hand to the base of the little finger, pass the bandage around this and carry the roller back to the wrist, making a circular turn; it should then be carried obliquely across the hand to the base of the ring finger, and so successively until the base of each of the fingers and of the thumb has been included; the bandage is then completed by an oblique turn across the back of the hand, passing between the index finger and the thumb, and a circular turn around the wrist (Fig. 57).

The demi-gauntlet bandage may also be applied in such a manner as to cover over the palm and leave the dorsum of the hand uncovered.

Use.—This bandage may be employed to retain light dressings to the dorsal or palmar surface of the hand.

FIG. 58.

Complete bandage of hand.

FIG. 59.

Spica-bandage of the thumb.

Complete Bandage of Hand. *Roller Two Inches in Width, Two Yards in Length.*—The initial extremity of the bandage is placed upon the wrist and the hand is covered in by three or four recurrent turns, and these are secured by a circular turn around the wrist. The bandage is then carried obliquely across the back of the hand to the tip of the index finger, when a circular turn is made around the tip of the fingers; the bandage is then carried upward by spiral or spiral reversed turns covering in all of the fingers and the thumb as well as the body of the hand, and is completed by one or two circular turns around the wrist. This bandage may also be applied so as to leave the thumb uncovered (Fig. 58).

Use.—This bandage may be employed to secure dressings to the hand.

Spica-bandage of the Thumb. *Roller One Inch in Width, Three Yards in Length.*—The initial extremity of the roller is placed upon the wrist and fixed by two circular turns; then carry the roller obliquely over the dorsal surface of the thumb to its distal extremity; next make a circular or spiral turn around the thumb, and carry the bandage upward over the back of the thumb to the wrist, around which a circular turn should be made. The roller is then carried around the thumb and wrist, making figure-of-eight turns, each turn overlapping the previous one two-thirds as it ascends the thumb, and each figure-of-eight turn alternating with a circular turn around the wrist. These turns are repeated until the thumb is completely covered in with spica-turns; a circular turn around the wrist finishing the bandage (Fig. 59).

Fig. 60.

Spiral reversed bandage of arm.

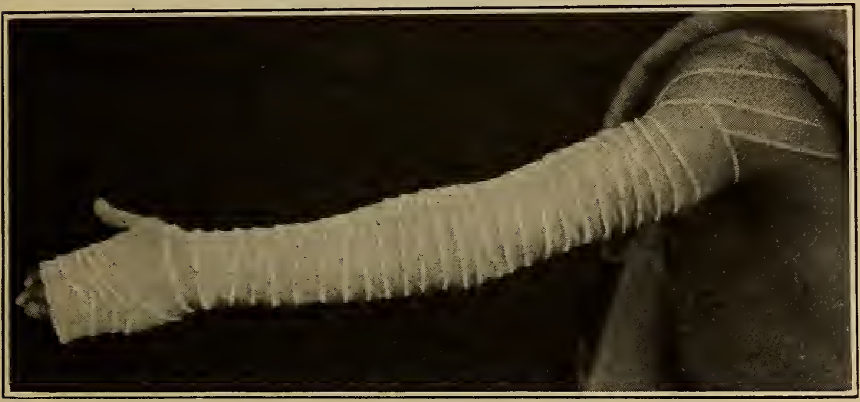
Use.—This bandage is employed to apply dressings to the dorsal surface of the thumb and for the retention of splints in the dressing of fractures or dislocations of the bones of the thumb.

Spiral Reversed Bandage of Arm. *Roller Two and a Half Inches in Width, Five Yards in Length.*—The initial extremity of the bandage is secured by one or two circular turns around the arm just above the elbow and is then carried up the arm by spiral reversed turns until the axilla is reached where the extremity is secured. Care should be used in applying this bandage that it is not applied so firmly that it causes venous obstruction and swelling of the forearm (Fig. 60).

Use.—This bandage is employed to secure dressings or splints to the arm.

Spiral Reversed Bandage of the Upper Extremity. *Roller Two and a Half Inches in Width, Seven Yards in Length.*—The initial extremity of the roller is placed upon the wrist, and secured by two turns around the wrist; the bandage is then carried obliquely across the back of the hand to the second joint of the fingers, where a circular turn should be made; the hand is covered in by two or

Fig. 61.



Spiral reversed bandage of the upper extremity.

three ascending spiral or spiral reversed turns. When the thumb has been reached, its base and the wrist are covered in by two figure-of-eight turns; the bandage is then carried up the forearm by spiral and spiral reversed turns until the elbow is reached; this may be covered in with spiral reversed turns, and the bandage is next carried up the arm with spiral reversed turns to the axilla (Fig. 61). If, on reaching the elbow, the arm is bent, or is to be flexed in the subsequent dressing, the elbow should be covered in with figure-of-eight turns, and when this has been done the arm may be covered in with spiral reversed turns. When properly applied, the reverses should be in line, and should not be made over the prominent ridge of the ulna.

Use.—This is one of the most generally employed of all the roller-bandages; it constitutes the primary roller which is applied in the dressing of fractures of the humerus, and it is also the bandage employed in holding dressings to the arm and forearm and in securing splints to these parts in the treatment of fractures and dislocations.

Figure-of-eight Bandage of the Elbow. *Roller Two Inches in Width, Four Yards in Length.*—The initial extremity of the bandage is placed upon the forearm a short distance below the elbow-joint, and fixed by one or two

Fig. 62.

Figure-of-eight bandage of the elbow.

circular turns, the arm being flexed. The bandage is then carried by an oblique turn across the flexure of the elbow-joint, and passed around the arm a few inches above the elbow; a circular turn is then made, and the roller is next carried across the flexure of the elbow and passed around the forearm. These turns are repeated, the turns from the forearm ascending and those from the arm descending, each set of turns crossing in the flexure of the elbow until it is covered in, and a final turn is passed circularly around the elbow joint (Fig. 62). This bandage is sometimes applied by first making one or two circular turns around the elbow and then applying the figure-of-eight turns as previously described (Fig. 63).

Use.—This bandage is often employed as a part of the spiral reversed bandage of the upper extremity when the arm is to be flexed, and is also used to hold dressings to the region of the elbow-joint. It was formerly much used

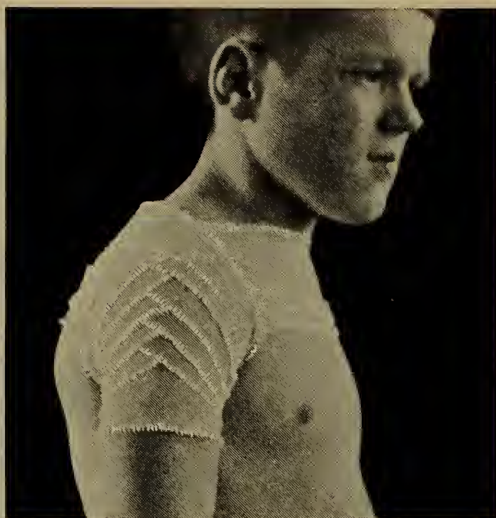
FIG. 63.

Figure-of eight bandage with primary turns around the elbow.

to hold the compress upon the wound resulting from venesection at the elbow.

Spica-bandage of the Shoulder (Ascending). *Roller Two and a Half Inches in Width, Seven Yards in Length.*—The initial extremity of the roller is placed obliquely upon the outer surface of the arm opposite the axillary fold, and fixed by one or two circular turns. If the right shoulder is to be covered, the bandage is next carried across the front of the chest to the axilla of the opposite side, then around the back of the chest to the point of starting upon the arm ; then the roller should be conducted around the arm of this side up over the shoulder, across the front of the chest, through the opposite axilla, and back over the posterior surface of the chest to the point of starting ; continue to make these ascending turns, each turn overlapping the preceding one about two-thirds until the shoulder is covered in (Fig. 64). when the extremity of the bandage may be secured by a pin at the point of ending, or the last turn may be carried from the shoulder around the back of the neck and brought forward over the opposite shoulder

Fig. 64.

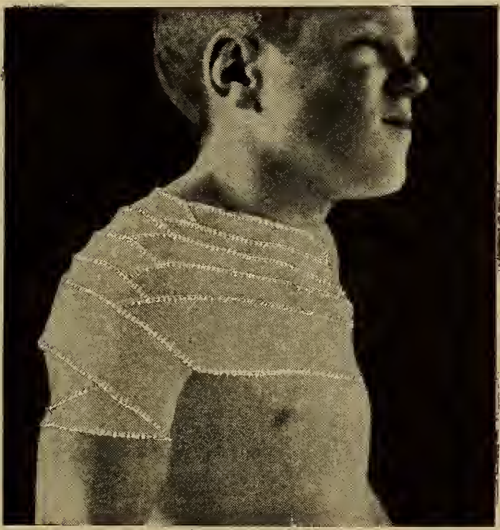


Spica-bandage of the shoulder (ascending).

and pinned to the turns which pass around the axilla. It should be remembered that the turns of the roller overlap each other exactly in the opposite axilla, and it will be found more comfortable to the patient to place a little cotton-wadding in the axilla to prevent the bandage from excoriating the skin of this part. Care should be taken to see that the turns are made in such a manner that the spica-turns occupy as nearly as possible the median line of the shoulder. When this bandage is applied to the left shoulder, after fixing the initial extremity by circular turns around the arm, the roller should be carried over the back of the chest to the axilla of the opposite side and then brought back to the point of starting; the succeeding turns are then applied in the same manner.

Spica-bandage of the Shoulder (Descending). *Roller Two and a Half Inches in Width, Seven Yards in Length.*—The initial extremity of the roller should be fixed upon the arm as near as possible to the axillary fold by one or two circular turns; and if it is applied to the right shoulder, the bandage should be passed under the axilla and carried obliquely over the shoulder to the base of the neck,

FIG. 65.



Spica-bandage of the shoulder (descending).

then downward across the front of the chest to the axilla of the opposite side; from the axilla the roller is carried over the back of the chest to the base of the neck, so as to cross the first turn at this point; it is then carried through the axillary space, then back to the neck, the turns descending toward the shoulder. These turns, taking the same course, are repeated, each turn overlapping two-thirds of the previous one until the shoulder is covered in and the circular turn around the arm is reached, at which point the extremity is secured by a pin (Fig. 65).

Use.—The spica-bandages of the shoulder are employed to hold dressings to the shoulder, to hold compresses over the acromial end of the clavicle in dislocation of that portion of the bone, to retain the shoulder-cap used in the treatment of fractures of the upper portion of the humerus, and to retain dressings to the axilla.

FIG. 66.

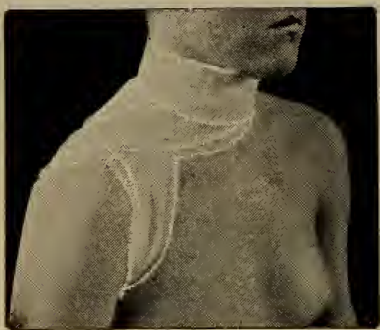


Figure-of-eight bandage of the neck and axilla.

Figure-of-eight Bandage of the Neck and Axilla. *Roller Two Inches in Width, Five Yards in Length.*—The initial extremity of the roller is fixed upon the side of the neck and secured by one or two loosely applied circular turns; if applied to the right axilla, carry the bandage from left to right over the right shoulder to the posterior part of the axilla under which it passes, to ascend in front over the same shoulder to the back of the neck; these figure-of-eight turns around the neck and axilla, each turn overlapping two-thirds of the preceding turn, are repeated until the desired space is covered and the bandage is completed by a circular turn around the neck (Fig. 66).

Use.—This will be found a useful bandage to secure dressings to the base of the neck, the upper part of the shoulder, and to the axilla, as it does not restrict the motions of the arm unless drawn too tight.

Velpeau's Bandage. *Two Rollers Two and a Half Inches in Width, Seven Yards in Length.*—The patient should place the fingers of the hand of the affected side on the opposite shoulder; the initial end of the roller should be placed on the body of the scapula of the sound side and secured by a turn made by carrying the bandage over the shoulder of the affected side, near its outer portion, then conducting it downward over the outer and posterior surface of the arm of the same side, behind the point of the elbow, and obliquely across the front of the chest to the axilla of the opposite side, thence to the point of starting. This turn should be repeated, to fix the initial extremity of the bandage. Having completed the second turn, carry the roller transversely around the thorax, passing over the flexed elbow of the affected side, from this point to the axilla, and through this to the back. From this point the roller is carried over the shoulder and down the outer and posterior surface of the arm behind the elbow, and obliquely across the front of the chest through the axilla to the back, and, continuing, passes transversely

Fig. 67.

Velpeau's bandage.

across the back of the chest to the elbow, which it encircles, and then passes to the axilla. These alternating turns are repeated until the arm and forearm are bound firmly to the side and chest. The vertical turns over the shoulder, each turn covering in two-thirds of the previous turn and ascending from the point of the shoulder toward the neck and from the posterior surface of the arm toward the elbow, are applied until the point of the elbow is reached. The transverse turns passing around the chest and arm are so applied that they ascend from the point of the elbow toward the shoulder, each turn covering in one-third of the previous one, and the last turn should pass transversely around the shoulder and chest, covering the wrist (Fig. 67).

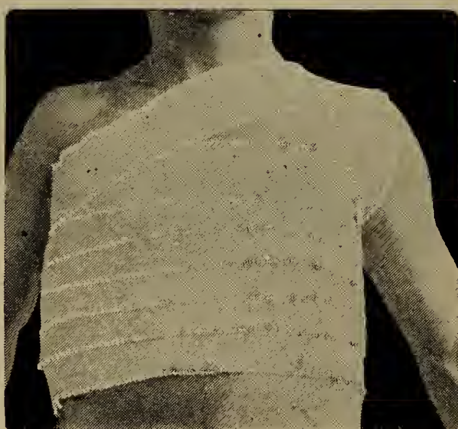
The extremity of the bandage should be secured by a pin where it ends, and additional fixation will be secured by introducing a number of pins at the points where the turns of the bandage cross each other.

Use.—This bandage is employed to fix the arm in the treatment of certain fractures of the clavicle and scapula; also to secure fixation of the humerus after the reduction of dislocations of the shoulder-joint.

Desault's Bandage. *Three Rollers Two and a Half Inches in Width, Seven Yards in Length.*—A wedge-shaped pad to fit in the axilla is also required. These rollers are known as the *first*, *second*, and *third* rollers.

First Roller of Desault's Bandage.—Before applying the first roller the arm of the patient on the injured side should

Fig. 68.

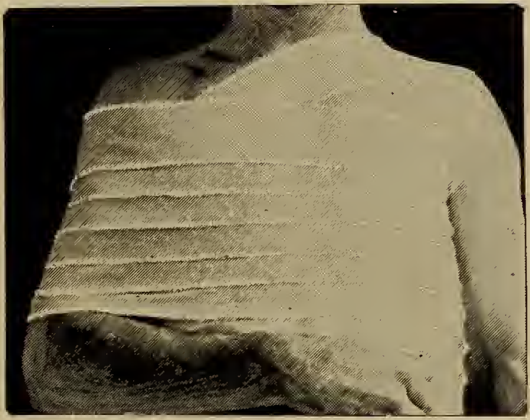


First roller of Desault's bandage.

be elevated and carried off at right angles to the body; the wedge-shaped pad with its base in the axilla should next be applied to the side of the chest, and the initial extremity of the roller should be placed upon the middle of the pad, which may be fixed by two or three circular turns around the chest; the bandage is then carried down the chest by oblique circular turns until the lower extremity of the pad is reached, and it is then carried up the chest by spiral turns until the upper extremity of the pad is reached, when it is conducted obliquely across the front of the chest to the sound shoulder and passed under the axilla, brought over the shoulder and conducted around the chest, where it is secured (Fig. 68).

Second Roller of Desault's Bandage.—The arm should be brought down against the side so as to press upon the pad previously applied, and the forearm should be flexed upon the arm and brought across the lower portion of the chest.

FIG. 69



Second roller of Desault's bandage.

The initial extremity of the roller is placed in the axilla of the sound side, and the bandage is carried around the chest and over the arm of the injured side, making a circular turn around the chest to fix it; then spiral turns are made around the chest from above downward until the elbow is reached, the turns being more firmly applied as they descend, and when this point is reached the end of the bandage is secured. Or the initial extremity of the bandage may be placed upon the chest of the sound side and a circular turn may be made to fix it, and then spiral turns, including the chest and arm, may be made from below upward until the axilla is reached (Fig. 69).

Third Roller of Desault's Bandage.—The initial extremity of the roller is placed in the axilla of the sound side, and the bandage is carried obliquely over the front of the chest to the shoulder of the injured side, passed over this, and conducted down the back of the arm to the elbow, thence obliquely upward over the upper fifth of the forearm to the axilla of the sound side. From this point it is carried backward obliquely over the back of the chest to the shoulder; crossing the previous shoulder-turn, it is conducted down the front of the arm to the elbow, then around this and backward obliquely over the back of the chest to the

Fig. 70.

Third roller of Desault's bandage.

axilla of the sound side. These turns are repeated until three sets of turns have been applied, which should overlie each other exactly (Fig. 70). The course of the turns of the third roller is considered the most difficult to remember, and the student may be assisted in its correct application by remembering that all the turns start at the axilla, pass to the shoulder, and then to the elbow, and from the elbow always return to the starting-point—the axilla. The turns of the third roller make two triangles, one on the anterior surface of the chest (Fig. 71), the other upon the back (Fig. 72).

After the application of the three rollers the hand and uncovered portion of the forearm should be supported in a sling suspended from the neck.

Use.—This bandage, applied completely, or some one of its various rollers, is employed in the treatment of fractures of the clavicle.

FIG. 71.

Anterior view of the turns of third roller of Desault's bandage.

FIG. 72.

Posterior view of the turns of third roller of Desault's bandage.

Arm-and-chest Bandage. *Roller Two and a Half Inches in Width, Seven Yards in Length.*—Before applying this bandage, the arm should be placed against the side of the chest and a folded towel or a pad of cotton should be placed in the axilla and allowed to extend from the axilla to the elbow; the latter is used to prevent the opposing surfaces of skin from becoming excoriated by contact.

The initial extremity of the bandage is placed upon the spine at a point opposite the elbow-joint, and it is fixed by a turn or two passing around the arm and chest; the bandage is then continued by making ascending spiral turns, covering in the arm and chest until the axilla is reached; at this point the bandage is carried through the axilla of the sound side and over the back of the chest to the top of

Fig. 73.

Arm-and-chest bandage.

the opposite shoulder, and it is then conducted down the front of the arm to the elbow, is passed between the arm and chest, and carried up the back of the arm to the shoulder. It is then passed obliquely across the front of the chest, and is secured upon the back of the chest. Pins should be introduced at the points of crossing of the bandage (Fig. 73).

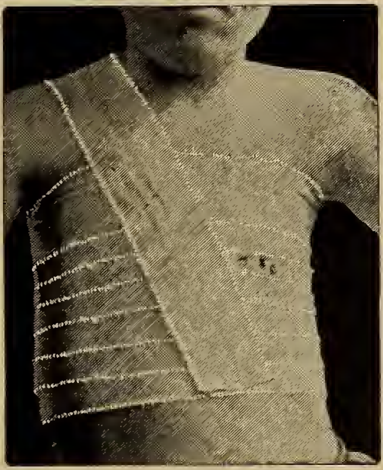
Use.—This bandage will be found useful in fixing the arm to the body and in fixing the shoulder-joint where it is desirable to allow the forearm to be free. It is employed in the treatment of fractures of the shaft and neck of the humerus to fix the arm and hold splints in position.

BANDAGES OF THE TRUNK.

Spiral Bandage of the Chest. *Roller Three Inches in Width, Nine Yards in Length.*—The initial extremity of the roller is applied to the anterior portion of the waist, and fixed by one or two circular turns; the bandage is then carried upward, encircling the chest by ascending spiral turns, each turn covering in one-half of the previous turn until the axillary fold is reached; the roller is next carried around the axilla to the back, and obliquely over this to the base of the neck of the opposite side, and then it may be passed down over the chest and pinned to the spiral turns at several points; a pin should also be inserted at the point where the last turn of the roller leaves the spiral turn upon the back of the chest (Fig. 74).

Use.—This bandage is employed to hold dressings to the chest, and may be used as a temporary dressing in fractures of the ribs or sternum. Care should be taken that the bandage be not so tightly applied as to interfere with respiration.

Fig. 74.



Spiral bandage of the chest.

Anterior Figure-of-eight Bandage of the Chest. *Roller Two and a Half Inches in Width, Seven Yards in Length.*—The initial extremity of the roller should be placed in the axilla of one side, and the bandage is then carried obliquely across the anterior portion of the chest to the shoulder of the opposite side; it is then carried backward around the shoulder and through the axilla, and is next conducted obliquely over the anterior portion of the chest to the opposite shoulder, through the axilla, and again back to the anterior portion of the chest, the turns crossing in the median line over the sternum. These turns should be repeated, ascending from the shoulder toward the neck, each turn overlapping three-fourths of the preceding one, until five or six turns have been applied, the end of the bandage being secured by a pin

Fig. 75.

Anterior figure-of-eight bandage of the chest.

(Fig. 75), or it may be completed by a circular turn around the chest.

Use.—This bandage may be employed to bring the shoulders forward, and to hold dressings to the anterior portion of the chest.

Posterior Figure-of-eight Bandage of the Chest. *Roller Two and a Half Inches in Width, Seven Yards in Length.*—The initial extremity of the roller should be placed in the axilla of the left side, and the bandage should then be carried obliquely across the back of the chest to the top of the opposite shoulder; it is next carried through the axilla and conducted across the posterior portion of the chest to the top of the opposite shoulder, and passed through the axilla to the point of starting. These turns are repeated, descending from the neck toward the shoulder, until five or six have been applied, the end of the bandage being secured by a pin (Fig. 76). In applying both of these bandages the crosses of the bandage, either anterior or posterior, should be made in the median line of the chest.

Use.—This bandage may be employed to hold dressings to the posterior portion of the chest and to draw the shoulders backward.

Fig. 76.

Posterior figure-of-eight bandage of the chest.

Suspensory and Compressor Bandage of the Breast. *Roller Two and a Half Inches in Width, Seven Yards in Length.*—The initial extremity of the roller should be placed upon the scapula of the affected side, and secured by two oblique turns carried over the opposite shoulder and conducted downward under the breast to be covered in, and then carried to the axilla of the same side. Next carry the roller transversely around the chest, covering in the lowest portion of the affected breast. These turns should be repeated, the oblique turns from the axilla over the shoulder alternating with the transverse turns around the chest, until the breast is covered in, each series of turns ascending and covering two-thirds of the preceding turns (Fig. 77).

Use.—This bandage is employed to support the breast and to make compression at the same time; it may also be employed to hold dressings to the breast.

FIG. 77.

Suspensory and compressor bandage of the breast.

Suspensory and Compressor Bandage of Both Breasts. *Two Rollers Two and a Half Inches in Width, Seven Yards in Length.*—The initial extremity of the bandage should be secured by oblique turns of the axilla and shoulder, passing under one breast, as in the preceding bandage; the roller should next be carried transversely around the back to the other breast, then under the breast and upward over the opposite shoulder, then obliquely downward around the chest to the other side, being carried transversely over the lower portion of both breasts to the point of starting upon the back. Repeat these oblique turns from the shoulder to the breast and from the breast to the shoulder, and alternate them with a transverse turn around the chest and over both breasts. Both series of turns should ascend, and each turn should overlap two-thirds of the preceding one (Fig. 78).

Use.—This bandage is employed to support and compress both breasts and to retain dressings to them.

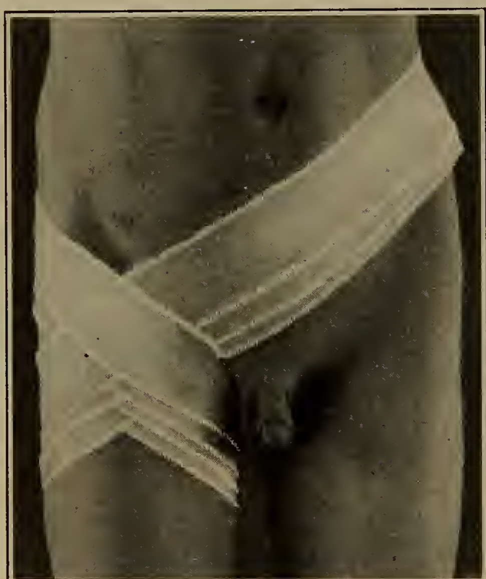
Fig. 78.

Suspensory and compressor bandage of both breasts.

BANDAGES OF THE LOWER EXTREMITY.

Single Spica-bandage of the Groin (Ascending). *Roller Two and a Half Inches in Width, Seven Yards in Length.*—Place the initial extremity of the bandage upon the anterior portion of the right thigh just below the groin, and secure it by one or two circular turns around the thigh, or place the initial extremity of the roller obliquely upon the upper part of the thigh and carry it behind the limb and upward around the outer side of the thigh to the abdomen, omitting the circular turns; then carry the bandage obliquely across the lower part of the abdomen to a point just below the crest of the left ilium, and conduct it transversely around the back of the pelvis to a corresponding point on the opposite side; then bring it obliquely downward to the groin and over to the inner portion of the thigh, carrying it around the limb, crossing the starting-turn in the middle line of the thigh. These turns are repeated, each turn ascending and covering in two-thirds of the preceding turn, until six or eight complete turns have been made, and the bandage is then secured at any point where it ends (Fig. 79). This bandage may also be applied by

Fig. 79.



Ascending spica-bandage of the groin.

placing the initial extremity of the bandage just below the anterior superior spinous process of the ilium, and making two turns around the pelvis and then carrying the bandage to the thigh below the groin, passing it behind the thigh, bringing it up on the opposite side of the thigh to cross the first turn in the middle line of the groin; ascending spica-turns are then made until a sufficient number have been applied to cover in the groin to the desired extent (Fig. 80). This bandage possesses the advantage that it is less likely to become displaced than the one previously described.

Single Spica-bandage of the Groin (Descending). *Roller Two and a Half Inches in Width, Seven Yards in Length.*—Place the initial extremity of the roller obliquely upon the anterior surface of the right thigh and secure it by one or two circular turns around the limb, or start the bandage with an oblique turn, as previously described; then carry the bandage obliquely across the abdomen to a point just below the crest of the ilium, and conduct it transversely around the back of the pelvis to a corresponding point on the opposite side; then bring it obliquely

Fig. 80.

Ascending spica-bandage of the groin applied with pelvic turns.

down over the lower portion of the abdomen, crossing the first turn, to the junction of the thigh with the scrotum, pass it under the thigh and bring it up over the lower part of the abdomen, and let it follow the course of the first turn. These turns are repeated, each turn descending and overlapping two-thirds of the preceding turn until the groin is covered (Fig. 81). When either of these bandages is applied to the left groin, after the initial extremity of the roller is fixed, it is carried first to the crest of the ilium of the same side, then around the back of the pelvis to a corresponding point on the opposite side, then obliquely across the lower part of the abdomen to the outer aspect of the thigh, being conveyed around this and brought up between the thigh and the scrotum, passing obliquely over the groin to follow the course of the original turn. This bandage may also be applied by making one or two circular turns around the pelvis, and the groin is next covered in by descending spica-turns.

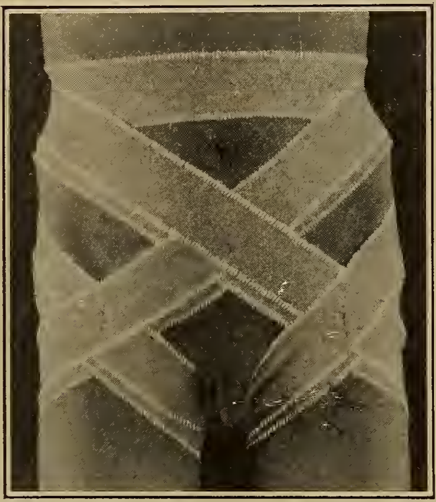
Double Spica-bandage of the Groins. *Roller Three Inches in Width, Nine Yards in Length.*—The initial extremity of the roller is placed upon the abdomen just above

Fig. 81.

Descending spica-bandage of the groin.

the iliac crests and secured by one or two circular turns: the bandage is then carried from a point just below the crest of the right ilium obliquely across the lower portion of the abdomen to the outer portion of the left thigh, is carried around this and brought up between the scrotum and the thigh, and is passed obliquely over the groin, crossing the previous turn in the median line, and is conducted to a point just below the crest of the ilium on the same side. The bandage is then continued around the pelvis to the same point on the opposite side, and from this point is made to pass obliquely over the groin to the inner side of the right thigh, passing around this and coming up on its outer side, crossing the preceding turn at the middle line of the groin, to be carried obliquely across the groin and lower part of the abdomen to the crest of the ilium on the opposite side. These turns are repeated, each turn covering in two-thirds of the previous turn, until both groins have been covered (Fig. 82). The turns may be so applied as to ascend or descend, forming the ascending or descending double spica-bandage of the

Fig. 82.



Double spica-bandage of the groins.

groins. When properly applied, this bandage presents three sets of crossing-turns, one in each groin and one in the median line of the abdomen.

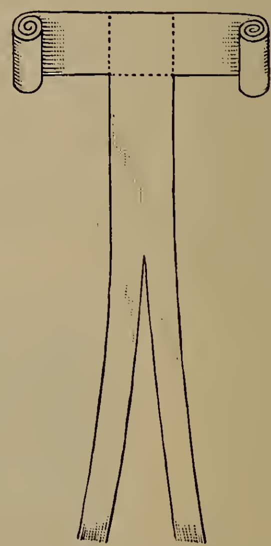
Use.—The spica-bandages of the groin, either single or double, are employed to hold dressings to wounds in the inguinal region—for instance, those resulting from herniotomy, or from operations upon the glands of the groin. They are also employed to make pressure upon this region, and will often prove of use in the securing of compresses applied for the temporary retention of herniæ.

Spica-bandage of Buttock. *Roller Two and a Half Inches in Width, Seven Yards in Length.*—The initial ex-

Fig. 83.

Spica-bandage of buttock.

Fig. 84.



T-bandage of perineum.

tremity of the bandage is placed upon the back of the thigh just below the gluteal fold, and is carried around the thigh and brought back to the posterior aspect of the limb, so as to fix and cross the starting-turn near the middle of the thigh. It is next conducted obliquely across the thigh and buttocks and carried to the brim of the pelvis of the opposite side, when it is brought obliquely over the abdomen and back to the posterior surface of the thigh. These ascending turns are applied, each turn covering in about three-fourths of the preceding one, until the buttock is covered, and the bandage is then finished by one or two circular turns around the pelvis and abdomen (Fig. 83).

Use.—This bandage is employed to hold dressings to the upper posterior portion of the thigh, or the buttock.

T-Bandage of the Perineum.—This bandage, which consists of a strip of muslin three inches in width and four feet in length, has pinned or sewed to its centre a strip of similar material about forty inches in length. The horizontal strip is tied around the abdomen just above the pelvis with the attached strip on the lower end of the spine; this strip is brought between the nates and over the perineum, and its extremity is split into two tails to a point where the scrotum joins the perineum. The tails are next carried up on each side of the scrotum and tied to the horizontal strip around the abdomen. When used in the female the perineal strip need not be split. (Fig. 84).

Use.—This bandage is employed to hold dressings to the anus and perineum. A very satisfactory substitute for this bandage consists in the use of a pair of *swimming tights* which may be employed to hold dressings to the anus, perineum, or scrotum.

FIG. 85.

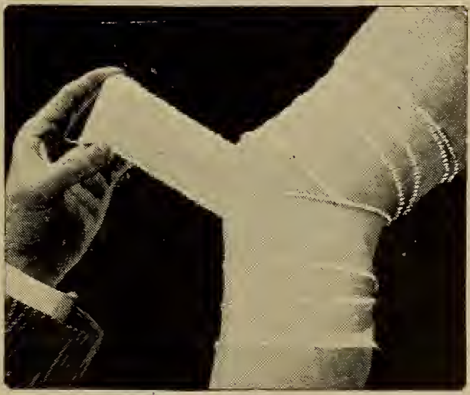


Figure-of-eight bandage of the knee.

Figure-of-eight Bandage of the Knee. *Roller Two and a Half Inches in Width, Five Yards in Length.*—The initial extremity of the roller is placed upon the left thigh three inches above the patella and secured by two or three circular turns; then conduct the bandage over the outer condyle of the femur across the popliteal space to the inner border of the tibia and around the anterior surface below the tubercle and head of the fibula, and make one circular turn ; the roller should then be carried obliquely across the popliteal space to the inner condyle of the femur, crossing the previous turn; then carry it around the front of the thigh to the outer condyle; repeat these turns, ascending toward the knee from the leg and descending from the thigh toward the knee, and finish the bandage by a circular turn over the patella (Fig. 85).

This bandage may also be applied by making two circu-

Fig. 86.

Figure-of-eight bandage of the knee.

lar turns around the patella and popliteal space, and then carrying the bandage to the thigh three inches above the patella, and finishing it with descending turns from the thigh and ascending turns from the head of the tibia, making all turns cross in the popliteal space (Fig. 86).

Use.—This bandage is employed to hold dressings to the knee-joint either anteriorly or posteriorly. These figure-of-eight turns are often employed in covering the knee in applying the spiral reversed bandage of the lower extremity when it is desired that the patient be allowed to bend the knee.

Figure-of-eight Bandage of Both Knees. *Roller Two and a Half Inches in Width, Seven Yards in Length.*—Place the knees of the patient together with a compress between them; then place the initial extremity of the roller upon one thigh, about three inches above the patella, and secure it by one or two circular turns around both thighs;

Fig. 87.

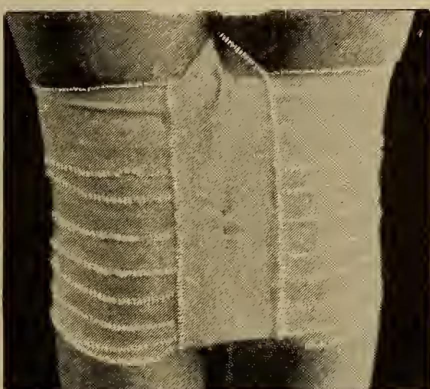


Figure-of-eight bandages of both knees.

Fig. 88.

Complete bandage of the foot.

then conduct the roller from the outer condyle of the left femur obliquely across the popliteal spaces of both legs to the head of the fibula on the opposite side, making a circular turn around both legs; pass the roller from the head of the fibula on the opposite side across the popliteal space to the external condyle opposite the point of starting.

Repeat these turns, descending from the thighs and ascending from the legs, until the knees are covered, and finish the bandage by carrying a turn of the bandage at right angles to the preceding turns between the thighs and the legs (Fig. 87).

Use.—This bandage is employed to secure fixation of the limbs after operations upon the perineum, and may also be employed to obtain temporary fixation of the limbs in transporting cases of fracture of the femur, and after the reduction of dislocations of the head of that bone.

Complete Bandage of the Foot. *Roller Two Inches in Width, Three Yards in Length.*—The initial extremity of the bandage is placed upon the sole of the foot near the heel, and the foot is covered in by three or four recurrent turns; these are fixed by one or two circular turns around the instep; the heel is then covered in by a circular and figure-of-eight turn, which passes around the ankle. The bandage is then carried obliquely over the dorsum of the foot to the tip of the toes, when a circular turn should be made; the foot is then covered in by ascending spiral reversed turns until the ankle is reached, when it is secured by one or two circular turns. This bandage may also be applied by first making two or three recurrent turns, covering in the toes, the plantar, and dorsal surface of the foot, and the bandage is then completed by spiral reversed turns as described above (Fig. 88).

Spica-bandage of the Foot. *Roller Two and a Half*

Fig. 89.

Spica-bandage of the foot.

Inches in Width, Five Yards in Length.—Fix the initial extremity of the roller upon the ankle and secure it by two circular turns; then carry the bandage obliquely over the dorsum of the foot to the metatarso-phalangeal articulation, and make a circular turn around the foot at this point; then continue it upward over the metatarsus by making two or three spiral reversed turns; next carry the bandage parallel with the inner or outer margin of the sole of the foot, according to whether it is applied to the right or left foot, directly across the posterior surface of the heel; thence along the opposite border of the foot and over the dorsum, crossing the original turn in the median line of the foot. This completes the first spica-turn. These spica-turns are repeated, gradually ascending by allowing each turn to cover in three-fourths of the preceding turn, until the foot is covered in with the exception of the posterior portion of the sole of the heel (Fig. 89). Care should be taken to see that the turns cross each other in the median line, and that they are kept parallel to each other throughout their course.

Use.—This bandage will be found very useful when it is desired to make firm compression upon the foot or to retain dressings to it; it is especially useful in the treatment of sprains of the ankle or the anterior tarsus.

Bandage of Foot Covering the Heel (**American**). *Roller Two and a Half Inches in Width, Seven Yards in Length.*—The initial extremity of the roller is placed upon the leg just above the malleoli and fixed by two circular turns around the leg; the bandage is then carried obliquely across the dorsum of the foot to the metatarso-phalangeal articulation, at which point a circular turn is made; two or three spiral or spiral reversed turns are then made, ascending the foot; the roller is next carried directly over the point of the heel and continued back to the dorsum of the foot; thence beneath the instep around one side of the heel and up over the instep; from this point it is carried beneath the instep around the other side of the heel (Fig. 90), and up in front of the ankle, from which point it may be continued up the leg (Fig. 91),

Use.—This bandage is employed to cover in the foot, and retain dressings to the foot and heel.

Fig. 90.

Turns covering heel in American bandage.

Fig. 91.

Bandage of foot covering the heel.

Bandage of Foot Not Covering the Heel (French). *Roller Two and a Half Inches in Width, Seven Yards in Length.*—Fix the initial extremity of the roller upon the leg just above the malleoli and secure it by two circular

Fig. 92.

Bandage of foot not covering the heel.

Fig. 93.

Bandage of the heel.

turns around the leg; the bandage is then carried obliquely across the dorsum of the foot to the metatarso-phalangeal articulation, and at this point a circular turn should be made. The roller is now carried up the foot, covering it in with two or three spiral reversed turns, and at this point a figure-of-eight turn is made around the ankle and instep; this should be repeated once, which will cover in the foot with the exception of the heel; the bandage may then be continued up the leg with spiral reversed turns (Fig. 92).

Use.—This bandage may be employed to secure dressings to the foot, and is the one generally used to cover this part in applying the spiral reversed bandage of the lower extremity.

Bandage of the Heel. *Roller Two Inches in Width, Three Yards in Length.*—The initial extremity of the bandage is placed over the anterior surface of the ankle and is fixed by two circular turns passing over the point of the heel. The bandage is then carried obliquely over the dorsum of the foot to the tarso-metatarsal articulations, at which point a circular turn is made; the bandage is then carried beneath the instep around one side of the heel and upward over the instep; from this point it is carried beneath the instep around the other side of the heel. Several layers of these turns should be made, and the bandage may be finished by a circular turn around the leg just above the ankle (Fig. 93).

Use.—This bandage may be employed to retain dressings to the heel.

Spiral Reversed Bandage of the Lower Extremity. *Roller Two and a Half Inches in Width, Seven Yards in Length.*—The initial extremity of the roller is placed upon the leg just above the malleoli and secured by two circular turns. It is then carried obliquely over the foot to the metatarso-phalangeal articulation, where a circular turn is made around the foot. Two or three spiral reversed and two figure-of-eight turns of the ankle and instep should be made, while just above the ankle one or two circular or spiral turns are made around the leg, and as the bandage is carried up the leg, as it increases in diameter, spiral reversed turns are made until it approaches the knee; at this point, if the limb is to be kept straight, the spiral reversed turns may be continued over this region and up upon the thigh. If the knee is to be bent, figure-of-eight turns may be applied until the knee is covered, and then the thigh may be covered with spiral reversed turns (Fig. 94). To cover in the thigh as

Fig. 94.

Spiral reversed bandage of the lower extremity.

well as the leg, two bandages of the dimensions before given will be required. Care should be taken to keep the reverses in a line, and not to make them over the spine of the tibia, as they may thus become painful to the patient.

Use.—This is one of the most frequently employed of the roller-bandages; it is used to apply pressure to the lower extremity, to retain dressings, and to secure splints in the treatment of fractures and dislocations.

Spiral Reversed Bandage of the Thigh. *Roller Three Inches in Width, Six Yards in Length.*—The initial extremity of the bandage is secured around the thigh just above the knee-joint by two or three circular turns, and the bandage is carried up the thigh by spiral reversed turns until the groin has been reached, when it is secured by one or two circular turns around the thigh. Care should be taken that it is not applied too firmly, that the superficial veins are not obstructed, causing swelling of the leg below the knee (Fig. 95).

Use.—This bandage is employed to retain dressings or splints to the thigh.

Figure-of-eight Bandage of the Leg. *Roller Two and a Half Inches in Width, Seven Yards in Length.*—This bandage differs from the spiral reversed bandages of the

FIG. 95.

Spiral reversed bandage of the thigh.

lower extremity only in the fact that when the swell of the calf is reached figure-of-eight turns are made around

FIG. 96.

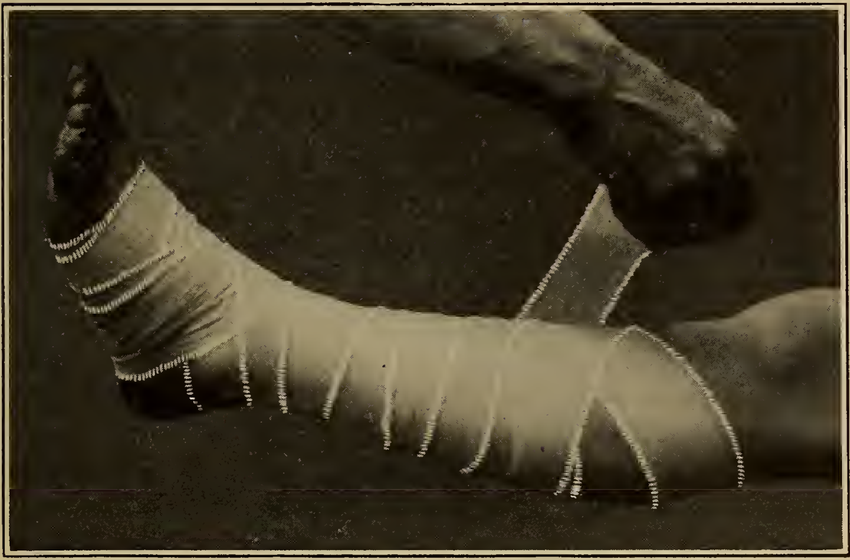


Figure-of-eight bandage of the leg

the leg instead of spiral reversed turns. In applying the roller, when the calf of the leg is reached the bandage is carried obliquely around the leg to the crest of the tibia and then made to cross the starting-turn in the median line; these descending and ascending turns are repeated until the calf of the leg has been covered in, and the bandage is finished with one or two circular turns just below the knee (Fig. 96).

Use.—This bandage holds its place more firmly than the ordinary spiral reversed bandage of the leg, and may be employed in the treatment of ulcers of the leg in conjunction with strapping, where it is desirable to change the dressings at infrequent intervals and to allow the patient to walk about during the course of treatment.

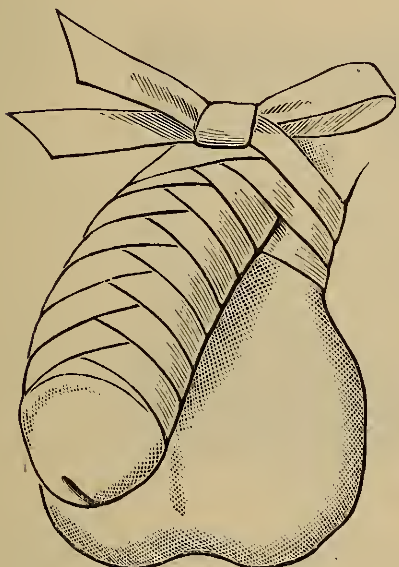
SPECIAL BANDAGES.

Spiral Reversed Bandage of the Penis. *Roller Three-quarters of an Inch in Width, Thirty Inches in Length.*—Fix the initial extremity of the roller by two circular turns around the penis close to the pubis; then carry the bandage obliquely down to the corona glandis; from this point ascend the body of the penis by spiral reversed turns to the pubis, and finish the bandage by two figure-of-eight turns around the neck of the scrotum and root of the penis, or split the end of the bandage so as to form two tails, and secure it by tying these around the root of the penis (Fig. 97).

Bandage of Perineum.—To hold dressing to the perineum or anal region a single T-bandage is usually employed. (Fig. 84). To secure dressings to this region the use of swimming tights will be found very satisfactory in holding the dressings in place if the patient is compelled to be on his feet (Fig. 98).

Recurrent Bandage of a Stump. *Roller Two and a Half Inches in Width, Five to Seven Yards in Length.*—Place the initial extremity of the roller upon the anterior or posterior surface of the limb a few inches above the extremity of the stump, and carry the bandage to the end of the stump, and then conduct it upward or downward on the limb, as the case may be, to a point directly opposite the point of starting; then bring the bandage back

FIG. 97.



Spiral reversed bandage of the penis.

FIG. 98.

Swimming tights employed to secure dressing to perineum or anal region or groin.

over the face of the stump to the point of starting, and continue these recurrent turns, each turn overlapping two-thirds of the preceding one, until the face of the stump is covered; then reverse the bandage and secure the recurrent turns at their points of origin by two or three circular turns. The roller should next be carried obliquely down to the end of the stump, and a circular turn should be made around this. The bandage should then be carried up the limb by spiral or spiral reversed turns beyond the point at which the recurrent turns terminated, and secured by one or two circular turns (Fig. 99).

In applying this bandage to very short stumps resulting from amputations at or near the shoulder- or hip-joint, after making the recurrent and spiral turns, it will be found necessary to carry the bandage, in the case of amputations of the shoulder, across the chest to the opposite axilla and back, and apply several of these turns; so in case of hip amputations it will be found best to finish the bandage with a few turns about the pelvis.

FIG. 99.

Recurrent bandage of a stump.

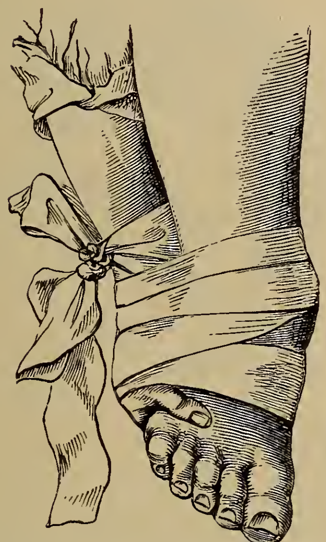
Bandage for Securing the Hands and Feet in the Lithotomy Position.—The hand of the patient should be brought down and made to grasp the outer side of the foot; the initial extremity of the roller is fixed by two circular turns around the wrist and ankle, and the bandage is then passed around the foot and hand, and these turns are alternated with turns around the wrist and ankle until the hand and foot are firmly secured. The same procedure is adopted with the hand and foot of the opposite side Fig. 100.

Liebreich's Eye-bandage.—This bandage consists of a strip of flannel two and a half inches in width and from six to ten inches in length, to the extremities of which tapes are sewed. It may be applied transversely so as to cover both eyes, or obliquely so as to cover only one eye; it is secured by the tapes carried around the head and tied over the forehead (Fig. 101).

Use.—This bandage is used to hold compressed or dressings to the eye or eyes; the elasticity of the flannel permits of its being applied so as to make a variable amount of pressure.

Borsch's Eye-bandage.—This bandage is employed for holding a dressing to one eye, and consists in a strip of flannel, two or two and a half inches in width, which is passed around the head from the occiput and covers both

FIG. 100.



Bandage for securing the hands and feet for lithotomy.

FIG. 101.

Liebreich's eye-bandage.

eyes (Fig. 102). A narrow strip of flannel is attached to the posterior portion, which is carried over the head and passed under the horizontal strip in front of the eye which is to be left uncovered, and is then folded back so as to raise the horizontal strip from the eye, and secured (Fig. 103).

Bandages of Scultetus.—This is a compound bandage, consisting of a number of pieces of muslin, and may be prepared from a two and a half or three inch roller by cutting off strips sufficiently long to encircle the part about one and one-third times. The strips are placed under the part in such a manner that the first piece shall be overlapped by the second, the second by the third, and so on from below upward; the pieces are then brought around the limb, and the extremities of the last piece are secured by pins (Fig. 104). This bandage was formerly much employed in the treatment of compound fractures to secure dressings to the wound, and possessed the advantage that

Fig. 102.

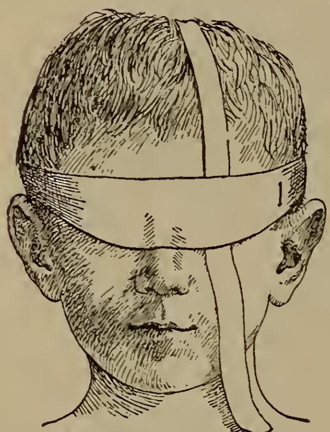
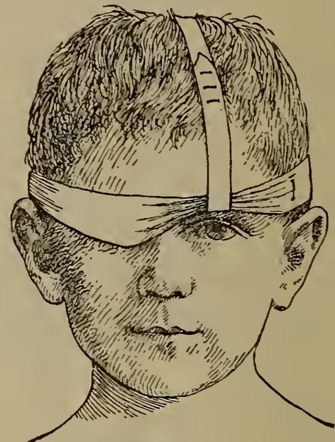


Fig. 103.



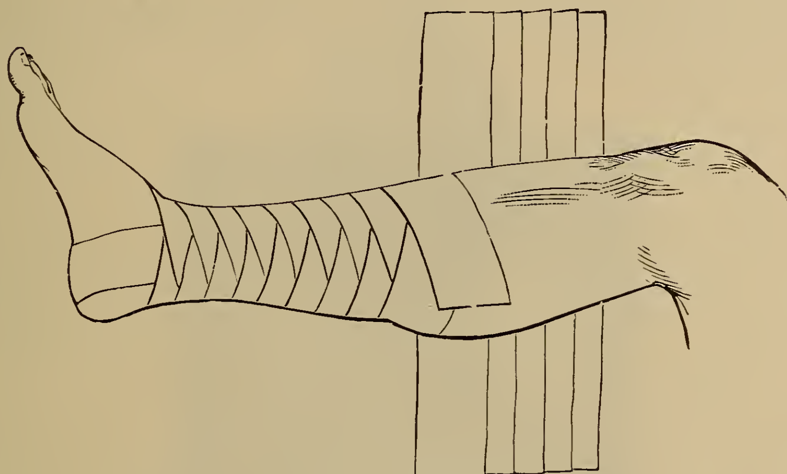
Application of Borsch's eye-bandage.

when a single strip became soiled it could be removed without disturbing the whole dressing, the new strip to be introduced being pinned to the extremity of the soiled piece to be removed, and then being drawn through by its removal. This bandage will often be found convenient in applying dressings to cases of excision of the joints, where as little disturbance of the parts as possible is important in dressing the wound. When the strips are attached to each other by a thread passed through the centre of each strip, the bandage is known as *Pott's bandage.* It is applied and secured in the same manner, but it possesses no advantages over the bandage of Scultetus.

Gauze Bandages.—Bandages may be prepared from gauze, the same material that is used for gauze dressings, and are now very extensively used in surgical practice.

The gauze bandages are prepared by cutting or tearing the material into strips varying in width from two inches to three inches, and in length from five yards to eight yards; these strips are then wound so as to form roller-bandages. Gauze bandages are sometimes employed in the dressing of fractures, but do not furnish as substantial a dressing as the ordinary muslin bandages. They, how-

FIG. 104.



Bandage of Scultetus.

ever, constitute a soft and comfortable material for holding dressings to wounds. They are applied in the same manner as the ordinary muslin roller, with the exception that in their application reverses are seldom required, as the open mesh of the bandage gives it considerable elasticity, so that the bandage can be made to adapt itself to the part without making reverses. Any of the ordinary bandages which have been previously described may be applied by means of the gauze bandages, such as those of the head, extremities, and trunk.

Gauze Bandage of Head and Neck.—In applying dressings to wounds of the head and neck, it is advisable to cover in both the head and neck, and also to make a few turns over the upper part of the chest and around each shoulder, which prevents the turns of the bandage from slipping and holds the dressing in place, so that it cannot be disarranged by movements of the patient (Fig. 105).

Gauze Bandage of Upper Extremity.—The initial extremity of the bandage is secured by two or three turns around the wrist, and the bandage is then carried obliquely over the dorsum of the hand to the tip of the little finger,

FIG. 105.

Gauze bandage of head and neck.

when a circular turn is made; the hand is then covered in by circular turns. The region of the wrist is next covered by figure-of-eight turns and the bandage is carried up the forearm by circular turns. Figure-of-eight turns are made at the elbow and the bandage is continued with circular turns around the arm. No reverses need be made in applying this bandage.

Use.—This bandage is used for the same purposes as the spiral reversed bandage of the upper extremity.

Gauze Bandage of Chest and Shoulder.—In applying this bandage, a gauze roller, three or four inches in width, is employed. The initial extremity of the bandage is secured around the lower portion of the chest by one or two turns and it is carried up to the axillary lines by circular turns; at this point it is secured obliquely across the chest to the base of the neck and then behind the shoulder to the posterior portion of the axilla. From this point the turn is

Fig. 106.

Gauze bandage of chest and shoulder.

carried through the axilla and over the shoulder and is conducted over the back of the chest to the posterior aspect of the opposite axilla, through which it passes to be carried over the anterior portion of the chest and shoulder to the opposite axilla. Then turns are repeated until a dressing of sufficient firmness is applied (Fig. 106). This bandage is used to secure dressings to the chest, axilla, and shoulder.

Flannel Bandage.—These bandages are prepared from flannel, which is cut into strips from two to four inches in width and from five to seven yards in length. These strips are formed into rollers either by hand or by means of the bandage-winder. Flannel bandages, by reason of the elasticity which they possess, can be applied without

FIG. 107.

Black muslin bandage of hand and arm.

reverses, and are used to make a moderate amount of elastic pressure. They are often employed in applying dressings

FIG. 108.

Black muslin bandage of the hand.

to the head, especially after operations upon the eyes, and are generally applied as a primary roller before the application of plaster-of-Paris dressings, and may also be used in subacute joint-affections, both to protect the parts and to make a moderate amount of elastic pressure.

Black Muslin Bandages.—From the fact that dark-colored bandages are less conspicuous than white ones, they are sometimes prepared from black or brown muslin. They are applied in the same manner as the ordinary muslin or gauze bandage. For this reason they may be used for bandages of the head, hand, or arm in patients who are treated as walking cases, and who object to the conspicuousness of a white bandage (Figs. 107, 108 and 109).

The Rubber Bandage.—This bandage, which was introduced to the profession by Dr. Martin, of Boston, is made from a strip of rubber-sheeting, from one inch to four inches in width and from three to five yards in length, which, for convenience of application, is rolled into a cylinder. It will be found a useful form of dressing where it is considered desirable to apply elastic pressure to a part (Fig. 110).

Fig. 109.

Black muslin bandage of head.

It may be employed in the treatment of varicose veins of the legs, in chronic ulcers of those parts where pressure is an important element in the treatment, and may be used as a substitute for strapping to secure this object. Its application has also been recommended in the treatment of swelled testicle in that stage of the affection in which pressure is indicated.

For applicatin to the leg, a rubber bandage two and a half inches in width and three yards in length is required. The initial extremity of the roller is fixed upon the foot near the toes and secured by a circular turn; the foot is then covered in by spiral turns overlapping each other about two-thirds, and a figure-of-eight turn is made from the ankle to the instep. The bandage is then carried up the limb to the knee with spiral turns, where it is secured by two tapes sewed to the terminal extremity of the bandage, which are passed around the leg and tied. The bandage need not be reversed, as its elasticity allows it to conform to the shape of the limb. Care should be taken not to apply the turns with too much firmness; the bandage should be stretched very slightly; if this precaution is not taken, it soon becomes uncomfortable to the patient. A patient using one of these bandages will soon learn to apply it himself, making just the requisite amount of tension to secure its holding its place, and to insure a comfortable degree of pressure upon the part. A well-fitting stocking may be placed upon the limb before the bandage is applied, or it may be applied directly to the skin.

Fig. 110.

Martin's rubber bandage.

The bandage should be removed at night when the patient goes to bed and hung up to dry, as its inner surface becomes moist from the secretions from the skin; it should be reapplied as soon as the patient rises in the morning.

In using it in the treatment of ulcers of the leg no ointment should be applied to the ulcer, as oily dressings soon destroy the rubber; applications may be made to the ulcer by means of dry powders, such as oxide of zinc, iodoform, or aristol, before the bandage is applied.

In the treatment of swelled testicle the bandage is applied to the testicle by means of recurrent turns not too firmly made, and secured in place by spiral turns, until the whole surface of the organ is covered in; the end of the bandage is secured with tapes tied around the root of the scrotum. The same precaution to apply the bandage so as to make only moderate pressure should also be observed here.

Elastic-webbing Bandage.—This bandage, which is woven from threads of rubber covered with cotton or silk, has recently been introduced, and possesses all the advantages of the rubber bandage as regards elasticity, and has the additional advantage that air can circulate through the meshes of the bandage and moisture can evaporate from the surface covered by the bandage, so that the skin covered by it does not become bathed in perspiration, as is the case with the rubber bandage. It is applied in the same manner and for the same purposes as the rubber

Fig. 111.

Elastic webbing bandage applied to leg.

bandage (Fig. 111). The patient soon learns to apply it himself, so as to make the requisite amount of pressure. In the treatment of varicose veins and œdema of the legs we have found it a most satisfactory dressing.

FIXED DRESSINGS, OR HARDENING BANDAGES.

For the application of these dressings a variety of substances are used which are incorporated in the meshes of some fabric, such as crinoline or cheese-cloth, or painted over its surface to give fixity or solidity to the bandage.

The materials most commonly used in the preparation of fixed dressings are plaster-of-Paris, starch, silicate of sodium or potassium, and paraffin.

Plaster-of-Paris Dressings.

The plaster-of-Paris used for the application of surgical dressings should be of the same quality as that which dental surgeons employ in taking casts for teeth—that is, the *extra-calcined* variety. If moist or of inferior quality, it will not set rapidly or firmly, and will fail to give sufficient fixation to the dressing.

Methods of Applying Plaster-of-Paris Dressings.—The plaster-of-Paris dressing may be applied in several ways, either by covering the part to be enclosed with some loose fabric, and rubbing the moist plaster into it, alternating the layers of the fabric with layers of moist plaster, or it may be applied by means of a roller which has been prepared by incorporating plaster-of-Paris in its meshes.

It may also be applied in the form of the Bavarian dressing (page 112), or in the form of moulded plaster-of-Paris splints (page 113).

To apply a plaster-of-Paris dressing according to the first method, the part to be enclosed—the leg, for instance—should first be covered by a neatly applied flannel bandage, or a muslin bandage which has been shrunken by being washed; new muslin is not satisfactory as a primary application to a limb in applying a plaster-of-Paris dressing, as the moisture from the plaster wets it and causes it to shrink, so that it may exert injurious pressure after the bandage becomes dry.

The limb having been covered by the bandage, and any bony prominences, such as the malleoli, having been padded with small wads of cotton to prevent undue pressure upon them, the part is next covered by a layer of turns of a crinoline bandage or by strips of cheese-cloth or any other loose material. A small quantity of plaster-of-Paris is next mixed with water until it has the consistence of thick cream, when it is smeared evenly over the whole surface of the previously applied bandage. Another layer of the bandage or of strips is next applied, and the plaster is smeared over this in the same manner, and so alternate layers of plaster-of-Paris and bandage are applied until a casing of the desired thickness is obtained. If plaster-of-Paris of the quality previously described be used, it will set or become hard in a few minutes.

The most convenient method of applying the plaster-of-Paris dressing is that introduced by the late Professor Sayre, which consists in the use of bandages which have been previously prepared with plaster-of-Paris; these are moistened and applied while moist to the part to be encased.

Preparation of Plaster-of-Paris Bandages.—These bandages are prepared by taking cheese-cloth, mosquito-netting, or crinoline, which latter is by far the best fabric, and cutting or tearing it into strips two and a half to three inches in width and five yards in length. These are laid on a table, and plaster-of-Paris of the quality before mentioned is dusted over them and rubbed into the meshes of the fabric; the material when impregnated with plaster is loosely rolled into a cylinder, and these bandages when prepared should be placed in air-tight jars or tin cans until required.

Bandages thus prepared, which have been exposed to the air or have been kept for a long time, are not apt to set well when applied; but if such bandages are placed in a hot oven and baked for half an hour before being used, they will be found to set as satisfactorily as those freshly prepared.

These bandages may be prepared by a machine made for this purpose; but I do not think that they are apt to have the plaster as evenly distributed through them, and, therefore, are not as satisfactory as those prepared by hand.

Application of the Plaster-of-Paris Bandage.—Before applying this dressing, the part to be encased—the leg, for instance—should be covered by a flannel roller, the bony prominences being protected by pads of cotton, or a closely fitting stocking may be applied to the part. Cotton wadding cut into strips of the desired width and formed into a roller may be used instead of the flannel roller.

The bandage should be dipped in warm water and kept completely immersed for a few minutes; it should then be squeezed with the hand, and as soon as bubbles of air cease to escape it is a sign that it is thoroughly soaked

Fig. 112.

Leg encased in plaster-of-Paris dressing.

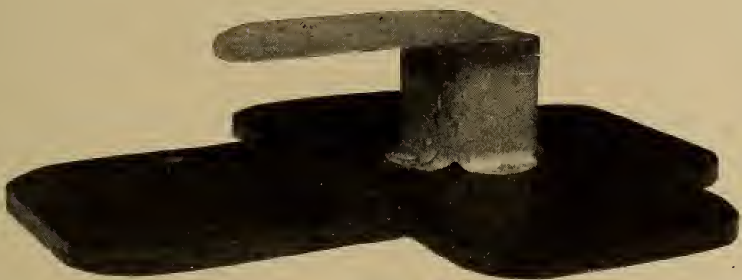
and is ready for application. On removing it from the water the excess of water should be squeezed out by the hand, and the bandage should then be applied evenly to the limb with just sufficient firmness to make it fit the part nicely, and as few reverses as possible should be made. A sufficient number of bandages are applied to make a dressing as firm as may be required; three rollers of the above dimensions are usually ample for a dressing for the leg, and when the last roller has been applied dry plaster should be moistened with water until it has the consistency of thick cream, and rubbed evenly over the surface of the bandage to give it a finish (Fig. 112). If a good quality of plaster has been used, the bandage should be quite firm in from ten to fifteen minutes, but the patient should not for a few hours be allowed to bear any weight upon the bandage.

An equally firm dressing may be applied with the use of a less number of bandages, if the surgeon rubs over the surface of each layer of bandage applied a little moist plaster, then applying another layer and repeating the procedure; finishing the dressing by an external coating of moist plaster, as above described.

In applying these dressings a fewer number of bandages will be required if narrow strips of tin, zinc, or binders' board are incorporated in the layers of the bandage, which increase the strength of the dressing.

Application of the Plaster-of-Paris Bandage to the Thigh and Pelvis.—Where it is desirable to apply a

Fig. 113.



Pelvic supporter.

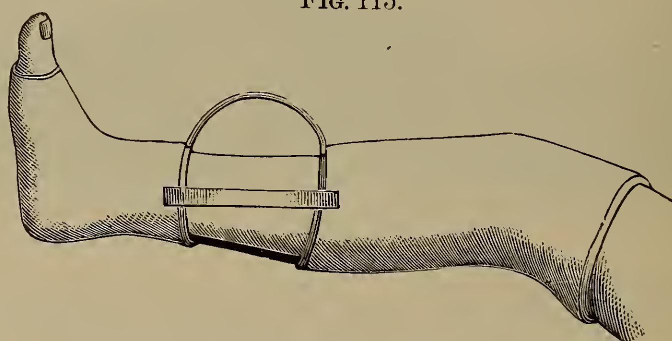
plaster-of-Paris bandage to the thigh, and at the same time fix the hip-joint by including the pelvis in the bandage, the use of a pelvic supporter (Fig. 113) is most satisfactory. The patient is placed upon the supporter so that the lumbar spine rests upon the body of the supporter, while the pelvis rests upon the metal shelf which extends from it, as seen in Fig. 114. The limb is extended and held in the required position, and the plaster bandage is applied to the thigh, and is also carried around the pelvis and passed over the metal shelf upon which the pelvis rests. When the bandage has become firm, the supporter is removed by slipping it upward.

FIG. 114.

Position of patient upon pelvic supporter.

Interrupted Plaster-of-Paris Dressing.—This form of plaster-of-Paris dressing is applied by first placing a short iron rod under the extremity, opposite to and extending some distance above and below the point at which the

FIG. 115.



Interrupted plaster-of-Paris dressing. (STIMSON.)

dressing is to be interrupted; this is fixed by a few turns of the plaster bandage above and below the portion of the limb which is to be left exposed; stout wire is next bent into loops, the extremities of which are incorporated in the subsequent turns of the plaster bandage; three loops thus placed in addition to the posterior iron bar will usually make the dressing sufficiently firm (Fig. 115). A number of turns of the bandage are applied to fix the metal loops firmly, and the limb is held in the desired position until the plaster has set.

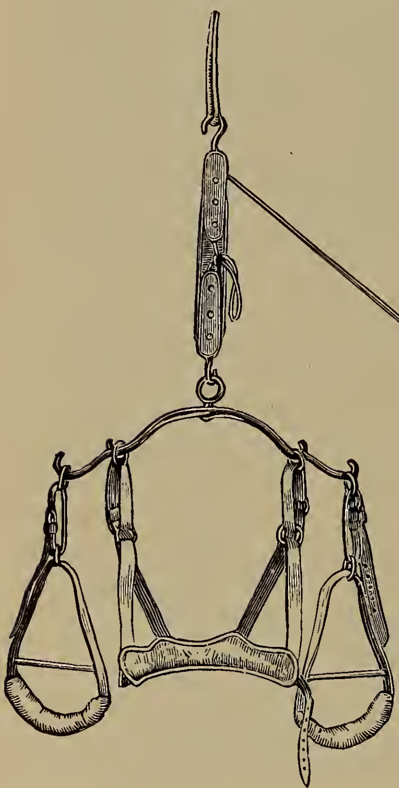
Application of the Plaster-of-Paris Jacket.—The patient's body should be covered with a soft, closely fitting woven shirt without arms, but with shoulder-straps to hold it in position, or an ordinary woven undershirt may be employed; one or two folded towels, or a pad of cotton wrapped in a towel, are next placed over the abdomen between the shirt and the skin—this was called, by Professor Sayre, the *dinner pad*, and is intended to leave space for distention of the abdomen after eating. Small pads of raw cotton may also be placed over the anterior iliac spines, and, in the case of females, a pad of cotton wrapped in a handkerchief may be placed over each mammary gland.

The patient should next be suspended by the apparatus, consisting of a collar and arm-pieces attached to a cross-bar (Fig. 116), which is attached by a cord and pulley to a tripod. If this apparatus is not at hand, a very satisfactory substitute may be made by folding two towels into cravats and tying together the ends, so as to make two loops, one of which is placed in each axilla; a bar of wood two and a half feet in length is next taken, and the loops are secured to the ends of this by stout cords or handkerchiefs; a Barton's bandage is next applied to the head, and a strip of bandage is passed under the turns which cross the vertex and is secured to the middle of the cross-bar. The bar is next suspended by a cord passed through a pulley or ring, which may be attached to the top frame of a door if the ordinary tripod cannot be obtained.

The patient should be raised slowly by the apparatus until the toes only are in contact with the floor, and the extension should not be carried to the point which makes it uncomfortable to the patient (Fig. 117). The shirt should be drawn downward over the hips by an assistant and held in place until a few turns of the bandage have been applied.

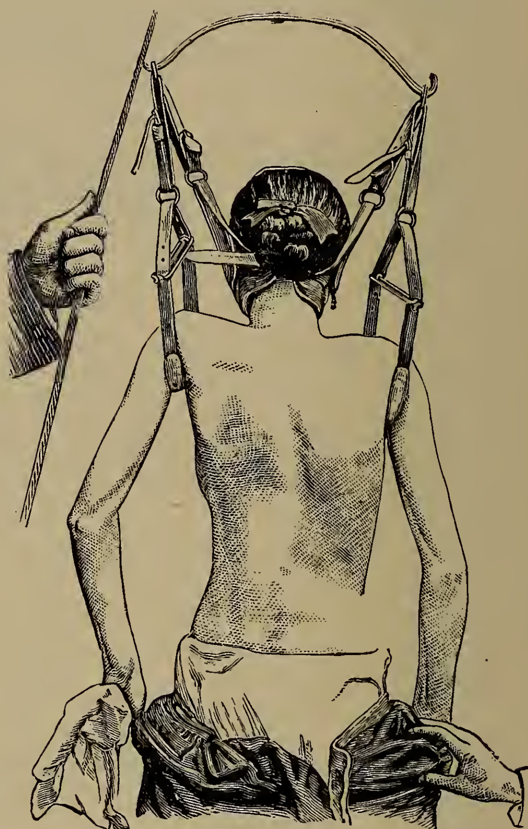
The plaster-bandage having been soaked and squeezed, a turn should be made around the body above the pelvis, and it should then be carried downward below the iliac spines, and from this point made to ascend gradually by spiral turns until it reaches the axillary line. The turns should be applied smoothly and not too tightly. After two or three layers of turns have been applied, the surgeon may rub some moist plaster upon their surface if

FIG. 116.



Suspensory apparatus.

FIG. 117.

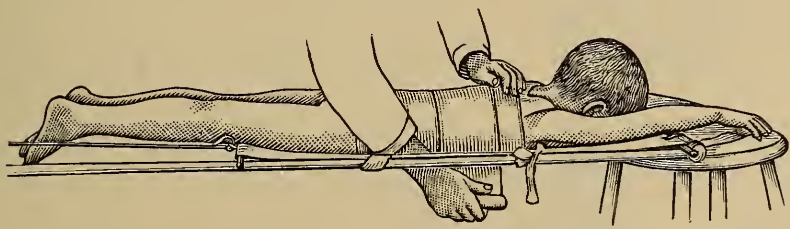


Patient suspended for application of plaster jacket.

he desires to use fewer bandages. These turns are repeated until a bandage of the desired thickness is applied, and the surface of the dressing may be finished by rubbing it over with moistened plaster. This jacket for a child will generally require the use of three or four bandages of the dimensions given; for an adult, from six to eight bandages.

The patient should be kept suspended until the bandage has set, usually from ten to fifteen minutes, and then should be lifted carefully so as not to bend the spine, and placed on his back upon a mattress, until the dressing becomes perfectly hardened. The dinner pad and mammary pads,

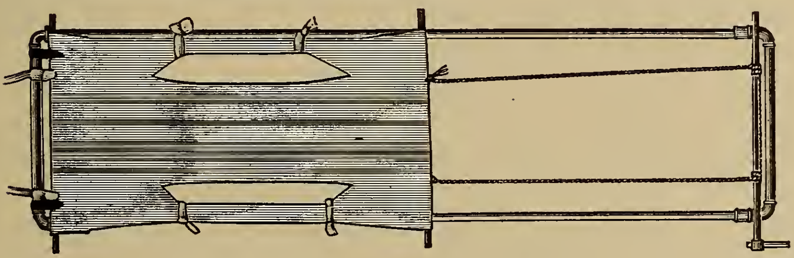
FIG. 118.



Application of plaster jacket in the recumbent posture. (Lovett.)

if they have been used, should next be removed. In applying this dressing, strips of zinc or tin may be placed between the layers of bandage if it is desired to give more strength to the jacket.

FIG. 119.

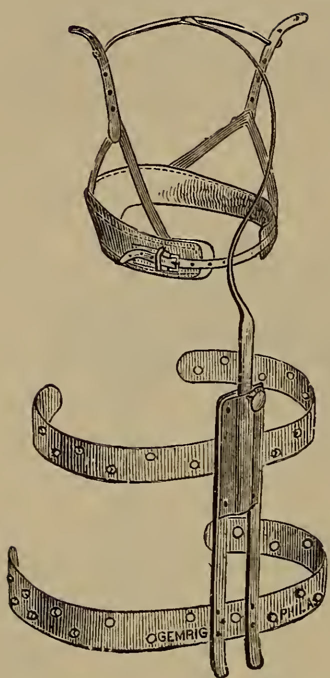


Frame for the application of plaster jacket in the recumbent posture. (Lovett.)

The plaster jacket may also be applied in the recumbent posture, the patient being placed upon a frame (Figs. 118 and 119).

Application of the Jury-mast by Means of Plaster-of-Paris.—In disease of the spine involving the cervical or upper dorsal region the ordinary plaster-of-Paris jacket

FIG. 120.



Head-support and jury-mast.

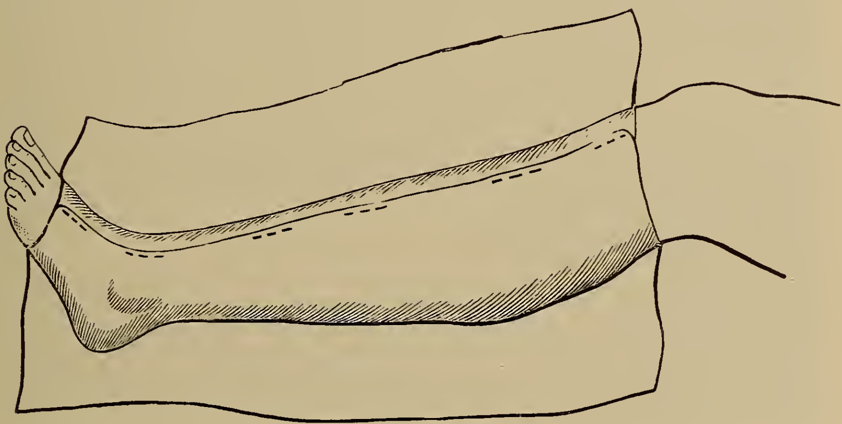
is not satisfactory, and in such cases the "jury-mast" is employed in connection with the plaster jacket. In applying the "jury-mast," the same steps are taken in the preparation of the patient as in applying the plaster-of-Paris jacket, with the exception of extension, which need not be used.

After three or four layers of the plaster-bandage have been applied to the body, an apparatus made of two bars of metal having two perforated strips of zinc attached to them a few inches apart, which partly encircle the body, is applied and held in position by turns of the plaster-bandage. The perpendicular bars have at their upper part a slot, into which the lower end of the "jury-mast" fits, and is secured by a screw; to the upper part of this is attached a movable cross-bar, to which are fastened the straps of the collar from which the head is suspended (Fig. 120).

The Bavarian Dressing.—To apply this dressing, which is sometimes employed in the treatment of fractures of the extremities, take two pieces of Canton flannel the length of the part to be enclosed, and more than wide enough to envelop its circumference. In applying it to the leg, these pieces should be cut so as to correspond to the outline of the leg and posterior portion of the foot. These pieces should be placed one over the other and sewed together in the middle line, the seam corresponding to the back of the leg. This dressing is then placed under the foot and leg, and the inner layer of flannel is brought up in front of the leg and over the dorsum of the foot, and made fast with pins or a few stitches (Fig. 121). Plaster-of-Paris is next mixed with water to form a paste, which is rubbed thickly and evenly over the flannel next the limb until a sufficient thickness is obtained; the outer layer of flannel is then brought up about the leg and moulded to its surface by the hands. A loosely applied roller may be used to hold the dressing in place until the plaster has set.

When it is necessary to inspect the parts, the turns of the bandage are cut, and upon separating the layers of flannel the two halves can be turned aside, the seam at the back acting as a hinge. Upon reapplying the splints to

FIG. 121.



Bavarian dressing.

the leg they may be retained in position by a roller or by one or two strips of bandage.

Moulded Plaster Splints.—It is sometimes found difficult to apply the ordinary plaster dressings to parts irregular in shape, and at the same time to have a splint which can be removed with ease. To accomplish this purpose, moulded splints of plaster may be made by cutting a paper pattern of the part to be covered in, and then cutting pieces of crinoline to conform to this pattern; eight or ten pieces will usually form a splint of sufficient thickness. One of these pieces of crinoline is laid upon a table and dry plaster is rubbed into its meshes; another is laid upon this and plaster is applied to it in the same way, and so on until all the pieces have been placed in position, one over the other, with plaster rubbed well into the meshes. The dressing is then folded up and dipped into water, squeezed out, and moulded to the part and held in position, until it sets, by the turns of a bandage. The edges should overlap slightly, and in applying it a strip of waxed paper may be placed under the overlapping edge to prevent its adhesion to the dressing below, and thus facilitate its removal. Splints prepared in this way can be removed with ease, and are often of service in cases where it is desirable to inspect the parts frequently. I have employed with advantage such splints in making fixation of the hip-joint in cases of coxalgia, and also for the same purpose in diseases of other joints. The splints upon being reapplied are secured by a few strips of adhesive plaster or by a roller-bandage.

Trapping Plaster-of-Paris Bandages.—In applying the plaster-of-Paris dressing to a part where there is a wound which is covered by the plaster-bandage, it is well to make some provision whereby the plaster dressing over the site of the wound may be cut away, making a trap or window through which the wound may be inspected, or dressed if necessary (Fig. 122). To accomplish this, before applying the plaster-bandage, a compress of lint or gauze or a small pasteboard box should be placed over the wound, which, when the dressing is completed, forms a projection on its surface, indicating the position of the wound, and also allows the surgeon to cut away the dressing without injuring the skin below. These traps may be cut out after the bandage has partially set, or after it has become hard. In applying the plaster-of-Paris dressing in cases of compound fracture, I always make provision for trapping of the bandage if it should become necessary, although in the vast majority of cases if the wound remain aseptic it does not have to be done.

Removing Plaster-of-Paris from the Hands.—One objection to the use of plaster-of-Paris dressings is the difficulty of removing it from the hands of the surgeon, and the harsh condition in which the skin is left after its removal. If, however, the hands are washed in a solution of carbonate of sodium—a tablespoonful to a basin of water—the plaster will readily be removed and the skin will be left in a soft and comfortable condition. Rubbing the hands with glycerine, moist brown sugar or corn-meal accomplishes the same object.

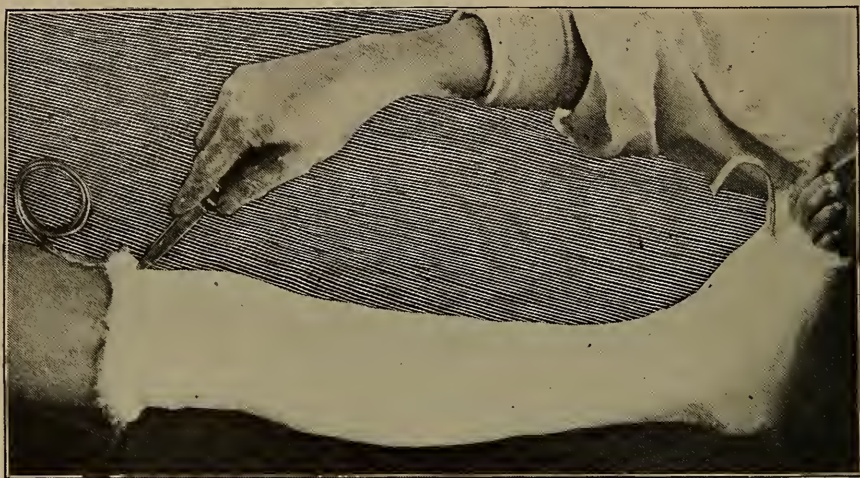
FIG. 122.

Plaster-of-Paris bandage trapped.

Removal of the Plaster-of-Paris Bandage.—The removal of the plaster-bandage is sometimes a matter of difficulty, particularly, in the case of fractures, if it has to be removed before the fragments below it are consolidated, as it may disarrange them and cause the patient pain if it is not accomplished without much force.

When the bandage is applied to get a cast of a part, or in the treatment of fractures where it may be necessary to remove the bandage in a few days to inspect the parts, a strip of sheet-lead one-half of an inch in width is first placed over the flannel bandage and is allowed to project at each end beyond the dressing; the plaster can then be readily cut through upon the strip of lead with a knife without injury to the parts below (Fig. 123). As soon as the

Fig. 123.

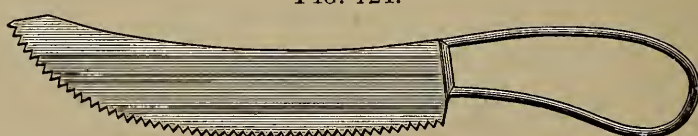


Cutting plaster-bandage upon lead strip.

bandage has become firm, the lead strip is removed by traction upon one end of it; and, if the bandage has been entirely divided, it can be removed at any time without difficulty.

In applying plaster dressings to the extremities, even if their removal is not likely to be immediately required, I usually employ the lead strip, cutting the bandage upon it, but leaving three or four bridges of undivided band-

Fig. 124.

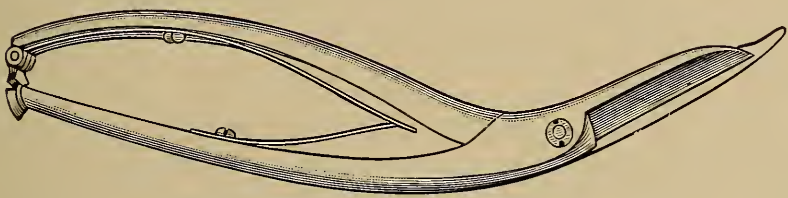


Hunter's saw for removing plaster bandages.

age, which can easily be divided when the removal of the bandage is finally required.

Plaster-bandages may also be removed by means of a saw devised for this purpose (Fig. 124); by Gigli's wire saw drawn under the bandage by a string, which cuts rapidly and does not endanger the skin; by strong cutting-shears of various kinds (Fig. 125); or a line may be painted over the dressing with hydrochloric acid or vinegar, which softens the plaster, so that it can readily be cut through with a knife. The incision of the bandage upon the lead strip or the use of the saw or shears is, I think, most satisfactory in removing these dressings. They should

FIG. 125.



Shears for cutting plaster-bandages.

be used carefully, as the final layers of the bandage are divided, to avoid wounding the skin.

Uses of Plaster-of-Paris Dressings.—These dressings are employed to secure fixation as primary or secondary dressings in the treatment of fractures, and in the ambulant treatment of fractures, and for a like purpose in injuries and diseases of the joints. They are also largely employed in the treatment of diseases and deformities of the spinal column, and will be found most satisfactory applications after osteotomy and tenotomy, to secure immobility and to hold the parts in their corrected positions; when employed in the dressing of cases after tenotomy, they are generally used for a few weeks until the appropriate mechanical apparatus is applied.

The Starched Bandage.—To apply this bandage, starch is first mixed with cold water until a thin, creamy mixture results, and this is heated until it is converted into a clear mucilaginous liquid. The part to be dressed is first covered with a flannel roller, and over this a few layers of a cheese-cloth or crinoline bandage, which has been shrunken, are applied; the starch is then smeared or rubbed with the hand evenly into the meshes of the material, and the part is again covered with a layer of turns of the bandage, and the starch is again applied; this manipulation is continued until a dressing of the desired thickness is produced. Strips of pasteboard may be applied between the layers of the bandage, to give additional strength to the dressing, if desired.

It requires from twenty-four to thirty-six hours for the starched bandage to become dry and thoroughly set. It may be removed in the same way in which the plaster-of-Paris dressing is removed.

Use.—Before the introduction of the plaster-of-Paris dressing, it was frequently employed in the treatment of fractures, and in injuries and diseases of the joints. It may be used in such cases, but possesses no advantage over the plaster-of-Paris dressing, and has the disadvantage of setting much less promptly.

Silicate of Potassium or Sodium Bandage.—In applying this bandage, after a flannel roller and several layers of a cheese-cloth or crinoline bandage have been applied to the part, the surface of the latter is coated with silicate of sodium or potassium applied by means of a brush, then a second layer of bandage is applied and treated in the same manner, and this manipulation is continued until a bandage of the desired thickness is produced. This dressing may also be applied by soaking loosely wound rollers of crinoline in silicate of potassium or sodium and applying them to the part as the plaster-of-Paris bandage is applied. It requires twenty-four hours for this dressing to become firm. As it is irksome for a patient to keep a part quiet while the silicate bandage is becoming firm, I often cover it as soon as applied with a layer of tissue-paper, and apply over it a light plaster-of-Paris bandage, which sets in a few minutes; this is removed at the end of twenty-four hours, when the silicate bandage is usually firm. In removing the silicate bandage, it may first be softened by soaking it in warm water, and then it can readily be cut with scissors, or it may be cut with bandage-shears.

In applying either the starched bandage or the silicate of potassium bandage, care should be taken to use cheese-cloth or crinoline which has been shrunken by being moistened and allowed to dry before being employed; otherwise, dangerous compression of the part may occur if the bandage has been firmly applied and shrinks after its application.

The Paraffin-bandage.—Paraffin, which melts at from 105° to 120° F., is used in the application of this bandage. The limb being covered by a flannel roller, a vessel containing paraffin is placed in a basin of boiling water. As the roller, which may be either of flannel, cheese-cloth, or crinoline, is unwound, it is passed through the melted paraffin and applied to the part, and the turns are repeated until a dressing of sufficient thickness results, when the surface may be brushed over with melted paraffin. This dressing sets very rapidly, being quite firm in from five to ten minutes.

Moulded Splints.

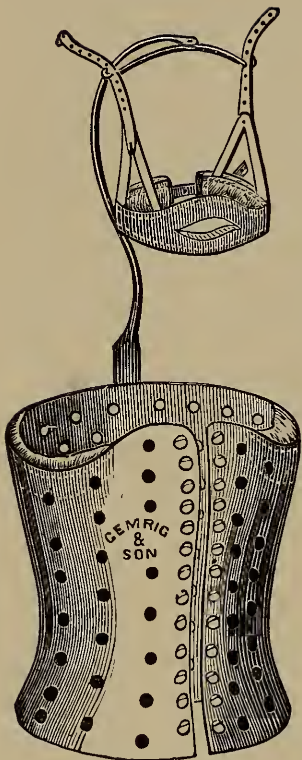
Raw-hide or Leather Splints.—In moulding raw-hide or leather splints, it is necessary, first, to apply a plaster-of-Paris bandage to the part to which the raw-hide splint is to be fitted; and as soon as the plaster has set, it is removed, and a solid plaster cast is next made by pouring liquid plaster-of-Paris into this mould. When this has become dry, a piece of raw-hide, which has been soaked for a time in warm water, is moulded to the cast and held firmly in contact with it by tacks or a bandage until it has become perfectly dry. It is then removed, and its surface is covered with several coats of shellac, to prevent its absorbing moisture from the skin when applied, and changing its shape. Eyelets or hooks are fastened to the edges of the splint, through which tapes are passed to secure it in place.

Made in this manner, raw-hide splints fit the part very accurately, and constitute a very satisfactory dressing for cases of joint-disease, and in the form of leather jackets are often employed in the treatment of disease of the spine in place of the plaster-of-Paris jacket (Fig. 126).

In the treatment of high dorsal or cervical caries a leather splint in two sections, which rests upon the shoulders and supports the head, is often used with good results (Fig. 127).

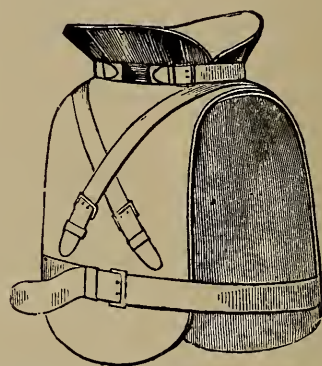
Binders' Board or Pasteboard Splints.—This material, which can be obtained in sheets of different thicknesses, is frequently employed for the manufacture of splints. In moulding these splints, a portion of the board of the requisite size and

Fig. 126.



Leather jacket with jury-mast.

Fig. 127.



Leather splint for cervical caries. (Owen.)

thickness is dipped in boiling water for a short time, and when it has become softened it is removed and allowed to cool; a thick layer of cotton-batting is next applied over it, and it is then moulded to the part and held firmly in place by the turns of a roller-bandage; in a few hours it becomes dry and hard.

This material, from its cheapness and the ease with which it is obtained, is frequently employed to mould splints in the treatment of fractures. Moulded splints of this kind on account of the ease of their application and removal are often useful in the temporary treatment of compound fractures and excision of joints to fix the ends of the bones. In such cases it is often desirable to inspect and dress the wounds until healing has occurred, when a fixed dressing of plaster-of-Paris may be employed.

Porous Felt Splints.—This material is also employed for the manufacture of splints, and is applied by dipping the material in hot water and then moulding it to the part and securing it by a bandage; as it dries it becomes hard.

Hatters'-felt Splints.—Hatters'-felt may also be employed for the manufacture of splints or dressings. It is softened by dipping it in boiling water or heating it in the flame of an alcohol lamp, and when soft and pliable it is moulded to the part, and as it cools it again becomes hard. These splints are employed for the same purpose as those made of plaster-of-Paris, leather, or pasteboard.

Elastic Cotton Bandage.—The elasticity of this bandage is due to the manner in which the bands are woven. Where moderate elasticity is required it is a most useful dressing, and has the advantage in that it may be washed without interferring with its elasticity. It is used for varicose veins of the lower extremities and for joints where moderate elastic pressure is required.

PART II.

MINOR SURGERY.

Antiseptic and Aseptic Surgical Dressings.—This subject is considered on page 421.

MATERIALS USED IN SURGICAL DRESSINGS.

Lint.—This material is employed in surgical dressings, and is of two varieties: the domestic lint, which consists of pieces of old linen or muslin which have been thoroughly washed or boiled and then dried, or the surgical lint, which resembles Canton flannel in appearance; the latter is the best material, as it has a greater absorbing capacity.

Lint is used as a material on which unctuous preparations are spread in the dressing of wounds, and is employed also as a material for saturating with the various solutions which are used in wet dressings, such as lead-water and laudanum; the lint, after being saturated with the solution, is covered with rubber-tissue or oiled silk when applied, to prevent too rapid evaporation of the solution. It is also one of the best materials from which to construct the compresses employed in the treatment of fractures.

Paper-lint.—This is made from old rags or wood-pulp, has great absorbing power for fluids, and may be used as a substitute for surgical lint in the application of wet dressings to surfaces when the skin is unbroken.

Oakum.—This material, made from old tarred rope, was formerly much employed in the dressing of wounds, before the introduction of the antiseptic method of wound treatment. From its elasticity it is found to be an excellent material for padding splints or other surgical appliances. It is employed also in the form of pads to place under patients to relieve portions of the body from pressure, or to absorb discharges which soak through the dressings. A mass of oakum which has been well teased out and wrapped in a towel forms an excellent pillow on which to support a stump.

Cotton.—Cotton is now employed in surgical dressings principally as a material to pad splints or to relieve salient parts of the skeleton from pressure in the application of splints or bandages; for instance, in the application of the plaster-of-Paris bandage, the bony prominences are generally covered with small masses of cotton. It possesses but little absorbent power unless used in the form of absorbent cotton, and is not much employed in surgical dressings except for the purposes mentioned above.

Absorbent Cotton.—This material is prepared from ordinary cotton, which is boiled with a strong alkali to remove the oily matter which it contains. When so prepared, it absorbs liquids freely, and by reason of its great absorbing capacity it is employed largely in surgical dressings. A small mass of sterilized absorbent cotton wrapped upon the end of a probe is now generally employed to make applications to wounds, and has taken the place of the sponge or brush which formerly was employed for this purpose. On account of its cheapness, after one application it can be thrown away and a new piece used, and thus the danger of carrying infection from one wound to another by the applicator is abolished. It is largely employed in gynecological practice for making applications to the female genital organs.

Wood-wool.—Wood-wool made from wood-pulp, such as is employed in the manufacture of paper, is also furnished in the shape of lint, sponges, and pads, and may be used for the same purposes as the ordinary surgical lint.

Oiled Silk or Muslin.—These materials are employed as an external covering for moist dressings to prevent rapid evaporation from the dressings; they form excellent materials for this purpose, but as they are quite expensive their use is limited.

Waxed or Paraffin-paper.—This dressing is prepared by passing sheets of tissue-paper through melted wax or paraffin, and then allowing them to dry. Paper thus treated forms an excellent and cheap substitute for oiled silk or muslin, and may be employed for the same purpose for which the latter materials are used.

Rubber-tissue.—This material, which is prepared by rubber manufacturers, consists of rubber run out into very thin sheets. It has a glazed surface, is very pliable, and at the same time strong, forming, therefore, a cheap and satisfactory substitute for oiled silk, and is employed for the same purposes. A tent made of rubber-tissue may be used as a drain for wounds; it is also used in making the cigarette drain.

Parchment-paper.—This paper is prepared so as to render it water-proof; it is employed in surgical dressings for the same purposes as oiled silk and rubber-tissue.

Compresses.—Compresses are prepared by folding pieces of lint, muslin, linen, or gauze upon themselves, so as to form firm masses of variable size; oakum or cotton may also be used to form compresses. Compresses are employed to make pressure over localized portions of the body, as in the treatment of fractures, or to make pressure upon vessels for the control of hemorrhage.

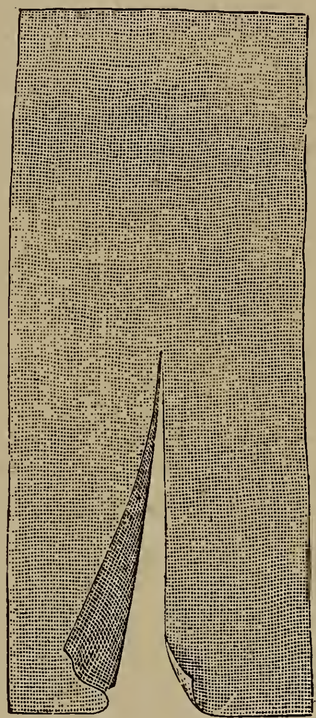
Tampon.—A tampon is a form of compress which is employed in cavities to make pressure, to control hemorrhage, or to apply various solutions or powders to the surface of the cavity. Tampons used to control hemorrhage are generally made of strips of bichloride, iodoform or sterilized gauze. In applying these, the strips of gauze are packed into the cavity, and when the latter is full a compress is applied superficially and held in place by a bandage. The application of a tampon to the vagina is a favorite method of controlling uterine hemorrhage.

Glycerin Tampon.—This is made by pouring half an ounce of glycerin on a piece of cotton or wool, and then turning up the ends and securing them by a string, one end of which is allowed to remain long enough to hang from the vagina, to facilitate its removal; it is a favorite application to the os uteri. The glycerin may be medicated with any drug that is desired, ichthyol and iodine being frequently employed.

Tent.—This consists of a small portion of lint, oakum, muslin, or sterilized or antiseptic gauze rolled into a conical shape, which is employed to keep wounds open and to facilitate the escape of discharges.

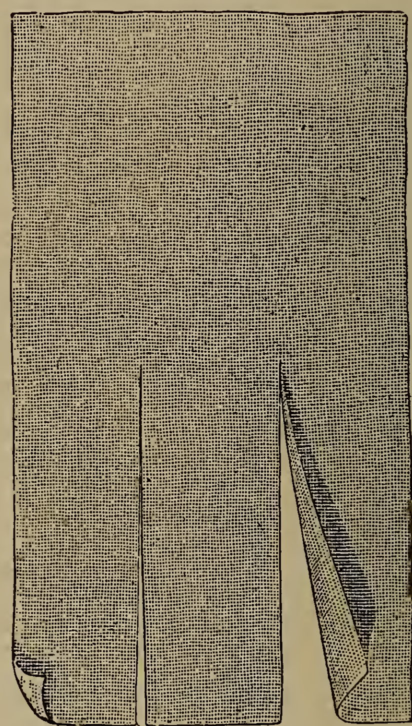
Sand-bags, or Sand Pillow.—These are muslin bags, covered with rubber cloth, of different sizes and shapes, and filled with dried sand. They are placed under the skull and extremities in operations upon these parts, and in operations upon the gall-bladder a sand-bag placed under the spine renders that organ and the ducts much more accessible. A bag from eight to twelve inches square and three inches in thickness is one of convenient size.

Fig. 128.



Two-tailed retractor.

Fig. 129.



Three-tailed retractor.

Retractors.—Retractors are made by taking a piece of muslin four inches wide and twelve to eighteen inches in length, and splitting it as far as the centre, thus making a *two-tailed retractor* (Fig. 128). A *three-tailed retractor* is made in the same way, except that the muslin is slit twice instead of once (Fig. 129). Retractors are used to retract the soft parts in amputations, to prevent their injury by the saw in the division of the bones. When one bone is sawed a two-tailed retractor is used, and when two bones are sawed a three-tailed retractor is employed.

Plasters.—The varieties of plaster which are most commonly employed in surgical dressings are *adhesive* or *resin plaster*, *isinglass plaster*, and *rubber adhesive plaster*.

Before using any of these plasters upon parts which are covered by hairs, the latter should be removed by shaving, otherwise traction upon them, if the plaster be used for the purpose of extension, will cause the patient discomfort, and unnecessary pain will also be inflicted at the time of its removal.

Resin Plaster.—This plaster, which is machine-spread, is employed frequently in surgical dressings; the spread surface is covered with a layer of tissue-paper, which should be removed before it is used; it is cut into strips of the required width and length, and the strips should be cut lengthwise from the roll of plaster, as the cloth upon which it is spread stretches more transversely than in a longitudinal direction. When heated and applied to the surface it holds firmly; it is prepared for application by applying the unspread side to a vessel containing hot water, or it may be passed rapidly through the flame of an alcohol lamp.

This is the variety of plaster which is generally used in making the extension-apparatus for the treatment of fractures, for strapping the chest in fractures of the ribs and sternum, for strapping the pelvis in cases of fractures of the pelvic bones, and for strapping the breast, the testicle, ulcers, or joints.

Swans'-down Plaster.—This plaster is much the same as resin plaster, but is spread upon a heavier material, and is an excellent plaster to use for an extension-apparatus, where it is to be worn for a long time.

Ichthyol Plaster.—This plaster is prepared by incorporating ichthyol and the ordinary rubber plaster, it is much less irritating to the skin and possesses the same adhesive properties and is used for the same purposes as the resin or zinc oxide plasters.

Rubber Adhesive Plaster.—This plaster is made by spreading a preparation of India-rubber on muslin, and has the advantage over the ordinary resin plaster that it adheres without the application of heat. It is employed for the same purpose as resin plaster, but when applied continuously to the skin it is apt to produce a certain amount of irritation, and for this reason when it is to be applied for some time, as in the case of an extension-apparatus, it is not so comfortable a dressing as that made from resin plaster.

Zinc Oxide Adhesive Plaster.—This plaster is prepared by incorporating with rubber adhesive plaster oxide of zinc. It is equally as adhesive as the rubber plaster, and possesses the advantage that it is not apt to produce irritation of the skin. This plaster has largely supplanted both the resin and rubber adhesive plaster in surgical dressings.

Sterile Z. O. Plaster.—The ordinary adhesive plaster cannot be sterilized after it has been made, but the plaster manufacturers now furnish a reliable sterile plaster. It may be used to approximate the skin in wounds where subcutaneous sutures have been employed, or in any case where support of a wound is required or where an aseptic dressing is essential.

Isinglass Plaster.—This plaster is made by spreading a solution of isinglass upon silk or muslin, and it has been found a most useful dressing in the treatment of superficial wounds. It is caused to adhere to the surface by moistening it, and when used in the treatment of wounds it should be moistened with an antiseptic solution. The best variety is spread on muslin, and when properly applied adheres as firmly and possesses as much strength as the ordinary resin plaster.

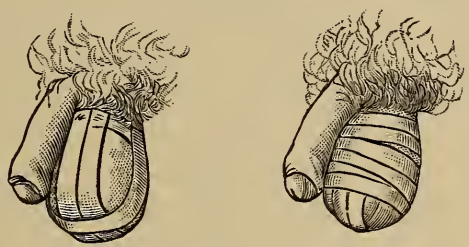
Soap Plaster.—Soap plaster for surgical purposes is prepared by spreading *emplastrum saponis* upon kid or chamois skin. It is not employed for the same purposes as the resin or rubber plaster, as it has little adhesive power, and is used simply to give support to parts or to protect salient portions of the skeleton from pressure. It is found to be a most useful dressing when applied over the sacrum in cases of threatened bedsores, and may be applied for the same purpose to other parts of the body where pressure-sores are apt to occur.

In the treatment of sprains of joints, a well-moulded soap-plaster splint secured by a bandage will often be found a most efficient dressing, and in the treatment of fractures the comfort of the patient is often materially increased by applying small pieces of soap plaster over the bony prominences, upon which the splints, even when well padded, are apt to make an undue amount of pressure.

STRAPPING.

This consists in applying pressure to parts by means of strips of plaster firmly applied. It is a procedure often employed in surgical practice. Resin adhesive plaster was formerly employed, but as it has to be heated before used it is usually found more convenient to employ some form of

Fig. 130.



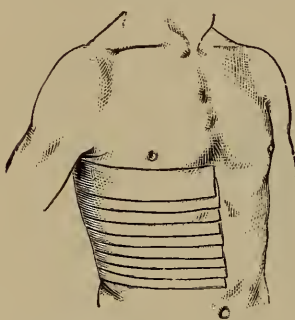
Strapping the testicle.

rubber adhesive plaster, of which Z. O. plaster is the least irritating to the wound and is the one most frequently used.

Strapping the Testicle.—In strapping the testicle, strips of resin or Z. O. plaster are usually employed; a dozen or more strips ½ inch wide and 12 inches in length will be required. The scrotum should first be washed and shaved, and the surgeon next draws the skin over the affected organ tense by passing the thumb and finger around the scrotum at its upper portion, making circular constriction; a strip of muslin is passed in a circular manner around the skin of the scrotum above the organ, and is tightly drawn and secured by passing around it a strap of plaster; this isolates the part and prevents the other straps from slipping. Straps are now applied in a longitudinal direction, the first strap being fastened to the circular strap and carried over the most prominent part of the testicle, and then carried back to the circular strap and fastened. A number of these straps are applied in an imbricated manner until the skin is covered (Fig. 130), and the dressing is completed by passing transverse straps around the testicle from its lowest portion to the circular strap; care should be taken to see that no portion of the skin is left uncovered.

Strapping the testicle is employed with advantage in the subacute stage of orchitis or epididymitis. As the swelling of the testicle diminishes the straps become loose, and the part will require restrapping. It will also be found a useful means of applying pressure to the scrotum after the injection treatment of hydrocele.

Fig. 131.



Strapping over the chest.

Strapping of the Chest.—To strap one-half of the chest, strips of resin or Z. O. adhesive plaster $2\frac{1}{2}$ inches wide, and sufficiently long to extend from the spine to the median line of the sternum, are required—18 to 20 inches in length. The first strap is placed upon the spine opposite the lower portion of the chest; it is then carried over the chest, and its other extremity is fixed upon the skin in the median line of the sternum. Straps are next applied from below upward in the same manner, each strap overlapping one-third of the preceding one, until the axillary fold is reached (Fig. 131); a second layer of straps may be applied over the first, if additional fixation is desired, or a few oblique straps may be employed.

Adhesive straps applied in this manner very materially limit the motion of the chest-wall upon the affected side, and are frequently employed in the treatment of fractures and dislocations of the ribs, in contusions of the chest, and in cases of plastic pleurisy when the motions of the chest-wall are extremely painful to the patient.

Strapping of Ulcers.—This method of treating ulcers in their chronic stage is most satisfactory, and may be applied to ulcers in any part of the body. Properly applied straps tend to approximate the edges of the ulcer and diminish its size, and also appear to stimulate the growth of the epithelium from its edges. After the application of the straps, a gauze dressing or an ointment dressing should be applied, and the strapping should be renewed at intervals of a few days. (For method of strapping employed in ulcers of the leg, see p. 377).

Strapping of Joints.—This treatment is frequently employed in sprains of the wrist, knee and ankle-joint (see p. 339).

Strapping will be found a satisfactory dressing in the treatment of sprains of joints in their acute or chronic state.

Strips of Z. O. adhesive or rubber adhesive plaster $1\frac{1}{2}$ inches in width are applied around the joint, and are made to extend some distance above and below it; a gauze bandage is next applied over the straps, and the patient is allowed to use the part as soon as he can do so without discomfort.

Strapping the Back.—After contusions or sprains of the lumbar region of the back the firm application of straps gives fixation and support to the parts, and relieves pain. The patient should be placed in such a position that the spine is moderately extended, and strips of plaster $2\frac{1}{2}$ inches in width should be applied, one slightly overlapping the other, from the upper part of the sacrum to the lower ribs. The straps should be long enough to include the posterior half of the trunk, and several layers should be applied.

POULTICES.

This form of dressing was formerly much employed in the treatment of inflammatory conditions as a means of applying heat and moisture to the part at the same time, and although the use of poultices is now much restricted since the introduction of the antiseptic method of wound treatment, yet I think there are still conditions in which their employment is both useful and judicious. They are often employed with advantage in inflammatory affections of the chest and of the abdominal organs; and in inflammatory affections of the joints and of bone, combined with rest, their action is often most satisfactory. They constitute a form of dressing which is conducive to the comfort of the patient in cases of deep suppuration by their relaxing effect upon the tissues, and their previous use does not prevent the surgeon from using all aseptic precautions in the opening and drainage of these abscesses, and the employment of aseptic or antiseptic dressings in their subsequent treatment.

Flaxseed Poultice.—This poultice is prepared by adding first a little cold water to ground flaxseed, and then boiling and stirring it until the resulting mixture is of the consistency of thick mush. A piece of gauze or muslin is next taken which is a little larger than the intended poultice, and this is laid upon the surface of a table, and with a spatula or knife the poultice-mass is spread evenly upon it from $\frac{1}{4}$ to $\frac{1}{2}$ inch in thickness; a margin of the muslin of 1 or $1\frac{1}{2}$ inches is left, which is turned over after the poultice is spread, and serves to prevent it from escaping around the edges when applied. The surface of the poultice may be thinly spread over with a little olive oil, or may be covered with a layer of thin gauze, to prevent the mass from adhering to the skin. It is next applied to the surface of the skin, and is covered with a piece of oiled silk, rubber-tissue, or waxed paper, and held in position by a bandage or a binder.

Soap Poultice.—This is made by saturating a number of layers of gauze in a mixture of 1 part of green soap to 6 parts of water. It is then applied to the surface and covered with oiled muslin or waxed paper. It may be employed as a primary dressing for some hours to the feet or other parts of the body where the epidermis is thick, before sterilizing these parts previous to operation.

Starch Poultice.—This poultice is prepared by mixing starch with cold water until a smooth, creamy fluid results; boiling water is then added, and it is heated until it becomes clear and attains about the same consistency as the starch used for laundry purposes. When sufficiently cool, it is spread upon gauze or muslin, applied to the part, and covered with oiled silk or waxed paper. This variety of poultice is principally useful in the treatment of diseases of the skin, especially those of the scalp accompanied by the formation of scabs or crusts, to facilitate their removal and to afford a clean surface for the application of ointments or wet dressings.

Antiseptic Poultice.—This is prepared by soaking a pad of sterilized gauze in hot bichloride, carbolic or saline solution, and wringing it out to remove the excess of fluid. It is next applied to the part and covered with oiled silk or rubber-tissue, which may be held in place by a bandage. Such a dressing will absorb a considerable amount of discharge. If used for some time, carbolic, or bichloride solutions may cause marked irritation of the skin.

Hot Fomentations.—Hot fomentations are employed to keep up the vitality of parts which have been subjected to injury, as seen in severe contusions resulting from railway or machinery accidents; also to combat inflammatory action. Gauze (several layers in thickness) or surgical lint should be soaked in sterilized water having a temperature of 120° F.; these are wrung out, placed over the part, and covered with waxed paper or rubber-tissue; a second pad should be placed in the hot water, and applied as soon as the first-applied cloth begins to cool, and so by continuously reapplying them the part is kept constantly covered by a hot dressing. The use of these hot fomentations may in many cases require to be continued for hours before the desired result is obtained. *Hot compresses,* dry or moist, applied in this manner are frequently employed in treating inflammatory conditions of the eye, and are also of the greatest service in keeping up the vitality of parts which have been subjected to severe injury interfering with their blood supply. I have seen contused limbs, which were cold and seemed doomed to gangrene by reason of diminished blood-supply, have their temperature and circulation restored by the patient and persistent use of this dressing. After the vitality of such a part is restored, it should be covered with cotton and a flannel bandage and surrounded by hot-water bags or hot-water cans.

Hot Dry Compresses.—These may be used when it is desirable to avoid moisture. Small gauze pads may be heated in an electric oven, or in a closed vessel partly immersed in boiling water, the pads being changed as they cool and replaced by hot ones.

Lead Water and Laudanum.—This consists of a mixture of liquor plumbi subacetatis, ℥ss; tr. opii, ℥ss; aquæ, ℥iv. The strength of this mixture may be varied according to the requirements of the case. Lead water and alcohol may also be employed.

This is used as a local application, being applied on lint saturated with the solution.

It has long been a popular application in the early treatment of fractures, contusions and sprains and in certain forms of dermatitis. It should not be applied to open wounds or a broken skin surface.

Magnesium Sulphate Solution.—A saturated solution of magnesium sulphate is frequently employed as a local application in the treatment of inflammatory affections of the joints, cellulitis, epididymitis and orchitis.

The solution may be applied to the affected part by saturating a number of layers of lint, or 15 to 20 layers of ordinary surgical gauze. The dressing should be changed every half hour, or covered with waxed paper or oiled muslin to keep it moist. It is usually applied for from twenty-four to thirty-six hours. It is a cleanly dressing, and seems to relieve pain and swelling, and is frequently employed as a substitute for lead water and laudanum.

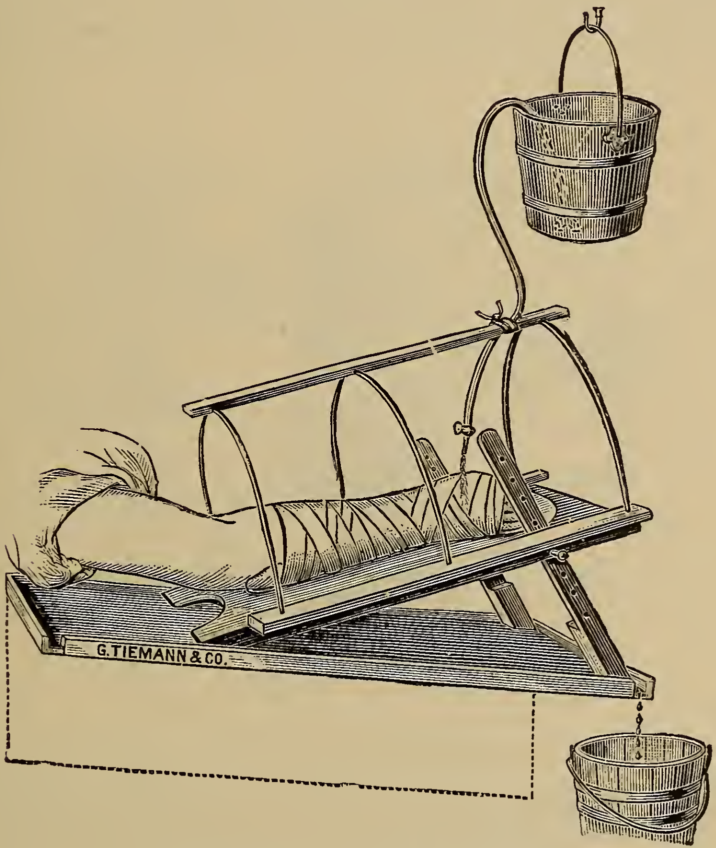
Ichthyol.—This substance, combined with lard or lanolin, is frequently used in the treatment of inflammatory affections. The ointment generally employed consists of ichthyol ammoniat., ʒij; adipis or lanolin, ℥j. This may be rubbed over, or spread upon lint and applied to the part. It is used in the treatment of sprains, inflamed joints, erysipelas, enlarged lymphatic glands, frost-bites, chilblains and burns.

IRRIGATION.

This may be accomplished by allowing the irrigating fluid to come in contact with the wound or inflamed part—*immediate irrigation;* or by allowing the cold or warm fluid to pass through rubber tubes which are in contact with or surround the part—*mediate irrigation.*

Immediate Irrigation.—In employing immediate irrigation in the treatment of wounds or inflammatory conditions, a funnel-shaped can with a stop-cock at the bottom, or a bucket is suspended over the part at a distance of a few inches (Fig. 132), or a jar with a skein of thread or lamp-wick arranged to act as a siphon may be employed (Fig. 133). The can or jar

Fig. 132.

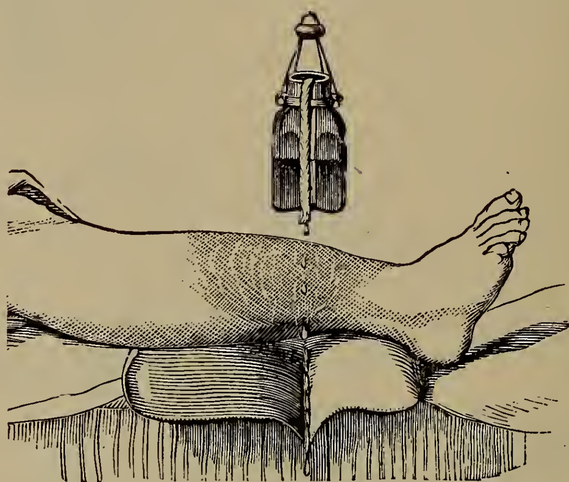


Apparatus for continuous irrigation.

is filled with water, and this is allowed to fall drop by drop upon the part to be irrigated, which should be placed upon a piece of rubber sheeting so arranged as to allow the water to run off into a receptacle, to prevent wetting the patient's bed. The water employed may be either cold or warm, in accordance with the indications in special cases. If it is desired to make use of antiseptic irrigation, the water is impregnated with carbolic acid or bichloride of mercury, a 1 : 5000 to 1 : 10,000 bichloride solution, or a 1 : 60 carbolic acid or acetate of aluminum solution, being frequently employed with good results.

Antiseptic irrigation employed in this manner will be found a most useful method of treating lacerated and contused wounds of the extremities in which the vitality of the tissues is much impaired; in such cases water at a temperature of 100° to 110° F. should be preferred to cool water.

FIG. 133.

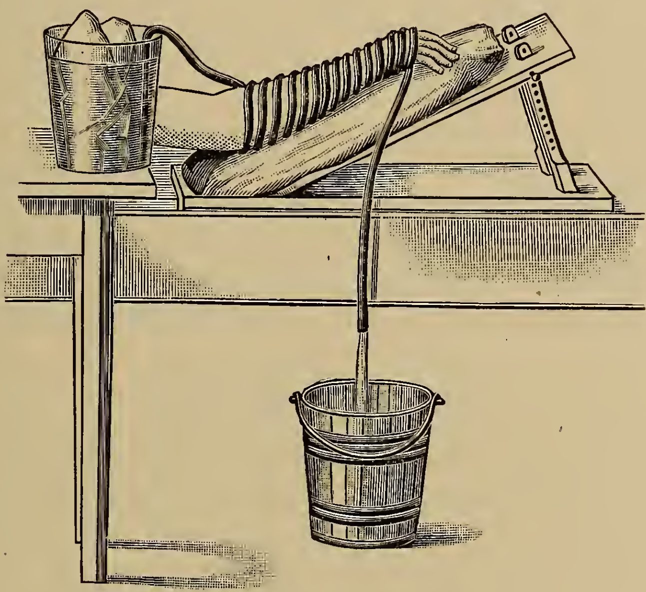


Irrigating apparatus.

Under the use of warm irrigation it is sometimes surprising to see tissues apparently devitalized regain their vitality in a short time; the absence of tension from the non-introduction of sutures and firm dressings, and the warmth and moisture kept constantly in contact with the wound by this method of irrigation, are the important factors in the attainment of this favorable result.

Mediate Irrigation.—In this method of irrigation cold or warmth is applied to the surface by means of cold or warm water passing through a rubber tube in contact with the part. A flexible tube of India-rubber $\frac{1}{2}$ inch in diameter, with thin walls, and 16 to 20 feet in length, is applied to the limb like a spiral bandage, or is applied to a coil to the head, breast or joints, and held in place by a few turns of a bandage; the end of the tube is attached to a reservoir filled with cold or warm water above the level of the patient's body, and the water is allowed to flow constantly through the tubing and escape into a receptacle arranged to receive it (Fig. 134). Coils of rubber tubing adapted to fit different portions of the body, known as Leiter's coils, are frequently employed in this method of irrigation.

Fig. 134.



Cold coil applied to arm.

Cold-water Dressings.—These dressings are applied by bringing the cold water either directly in contact with the part or by applying it by means of a rubber bag or bladder. The temperature of the water may vary from cool water to that of ice-water.

These dressings are employed in local inflammatory conditions. A favorite method for the employment of this dressing is by means of *cold compresses*, which are made of a few layers of gauze or surgical lint, dipped in water of the desired temperature and applied to the part; they are renewed as soon as they become warm. When it is desirable to have the compresses very cold, they may be laid upon a block of ice or in a basin with broken ice; to obtain the best results from their employment, they should be renewed at very short intervals.

Ice-bag.—A convenient method of applying cold without moisture is by the use of the ice-bag. This is either a rubber bag or bladder, which is filled with broken ice and applied to the part. In using an ice-bag, it is better to cover the part first with a towel or a few layers of lint or gauze, which prevent the surface from becoming wet by absorbing the moisture which condenses upon the surface of the bag or bladder, and thus renders the dressing more comfortable to the patient. The ice-bag is often employed as an application to the head in inflammatory conditions of the brain or membranes; to the abdomen in cases of appendicitis or peritonitis, and is used also upon the surface of the body to control internal hemorrhage. The continuous application of an ice-bag in some cases gives rise to a local congestion and redness of the skin at the point of its application, the appearance being that of a burn of the first degree, hence the name *ice burn.*

COUNTER-IRRITATION.

Counter-irritants are substances employed to excite external irritation, and the extent of their action varies according to the material used and the duration of their application; superficial redness or complete destruction of the vitality of the parts to which they are applied may result.

The use of counter-irritants under favorable circumstances is found to have a decided effect in modifying morbid processes, and they are widely employed as local revulsants in cases of congestion or inflammation, and in cases of collapse for their stimulating effect.

Caution should be exercised in applying counter-irritants to patients who are comatose or under the influence of a narcotic, for here the sensations of a patient cannot be used as a guide to their removal, and their too long-continued application when the vitality of the tissues is impaired may result in their superficial destruction.

Rubefacients.—These agents, by reason of their irritating properties when applied to the skin, produce intense redness and congestion.

Hot Water.—When it is desired to make a prompt impression upon the skin, the application of gauze, muslin, or flannel cloths, wrung out in hot water and renewed as rapidly as they become cool, will soon produce a superficial redness of the integument.

Spirit of Turpentine.—This drug applied to the skin is a very active counter-irritant; it may be rubbed upon the surface until redness results. When used upon patients whose skin is very delicate, its action may be modified by mixing it with an equal part of olive oil before applying it; this combination will be found useful as a rubefacient to the tender skin of young children.

When redness of the skin has resulted from the application, the skin should be wiped dry by means of a soft towel or absorbent cotton, to remove any turpentine from the surface, which by its continued contact may cause vesication.

Turpentine Stupe.—This is prepared by sprinkling spirit of turpentine over flannel cloths which have been wrung out in hot water, or by dipping hot flannel in warm spirit of turpentine: prepared in either way, the stupe should be squeezed as dry as possible to remove the excess of turpentine before being applied to the surface of the body. A turpentine stupe may cause vesication if allowed to remain for too long a time in contact with the skin; its application for from five to ten minutes will usually produce the desired effect; it should be removed after this time, and it may be reapplied if desired.

If the patient complains of severe burning of the skin after the use of turpentine, the painful surface should be smeared freely with vaseline or lard, which will relieve the uncomfortable sensation.

Tincture of Iodine.—This drug is frequently used as a counter-irritant in chronic inflammation. It is painted upon the part at intervals until irritation of the skin is observed, when its use is discontinued for a few days before reapplying the application.

Chloroform.—A few drops of chloroform applied to the surface of the body by means of a piece of lint, muslin, or flannel, and covered by oiled silk or rubber-tissue, will excite a rapid rubefacient effect.

Mustard.—Ground mustard or mustard flour, prepared from either *sinapis alba* or *sinapis nigra*, is one of the most commonly used substances to produce rubefacient action. It is generally employed in the form of the *mustard plaster* or *sinapism*, which is prepared by mixing equal parts of mustard flour with wheat flour or flaxseed meal, and adding to this sufficient warm water to make a thick paste; this is spread upon a piece of old muslin, and the surface of the paste covered with some thin material, such as gauze, to prevent the paste from adhering to the skin. In making a mustard plaster for application to the skin of a child, 1 part of mustard flour should be mixed with 3 parts of wheat flour or flaxseed meal.

A mustard plaster or sinapism may be allowed to remain in contact with the skin for a period varying from fifteen to thirty minutes, the time being governed by the sensation of the patient; if it is allowed to remain longer, it may cause vesication, which is to be avoided, as ulcers produced by mustard are very painful and extremely slow in healing. After removing a sinapism, the irritated surface of the skin should be dressed with a piece of muslin or lint spread with vaseline, boric acid or oxide of zinc ointment.

To excite a rapid revulsive action, the *mustard foot-bath* is often employed; it is prepared by adding 2 or 3 tablespoonfuls of mustard flour to a bucket or foot-tub of water at a temperature of 100° F.; in this the patient is allowed to soak his feet for a few minutes.

Mustard Papers.—*Chartæ sinapis*, which can be obtained in the shops ready for use, are a convenient means of obtaining the rubefacient action of mustard. They are dipped in warm water, and as they are generally very strong, it is well to place a layer of muslin between the surface of the plaster and the skin before applying it to the latter.

Capsicum.—This is also sometimes employed alone as a rubefacient, but it is generally used in combination with spices, forming the well-known *spice plaster;* this is prepared by taking equal parts of ground ginger, cloves, cinnamon and allspice, and adding to them one-fourth part of Cayenne pepper; these are thoroughly mixed, enclosed in a flannel bag, and evenly distributed; a few stitches should be passed through the bag at different points, to prevent the powder from shifting its position; before applying it, one side of the bag should be wet with warm whisky or alcohol. *Capsine* plasters are employed also to obtain the rubefacient effect of Cayenne pepper.

Aqua Ammoniæ.—This may also be employed for its rubefacient action. A piece of lint saturated with the stronger water of ammonia, placed upon the skin and covered with waxed paper, and allowed to remain for one or two minutes, will produce a marked rubefacient effect.

Vesicants.—Where it is desirable to make a more permanent counter-irritant effect than that produced by rubefacients, substances are employed which by their action on the skin cause an effusion of serum, or of serum and lymph, beneath the cuticle, thus giving rise to vesicles or blisters; they are known as vesicants. The substance most commonly employed to produce vesication is *cantharis,* or Spanish fly, and the preparation commonly used is the *ceratum cantharidis.*

Fly Blister.—This is prepared by spreading ceratum cantharidis upon adhesive plaster, leaving a margin ½ inch in width uncovered, which will adhere to the skin and hold the blister in position. The time required for a fly blister to produce vesication is from four to six hours; it should then be removed, and the surface covered with a flaxseed-meal poultice or with a warm-water dressing. When the blister or vesicle is well developed, it may be punctured at its most dependent part to allow the serum to escape, and it should be dressed with vaseline or boric ointment. If for any reason it is desired to keep up continued irritation after allowing the serum to escape, the cuticle should be cut away and the raw surface should be dressed with some stimulating material, such as the compound resin cerate.

Cantharidal Collodion.—This may be employed to produce vesication; it is applied by painting several layers upon the skin with a brush over the part on which the blister is to be produced. It is a convenient preparation to use when the patient would disturb the ordinary blister, as in the case of a child or an insane patient, or where the surface is so irregular that the ordinary blister cannot well be applied. The after-treatment of blisters produced by cantharidal collodion is similar to that described above.

Caution should be observed in using blisters upon the tender skins of children; if employed, they should be allowed to remain in contact with the skin for a short time only. They are contraindicated in patients in whom the vitality of the tissues is depressed by adynamic diseases, and in aged persons.

Strangury, which is shown by frequent and painful micturition, the urine often containing blood, sometimes occurs from the use of cantharidal preparations as blisters. This condition should be treated by the use of opium and belladonna by suppository, demulcent drinks and warm sitz-baths, and by leeches to the perineum if the symptoms are very severe.

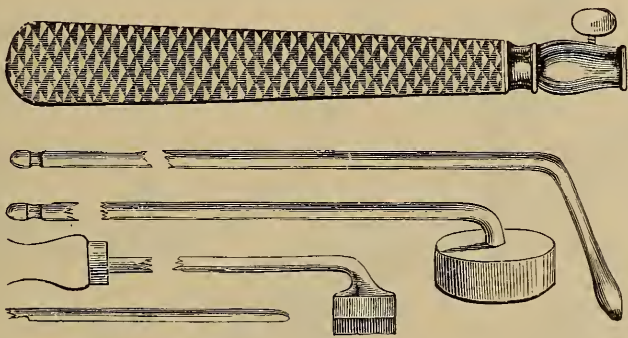
To avoid the development of strangury, small blisters should be employed, and they should not be allowed to remain too long in contact with the surface; cantharidal preparations should not be employed in cases where renal or vesical irritation has existed or is present. Strangury may also be avoided by incorporating opium and camphor with cantharidal cerate.

Aqua Ammoniæ Fortior and Chloroform.—These drugs may be employed to produce rapid vesication, a few drops being placed upon the surface of the body and covered by an inverted watch glass for a few minutes; or lint saturated with aqua ammonia or chloroform may be placed upon the skin and covered with waxed paper or oiled silk. Either of these agents applied in this manner, and allowed to remain in contact with the skin for fifteen minutes, will produce marked vesication. The blisters resulting from these agents are painful and they are only to be used where a rapid result is desired.

Seguin's Method of Counter-irritation.—This consists in stroking the surface of the skin lightly and rapidly with the point of a Paquelin cautery; the lines of stroking may be made at right angles; the application is practically painless, but a very decided counter-irritant effect is produced. It is employed with advantage in neuralgic affections of the spine and joints, and in cases of neuritis of superficial nerves.

Actual Cautery.—This method of counter-irritation is accomplished by bringing in contact with the skin some metallic substance brought to a high degree of temperature. This constitutes one of the most powerful means of counter-irritation and revulsion; it is rapid in its action, and is not more painful than some of the slower methods. The cauteries generally employed are made of iron, and are fixed in handles of wood or other non-conducting material, and have their extremities fashioned in a variety of shapes (Fig. 135). The irons are heated by placing their extremities in an ordinary

Fig. 135.



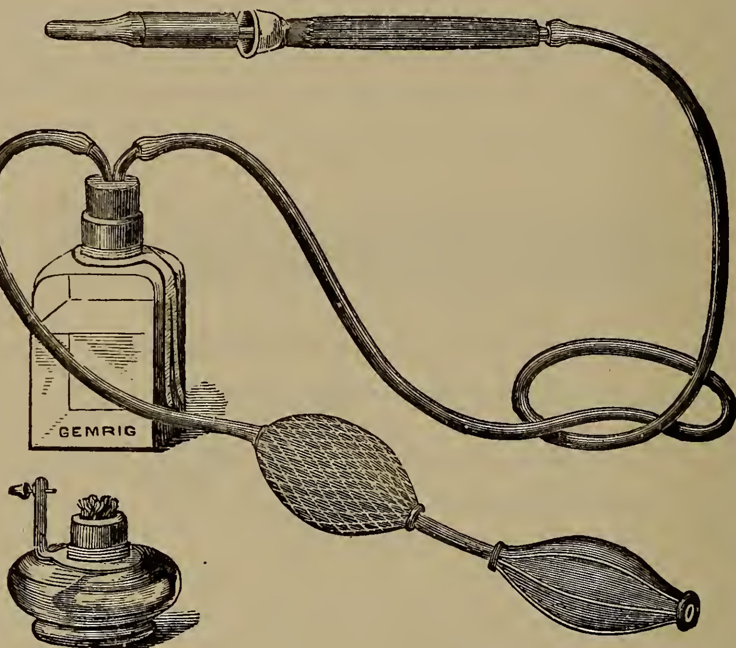
Cautery irons.

fire, or by holding them in the flame of a spirit lamp until they are heated to the desired point, either a white or a dull-red heat. They are then applied to the surface of the skin at one point, or drawn over it in lines either parallel to or crossing one another. The intense burning which follows the use of the cautery may be allayed by placing upon the cautery marks compresses wrung out in ice-water or saturated with equal parts of lime-water and sweet oil.

Where the ordinary cautery irons are not at hand, a steel knitting needle or iron poker heated in the flame of a spirit lamp or in a fire may be employed with equally satisfactory results. Where the cautery iron is held in contact with the surface for some time to make a deep burn, the pain of its application may be allayed by placing a mixture of salt and cracked ice upon the spot to be cauterized, for a few minutes immediately before its application. The cautery iron should not be placed over the skin covering salient parts of the skeleton or over important organs.

The actual cautery, in addition to its use in producing counter-irritation and revulsion, is often employed to control hemorrhage and to destroy morbid growths.

Fig. 136.



Paquelin's cautery.

Paquelin's Thermo-cautery.—A very convenient and efficient means of using the thermo-cautery is the apparatus of Paquelin, which utilizes the property of heated platinum sponge to become incandescent when exposed to the vapor of benzole or rhigolene (Fig. 136). The cautery is prepared for use by attaching the gum tube to the receiver containing benzole, and heating the platinum knife or button, which also is attached to the benzole receiver by a rubber tube, in the flame of the alcohol lamp for a few moments, and then passing the vapor of benzole through the platinum sponge, which is enclosed in the knife or button, by compressing the rubber bulb. The point may be brought to a white heat or only to a dull-red heat.

This form of cautery may be employed for the same purposes as is that previously mentioned; its great advantage consists in the ease with which it can be prepared for use. The knives heated to a dull-red heat will be found of great service in operating upon vascular tumors, where the use of an ordinary knife would be accompanied by profuse or even dangerous hemorrhage. Wounds made by the actual cautery are aseptic wounds, and when dusted with an antiseptic powder generally heal promptly under the scab without suppuration.

BLOODLETTING.

This procedure is often resorted to, to obtain both the local and the general effects following the withdrawal of blood from the circulation. Local depletion is accomplished by means of some one of the following procedures: *scarification, puncturation, cupping* and *leeching;* and general depletion is effected by means of *venesection* or by *arteriotomy.*

Scarification.—Scarification is performed by making small and not too deep incisions into an inflamed or congested part with a sharp-pointed bistoury; the incisions should be in parallel lines, and should be made to correspond to the long axis of the part, and care should be taken in making them to avoid wounding superficial veins and nerves. Incisions thus made relieve tension by allowing blood and serum to escape from the engorged capillaries of the infiltrated tissue of the part. Warm fomentations applied over the incisions will increase and keep up the flow of blood and serum. Scarification is employed with advantage in inflammatory conditions of the skin and subcutaneous cellular tissue and in acute inflammatory swelling or edema of the mucous membrane, for instance, of the conjunctiva, and in acute inflammation of the tonsils, tongue and epiglottis it is an especially valuable procedure.

A modification of scarification, known as *deep incisions,* is practised in urinary infiltration to establish drainage and to relieve the tissues of the contained urine, and to prevent sloughing; in threatened gangrene and phlegmonous erysipelas the same procedure is adopted to relieve tension by permitting of the escape of blood and serum, and its employment is often followed by most satisfactory results.

Puncturation.—This procedure consists in making punctures into inflamed tissues with the point of a sharp-pointed bistoury, which should not extend deeper than the subcutaneous tissue; it is an operation similar in character to that just described, its object being to relieve tension and bring about depletion. It is employed in cases similar to those in which scarification is indicated, and is resorted to in cases of diffuse areolar inflammation or erysipelas.

Cupping.—Cupping is a convenient method of employing local depletion by inviting the blood from the deeper parts to the surface of the body. Cupping is accomplished by the use or *dry* or *wet* cups. When the former are used, no blood is abstracted, and the derivative action only is obtained; when wet cups are employed, there is an actual abstraction of blood or local depletion as well as the derivative action.

Dry Cupping.—Dry cups as ordinarily applied consist of small cup-shaped glasses, which have a valve and stop-cock at their summit; these are placed upon the skin and an air pump is attached, and as the air is exhausted in the cup the congested integument is seen to bulge into the cavity of the cup. When the exhaustion is complete the stop-cock is turned and the air-pump is disconnected, the cup being allowed to remain in position for a few minutes, and is then removed by turning the stop-cock and allowing air again to enter the cup. This procedure is repeated until a sufficient number of cups have been applied (Fig. 137).

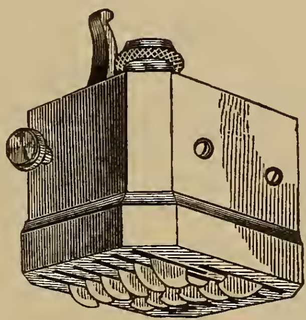
In cases of emergency, when the ordinary cupping glasses and air pump are not available, a very satisfactory substitute may be obtained by taking a wineglass and burning in it a little roll of paper, or a small piece of lint or paper wet with alcohol, and before the flame is extinguished rapidly inverting it upon the skin; or the air may be exhausted by the introduction, for a moment or two, of the flame of a spirit lamp into the cup. Applied in this manner, cups will draw as well as when the more complicated apparatus is used; and when they are to be removed it is only necessary to press the finger on the skin close to the edge of the cup until air enters it, when it will fall off. Although dry cups do not remove blood directly, there is often an escape of blood from the capillaries into the skin and cellular tissue, as is evidenced by the ecchymosis which frequently remains for some days at the seat of the cup marks.

Wet Cupping.—When the abstraction of blood as well as the derivative action is desired, wet cups are resorted to, and here it is necessary to have a scarificator as well as the cups and air pump (Fig. 138).

Fig. 137.

Cupping-glass and air-pump.

Fig. 138.

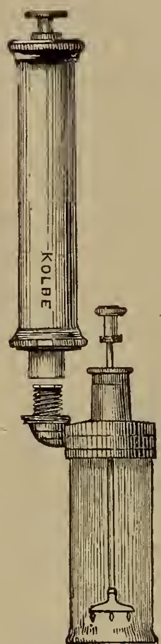


Scarificator.

Before applying wet cups, the skin should be washed carefully with bichloride or carbolic solution, and the scarificator should also be sterilized by boiling. A cup is first applied to produce superficial congestion of the skin; this is removed, and the scarificator is applied and the skin is cut by springing the blades. The cups are immediately reapplied and exhausted, and they are kept in place as long as blood continues to flow. When the vacuum is exhausted and blood ceases to flow they should be removed and emptied, and may be reapplied if it is desirable to remove more blood. A sharp-pointed bistoury which has been sterilized may be employed to make a few incisions into the skin instead of the scarificator, and improvised cups may be employed if the ordinary cupping apparatus cannot be obtained.

After the removal of wet cups the skin should be washed carefully with a bichloride or carbolic solution, and an antiseptic dressing should be placed over the wounds and held in place by a roller bandage.

Fig. 139.



Mechanical leech.

Leeching.—The abstraction of blood by leeches is not employed at the present time. Two varieties of leeches were used—the *American* leech, which drew about a teaspoonful of blood, and the *Swedish* leech, which drew three or four teaspoonfuls.

The Mechanical Leech.—The mechanical leech is an apparatus which has been constructed to take the place of the leech; it consists of a scarificator, cup and exhausting syringe or air pump (Fig. 139). In using this apparatus, after the scarificator has been used the piston of the exhausting instrument should be drawn out slowly, which secures a better flow of blood than if a sudden vacuum is created.

Venesection.—Venesection, as its name implies, consists in the division of a vein, and it is the ordinary operation by which general depletion or bleeding is accomplished. Venesection at the bend of the elbow is the operation which is now usually resorted to for general bloodletting; the vein selected is the median cephalic, which is further from the line of the brachial artery than the median basilic vein (Fig. 140).

To perform venesection the surgeon requires a bistoury or lancet—the spring lancet was formerly much used, but it is not employed at the present time—several bandages, a small antiseptic dressing, and a basin to receive the blood.

The patient's arm should carefully be cleansed, washed over with a bichloride solution or painted with tincture of iodine, and a few turns of a roller bandage placed around the middle of the arm, being applied tightly enough to obstruct the venous circulation and make the veins below become prominent, but not tight enough to obstruct the arterial circulation. The patient at the same time should be instructed to grasp a stick or a roller bandage and work his fingers upon it. The surgeon should next assure himself that there is no abnormal artery beneath the skin, and having selected the vein, the median cephalic by preference, he steadies it with the thumb and passes the point of the bistoury or lancet beneath it and cuts quickly outward, making a free skin opening. The blood usually escapes freely and the amount withdrawn is regulated by the condition of the pulse and the appearance of the

Fig. 140.

Venesection.

patient. For this reason it is better to have the patient sitting up or semi-reclining when venesection is performed, as the surgeon can appreciate better the constitutional effects of the loss of blood while the patient is in this position.

When a sufficient quantity of blood has been removed a sterile gauze compress is placed over the wound of the vein and the bandage removed from the arm above. The compress is held in position by a figure-of-eight bandage. The dressing need not be disturbed for five or six days, at which time the wound is usually found to be healed.

Wounds of the brachial artery have occurred in opening the veins at the bend of the elbow, but if care is taken, this accident should not take place.

Venesection may be practised on the *external jugular vein* when, from excess of fat or in the case of children, the veins at the bend of the elbow cannot be easily found. The vein is rendered prominent by placing the thumb or a pad over the vein at the outer edge of the sternocleidomastoid muscle just above the clavicle. The vein is next opened over this muscle by an incision parallel to its fibers. After a sufficient quantity of blood has escaped the wound is washed with an antiseptic solution and closed by a compress of antiseptic gauze held in position by a bandage carried around the neck.

The *internal saphenous vein* is also sometimes selected for venesection, and here care should be taken not to wound the accompanying nerve which lies directly behind the vein.

Arteriotomy.—This operation is now scarcely ever performed; but if done, the vessel generally selected is the anterior branch of the temporal artery. The position of the vessel is fixed by the finger and thumb, and it is opened by a transverse incision with a bistoury. After a sufficient quantity of blood has escaped the wound is inspected, and if the vessel is not completely divided, its division is completed and the ends of the vessel should be secured with ligatures, and the wound closed with sutures. A gauze compress should next be applied and held in position by a firmly applied bandage.

TRANSFUSION OF BLOOD.

This consists in introducing blood into the circulation of a patient who is suffering from anemia. Transfusion of blood has been employed for many years, but under the older methods subjected the patient to great risk and gradually fell into disuse until revived by Crile. Improvement in the technic of the operation and examination of the blood of the donor and recipient to eliminate the danger of hemolysis have been the important factors in the revival of this procedure.

The brilliant results following the use of intravenous saline solution, as a means of restoring intracardiac pressure, also tended to the disuse of transfusion of blood, but it has been shown that the results of the former procedure are much less lasting. The use of saline solution is most efficient in emergencies, but does not preclude the employment of transfusion of blood later, which is much more lasting in its effects.

Transfusion of blood with the modern technic is a comparatively safe procedure. Bernheim records 800 transfusions with hemoglobinuria in 15 cases with 11 deaths and 4 recoveries. The causes of death in this operation are hemolysis, embolism and acute dilatation of the heart.

Hemolysis.—The destruction of the red blood corpuscles is a pathological process which always occurs when the blood of different species are mixed. Bloods of the same group neither hemolize or agglutinate each other. Hemolysis never occurs when agglutination is absent. In the case of two human beings not of the same type the serum of one may destroy the blood corpuscles of another, liberating in the circulation the hemoglobin contained in them, the result being hemoglobinuria, as the liberated hemoglobin is secreted by the kidneys.

Individuals may be classified in one of four groups, according to the agglutinative action of their serum and corpuscles with the sera and corpuscles of individuals of the other three groups. To determine the group of an individual it is necessary to test his corpuscles against known sera of Group II and III. Lee's classification of blood groups is often employed and is shown in the following table:

CELLS.	SERUM.			
	I.	II.	III.	IV.
I	0	+	+	+
II	0	0	+	+
III	0	+	0	+
IV	0	0	0	0

+ = agglutination. 0 = no agglutination.

In testing the blood of an individual place a drop of Group II serum on left side of a glass slide, and a drop of Group III serum on the right half of the slide. Puncture the finger of the individual to be tested, and transfer to the sera about half a drop of blood on end of a glass rod, mixing the blood intimately with the serum. Care should be taken to transfer the blood before coagulation has commenced, and to avoid mixing the two sera. Shaking the slide hastens the appearance of an agglutination. Red cells make a uniform suspension in the citrated serum. If there is no agglutination and the test is negative this suspension persists. If the test is positive and agglutination takes place it usually appears in less than a minute in the form of masses of agglutinated cells which can be recognized by the naked eye.

As a rule, the donor should be selected from the same group as the one to which the recipient belongs. It is not difficult when the patient is a member of Group II or IV (common group), but may be difficult when the patient is a member of Group I or III. For the latter a Group IV donor is more suitable. Where a donor of the same group is not available, Group IV donors may be used for any of the four groups. Group IV corpuscles are not agglutinated by any serum, and the agglutinative reaction of Group IV serum upon the corpuscles of any of the three other groups is unimportant because the serum is promptly diluted by the serum of the recipient. Group IV donors are termed *universal* donors. The serum of Group I does not agglutinate the cells of any group, and may receive blood from any of the four groups. Members of Group I are termed *universal* recipients.

The Donor.—The selection of the donor is most important. He should be a young person in good health; the very young and old should be eliminated. He should have a negative Wassermann test, and should also be examined for tuberculosis and malaria. Blood relatives are apt to furnish blood of the same group and are good donors if of suitable age. Professional donors are often employed. Many hospitals have lists of these for use in emergencies; they should be retested at short intervals. The amount of blood taken from a donor should not be more than 750 cc to 1000 cc. If more blood is required two donors should be employed.

During removal of blood from the donor he should be carefully watched. If pallor develops the blood-pressure falls suddenly, and the pulse becomes weak, the removal of blood should be promptly stopped.

Transfusion of blood is the most effective treatment for acute anemia resulting from profuse hemorrhage. The sudden loss of a large amount of blood is much more serious than the gradual loss of the same amount of blood. It is now frequently employed as a preoperative procedure in patients who are anemic and exhausted from infection, and show a low blood-pressure combined with a low blood count, hemoglobin 50 or less and red corpuscles 2,000,000 or less. Such cases without transfusion are often poor operative risks, but after transfusion become favorable risks and show an improved blood picture. It is sometimes employed during the operation or immediately afterward, with the best results. It has also been employed in constitutional diseases which are characterized by a disordered state of the blood, primary pernicious anemia, hemophilia, leukemia and in jaundice cases requiring operation, but showing very slow coagulation; in postpartum hemorrhage, or that occurring in typhoid fever, and in shock complicated by acute anemia following hemorrhage. In poisoning by illuminating gas this procedure is especially indicated. The patient may be given 500 cc to 1000 cc. When larger amounts are given the blood from two donors would be required. It should be noted that children require much less blood than adults to attain the same result.

The symptoms which point to the need for transfusion of blood are coldness and pallor of the skin, rapid weak pulse, air hunger, thirst and low blood-pressure. When the latter is as low as 80 the condition is urgent. After transfusion the pulse, which has been 140 to 150, should fall to 100, and the blood-pressure should rise from a point below 80 to 110 to 112.

Transfusion may be accomplished by the *direct* method, in which the blood is conveyed directly and without exposure to the air from the bloodvessels of one person to those of another. In the *indirect* method the blood is first taken from vessels of one person, and is injected or allowed to flow by gravity into the vessels of another. Crile, Bernheim, Unger, Hartwell, Brewer and Fauntleroy have devised methods of direct transfusion which have been extensively employed. The indirect methods of transfusion used by Lewisohn, Kimpton Brown and Vincent are widely used at the present time. Transfusion from vein to vein does not furnish sufficient current unless an artificial pump is employed. In all methods of transfusion the entrance of air with the blood should be avoided. Crile devised a method of arterio-venous anastomosis which brings the endothelium of the artery of the donor in contact with the endothelium of the vein of the recipient, so that clotting does not take place. The donor and recipient are laid side by side on two tables, head to foot.

Crile's Method.—Crile exposes the radial artery of the donor and a superficial vein of the recipient under infiltration anesthesia. A Crile clamp is applied to the proximal end of the artery and the distal end is ligated and the artery divided, the vein of the recipient having been exposed the distal part is ligated, and the proximal closed with a Crile clamp. The vein is then pushed through a small silver cannula and the freed end turned back like a cuff and secured by a ligature. The artery is then dilated and slipped over the vein and snugly tied with a fine ligature. This completes the anastomosis and upon removing the clamps the blood passes from the artery of the donor to the vein of the recipient.

Bernheim has devised for the direct transfusion of blood a two-piece cannula, one section of which is introduced into the artery of the donor, the other section is placed in the vein of the recipient. The tubes are filled with liquid vaseline before the union is effected. When this is done and the clamps removed the anastomosis is completed.

Fig. 141.

Brewer's tube.

Brewer's Method.—Brewer devised and used a glass tube 2½ inches long, small at one end for insertion into the artery, larger at the other for application to the vein. The tube before being used is coated with paraffine by being dipped in melted paraffine, or in a solution of paraffine in benzine (Fig. 141). Brewer connected the radial artery of the donor with the median basilic or other available vein of the recipient.

Hartwell's Method.—This consists in making a direct connection between an artery and vein without the intervention of a tube. The artery and vein are exposed and clamped. The adventitia is removed from each, except that a small cuff from the cut end is left curled up on the outside of the artery, about $1\frac{1}{2}$ inches from the proximal cut end. Three fine silk sutures are passed at equally distant points through the edge of the circumference of the vein. The end of the artery is lubricated with sterilized vaseline, and the mouth of the vein is held open by the three sutures, and the artery is passed directly into it for the distance of 1 inch. One of the sutures in the vein is passed through the rolled-up adventitia of the artery, and the excess caliber of the vein is closed around the artery with a clamp or sutures. The occluding clamps are removed and the blood is allowed to flow.

Lewisohn's Sodium Citrate Method.—Lewisohn found that by mixing sodium citrate in 0.2 per cent solution with blood the mixture could not coagulate and will remain fluid for two days. The advantage of citrate mixture is that coagulation need not be feared in the apparatus. It also can be carried from the donor to the recipient at a distant point. The technic of the citrate method is simple. The arm of the donor in the region of the elbow is painted with tincture of iodine and a tourniquet applied below the shoulder. The median cephalic vein is punctured with a large sterilized hollow needle, or a trocar and cannula. The blood should flow into a warmed graduated glass vessel containing 2 per cent. solution of sodium citrate. If an infusion of 500 cc is to be given, 50 cc of sodium citrate is placed in the jar and 450 cc of blood is added, and the mixture is constantly stirred with a glass rod. The recipient's arm is sterilized, and a vein at the elbow, perferably the median cephalic, is exposed and punctured with a hollow needle attached to a tube and glass funnel, which is kept filled with normal salt solution. As soon as the salt solution is passing freely from the funnel into the vein blood is poured into the funnel, care being taken that the latter does not become empty. As soon as the desired amount of blood has been given the needle is removed and the wound is closed with sutures and a gauze compress and bandage applied.

Some surgeons prefer to use a cannula instead of the hollow needle to introduce the blood into the vein of the recipient. In this case the vein being exposed, two catgut literatures are passed around the vein about $\frac{1}{2}$ inch apart, the distal ligature is tied and the vein is picked up with forceps between the ligatures, and a small opening made into which the cannula is inserted and secured by tying the proximal ligature. When a sufficient quantity of blood has been introduced salt solution is poured into the funnel and as the cannula is withdrawn the proximal ligature is tied.

Slight reaction sometimes follows the use of citrated blood, but I have personally never seen any serious symptoms follow its use.

Kimpton Brown's Method.—In this procedure a graduated glass tube, holding 100 to 250 cc, has its lowest portion drawn to a hollow point and is ground to fit a cannula. This tube has its inner surface coated with paraffine to prevent clotting of the blood. A vein at the elbow is exposed. A cannula may be introduced in the vein and attached to the glass tube, or the end of the tube may be inserted in the vein and secured by a catgut ligature. When the requisite amount of blood has been obtained the tube is withdrawn and the wound dressed. As rapidly as possible the cannula is now inserted into the vein of the recipient. Air pressure is now applied to the contents of the tube by means of a rubber bulb attached to an outlet at the top of the tube and in this way the blood is forced into the vein of the recipient.

The various methods of direct and indirect transfusion described above have all been used with satisfactory results. The results of the direct method in hands of experts cannot be excelled, but for ease of performance, general adaptibility and satisfactory results, the citrated blood method which was the method of transfusion employed by the Medical Department of the United States in the late war is to be recommended. The objection to this method, that the sodium citrate acts upon the blood corpuscles, causing a diminution of the coagulability of the recipient's blood, is negligible, as it has been shown that it is actually increased. Febrile reactions, however, are more common than with the direct methods.

Arterial Transfusion.—This procedure has been advocated by Heuter, who preferred this method of transfusion as tending to send the blood gradually to the heart and thus prevent sudden disturbance of the circulation. If the proximal end of the artery of the donor is anastomosed with the proximal end of the artery of the recipient, there is practically no risk of excessive blood transference, as the two pressures will tend to balance at some point lower than the normal. The technic of the operation is similar to that of arterial anastomosis.

Autotransfusion.—This procedure is recommended in cases of excessive hemorrhage to support a moribund patient until other means of resuscitation can be adopted. It consists in the application of rubber or muslin bandages to the extremities for the purpose of forcing the blood toward the vascular and nervous centers.

INTRAVENOUS INFUSION OF SALINE SOLUTION.

It has been proved by experiments and by clinical experience that saline solution is most efficacious in supplying volume to and restoring a rapidly failing circulation, and as it can be obtained with much more ease than blood, its use for a time *largely superseded the latter*. With the perfected technic of direct and indirect transfusion of blood, recently introduced by Carrell and Crile and others, transfusion of blood is much more frequently resorted to in the treatment of severe hemorrhage.

It is now known that the grave results following severe hemorrhage are due not only to the loss of corpuscular elements, but to the mechanical disproportion between the area of the vascular system and its content. Saline solution introduced into the veins in sufficient quantity increases the arterial pressure and restores the activity of the circulation.

It has been shown by experiments that plain distilled water is destructive to the red corpuscles, but that when a certain amount of sodium chloride is added this result does not occur.

Normal saline solution consists of 6 to 9 parts of sterilized sodium chloride to 100 parts of distilled water. For practical purposes it may be prepared by adding a heaping teaspoonful of table salt to 1 quart of distilled water.

Various modifications of normal salt solution have been proposed and employed with good results. Of these, Locke's is said to be one of the most satisfactory. It consists of distilled water, 1 liter; sodium chloride, 9 to 10 gm.; calcium chloride, 0.2 gm.; potassium chloride, 0.1 to 0.2 gm.; sodium bicarbonate, 0.1 to 0.2 gm.; glucose, 1 gm.

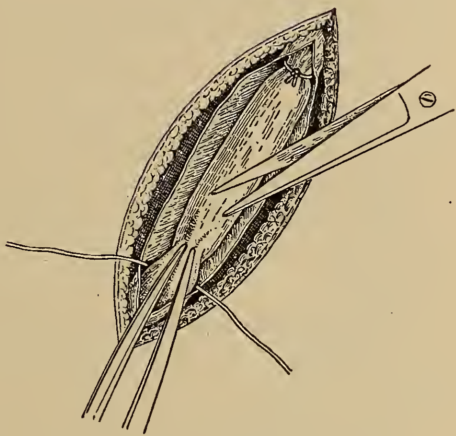
A vein of the patient at the elbow, should be exposed, and should have placed under it about $\frac{1}{2}$ inch apart two catgut ligatures; the distal ligature is then tied and an opening is

Fig. 142.

Vein exposed; introduction of cannula.

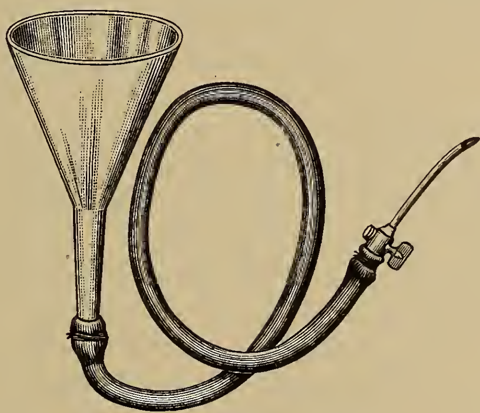
made into the vein between the ligatures (Fig. 142); a cannula is next inserted into the opening in the vein, and is secured in position by tying the proximal ligature. The solution should be used at a temperature of 105° to 110° F. The cannula is first filled with the saline solution, and is then connected with a funnel or graduated glass jar by means of a rubber tube (Fig. 144), which is filled with saline solution to displace the air, and upon raising the funnel above the part the solution enters the vein; care should be taken to see that the funnel is kept well supplied with the solution until a sufficient quantity has been introduced. The quantity introduced into the circulation must be regulated by its effects. In acute hemorrhagic anemia, 1 or 2 pints will often restore the radial pulse; larger quantities may be used. The larger the quantity of solution required to restore the pulse the graver the prognosis. In grave cases the addition of adrenalin chloride solution, 1 to 1000 to the saline solution, may be used with advantage. Crile recommends its use in the following manner: When the fluid begins to flow into the vessel, thrust the needle of a hypodermic syringe filled with the adrenalin chloride solution through the rubber tube near the cannula, and during one minute

Fig. 143.



Opening the vein. (Ashhurst.)

Fig. 144.



Funnel and tube for intravenous infusion.

inject 10 to 15 mm. The fluid should be slowly and gradually introduced; the pulse should be carefully watched during its introduction. Ten minutes should usually be employed for the introduction of 1 pint of the solution.

When a sufficient quantity of the solution has been introduced, as shown by improvement in the pulse, the cannula is withdrawn, the proximal ligature is tied, the wound is closed by sutures and a dressing is applied.

The best results of intravenous infusion has been obtained in cases of acute anemia from severe hemorrhage, in shock, in anemia, uremia, postoperative suppression of urine and occasionally in sepsis.

Saline solution may also be introduced into a vein by means of a syringe when the apparatus described cannot be obtained.

Infusion of Saline Solution into Arteries.—Saline solution may be gradually introduced into the circulation through an artery.

The radial artery is exposed and surrounded by these ligatures a short distance apart, the ligature nearest the heart is first tied, and next the distal ligature is tightened to cut off the anastomotic blood supply; the artery is then partly divided and the cannula is inserted pointing toward the periphery and fastened by the remaining ligature; the second ligature is loosened and the fluid is injected.

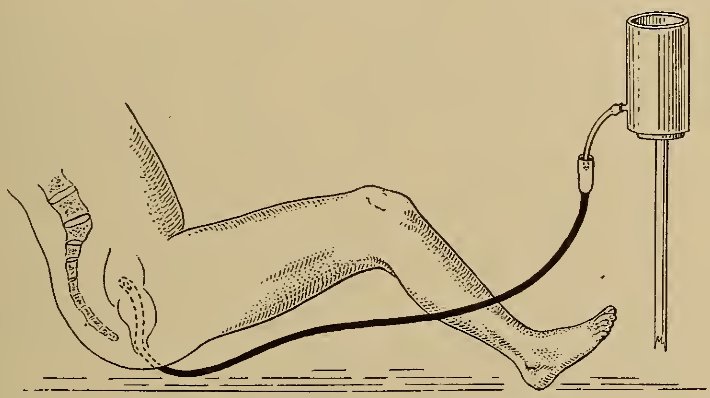
When a sufficient quantity of fluid has been introduced the distal ligature is firmly tied, the cannula removed, the division of the artery completed, and the wound is closed by sutures and a dressing applied.

Infusion of Saline Solution—Hypodermoclysis.—The introduction of saline solution into the cellular tissue has been followed by results equally as satisfactory as those obtained by intravenous injection, and this procedure is now very frequently employed.

The saline solution is conveyed into the cellular tissue through a large hypodermic needle, which should be sterilized by boiling, and is then introduced into the connective tissue, being previously connected by a rubber tube with a reservoir containing warm sterilized salt solution. The usual situations for the introduction of the solution are the external portions of the thighs and the anterior and lateral portions of the abdominal and thoracic walls. As much as two or three pints of the solution are often introduced in this manner with good results. Infusion of saline solution may be used with most satisfactory results in cases who have suffered from profuse hemorrhage, and has also proved of great service in cases of shock, and has a distinct value in the treatment of septicemia and uremia.

Enteroclysis.—This procedure is employed to supplement hypodermoclysis and intravenous saline infusion. It consists in introducing into the rectum warm saline solution by means of a tube with a nozzle which is attached to a vessel containing the solution.

FIG. 145.



Fowler's position with enteroclysis.

The solution is usually introduced in quantities from $\frac{1}{2}$ to 1 pint every three or four hours, or it may be allowed to percolate slowly into the rectum over long periods of time, as in the Murphy method in the treatment of peritonitis. Many patients will not retain large quantities of the solution thrown into the rectum at once. In such cases, 4 to 6 ounces of the solution may be given every two or three hours with good results. This method is most satisfactory in children who do not retain well large amounts of saline solution.

Murphy, in cases of diffused peritonitis, recommends that the patient be placed in the Fowler position to drain fluids into the pelvis—that is, a sitting or semi-sitting posture, and that he be given saline solution by the rectum continuously, the vessel containing the fluid being raised slightly above the body and the tube so arranged that the fluid passes slowly into the rectum, the object being to have only so much fluid enter the rectum as will be absorbed (Fig. 145). The temperature of the solution should be about 100° F. This method, with abstinence from food, is also most useful as a preoperative treatment in patients suffering from peritonitis, as favoring localization of inflammation and elimination of toxins by the kidneys.

ASPHYXIA OR APNEA.

These terms are used to describe a condition in which there is non-oxygenation or incomplete oxygenation of the blood. In asphyxia death is not immediate, the heart continuing to beat for sometime after respiration has ceased, and resuscitation is often possible. Asphyxia may result from foreign bodies in the air-passages, heavy bodies pressing on the chest or air passages, acute traumatic pneumothorax, by a clot in the pulmonary artery shutting off the blood supply of the lungs, drowning, throttling and irrespirable or irritant gases. The prominent symptoms of asphyxia are lividity, labored respiratory efforts, turgescence of the veins, convulsions and unconsciousness. Blood may escape from the nose, rectum and other mucous membranes, the pulse becomes weaker and the heart finally stops beating.

Sudden asphyxia is usually due to the presence of foreign bodies in the air passages or to wounds; gradual asphyxia is due to some intrathoracic lesion. The treatment of asphyxia consists in opening and examining the mouth for foreign bodies, pulling the tongue forward and dashing hot or cold water on the face and chest to excite respiratory movements. If there is cardiac dilatation bleeding is indicated; stimulation of the phrenic nerve by electricity may do good, and if the patient is breathing oxygen may be of service. Tracheal or laryngeal obstruction demand tracheotomy or intubation. In threatened death from asphyxiation artificial respiration is a most valuable procedure.

Gas Poisoning.—Inhalation of illuminating gas, either accidental or with suicidal intent, is quite common at the present time. Gas produced from coal by the old process contains about 7 per cent carbon monoxide, while that by the new process, known as water gas, has certain hydrocarbons added in the manufacture, and contains almost 38 per cent carbon monoxide. The latter is much more poisonous than the former. Air containing 0.05 per cent of carbon monoxide has a marked affinity for hemoglobin and destroys the oxygen-carrying power of the red blood cells.

The *symptoms* of gas poisoning are vertigo, headache, dizziness, weakness, throbbing in the head and great vessels of the neck; the pulse may at first be slow, but later becomes weak and rapid; respiration rapid and stertorous, or may be of the Cheyne-Stokes type. The temperature varies from 99° to 103° F. The tongue is red and swollen and cherry-red spots may be observed upon the surface of the body. Cyanosis is marked and coma may develop rapidly. Pulmonary complications (bronchopneumonia) and nervous sequelæ may develop later if the patient survives.

Treatment.—Remove the patient from gas-containing atmosphere. Practice artificial respiration. Administer oxygen to displace the carbon monoxide from the blood. Give sodium phosphate or Seidlitz powder by the mouth, also spts. ammonii aromat., strychnine, digitalis and camphor by the mouth, as indicated. If the patient is asphyxiated or comatose make artificial respiration with pulmotor which at the same time furnishes oxygen. Bleed and transfuse with normal blood.

Smoke Asphyxia.—DaCosta has called attention to the frequency, dangers and treatment of this variety of asphyxia. Smoke asphyxia is most commonly met with in firemen. The combustion of different substances produces different varieties of smoke, some of which are simply irrespirable while others are highly poisonous. Heat of the smoke renders it more irrespirable. Smoke from lumber, varnish, paper, rags, wet hay is very irrespirable; while that from pitch, tar and oil is much less pungent. Smoke impregnated with ammonia, sulphur dioxide and chlorine is an active irritant. Smoke containing nitric acid is highly irritant and is likely to cause edema of the glottis or lungs.

Three stages of smoke asphyxia are recognized: (1) Respiration is affected, but the patient is conscious; (2) consciousness is lost, but respiration continues; (3) respiration has been arrested.

Treatment.—The patient should be promptly removed from the smoky atmosphere; all constricting clothing removed. If the patient attempts to vomit this should be encouraged by giving effervescent drinks, as vomiting removes the mucus and gases from the stomach and lungs. If respiration has been suspended the lips are cyanotic, skin cold and clammy, the pupils are fixed and dilated, pulse weak and fluttering and there is bleeding from the nose and mouth, and sometimes involuntary passage of urine and feces. The mouth should be cleared of mucus or blood and artificial respiration should be started or the pulmotor or the lung motor employed, oxygen being given. If edema of glottis is present tracheotomy should be performed and oxygen administered through the tracheal tube.

ARTIFICIAL RESPIRATION.

This procedure is resorted to in cases of threatened death from apnea consequent upon drowning, profound anesthetization, electric shock or the inhalation of irrespirable gases, or when from any cause there is interference with the function of breathing. Before resorting to artificial respiration care should be taken to see that nothing is present in the mouth or air-passages which will obstruct the entrance of air into the lungs, such as mucus, foreign bodies or liquids, and also that all tight clothing interfering with the free expansion of the chest walls is removed from the chest.

In cases where the apnea is due to the presence of a foreign body in the larynx or trachea it is evident that no efforts at respiration can be successful until the air passages are freed from the occluding body; and if it cannot be removed through the mouth, tracheotomy should be performed before artificial respiration is attempted; the tracheal wound should be held open by retractors, which in a case of emergency can be made from bent hairpins, or by a dressing forceps or a tracheotomy tube, if one be at hand.

When artificial respiration is resorted to the operator should persevere with it for some time, even when no apparent spontaneous respiratory movements are excited; for resuscitation has been accomplished in seemingly hopeless cases by patient perseverance with the manipulations. When the first natural respiratory movement is detected the operator should not cease making artificial respiration, but should continue these movements in such a way as to coincide with the spontaneous inspiratory and expiratory movements until the breathing has assumed its regular character.

The temperature of the body should also be restored by friction to the surface by the hands or by rough towels and hot-water bottles and warm coverings should be applied for the same object.

Direct Method of Artificial Respiration (Howard's).—This method of artificial respiration is at the present time considered the most efficacious, and is the one adopted by the United States Life-saving Service; and although the rules given are for the resuscitation of cases of apparent drowning, the same procedures may be adopted in cases of apnea arising from other causes.

The rules laid down by Dr. Howard are as follows:

Rule I.—"To expel water from the stomach and lungs strip the patient to the waist, and if the jaws are clenched separate them and keep them apart by placing between the teeth a cork or a small piece of wood. Place the patient face downward, the pit of the stomach being raised above the level of the mouth by a roll of clothing placed beneath it (Fig. 146). Throw your weight forcibly two or three times upon the patient's back over the roll of clothing so as to press all fluids in the stomach out of the mouth.

The first rule applies only to cases of drowning, and in using Howard's method in apnea from other causes it is omitted.

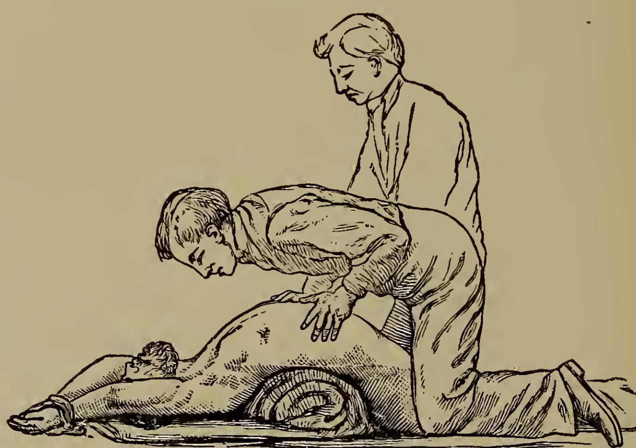
Rule II.—"To perform artificial respiration quickly turn the patient upon his back, placing the roll of clothing beneath it so as to make the breast bone the highest point of the body. Kneel beside or astride of the patient's hips. Grasp the front part of the chest on either side of the pit of the stomach, resting the fingers along the spaces between the short ribs. Brace your elbows against your sides, and steadily grasping and pressing forward and upward throw your whole weight upon the chest, gradually increasing the pressure while you count *one—two—three.* Then suddenly let go with a final

Fig. 146.

First manipulation in Howard's method.

push which springs you back to your first position (Fig. 147). Rest erect upon your knees while you count *one—two;* then

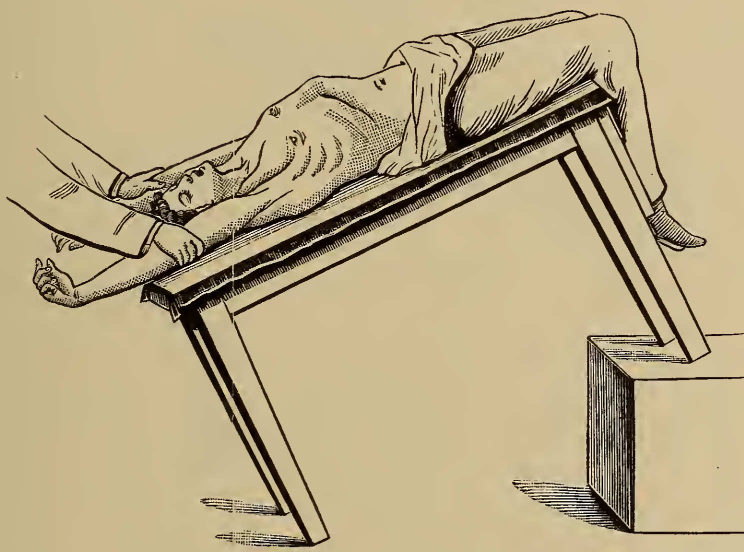
Fig. 147.



Direct method of artificial respiration.

make pressure as before, repeating the entire motions at first about 4 or 5 times a minute, gradually increasing them to about 10 or 12 times. Use the same regularity as in blowing bellows and as seen in the natural breathing which you are imitating. If another person is present, let him with one hand, by means of a dry piece of linen, hold the tip of the tongue out of one corner of the mouth, and with the other hand grasp both wrists and pin them to the ground above the patient's head." This method may be employed in cases of still-birth or in young children, the operator holding the body of the child in his left hand and compressing it with the right hand.

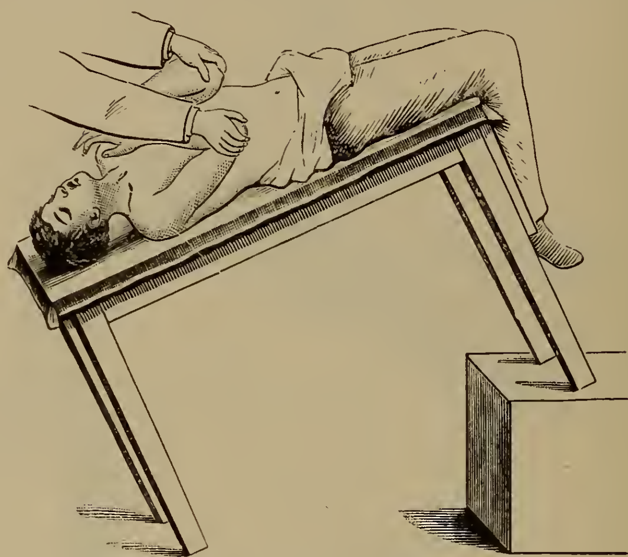
Fig. 148.



Silvester's method—inspiration.

Silvester's Method of Artificial Respiration.—In employing this method of artificial respiration the patient should be placed on his back upon a firm flat surface; a cushion of clothing is placed under the shoulders and the head should be dropped lower than the body by tilting the surface on which he is laid. The mouth being cleared of mucus or foreign substances, the tongue is drawn forward and secured to the chin by a piece of tape tied around it and the lower jaw, or may be pulled out of the mouth and held by an assistant. The operator, standing at the patient's head, grasps the arms at the elbows and carries them first outward and then upward until the hands are brought together above the head; this represents *inspiration* (Fig. 148); they should be kept in this position for two seconds, after which time they are brought slowly back to the sides of the thorax and pressed against it for two seconds; this represents *expiration* (Fig. 149). These movements are repeated 15 times in one minute until the breathing is restored or it is evident that the case is a hopeless one.

Fig. 149.



Silvester's method—expiration.

Laborde's Method of Artificial Respiration.—Laborde has shown that systematic and rhythmic traction upon the tongue is a powerful means of restoring the respiratory reflex, and consequently the function of respiration. The procedure is accomplished as follows: The body of the tongue is seized between the thumb and fingers, and traction is made upon it with alternate relaxation, 15 or 20 times a minute, imitating the function of respiration, taking care to draw well on the tongue. When a certain amount of resistance is felt it is a sign that the respiratory function is being restored. Noisy respiration first occurs, termed by Laborde *hoquet inspirateur* (inspiratory hiccough). Tongue forceps or dressing or hemostatic forceps may be used in place of the fingers to grasp the tongue. It is important to persist in the manipulations for a half to one hour, unless the case is absolutely hopeless. This procedure, which cannot be employed with advantage when there is fixation of the tongue from inflammation or malignant disease, has been employed with success in cases of drowning, toxic asphyxia, asphyxia during anesthesia and arrest of respiration from electric shock.

Schäfer's or Prone Method.—In this method of artificial respiration the patient is placed upon his stomach with the face turned to one side, the arms are brought above the head and a roll of clothing is placed under the chest. The operator kneels astride of the patient and grips the thorax, the fingers being parallel to the ribs, the elbows are firmly braced against the chest, and press firmly upward and inward, throwing the whole weight against the chest. Relieve pressure after two or three seconds and count *one—two* and again make pressure as before; repeat these manipulations about 15 times in a minute. This position in this method causes the tongue to fall forward without being held, and also facilitates the escape of fluids from the air passages.

Pulmotor.—By the use of this apparatus the administration of oxygen and artificial respiration are accomplished at the same time by means of oxygen which is under pressure. The apparatus is contained in a narrow wooden case and weighs less than 50 pounds—so that it is quite portable. Hospital ambulances, receiving wards and operating rooms are usually equipped with this apparatus. The mask is fitted to the face and the oxygen is turned on, and by an arrangement of valves the lungs are filled with the gas by pressure and emptied by suction. After respiration has been established, the valve is changed and oxygen is simply given by inhalation.

It has been shown that the air furnished by the pulmotor does not contain over 30 per cent of oxygen. The pulmotor is especially valuable in cases of asphyxiation from illuminating gases, or other poisonous gases, and in cases of drowning.

Lung Motor.—This apparatus, which is worked by hand and can be adjusted with great rapidity, not only furnishes air to the lungs but also causes the thorax to exert the proper suction upon the great vessels and the heart. Before using the instrument a rubber tube is passed into the esophagus and distended with air by means of an attached hand bulb; this prevents the air from entering the stomach. Air or air mixed with oxygen may be introduced. The mouth is next cleared of saliva or mucus and the mask is secured in place and the air pumps are started—one makes pressure; the other suction. The degree of movement necessary for the age period is marked upon the piston.

The lung motor may be used in cases of asphyxia from gas or smoke, from drowning or hanging, in which respiration is arrested by obstruction of the trachea.

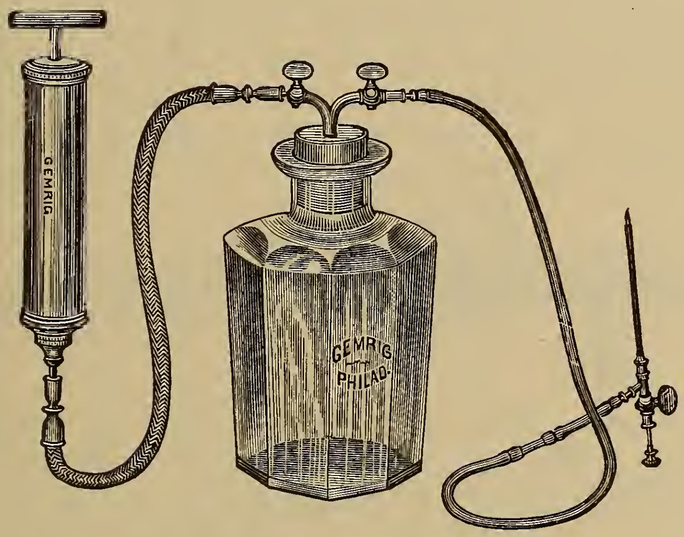
The method of *continuous intratracheal insufflation* of air described by Meltzer and Auer, which has been elaborated by Elsberg for ether anesthesia, would seem a valuable form of artificial respiration if the apparatus were available (p. 229).

Aspiration.—This procedure is adopted to remove fluid from a closed cavity without the admission of air, and the instrument which is employed to accomplish this object is known as an aspirator. The form of aspirator most generally employed is that of Potain.

Potain's Aspirator.—This consists of a glass bottle, into the stopper of which is introduced a metallic tube, which is connected with two rubber tubes, one of which is connected with an exhausting pump and the other with a delicate cannula carrying a fine trocar; the apparatus is provided with stopcocks to prevent the admission of air (Fig. 150). In using this aspirator the air is exhausted from the bottle by using the air pump; the cannula enclosing the trocar is next pushed through the tissues into the cavity containing the fluid to be removed; the trocar is then removed, and upon opening the stop-cock the fluid is forced out of the cavity by atmospheric pressure and passes into the bottle or receiver. If the fluid contains masses of lymph or clots which block the cannula, interrupting the flow of fluid, a stylet may be passed through the cannula to free it from the obstruction.

To diminish the pain produced in introducing the trocar and cannula the skin at the point to be punctured may be rendered less sensitive by holding in contact with it for a few minutes a piece of ice wrapped in a towel, or by the injection of a local anesthetic. Care should also be taken to see that the trocar and cannula have been perfectly sterilized; to accomplish this they should be boiled for five minutes or placed in a 5 per cent carbolic solution for twenty minutes and soaked in sterile water before being used. Before introducing the trocar and cannula the operator should sterilize the skin at the seat of puncture by painting it with tincture of iodine and in its introduction should be careful to avoid injuring important veins, arteries or nerves.

FIG. 150.



Potain's aspirator.

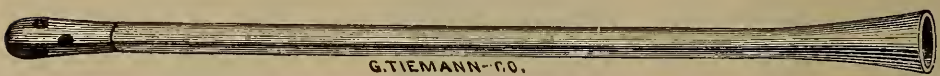
After removing the cannula the small puncture should be dressed with shreds of absorbent cotton held in place by collodion and a compress of sterile gauze held in place by a bandage or adhesive straps.

The aspirator is frequently employed in cases of hydrothorax, empyema and ascites, to evacuate the contents of abscesses in diseases of the hip and spine, and to remove the contents of a distended bladder until a more radical operation can be performed. It is also a valuable instrument for diagnostic purposes, being frequently used to ascertain the character of the contents of deep-seated tumors containing fluid.

Exploring Syringe.—A glass barrelled syringe, to the nozzle of which are fitted sharp-pointed hollow needles of different caliber and lengths, is a most useful instrument for exploratory aspiration. It should be sterilized by boiling; the skin should be sterilized by iodine. It is frequently used to ascertain the contents of inflammatory swelling or tumors. In effusions in the chest or the abdominal cavity, even after the abdomen has been opened and tumors exposed, it is often wise to use this instrument to ascertain the nature of their contents. It is well to use a small needle first, and if not satisfactory a larger one should be substituted; the smaller the puncture the less risk of leakage.

The Stomach-tube.—This consists of a partially flexible tube about 28 inches in length and $\frac{3}{8}$ inch in diameter, which is introduced while the patient is in the sitting posture, the head being thrown backward so as to bring the mouth and

Fig. 151.



The stomach-tube.

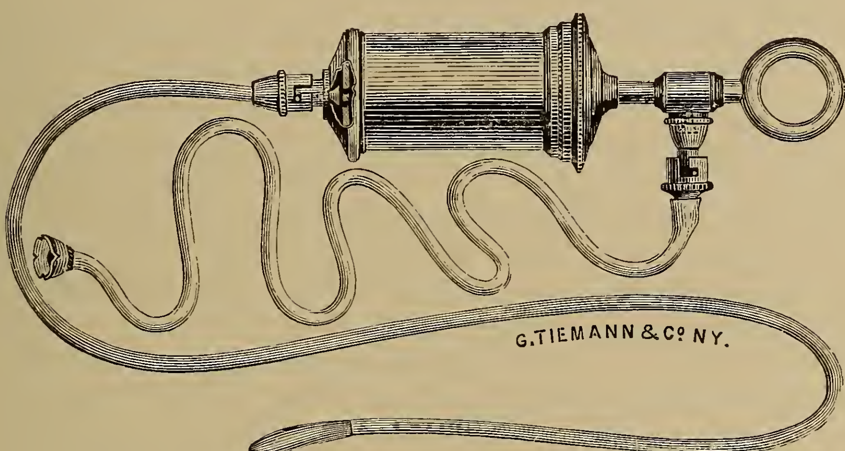
gullet as nearly as possible in the same line (Fig. 151). The tube being warmed and oiled, the surgeon standing in front of the patient passes it directly back to the pharynx, taking care to keep the lip in contact with the posterior wall of the pharynx. It is then passed gently downward into the stomach. If any obstruction is met with in its passage it should be withdrawn a little and then pushed gently downward; all manipulations should be made without much force to avoid perforating the wall of the esophagus.

The introduction of the stomach-tube may be required for the evacuation of poisons from the stomach or to wash out the cavity of this viscus. It may also be used to introduce liquid nourishment into the stomach of patients who are unable or unwilling to swallow food. In introducing liquid nourishment a syringe or funnel is fitted to the free end of the tube, which has been passed into the stomach; the syringe or funnel having been filled with milk or beef tea or broth, the contents are injected gently or allowed to run into the stomach.

In cases of poisoning where it is desirable to withdraw the contents of the stomach and to wash out the organ, a stomach-tube and syringe may be employed; several syringefuls of warm water are first thrown into the stomach and then withdrawn by suction, but in such cases the use of the stomach-pump will be found more satisfactory.

Lavage.—In the recently introduced method of treating disorders of the stomach by irrigation the introduction of a flexible rubber stomach-tube is required; the tube here employed is from 24 to 30 inches in length, and the fluid is introduced by means of a funnel attached to its free extremity or it may be attached to a stomach pump.

Fig. 152.



Stomach-pump.

The Stomach-pump.—This consists of a brass syringe, the nozzle of which is connected with two tubes, one at the end, the other at the side. The passage of fluid through the nozzle is regulated by a valve controlled by a lever. The nozzle of the pump is attached to a stomach-tube and the end of the lateral tube is placed in a pan of warm water. By withdrawing the piston and opening the valve, water may be drawn from the basin, and by closing the valve and depressing the piston it is forced through the stomach-tube into the stomach; when a sufficient quantity has been injected in this manner by reversing the action of the valve the fluid is drawn out of the stomach and discharged through the lateral tube into a basin. This manipulation is continued until the water returns clear and the stomach has been completely washed out. The stomach-pump shown in (Fig. 152) may also be employed.

Esophageal Bougie.—This instrument—which may be passed through the esophagus into the stomach for the purpose of diagnosis or for the purpose of dilating strictures of the esophagus—is employed in exactly the same manner as the stomach-tube, and, as in the case of the latter instrument, it should be introduced without the use of much force, as perforations of the esophagus have followed the forcible introduction of such instruments.

The Rectal Tube.—The introduction of the rectal tube is best accomplished by placing the patient upon his left side, and the surgeon should introduce his index finger well oiled into the rectum and guide the tube upon this through the anus, when by gentle pressure it is gradually passed into the rectum; if a stricture exists in the rectum within reach of the finger the latter should be used to guide the tube through the opening in this; if the tube becomes caught in a transverse fold of the mucous membrane and doubles upon itself it should be withdrawn and a fresh attempt made to pass it. In passing a rectal tube all manipulations should be made with extreme gentleness, as it has been shown that its passage is not without danger, perforations of the intestine having followed its use in some cases. In cases of stricture of the rectum high up the operator has to depend upon the sense of resistance experienced in passing the tube and in such cases the manipulations should be most carefully made. When the rectal tube is employed to introduce fluid into the large intestine the fluid may be introduced by means of a syringe, or by pouring it into a funnel attached to the free end of the tube, or by attaching the tube to a fountain syringe, thus allowing the liquid to pass slowly into the intestine.

The rectal tube is often employed with good results in irrigating the large intestine, relieving the intestine of flatus, and in introducing water or oil into the intestine in cases of intestinal obstruction, and in those cases where the obstruction results from intussusception or fecal accumulations its use will often prove satisfactory.

Rectal Bougies.—These instruments are made of India-rubber or the same material as the English flexible catheter and are of various sizes. They should first be oiled, and are introduced in the same manner as the rectal tube. They are generally employed in cases of stricture of the rectum, and should be introduced with great care to avoid perforating the wall of the rectum; this accident has occurred in the hands of skilful surgeons. A very satisfactory substitute for a rectal bougie is a tallow candle, one end of which is melted or rubbed down to conical shape.

Enemata.—These may be administered by means of an ordinary syringe, or by means of a gravity or fountain syringe; the precautions which should be observed are to introduce the nozzle of the syringe gently and in the right direction, as perforation of the lower portion of the rectum has taken place from careless and forcible introduction of the nozzle of the enema syringe; the fluid should also be injected slowly, as by so doing there is less resistance and less tendency for the patient to pass the fluid before the desired quantity has been introduced.

The enema most commonly employed to empty the lower bowel is made by adding a tablespoonful of sweet oil and 2 teaspoonfuls of spirit of turpentine to 1 or 2 pints of warm water in which a little Castile soap has been dissolved; warm water and sweet oil are also frequently used for the same purpose.

Glycerin Enema.—One or 2 teaspoonfuls of glycerin injected into the rectum or a *suppository* made of glycerin will often be found an efficient substitute for the larger enema of water.

Nutritious Enema.—When it is found necessary to resort to feeding by the rectum the substances employed should be injected into the rectum by means of a syringe and care should be taken that the quantity is not too large and that it is of such a nature as not to cause irritation of the walls of the rectum or it will not be retained; 2 to 4 ounces in the case of an adult is generally a sufficient quantity to inject at one time.

Peptonized milk or beef juice, or the yolk of an egg beaten up with milk, is often employed, and any unirritating drugs may be mixed with the enema and administered at the same time. Gloucose solution (6-10 per cent) is excellent.

Vaccination.—This is a minor surgical procedure which every physician is called upon to perform. The surface may be prepared for the reception of the lymph by abrading the skin at one or two points with a dull lancet or by making several superficial incisions with a knife, or by scratching the surface of the skin with the ivory point charged with lymph, in lines with crossing lines, *cross-scratch,* until a little serum exudes. It is not advisable to draw blood which washes away the lymph and for this reason we prefer the abraded surface made by the dull knife or the ivory point.

The lymph used may be the *humanized* or the *bovine.*

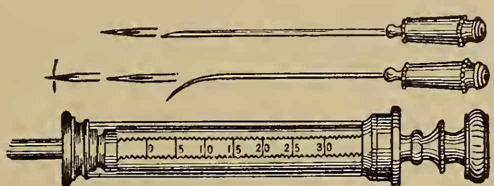
Bovine lymph or *virus,* which is now most generally employed, is taken from the vaccine vesicles upon the udders and teats of heifers. The lymph may be mixed with sterilized glycerin and placed in fine glass tubes which are sealed; or ivory points or quills are dipped in the lymph and allowed to dry, and in using these they are dipped in water for a moment to moisten the lymph before being applied to the abraded surface. The ivory point is one of the most convenient means of vaccination, as the surface may be abraded with it before the lymph is applied.

It has recently been advised that antiseptic precautions be exercised in performing vaccination, and although all of the details cannot be carried out we have found that the exercise of care as regards cleanliness of the surface has been followed by much fewer inflammatory complications in vaccination wounds.

The surface to be abraded, usually the left arm below the deltoid, is first washed with soap and water, then with a 1:2000 bichloride solution, or with alcohol and finally washed with sterilized water. Two points of this surface, 1 inch apart, are then abraded by using a knife which has been washed or dipped in boiling water, or by using the ivory point which has been dipped in water that has been boiled and cooled. When the surface has been prepared in the manner described the moistened virus is rubbed upon it and allowed to dry. Vaccination upon the leg, which is practised by some physicians to prevent the scar from showing, I think is not to be recommended, and I never practise it in this situation, as it is more difficult to keep this part at rest.

Hypodermic Injections.—The syringe used to make hypodermic injections is provided with a perforated needle, which is passed into the cellular tissue (Fig. 153). Care should be taken to see that the instrument and needle are perfectly clean before being used; they should be rendered aseptic by soaking them for a few minutes in boiling water or in a 5 per cent carbolic solution. Hypodermic injections are generally made into parts in which the cellular tissue is abundant, and great care should be observed to avoid introducing the needle into a large vein or artery, as by neglect of this precaution serious symptoms have resulted from the drug being thrown rapidly into the circulation instead of being slowly absorbed

FIG. 153.



Hypodermic syringe and needles.

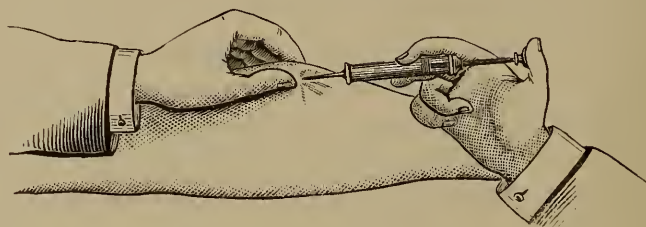
from the subcutaneous cellular tissue; injury of superficial nerves should also be avoided. Care should also be taken to see that the solutions employed are sterilized if possible, and freshly made solutions should be preferred.

To avoid using solutions for hypodermic use which undergo change in keeping, it will be found convenient to use the compressed pellets which are prepared by manufacturing chemists, the alkaloids being compressed with a little sulphate of sodium which increases their solubility, the solution being prepared with boiled water just before being used.

The portions of the body usually selected for hypodermic injection are the outer surface of the thighs or arms and the anterior surface of the forearms. In making a hypodermic injection the syringe is charged and the needle is fastened to the nozzle of the syringe; the skin is next pinched up and the needle is quickly thrust through this into the cellular tissue (Fig. 154); the syringe is then emptied by pressing down the piston, and when the cylinder is empty the needle is withdrawn.

Injection of Antitoxins.—In the treatment of diseases such as diphtheria, anthrax, septicemia, pneumonia and tetanus by the injection of serum, the hypodermic method is made

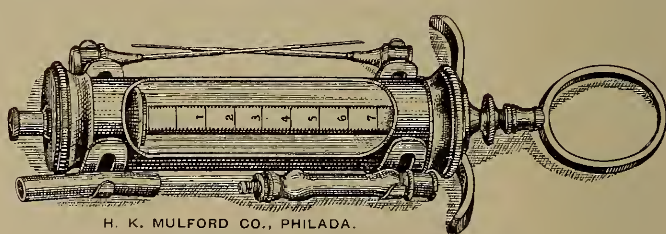
Fig. 154.



Method of giving a hypodermic injection.

use of; in using antitoxin injections in diphtheria the dose of the antitoxin is proportionate to the age and weight of the patient as well as to the severity and duration of the disease. A child, aged three years, should be given 2000 units; an adult, not less than 3000 units; and the injection should be repeated in twelve to twenty-four hours. In severe cases much larger doses should be given. The immunizing dose

Fig. 155.



Syringe for serum injection.

of antitetanic serum is 1500 units. When the disease has developed large amounts of the serum should be injected directly into a vein and into the spinal canal. Before employing the injection the skin should be sterilized and the best variety of syringe to employ is one holding about 20 cc (Fig. 155).

The various antitoxins are now furnished in glass tubes, with a needle and piston. The tube contains the approximate dose. By removing the plug at one end of the tube, inserting the piston, removing the tapering end of the tube and attaching the needle, the injection may conveniently be given.

It is well to have the needle connected with the syringe by a short rubber tube so that the needle will not be broken if the patient struggles. The injections are usually made below the angle of the scapula or in the lumbar region and the serum is introduced slowly to avoid local reaction.

Coley's Fluid.—This fluid, which consists of the mixed toxins of Streptococcus erysipelatis and Bacillus prodigiosus, has been employed in the treatment of sarcoma with some success. It has been especially used in inoperable sarcomata of the abdomen and recurrent and secondary sarcomata of bone. Two to 10 minims are injected hypodermically at intervals of a few days, depending upon the amount of constitutional reaction produced, and the dose is gradually increased if the patient bears it well. The treatment should be continued for some weeks until it is shown that no results are obtained or the growths are diminishing.

The Wassermann Test.—The Wassermann reaction is a test used in the diagnosis of syphilis. Its principles are complicated, and it can be made only in well-equipped laboratories by technicians of experience. It depends upon the behavior of a so-called hemolytic system. In a hemolytic system, hemolysis, or solution of red blood cells, is due to the action of the hemolysin upon the red blood cell through the medium of a hypothetical substance known as complement which is present in all normal serum. Wassermann showed that extracts of syphilitic organs in the presence of the serum of a syphilitic possessed the power of combining with complement, thus rendering it inert. Certain lipoidal bodies have the same property. Complement may be destroyed in serum also by a low heat which is insufficient to change the other properties of the serum.

Employing these principles, the presence of syphilis is demonstrated in the following manner: The serum of the person to be tested is heated to destroy complement. It is then mixed with the organ extract and with guinea-pig serum to furnish a known amount of complement which has been previously determined by titration. If the serum is syphilitic a part or all of the complement thus added will be combined and rendered inert. In order to determine whether complement is present the red blood cells of some animal, usually the sheep, and a quantity of hemolysin are added. If the complement has not been previously exhausted by combination of the organ extract to be tested hemolysis will take place; if complement has been destroyed however, hemolysis will be partially or completely inhibited. This inhibition of hemolysis, therefore, becomes the indication of the existence of syphilis, and according to the degree of inhibition we say the test is weakly, medium or strongly positive, or for convenience it is usually designated Plus 1, 2, 3 or 4.

If complete hemolysis occurs the test is negative. This is an extremely valuable test for syphilis, and especially so for control of results of treatment. It is not infallible. A negative test may be found in latent syphilis, and positive reactions are sometimes obtained when there is practical certainty that syphilis does not exist or has never existed.

A persistently positive reaction with certain variations of technic, which cannot be described here, are practically diagnostic. The test is not usually positive until two or more weeks after the primary lesion. Under successful treatment it frequently becomes negative and is the most delicate indication of complete cure. Wet nurses and prospective donors for blood transfusions should be tested by this method before being used. The test may be positive with spinal fluid in syphilis of the nervous system even when negative in the blood.

Injections of Mercury in Syphilis.—Injections of mercury may be made into the subcutaneous tissue of the loins, buttocks or scapular regions in the treatment of syphilis. Injections may also be into the veins. The solution most commonly used is a 1 per cent solution of the cyanide of mercury, 20 minims being injected every day or on alternate days.

Injection of Salvarsan or Arsphenamine.—The researches of Ehrlich upon the action of the organic compounds of arsenic upon animals infected with parasitic protozoa induced him to use these arsenical compounds in the treatment of syphilis.

Salvarsan, known also as "606," was the first drug employed. It is a yellow crystalline powder containing about one-third of its weight of arsenic. Neosalvarsan, a more recent preparation of Ehrlich's is a combination of salvarsan with formaldehyde sulpholoxylate.

Arsphenamine, an American preparation, is very extensively employed at the present time.

They are powerful antiseptics and destroy syphilitic parasites with which they are brought in direct contact. They have no eliminative action like the iodides, and are useless for lesions to which they cannot be conveyed directly through the blood stream. They are best administered by intravenous injection; the solution may be injected into the vein by a puncture through the skin with a hollow needle or the vein may be exposed and opened with full antiseptic precautions as in the transfusion of blood or saline solution. The usual dose of salvarsan is 0.6 gm. in 40 cc of freshly prepared sterilized saline solution. This mixture is rendered alkaline by adding drop by drop 1 cc of a 15 per cent solution of sodium hydrate, constantly agitating the mixture. Saline solution is next added to make 300 cc. Each 50 cc of the mixture contains 0.1 gm. of salvarsan.

Clinical experience has proved these arsenical compounds to be of great value in the treatment of syphilis, being absolutely curative in some cases, shown not only by rapid and permanent disappearance of the symptoms, but also by the persistently negative Wassermann tests.

A number of injections are required and should be given in courses with an interval of rest.

Salvarsan injections cause the rapid disappearance of the lesions in syphilis, but if they are not continued at intervals or mercury or iodides not given relapses are almost certain to occur.

The best results have been obtained by the more or less prolonged use of mercury and the iodides after the injections of salvarsan.

After the infusion of salvarsan, patients within a few hours sometimes develop gastric irritation, high temperature, weakness and vertigo and loose stools. Death has followed the injection of salvarsan in a number of cases.

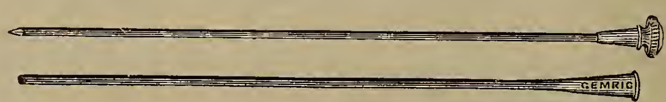
Exploring Needle.—This consists of a fine-grooved needle fitted into a handle (Fig. 156), which is introduced into

Fig. 156.

Exploring needle.

tumors or swellings to ascertain the nature of their contents, its use is often of service for purposes of diagnosis. The exploring trocar (Fig. 157) is employed for the same purpose, or the needle of the hypodermic syringe or a fine needle attached to an aspirator may be used for a like purpose. When either the exploring needle or trocar is employed care should be taken to see that it is rendered perfectly aseptic before being used; otherwise its employment is not without

Fig. 157.



Exploring trocar.

danger for we have seen the introduction of an exploring needle into an effusion in a joint for diagnostic purposes followed by infection and destruction of the joint, which subsequently necessitated its excision.

Skin Grafting.—This is a surgical procedure which may employed to insure healing or to hasten cicatrization where large granulating surfaces are exposed, such as result from extensive operations and from burns.

The operation consists in applying shavings of the epidermis, or of the epidermis and cutis together, to the granulating surface and holding them in contact with it for a few days; the grafts often seem to disappear, but at the end of a few days, if the part is closely inspected, bluish-white points will be seen to occupy the positions at which the grafts were applied, which become converted into isolated islands from which the healing process rapidly extends. To have a successful result follow the use of skin grafts the granulating surface should be healthy, and its surface as well as the surrounding skin rendered aseptic and the grafts should be applied at a number of points.

When it is possible grafts should be taken from the body of the patient. Autografts are more likely to grow than those taken from another person. Skin containing hair is not suitable for grafting as it is difficult to sterilize and is not so likely to grow, and deformity may result from the reproduction of hair upon the grafts. Grafts are usually taken from the skin of the outer surfaces of the thighs or arms or from the lateral thoracic or abdominal walls.

Skin grafting may be employed to cover fresh raw surfaces at the time of operation or later when the surfaces are covered with granulations.

Three methods of skin grafting are usually employed, known as the Reverdin, Thiersch and Wolfe-Krause methods.

Reverdin's Method.—In applying skin grafts by this method, small portions of the skin are raised on the point of a needle and cut off with a sharp scalpel or scissors and transferred immediately to the granulating surface which has been previously prepared. The graft is applied to bring the raw surface in contact with the granulations and is pressed firmly upon them, a sufficient number of grafts are applied to partially cover the granulating surface. As the individual grafts are small, this method of skin grafting is not employed where the raw or granulating surface is extensive. After the skin grafts have been applied the entire area is covered with a layer of wide meshed paraffine gauze over which is placed a pad of gauze moistened with saline or 2 per cent sodium bicarbonate solution. The dressing need not be disturbed for five or six days, at which time inspection will show that many of the grafts have taken.

The surface from which the grafts are to be taken should also be rendered aseptic and the skin should be removed by scissors or by a sharp razor, or by raising the epidermis with a needle or with forceps and cutting out a small portion with a sharp scalpel.

Thiersch's Method.—In skin grafting, according to this method, the surface of the ulcer is rendered aseptic, and all antiseptics are washed away with sterilized salt solution. The surface of the ulcer is next curetted to remove soft granulations, and it is then irrigated and covered with a moist compress to control bleeding. Long strips of the epidermis with only the superficial layers of the cutis are then removed from a surface—which has been rendered aseptic—by means of a razor or section knife while the skin is made taut; the use of McBurney's hooks (Fig. 158) will facilitate

Fig. 158.

McBurney's hook.

the removal of the grafts. Each graft should be as long and broad as possible, and when cut it should be floated from the section knife upon the prepared surface of the ulcer by a stream of salt solution and gently pressed into place. After a sufficient number of grafts have been applied, strips of protective or a layer of paraffine gauze are laid over the surface of the grafts, and over these is placed a compress moistened with salt solution, and a few layers of sterilized gauze and cotton are next applied over this, and the dressing is held in position by a bandage.

The dressings need not be removed for a week or ten days and a second dressing should be applied in the same manner until the grafts have become thoroughly vitalized. The skin of the bellies or backs of frogs, or the hairless skin of young animals has been used in place of human skin, but has not proved satisfactory.

Wolfe-Krause's Method.—Skin grafting is sometimes accomplished by immediately applying an isolated piece of skin to a raw surface to fill a gap; the graft in such cases includes the whole thickness of the skin, but has all of the cellular tissue removed from it, and should be cut one-third larger than the gap to be filled to allow for the shrinking after its removal, it is secured in position by sutures.

The wound should be dressed as in the other methods of grafting and the dressings should be covered with a hot-water bag for a few days. This is the best method of grafting for a raw surface after operation if it can be covered by a single graft. If the graft is more than 7 cm. in diameter it is not likely to retain its vitality. A modification of this method, which is often successful in granulating surfaces, is to cut numerous grafts from 1 to 2 cm. in diameter and apply them to the granulating surface not more than 1.5 cm. distant from each other. The wound should be dressed as previously described.

Bone Transplantation or Bone Grafting.—This procedure is resorted to to replace portions of bone which have been lost by disease or operation, to fill up cavities in bone, or for immobilization of the spine in tuberculosis, in ununited fractures to bridge the gap and give fixation and act as an osteoconductive tract to promote bony union. It consists in transplanting a portion of bone from one part of the body to another and bringing it in contact with living bone; the bone transplanted should if possible have the periosteum retained, but one without periosteum may be successfully transplanted. It is essential that the graft be removed from the same individual. The bone transplant is usually taken from the subcutaneous surface of the tibia, a portion of a rib or parts of other bones may be used.

Albee has developed a very satisfactory technic for bone transplantation or bone grafting, which can be employed in fractures, ununited fractures and tuberculosis of the spine (p. 526).

The transplant, according to Murphy, being brought in contact with living osteogenetic bone at one or both ends, always becomes united to the living bone and acts as a scaffolding for the reproduction of new bone of the same size and shape as the transplanted fragment. The transplanted fragment gives mechanical support to the capillaries and bloodvessels, with their living osteogenetic cells, as they advance from the living bone at both ends of the transplant. New lamellæ are deposited around the new capillaries so that bony union is actually formed before the transplant is entirely absorbed and replaced by new bone.

The transplanted fragment is always ultimately absorbed. Murphy holds that the regenerative cells are supplied entirely from the osteogenetic cells of the capillaries from the living bone, and that the graft is absolutely necessary for the regeneration.

The surface of bone covered with periosteum should not be brought in contact with living bone, as the Haversian vessels of the living bone do not penetrate the fibrous periosteum of the transplant and regeneration does not take place.

To obtain regeneration of bone in bone transplantation it is essential that the wound is aseptic.

The technic of the operation is as follows: The bone surfaces to which the transplant is to be applied are freshened with saw or chisel and a cavity is made in each fragment with a reamer of sufficient size to accommodate the ends of the transplant. An accessible bone of the same individual, the anterior edge of the tibia, the upper edge of the ulna or the upper portion of a rib is next exposed, and a section of bone of the desired size is removed with a saw and chisel. The size of the graft required depends upon the size of bones to which it is to be applied and the defect which it is desired to bridge. This transplant is then transferred to the bone surface prepared for it, the ends of the transplant being fitted into the cavities previously made, acts as a dowel and fixes the fragments. If additional fixation is required screws or a metal plate may be employed. The wound is next closed by deep and superficial sutures without drainage, and the part is immobilized by the application of a plaster-of-Paris dressing.

In the case of parallel bones, such as the tibia and fibula, where there has been a loss in substance of the tibia, the fibula has been divided on a line with the lower end of the tibia, and after freshening the end of the tibia the upper end of the lower fragment of the fibula is shifted over to the tibia and secured to it by sutures.

Decalcified Bone Plates or Chips.—These were formerly used in filling up the cavities resulting from extensive removals of bone by injuries or in the operation for necrosis or caries. They were not usually successful on account of the difficulty of completely sterilizing the bone cavity.

Bone Wax.—This material, devised by Mosetig-Moorhof, is employed to fill up cavities in bone remaining after the removal of diseased bone or tumors of bone. The wax is prepared by melting together iodoform, 20 parts; spermaceti, 40 parts; and oil of sesame, 40 parts. This preparation is heated to 50° C. and is poured into the cavity, which has been rendered sterile and dry, and when the wax has become firm the soft tissues are sutured over it. The cavity may be dried and sterilized by the hot-air blast or it may be seared with the actual cautery, or swabbed with formalin and dried with sterile gauze. Very good results have been obtained by the use of this preparation, although symptoms of iodoform poisoning have been reported from its use.

Moore has employed a bone wax containing iodine which he considers more satisfactory than that of Moorhof. It consists of iodine, 1 per cent.; olive oil, 2 parts; and spermaceti, 8 parts. The iodine is added after the spermaceti and olive oil have been mixed in a water bath, and heat should not be applied after the iodine has been added. The mass becomes solid at the body temperature. The *bismuth emulsion* recommended by Beck may also be used in the same manner as bone wax in filling cavities in bone. This consists of bismuth subnit., 30 gm.; white wax, 5 gm.; vaseline, 60 gm.

Thiersch grafts have also been employed with success in the treatment of open surfaces in bone cavities. The surface of the bone cavity is covered with Thiersch grafts and they are held in contact with the bone by a dry gauze tampon.

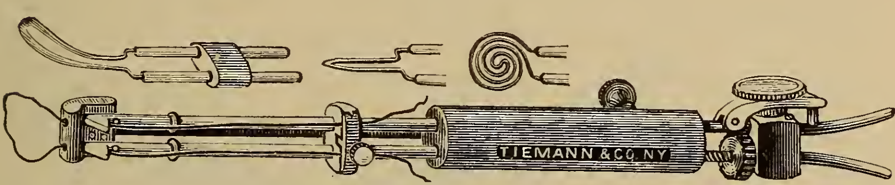
Muscle grafting and *nerve grafting* are also occasionally resorted to to supply deficiencies in muscles or nerves, fresh muscle or nerve tissue being employed to fill up the gap. Fat is also used to fill cavities or other defects.

Electrolysis.—Electrolysis, or the chemical decomposition induced by electricity is employed in surgery to destroy morbid products, tumors or exudations. For this procedure a galvanic or continuous-current battery is required, which is provided with electrodes and needles of suitable shapes. In applying electrolysis to a tumor, for instance, the needle connected with one of the poles of the battery is inserted into the tumor, and the other rheophore is applied to the surface of the body, or two fine needles, carefully insulated nearly to their extremities, are connected with both poles of the battery by conducting cords; these are introduced into the tumor and a weak current is allowed to pass. The strength of the current is gradually increased as the operation advances; the current is passed for fifteen or twenty minutes, and the procedure is repeated at intervals of several days until some decided change occurs in the tumor.

Electrolysis has been applied with success in the treatment of aneurysm inaccessible to other operative procedures, in malignant growths, in nevi, goiters, cysts and hydatids. It is at the present time the most satisfactory method of removing superfluous hairs from those portions of the body in which their presence causes disfigurement.

Galvano-cautery.—Galvano-cautery batteries are so constructed with plates of large size, placed closely together, that the internal resistance is reduced and a current is quickly obtained which will keep a metallic electrode at a white heat. The advantage in the use of this form of cautery is that the electrode can be introduced into the cavities of the body while cold and quickly heated to the desired temperature. The electrodes are made of various shapes and sizes, according to the object desired (Fig. 159). The galvano-cautery is applied for the same purpose as the actual cautery; but, as previously stated, its use is more convenient in the cavities of the body, its action can be more easily localized and by its use hemorrhage is avoided. It is frequently employed to destroy morbid growths in the nasal passages, the throat, vagina or uterus and also may be employed in the treatment of superficial external growths; in using it for the removal of growths from the mucous membrane, its application may be rendered practically painless by previously thoroughly cocainizing the parts.

Fig. 159.

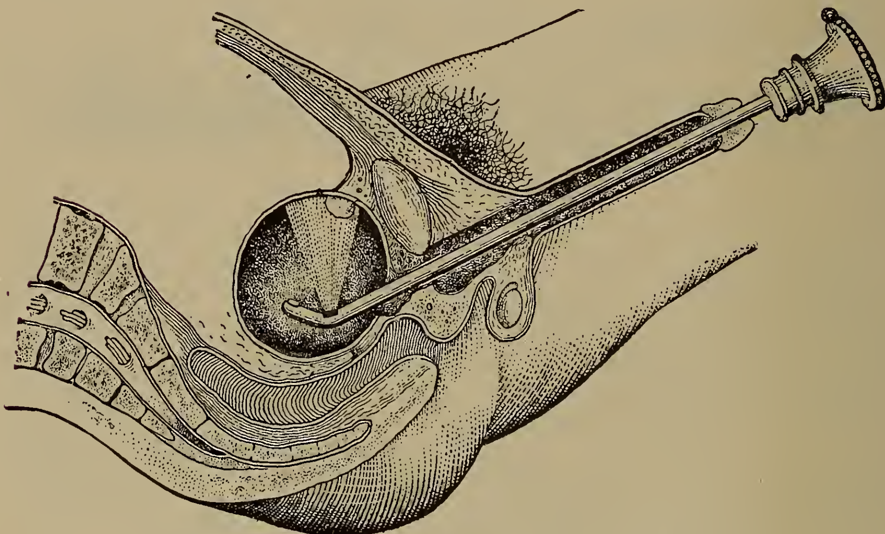


Electrodes for galvano-cautery.

Faradization.—The application of electricity in this form is often employed in surgical affections; in cases of wasting of the muscles following fractures or sprains, in some forms of club-foot and in lateral curvature of the spine the judicious use of the faradic current will often be found to be followed by the most satisfactory results. The current is applied in such a manner as to bring about contraction of the affected or wasted muscles and thus improve their nutrition.

The Cystoscope.—This is an instrument employed for ocular examination of the walls of the bladder, and is one of the most important and useful of the electric-lamp instruments. In females visual inspection of the interior of the bladder may be made by passing a narrow speculum into the bladder through the urethra with the patient in the knee-elbow or exaggerated lithotomy position, which allows the bladder to become distended with air as soon as the speculum is introduced. A cystoscope consists of a beaked sound in which there is a telescopic arrangement, by which the inner surface of the bladder is viewed through a small window of rock crystal. The lamp is enclosed in the beak of the instrument and throws its light through another window, also of crystal, upon any part of the bladder wall. Before introducing the cystoscope the deep urethra may be anesthetized by an injection of 4 per cent eucaine solution; in some cases a general anesthetic is required. The urine is drawn and the bladder irrigated with a boric-acid solution. If pus and blood are present in the urine the irrigation is continued until solution returns clear. Six to 8 ounces of the solution is next injected and allowed to remain as it is necessary that the bladder should contain this amount

Fig. 160.



Illumination of the wall of the bladder by the cystoscope.

of clear fluid if a proper view of the walls is to be obtained. If the fluid is turbid or contains blood the view is very much obscured; if too little fluid be present in the bladder the beak of the instrument containing the lamp is likely to become buried in the folds of mucous membrane and the light will be cut off, and the mucous membrane may be burned. The bladder may be emptied of urine and distended with air which accomplishes the same purpose. The cystoscope (sterilized in formalin solution, as it cannot be boiled) is introduced and when its beak is within the bladder the current is turned on and the operator proceeds to inspect the interior of the bladder. The ureteral orifices may be seen and the escape of urine, blood or pus from them observed. The condition of the vesical mucous membrane is carefully observed and foreign bodies, tumors or calculi or diverticula may also be located.

Cystoscopes are also provided with slots through which, it is possible to insert delicate instruments to make applications to ulcers, cauterize or excise tumors or locate and remove foreign bodies. In this manner catheters may be inserted into the ureters for the purpose of obtaining a separate specimen of urine from each kidney. A certain amount of practice is required to use the cystoscope properly and to recognize the appearance of the mucous membrane of the bladder in health and in its varied morbid conditions.

The Urethroscope.—The urethroscope consists of a straight metal tube provided with an obturator of hard rubber, which projects slightly beyond the end of the tube. This tube is introduced into the urethra until the bladder is reached, when it is slightly withdrawn and the obturator removed. The instrument is then attached to the mirror of an electric lamp, by which a strong light is thrown into the tube, and as the tube is withdrawn the urethra is exposed to view. By means of the urethroscope a very accurate inspection of all portions of the urethra can be obtained.

The Panelectroscope.—This instrument, introduced by Leiter consists of an electric lantern with tubes and a mirror. The light from a small incandescent lamp is projected by the mirror along the tube which is inserted into the part to be examined. Tubes of various sizes are adapted to the instrument. It is employed for endoscopy of the urethra, ear, pharynx and stomach.

Catheterization of the Ureters in the Males.—This is accomplished by introducing the cystoscope and passing through slots in this instrument, ureteral catheters or bougies. As soon as the position of the ureteral orifices are located the catheters or bougies are introduced. By this procedure unilateral or bilateral disease of the kidneys may be demonstrated as well as the condition of the ureters themselves. It is also useful in estimating the functional capacity of the kidneys.

The same instrument may be employed for the catheterization of the ureters in the female, but since the ureters are more accessible in the female, the direct or Kelly's method may be employed. The patient is placed in the dorsal position with the pelvis elevated in an exaggerated lithotomy position, or in the genu-pectoral position which allows the bladder to become distended with air as soon as the speculum is introduced; the external meatus is anesthetized by cocaine and the urethra is dilated to admit a cylindrical speculum 12 to 15 mm. in diameter. With the aid of a head mirror the interior of the bladder can be directly inspected. The opening of the ureter may be exposed by turning the speculum 30 degrees to one side and is recognized as a small depression, the mucous membrane being of a darker color than elsewhere. A delicate elastic catheter can be introduced into this opening, and by careful manipulation may be passed to the pelvis of the kidney.

Estimation of the Functional Capacity of the Kidneys.—This is accomplished by *chromo-ureteroscopy* by means of the indigo-carmine test; 4 cc of a 4 per cent solution of indigo-carmine is injected into the muscles or intravenously and the cystoscope is introduced. This solution stains the urine blue if the kidneys are healthy. Stained-blue urine should be observed to escape in less than nine minutes; non-appearance in the urine of the blue-staining in twenty minutes indicates serious incompetency of the kidneys. Or the ureters may be catheterized and the urine collected from each kidney separately tested. The phenolsulphonephthalein test may also be used as described by H. H. Young: The patient is given three glasses of water to drink and is then catheterized and the bladder washed out, and 1 cc of fluid containing 6 mg. of the drug is injected intramuscularly or intravenously. The time of the appearance of the first faint pinkish tinge as the urine escapes from the catheter into the test-tube, made alkaline by adding 1 drop of 25 per cent NaOH solution, is noted at the beginning of the test. In healthy patients the drug appears in the urine in about seven minutes after it is administered; 40 to 60 per cent is excreted in the first hour and from 20 to 25 per cent in the second hour.

Direct Laryngoscopy, Bronchoscopy, Esophagoscopy and Gastroscopy.—These are procedures using self-illuminated tubes which serve as specula for endoscopic examination and treatment of the interior of the larynx, bronchi, trachea, esophagus and stomach.

The perfection of the technic and the elaboration of the instruments employed in this procedure are due to the genius of Chevalier Jackson. The endoscopic tubes are without lenses, are straight and rigid instruments used as other specula to displace tissues that obstruct direct vision or draw tissues to be inspected into a new position into the line of sight.

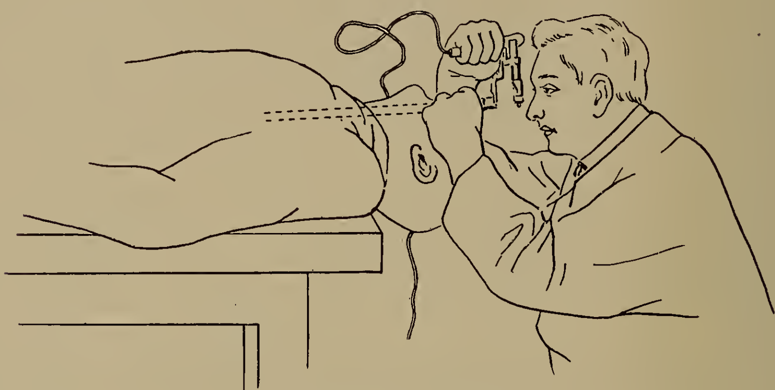
Through these tubes many of the most ingenious instruments, such as forceps, sponge-holders, loops, hooks, bougies, etc., are used for various procedures such as the removal of foreign bodies—pins, tacks, pieces of bone, safety-pins, needles, coins and staples—dilatation of structures, diagnosis of disease by inspection and removal of tumors and specimens of tissues for examination. By the use of instruments devised by Jackson it is possible in skilful hands to change the position of foreign bodies so as to make their withdrawal possible and safe, to close an open safety pin, to change the position of a pin or staple so that the point cannot interfere with its removal.

Jackson, in the use of the bronchoscope, laryngoscope or esophagoscope, does not use an anesthetic. Even in children in dyspnea general anesthesia is absolutely contraindicated. In adults he uses a hypodermic injection of a full dose of morphine to lessen the cough reflex. He paints the surface of the pharynx with a 10-gr. solution of cocaine.

Jackson states that these instruments can be passed into any patient who is able to open his mouth. In the introduction of these instruments the patient is placed upon a table and his head brought beyond the edge so that the middle of the scapula rests upon the edge of the table; the head is held by an assistant who can move it as directed by the operator. The instrument is passed into the larynx if inspection of this organ is desired, and deeper into the trachea or a bronchus if these parts are to be inspected.

In Jackson's clinic, bronchoscopic removal for foreign bodies has been successful in 98 per cent. of the cases. In 386 cases there were 6 failures to remove, and the mortality was 1.7 per cent. To use these instruments with success a considerable amount of practise is required.

FIG. 161.



Bronchoscopy. (Ashhurst.)

Massage.—Massage consists in a variety of manipulations, such as pinching up the integument and muscles and rolling them between the thumb and fingers; in stroking or rubbing the surface with the palm of the hand from the periphery toward the center, to empty the distended veins and lymphatics; rubbing the parts circularly with the extremities of the fingers and thumbs or the palms of the hands. Kneading of the parts is another method of practising massage. Massage may also be practised by tapping the surface of the affected part more or less forcibly with the tips of the fingers held in a row, or with the ulnar border of the hand or the palm of the hand. Before applying massage to an affected part, if there be a heavy growth of hair, it should be shaved off; otherwise the manipulation may give the patient pain and irritation of the hair follicles resulting in abscesses will be apt to occur. The part should also be rubbed over with olive oil, vaseline or cacao butter before and during the manipulations.

Massage is employed often with advantage in the treatment of sprains and strains in their subacute and chronic stages. Lucas-Championnière advocates and practises immediate and continuous massage in the treatment of fractures. It will also be found of great service in the later treatment of fractures involving the joints or their vicinity in restoring the motion of the parts as well as in improving the nutrition of muscles which have become wasted from disuse.

Passive Motion.—This manipulation consists in alternately flexing and extending or rotating the limb to imitate the normal joint movements. The motions should be carefully practised and in cases of fracture near joints they should not be undertaken, as a rule, until there is firm union at the seat of fracture; if for any reason passive motion is made use of before this time the fragments should be firmly supported while it is being employed. Other forms of massage, such as stroking and kneading, may be employed in conjunction with passive motion in the treatment of the stiffness of joints resulting from fractures, dislocations and sprains; passive motion applied in this manner in conjunction with baking, will often restore the function of a stiff joint more satisfactorily and with less pain to the patient than the forcible manipulations which are sometimes practised under an anesthetic.

Compression.—This is a valuable means of diminishing swelling in the early stages of inflammation and of bringing about the absorption of the effusion in the later stages. It may be applied by means of compresses, bandages or strapping. Pressure applied in this manner is often employed in the treatment of injuries of the joints and bursæ, and in chronic inflammatory swellings. It should be used with caution when the circulation in the tissues is impaired.

Application of Hot Air or Baking.—The employment of a continuous hot-air bath has recently been advocated in the treatment of painful and partially anchylosed joints, synovitis, tenosynovitis and chronic rheumatism. In applying this method of treatment the limb is wrapped loosely with a number of layers of woolen blanket and introduced into a metallic cylinder, the temperature of which is raised to about 300° F. The part is exposed to this temperature for twenty minutes to one hour, and at intervals of twenty minutes the door is opened for a short time to allow the ingress of fresh air; if the part is perspiring it is wiped dry, for if moisture is present upon the limb scalds are likely to result. Electric bakers are now generally used, having superseded the bakers heated by gas. In using the latter the part is covered and several layers of woolen blankets and a metallic hood, which is adapted to different parts of the body, is placed over the parts and the current which operates the electric lamps is turned on. Under this form of treatment pain is often temporarily or permanently relieved, synovial effusions absorbed and adhesions are softened and disappear. Clinically it has been found that the best results following this method of treatment have occurred in painful and anchylosed joints following traumatisms; and although temporary improvement has occurred in rheumatic, gouty, tuberculous and gonorrheal affections of joints, permanent improvement is not so likely to result. Massage is frequently employed directly after the baking. Bier has also recommended the use of hot air to produce arterial hyperemia in the treatment of certain joint and neuralgic affections, the part to be treated being enclosed in specially devised hot-air boxes.

Bier's Hyperemic Treatment.—Bier has called attention to the value of an artificial congestive hyperemia in the treatment of acute and chronic inflammations. He recognizes two kinds of congestion: (1) Arterial or active, produced by him with hot air; (2) venous or passive congestion.

Passive hyperemia may be caused by: (*a*) suction and (*b*) by constriction. To produce passive hyperemia by suction a glass vessel or cup is applied to the skin with a rubber bulb or suction pump attached to rarify the air within. The cups are now made of various sizes and shapes to adapt themselves to all surfaces of the body (Fig. 162). In applying this method the procedure should not cause pain and the suction should be intermittent. The patient is the best judge as to the amount of suction. If the patient complains of pain from the suction it is excessive and a lesser degree should be employed. If the suction is not intermittent but little benefit is derived. The cup is applied for three or four minutes, then renewed for one or two minutes and this procedure is repeated at intervals for at least half an hour.

Fig. 162.

Suction cup applied.

Fig. 163.

Rubber band applied to the arm to produce passive hyperemia.

This method of artificial hyperemia is employed with good results in abscesses, acute or chronic, enlarged or inflamed lymphatic glands, furuncles, carbuncles and many other localized inflammatory conditions.

If pus is present a small incision should be made and the subsequent suction favors its escape.

Passive hyperemia by constriction is produced by placing a thin rubber band or tube around a part and thus producing a congestion of the parts distal to it (Fig. 163). The compression should be just sufficient to produce a reddish-blue coloration of the skin, but never whiteness, beyond the point of constriction. It is especially applicable to the extremities. The arterial pulse should not be interfered with and should be as free as that upon the opposite limb. The temperature of the constricted part should be the same as the corresponding part on the other limb.

The constriction should not cause pain in the congested area. It should be noted that in acute inflammatory affections slight pain and throbbing is experienced even if the constriction is not too thoroughly applied. This usually disappears in from five to ten minutes.

By rubbing the parts active hyperemia should be produced.

When applied above wounds serum is poured out which improves the drainage and escape of pus.

When edema appears the treatment should be suspended and not resumed until it disappears.

If the part is edematous before the treatment is begun multiple incisions should be made before this is instituted.

The case should be under careful observation during the course of treatment and if any of the following signs appear it is evident that the compression is not accurate:

1. If the parts become very cyanotic.
2. Marked pain and discomfort.
3. Coldness of the part beyond the point of constriction.
4. Pulse diminished in force or lost.
5. Development of edema.
6. Non-appearance of active hyperemia upon rubbing the part.

The duration of treatment in acute cases should be short. Half an hour to an hour three or four times a day at intervals for twenty-four hours. It has been followed by good results in acute pyogenic infections. It has been employed in wounds of the extremities and inflammation of joints with most satisfactory results. Abscesses, if present, should be incised, but drainage should not be introduced. Bandages should be removed before the constriction is applied to permit of swelling of the congested part and not interfere with drainage.

In chronic cases the constriction should be applied for a longer period—from two to four hours a day for a number of days. Applied in this manner it has been employed with marked success in tuberculous affections of the bones and joints, chronic ulcers and in ununited fractures.

Patients can be taught how to apply the constriction to produce the proper amount of compression, and when so instructed can use this method of treatment at their own homes.

Active or Arterial Hyperemia.—This is produced by surrounding the affected area by hot air. This is accomplished by an apparatus which encloses the part, leaving an air space which is connected with an alcohol lamp. Various forms of hot-air boxes have been devised to fit different parts of the body. This form of treatment has been found especially serviceable in rheumatic joints, neuritis and neuralgia.

SKIAGRAPHY, OR EMPLOYMENT OF THE ROENTGEN RAYS.

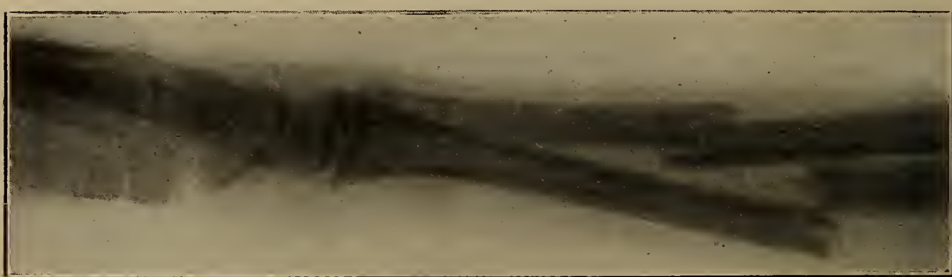
Roentgen, in 1895, while investigating the cathode rays as developed in Crookes' tubes, discovered the energy which he named *x*-rays. The rays are invisible, but have great power of penetration and pass through many substances which are opaque to sunlight and ordinary electric light. If the rays are intercepted by a body not readily permeable, which is placed between the Crookes' tube and a dry photographic plate, a shadow will be formed and an impression of this shadow will be formed upon the plate. Such a shadow is known as a *roentgenograph*. The fluoroscope consists of a fluoroscope screen, which is so placed that the rays emanating from the Crookes' tube and passing through any intercepted substance to be studied are reflected directly upon it.

If the body is more or less resistant the observer can see it clearly through the skin and subcutaneous tissue.

The time of exposure to the rays varies with the strength of the current and the thickness of the tissues. The exposure is usually from a few seconds to a few minutes. The tube should not be placed too near the surface of the body, and the exposure should be as short as possible. Exposures of a few seconds are now generally made.

There occasionally develops after the use of the roentgen rays a peculiar disturbance of the tissues, probably trophic in nature, which is known as a roentgen-ray or x-ray burn. The skin, several weeks after exposure to the rays, may become ulcerated, the nails may be lost and a very intractable form of ulceration or gangrene develop.

Fig. 164.



Fracture of both bones of the forearm. (Ashhurst.)

The roentgen rays are of great value in locating foreign bodies (Fig. 165), such as needles (Fig. 166), pins, bullets (Fig. 167) and pieces of glass if it is lead glass. A staple in left bronchus is shown in Fig. 168. They are employed also with advantage in locating mineral calculi in the bladder, ureter and kidney. They are also of value in locating purulent collections in the chest, subdiaphragmatic abscess and changes in the solid viscera. In carcinoma of the stomach and intestines or ulcers of the stomach or duodenum roentgen-ray studies, after the administration of barium are of great value. They are also useful in detecting the presence of fractures and dislocations. In fractures

FIG. 165.

Roentgenograph of jackstone in the esophagus. (Newcomet.)

FIG. 166.

Roentgenograph of needle in the hand. (Newcomet.)

about the joints, epiphyseal separations and ununited fractures their use has proved most satisfactory. Roentgenographs of fractures are shown in Figs. 169 and 170; of a bullet in the leg in Fig. 167; and of an epiphyseal separation of the humerus in Fig. 171.

Fig. 167.

Roentgenograph of bullet in the leg. (Newcomet.)

Roentgen-ray and Radium Therapy.—Roentgen Rays.—Changes produced in the cells by roentgen rays are identical with those seen after the application of radium rays. They should only be applied by an expert roentgenologist. Their fiction appears to consist in stimulating an overproduction of abrous tissue by which the growth of cellular elements is arrested or abolished.

These have been employed, where the cases are suitable, in the treatment of various ulcerations and tumors (both benign and malignant), in simple indolent ulcerations, uterine fibroids, enlarged glands and spleen associated with leukemia, warts, superficial epitheliomata about the face and hands and deep carcinoma or sarcoma where operation is not possible, as a preoperative and postoperative measure for prevention of recurrence in malignancy (especially in the breast, where it is often impossible to reach the deep glandu-

Fig. 168.

Roentgenograph of a staple in the left bronchus. (Newcomet.)

lar involvements of the various lymphatic chains, in the axilla or neck or chest) where it is used previous to operation for its effects upon the lymphatics changing them into fibrous tissue, in diseases of the skin (eczema, psoriasis, sycosis, tinea tonsurans and affections of kindred nature). In diseases involving the hair the cure usually follows complete depilation.

The "erythema dose" has been adopted as a standard and consists of that amount of exposure to the rays which will produce a slight redness of the skin. The principal factors involved in producing it depend upon the time of exposure, character of the ray, distance from the source and the filters employed. They must be modified according to the disease to be treated, as in superficial conditions, filters are not absolutely required. The reaction desired is a superficial one,

Fig. 169.

Roentgenograph of separation of upper epiphysis of the humerus.

and will be produced in less time without them. In a deep "dose" heavy filtration (3 mm. or more) of aluminum or corresponding thicknesses of copper or other metal, must be used and the roentgen-ray tube should be further away from the surface of the skin and a generator of higher value should be employed.

Radium.—Radium is used in the treatment of similar conditions, but has a much wider range of utility. It is usually employed by having one of the various salts, chloride or bromide, carbonate or sulphate, the last being very insoluble is preferred, placed in an applicator, the form depending upon the character of the disease to be treated. The "plaque," a piece of flat metal 1 or 2 cm. square, which has upon the

Fig. 170.

Multiple fracture of patella. (Newcomet.)

active surface 5 or 10 mg. of radium salt incorporated in a varnish is employed in the treatment of various dermal conditions. It may be used in the treatment of nevi, especially the cavernous type. When the radium is to be placed in cavities it is employed in small tubes of glass covered by silver, aluminum, lead or platinum, containing from 5 to 100 mg., estimated upon the basis of radium element and when it is to be placed directly in the tissues hollow pointed tubes of steel or non-corrosive metal called "needles" will be found useful. In institutions having a sufficient amount of radium the "emanation" is employed. It requires extensive and complicated apparatus for its collection. Being a gas, it is possible to obtain a very large dosage in an extremely small capillary tube. These small tubes or "seeds" may be

Fig. 171.

Roentgenograph of separation of upper epiphysis of the humerus.

imbedded directly in the tissue and not removed. As the activity of the radium products depend upon "active deposit" for their useful radiation, which is the gamma ray, it is immaterial if one employs a salt of radium, which has been properly aged, or the emanation. The latter being encased in a thin glass tube, permits the employment of considerably more of the beta radiation, which under some circumstances has been found desirable. The alpha radiation is practically never used.

When radium or emanation is used upon the surface of the body or when it is imbedded in tissues, the dosage is calculated in milligram hours for radium and millicurie hours for emanation, with notation as to the distance from the parts and the filters interposed. When a "plaque" is employed besides the beta and gamma rays there may be a small amount of alpha radiation present, but a thin piece of paper or rubber will remove it, and if the beta rays are not desired, practically all may be removed by employing a sheet of lead 1 mm. thick. Where the penetrating gamma rays alone are desired a small tube of lead or platinum with walls 1 to 3 mm. thick should be employed. These tubes are usually covered with rubber of about the same relative thickness to remove the secondary radiation which produces a degree of local irritation, due to the non-penetrating character of these rays. They are usually spoken of as being soft rays and to a great extent worthless compared with the hard rays which are penetrating. Radium has proved of value in carcinoma of the cervix uteri, as it brings the radiation in direct contact with the disease. It is not to be recommended for carcinoma of the body of the uterus. In carcinoma of the mouth, nose and other cavities of the body good results have been obtained. Thorium salts may be employed in the same manner as those of radium except their life is shorter.

In the employment of either roentgen rays or radium great care must be exercised not to produce a "burn" which will vary in degree depending upon the individual and the amount of radiation. In the milder form, the destruction of tissue may be slight, but healing is always slow and in those cases where there has been extensive destruction of tissue malignant disease may follow. In the more chronic effect of irradiation observed in those working about laboratories skin irritations, warts, keratoses, degenerations of the nails and hair of the hand, and, in more severe forms, malignancy follows. Varying degrees of telangiectasis often follow reactions upon the skin in the acute cases.

ANESTHETICS.

Anesthetics are agents which temporarily abolish sensation, inducing a condition which is known as anesthesia, which should be distinguished from analgesia which is characterized by the abolition of pain. Anesthesia may be *local, regional* or *terminal* or *general.*

Local Anesthesia.—This results from the direct application of anesthetic agents, such as cocaine or novocaine which are dissolved in saline solution, to nerve terminations, and causes analgesia of the tissues of a limited extent. Local anesthesia has the advantage over general anesthesia in that it is practically free from anesthetic accidents, changes in the blood and the dangerous and uncomfortable symptoms which often follow general anesthesia. It has the disadvantage that the patient knows what is being done, and for this reason cannot be employed with satisfaction in children and nervous adults.

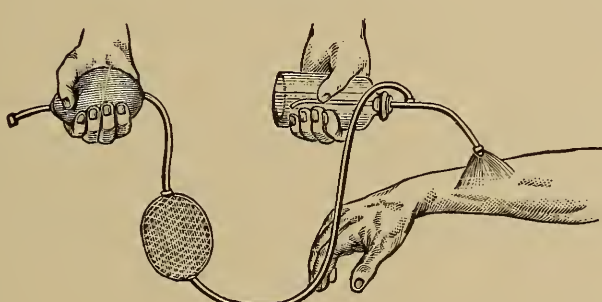
The safety of local anesthesia compared with that of general anesthesia should influence the decision of the surgeon in the selection of an anesthetic for operations. Local anesthesia is especially used in minor operations upon the fingers, toes, external genitals, superficial abscesses and tumors.

Extensive operations can be performed in proper subjects under local anesthesia, even operations involving the viscera; its use, however, is usually restricted to minor surgical operations and debilitated cases in which the administration of a general anesthetic would be dangerous. The field of local anesthesia has been extended since it has shown that viscera innervated by purely visceral nerves are insensitive, and sensation exists only in those which receive branches from the somatic nerves. The parietal peritoneum is very sensitive to pain. The stomach, intestines, edge of the liver, gall-bladder, mesentery, bladder, kidney, lung, testicle and epididymis, except their coverings, are insensitive. These organs may be incised, sutured and handled without causing pain, but if traction is made upon them pain is produced by reason of their parietal attachments. The skin and mucous membrane, near orifices and connective-tissue, muscle and fascia are less sensitive. Bloodvessels are sensitive while attached to connective tissue. Bone, cartilage and tendons are insensitive, the periosteum and perichondrium are insensitive. Articular synovial membrane is very sensitive. It may be produced by the use of cold, a spray of ether, rhigolene, ethyl chloride or kelene, cocaine or eucaine hydrochlorate, novocaine, holocaine hydrochlorate, stovaine hydrochloride, or by Schleich's method of infiltration.

Regional Infiltration or Terminal Anesthesia.—This is also sometimes described as *neural* anesthesia and results from the application of anesthetic agents to the nerve roots, nerve trunks or the spinal cord. The analgesia in this form of anesthesia extends from the point of application to the tissues supplied by the nerve or nerves and therefore is not limited in extent.

General Anesthesia.—This is characterized by unconsciousness, as well as abolition of sensation and may be induced by the administration of nitrous oxide gas, ether, chloroform, chloride of ethyl or kelene, A.-C.-E. mixture, C.-E. mixture, Schleich's anesthetic mixture or scopolamine. It may also be induced by a combination of these substances with nitrous oxide gas or oxygen. Hypnotism may also be employed to produce general anesthesia.

Fig. 172.



Application of rhigolene spray.

Local Anesthesia.—Cold.—Local anesthesia may be produced by the application of cold or freezing mixtures, either by a piece of ice or a mixture of ice and salt held in contact with the part for one or two minutes, or by directing a spray of *rhigolene or sulphuric ether* upon the surface of the part whose sensibility is to be obtunded (Fig. 172).

Chloride of Ethyl or Kelene.—This substance is used also to produce local anesthesia and is conveniently furnished in glass tubes, one end of which is drawn out into a fine point and hermetically sealed or in a tube with metal cap which can be unscrewed. When used the end of the tube is broken off or the cap removed and a fine jet of ethyl is projected upon the part to be anesthetized, the warmth of the hand being sufficient to force the fluid from the tube; analgesia occurs in less than a minute. This form of local anesthesia is made use of in minor surgical procedures, such as aspiration, the opening of abscesses and the removal of superficial tumors.

The objection to these methods of anesthesia consists in the pain which accompanies the thawing process and the interference with the vitality of the tissues by the freezing, which prevents prompt healing.

Cocaine.—Local anesthesia produced by the employment of an aqueous solution of the hydrochlorate of cocaine 1 to 100 to 1 to 200 or from $\frac{1}{2}$ to 2 per cent is often made use of in minor surgical procedures. Solutions as strong as 10 or 12 per cent were formerly employed, but experience has proved that there is always danger in the use of the stronger solutions of cocaine, so that it is now considered wise not to use one stronger than $\frac{1}{2}$ or 2 per cent, as the full analgesic effect can be obtained by a solution of this strength. When mucous membrane is to be operated upon or growths removed from it, analgesia is produced by brushing over the surface with the solution of cocaine, or by applying to the part for a few minutes a compress of absorbent cotton saturated with it; in mucous cavities the latter method of application will be found most convenient. It is the most effective local anesthetic for mucous membranes. It is unwise to use over $\frac{2}{3}$ gr. upon mucous surfaces, and not more than $\frac{1}{3}$ gr. should be used hypodermically; care should be taken that it does not enter a vein. In using a solution of cocaine to produce anesthesia in operations upon the eye a 2 per cent solution is dropped into the eye, and is repeated until analgesia is complete.

In applying cocaine to the urethra a 1 to 2 per cent solution is injected and is allowed to remain for two or three minutes; more than 1 or 2 gr. should not be injected at one time, as fatal results have followed the injection of larger quantities; this is especially the case in using cocaine in the urethra and the rectum and in these situations great caution should be exercised in its employment.

When it is desired to produce analgesia of the skin or deeper tissues the application of cocaine to the surface is not satisfactory and it should in such cases be injected *hypodermically* into the deeper layers of the skin and into the cellular tissue of the parts to be operated upon; to avoid multiple punctures the needle is not completely withdrawn from the wound, but its direction is changed and the solution is thrown into different portions of the tissues. It is not safe to inject more than $\frac{1}{3}$ gr. of this drug. It is well in situations where it can be accomplished, as in operations upon the hands and feet, to cut off the circulation from the part to be operated upon by placing around it a rubber strap or tube which prevents rapid absorption of the cocaine into the general blood current.

In employing any of these drugs hypodermically to avoid the pain following the puncture of the skin by the needle a minute drop of carbolic acid may be applied to the skin at the point of puncture which anesthetizes the skin so that the patient does not feel the insertion.

Some persons have an idiosyncrasy for cocaine, and children seem more susceptible to its constitutional effects than adults. I have seen several instances in children in which marked symptoms of cocaine poisoning resulted from the application of a 4 per cent solution to the nasal mucous membrane.

Cocaine poisoning is shown by restlessness, pallor, dryness of the mouth and weakness of the pulse; in dangerous cases there may be delirium or syncope.

The treatment of cocaine poisoning consists in placing the patient in the recumbent position and the hypodermic injection of morphine, strychnine or ether.

Cocaine analgesia may be employed with advantage in minor surgical operations, such as amputations of the fingers, circumcision, opening of abscesses and removal of superficial tumors, but its utility is most marked in operations upon the eye and upon the mucous membranes of the nose, throat, rectum, vagina and urethra. Applied for a few minutes to the surface of an ulcer which is to be cauterized, it will render the operation almost painless.

Eucaine Hydrochlorate (*β Eucaine*).—This drug, which possesses the same properties as cocaine as regards the production of analgesia, is employed as a local application to mucous surfaces and hypodermically in the deeper tissues to produce local and regional anesthesia. It has the advantage over cocaine that it can be used with safety in much larger quantities, as it is apparently free from toxic action. Kiessel states that 2 gm. have been injected without the production of toxic symptoms. It may be used in solutions varying in strength from 2 to 10 per cent, which may be sterilized by heating; a 2 per cent solution is that most usually employed hypodermically. It produces dilatation of the bloodvessels and may cause bleeding; this may be counteracted by combining it with adrenalin.

Novocaine.—This drug is similar in its action to cocaine, but is six times less toxic and is at the present considered the safest and most useful local anesthetic.

It is not destroyed by boiling, but is injured by contact with free or carbonate alkalies, and should not be used with instruments boiled in soda solution. Its effect is not as lasting as that of cocaine, but combined with adrenalin it is very effective; it is less effective than cocaine in producing analgesia of mucous membranes.

It does not cause irritation of the tissues or lower the blood-pressure. A 5 per cent novocaine solution has nearly the same specific gravity and freezing point as blood serum. It is used in a 2 to 4 per cent solution, or in a solution 1 to 200 to 1 to 400. It may be combined with adrenalin in the following solutions.

Solution No. 1:

1–400.	Novocaine	. . . .	grs. ii
	Saline solution	. . . .	f℥iss
	Adrenalin (1–1000)	. . . .	♏v

Solution No. 2:

1–200.	Novocaine	. . . .	grs. iv
	Saline solution	. . . .	℥iss
	Adrenalin (1–1000)	. . . .	♏v

Solution No. 1 may be employed for infiltration anesthesia, and used in amounts up to 3 ounces. Solution No. 2 may be used for endoneural infiltration.

Holocaine Hydrochlorate.—This drug, used in a 1 per cent solution, possesses as decided analgesic action as cocaine; it is also strongly bactericidal in its action. It may be used locally without producing constitutional symptoms, but cannot be used internally or injected into the tissues, on account of its marked toxic action.

Stovaine Hydrochloride.—The drug is said to have analgesic properties equal to cocaine, and is only one-third as toxic. It is acid in reaction, may be boiled without injury and acts as a vasodilator. It has a marked action on motor nerves and paralyzes the muscles supplied by the nerves affected by it. It is dangerous as a spinal anesthetic and if used in the nose may cause troublesome bleeding. It may be dissolved in warm water or salt solution. It is employed in the same manner as cocaine and eucaine to produce local anesthesia. The solution used is 2 to 5 per cent.

Apothesin.—The drug has a low toxicity and marked analgesic action in a 1 per cent solution. A combination of adrenalin (1 to 1000), 5 drops, to apothesin solution, 1 ounce, is used to produce infiltration analgesia.

Quinine-urea Hydrochloride.—This is a double salt of quinine and urea. It is dissolved in salt solution or sterile water. A 0.25 per cent solution is effective in inducing prolonged local anesthesia. The anesthesia may last for hours. A 10 per cent solution may be used externally or for anesthesia of mucous membranes. It has been used successfully in operations for hernia and in operations upon the anus. It is said to be most effective and the prolonged anesthesia insures the patient comfort after the operation. In massive doses it tends to devitalize the tissues.

Procaine.—This substance recently introduced closely resembles novocaine in its properties and may be used for the same purposes and in the same strength as novocaine solutions.

Adrenalin, Suprarenin, Epinephrin.—This drug is frequently used in combination with local anesthetic agents. It should be used in a strength of 1 to 10,000 and for injection of nerves or infiltration anesthesia in strength of 1 to 50,000 or 1 to 150,000. It should not be admitted into the general circulation except in very diluted solutions.

Infiltration or Terminal Anesthesia.—It has been shown by Liebreich that injection of simple water into the tissues in sufficient quantity to produce edema induces a transitory anesthesia. Infiltration is the preferred method of inducing local anesthesia. It results from the pressure of the injected fluid upon the nerves and by the direct action of the anesthetic substance upon them. It is called terminal anesthesia because the anesthetic acts upon the terminal branches of sensory nerves and regional anesthesia because the fluid injected affects the nerves of a localized area. To obtain anesthesia of a certain area the part should be distended by wide infiltration. Schleich found that minute quantities of cocaine and morphine in salt solution produced thorough and prolonged anesthesia. The solution he used consisted of cocaine hydrochlor. ($1\frac{1}{2}$ gr.), morphine hydrochlor. (gr. $\frac{1}{3}$), sodii chlor. (3 gr.) and aquæ dest. ($2\frac{1}{2}$ ounces). The fluid should be isotonic with the blood and should contain the least amount of the anesthetic agent necessary to render the part anesthetic. The addition of a small amount of adrenalin to the solution retards the circulation, hence favors analgesia and lessens bleeding during the operation.

Mitchell employs a tablet containing $\frac{3}{4}$ gr. of cocaine and $\frac{1}{400}$ gr. of adrenalin. These tablets are dry sterilized and before the operation solutions of two strengths are made by dissolving one tablet in a cup of saline solution containing 50 cc, another by adding a tablet to 100 cc of saline solution. The stronger solution is employed for infiltrating the skin or blocking nerves and the weaker solution is used for general infiltration of the tissues. The total dosage of cocaine by infiltration should not exceed 1 or $1\frac{1}{2}$ gr.

The solution is first injected into the skin by a needle which is passed in different directions which causes wheals to appear. If deeper infiltration is desired the needle is passed in the cellular tissues and muscles and they are injected with the solution. The operation may be begun after one or two minutes, and if during the operation pain is manifested additional infiltration should be made.

Infiltration anesthesia was first employed in minor operations, but its use has now been so extended that it is employed in many major operations, amputations, appendicitis, goiter, gastro-enterostomy, colostomy, typhoid perforation and many other operations. This method of anesthesia requires patience and skilful manipulation on the part of the surgeon and the intelligent coöperation of the patient.

The injection of the anesthetic agent into the nerve sheath or into the nerves supplying the part where the nerves are accessible is one of the most satisfactory methods. It is known as the *paraneural* or *endoneural* anesthesia. The tissues overlying the nerve are rendered insensitive by the injection of the solution and the nerve is exposed by dissection and the injection is made into the sheath or into the substance of the nerve. The result is complete anesthesia of the parts supplied by the nerve for twenty-five to thirty minutes. This method is frequently employed in operations upon the extremities and other parts of the body where the administration of a general anesthetic is considered inadvisable.

In children and nervous subjects it cannot be employed with advantage. It also has the disadvantage of causing swelling and edema of the tissues at the seat of operation, which may interfere with the satisfactory recognition of the various anatomical structures.

Epidural or Sacral Anesthesia.—The nerve trunks which form the sciatic and pubic nerves may be anesthetized in the spinal canal at the sacrococcygeal junction. The patient is placed upon his abdomen, a long needle is inserted and passed into the lower opening of the sacral canal and directed upward from $1\frac{1}{2}$ to 2 inches. A one-half of 1 per cent solution of novocaine is injected. By this injection satisfactory anesthesia generally results for operations upon the bladder and rectum.

Parasacral Anesthesia.—The sacral nerves may be anesthetized as they emerge from the sacral foramina. The patient is placed in the lithotomy position, the tip of the coccyx located, a mark made upon the skin $1\frac{1}{2}$ to 2 cm. from the midpoint. A needle is passed into the tissues at this point and pushed upward in the hollow of the sacrum until it strikes the bone. The needle is then withdrawn 1 cm. and 25 cc of a 0.5 to 1 per cent. novocaine solution is injected as the needle is withdrawn to the skin. The needle is then introduced at a slightly greater angle to strike the bone at a depth of 10 to 12 cm. After withdrawing it 1 cm. 20 cc of the solution is injected. The needle is withdrawn and 5 cc of the solution is injected between the coccyx and the rectum. The same procedure is repeated on the opposite side. For operation upon the uterus and adnexa, lumbar paravertebral anesthesia should be added.

Spinal or Subarachnoid Anesthesia.—Corning, Bier and Tuffier found that spinal analgesia may be produced by the injection of anesthetic substances into the subarachnoid space, which extends from the second lumbar vertebra to end of the dural sac at the third sacral vertebra. The drugs employed are cocaine, eucaine, novocaine, tropocaine and stovaine; an isotonic solution of one of these drugs is employed.

Cocaine and eucaine in 0.05 per cent. solution have been employed but seem to be more dangerous than novocaine, tropocaine and stovaine so that the latter are generally used. Novocaine in a 5 per cent solution or a stovaine solution made of stovaine, 4 parts, lactic acid, 2 parts, glucose, 5 parts, distilled water enough to make 100 parts or a 5 per cent solution of tropocaine which is heavier than the cerebrospinal fluid and sinks before it diffuses, may be used. The patient may be given a preliminary injection of morphine ($\frac{1}{6}$ gr.) or morphine and atropine (gr. $\frac{1}{150}$) an hour before the spinal injection to diminish the psychic shock.

The technic of the operation is as follows: The entire lumbar and sacral regions should carefully be sterilized, and the position of the third lumbar interspace—that is, the space between the third and fourth lumbar vertebræ—located. The patient next sits astride of the operating-table and bends forward in the position of ventral flexion, with his elbows resting upon his knees, which widens the space between the third and fourth lumbar vertebræ, or it may be given with the patient on his side with the body bent forward. A few drops of novocaine are next injected into the skin over the center of this space. A needle between 1 and 2 mm. in circumference, about three times the circumference of the ordinary hypodermic needle, and $2\frac{1}{2}$ to 3 inches in length, attached to a syringe, is next inserted through the skin midway between the spinous processes, or a puncture by a tenotome may be made through the skin and the needle inserted through this. The needle and syringe should be thoroughly sterilized by boiling before being used. The needle should be pushed forward and a little upwards to cause it to enter the spinal canal in the median line, and as soon as resistance disappears and fluid appears in the syringe it is evident that the canal has been entered. In no case should the analgesic solution be injected unless the fluid escapes satisfactorily. After a few drops of fluid have escaped the syringe is removed from the needle and replaced by one containing the anesthetic solution, and 15 to 20 minims of the solution are injected into the spinal canal. The needle is then removed and the puncture sealed with a small piece of gauze and collodion and the patient placed in the recumbent posture. In a few minutes anesthesia is usually sufficiently advanced for the operation.

Spinal anesthesia should not be employed in children, nor in nervous and excitable patients, but may be employed in cases where certain a general anesthetic is contraindicated.

Following spinal injection, nausea, vomiting, cardiac or respiratory failure or headache may occur. Paralytic affections of the ocular nerves and spinal paralysis have resulted from its use. It fails to furnish satisfactory anesthesia in from 5 to 10 per cent of the cases.

Spinal anesthesia is a dangerous method of anesthesia which has not increased in popularity, and probably has a mortality of 3 to 2000 according to Tuffier. It should be confined to operations below the diaphragm and should not be employed as a routine method of anesthesia.

Jonnesco employed high spinal anesthesia in which the injection is made at a level appropriate to the region to be operated. This is an even more dangerous method and is not to be recommended. The spinal injection of magnesium sulphate has also been used; 1 cc of a 25 per cent solution is employed; it is slow in its action, two or three hours often elapsing before analgesia results; recovery of sensation after its use is also slow.

General Anesthesia.—This is characterized by the loss of consciousness and abolition of sensation. It may be induced for surgical purposes by the inhalation of the vapor of volatile liquids or gases. As the anesthetic state produced by these drugs is one in which positive dangers exist, it should be maintained for as short a time as possible. The administration of the anesthetic should be in the hands of one who has had special training and experience in its use.

The substances used for general anesthesia are ether, chloroform, nitrous oxide gas or combinations of these drugs, ethyl chloride or kelene, A. C. E. mixture and scopolamine-morphine.

Preparation of Patient.—Before the administration of a general anesthetic the patient should have a careful examination a day or two before operation, if possible, to ascertain the condition of the heart, lungs and kidneys. Patients suffering from uncompensated valvular disease or myocardial degeneration especially the latter, are not good subjects for general anesthesia. The presence of albumin does not contraindicate the use of general anesthetics, but the risk of operation is increased. Sugar in the urine increases the risk of the anesthetic; diabetic coma may develop. The danger is not entirely dependent on the amount of sugar; cases showing a small percentage of sugar may develop coma, and in others, in which a large amount is present, develop no symptoms. The presence of acetone is always dangerous. If any of these conditions are present, except in cases of great urgency, the operation should be postponed and appropriate treatment instituted.

The bowels should be thoroughly moved the day before the operation; this is especially important in operations upon the intestines and rectum. The stomach should be empty at the time of anesthetization to avoid vomiting, which is a troublesome complication. During the twelve hours before operation no solid food should be given. If the patient is weak a little liquid nourishment may be given four hours before. In operations upon emergency cases where the stomach is full and vomiting occurs during the use of the anesthetic, great care should be taken to keep the fauces free, or in such cases the stomach should be washed out before the anesthetic is given. It is important that the patient has a good night before the operation; this should be secured by the use of medicine if necessary.

The amount of the anesthetic required may be diminished by the administration of $\frac{1}{6}$ gr. of morphine and atropine sulph. $\frac{1}{150}$ gr. one-half to one hour before the anesthetic is given. This is not indicated in all cases but acts well in nervous and timid patients and those who use alcohol to excess. Its use is most satisfactory before the administration of nitrous oxide. Its use is contraindicated in children, or aged or cachetic subjects, or those with obstructive dyspnea from goiter or disease of the respiratory tract. The use of morphine in properly selected cases insures the patient a quieter anesthetization and more comfortable period after recovery from the anesthetic. Atropine alone may be given if there are excessive excretions from the fauces and respiratory tract.

Choice of Anesthetic.—In selecting an anesthetic the surgeon should be guided by the results of his examination of the patient, its safety and suitability to the individual case. Ether is the safest and most easily administered anesthetic, and should be selected for the majority of patients. It is a cardiac stimulant and increases the blood-pressure, but causes irritation of the kidneys and pulmonary mucous membranes. Hence, it should not be used in cases having high arterial tension, arteriosclerosis, inflammation of the respiratory tract or nephritis.

Chloroform is a cardiac depressant and lowers blood-pressure, is stronger than ether and should be administered in smaller amounts with a greater quantity of air and requires more skill, experience and watchfulness in its administration. In this climate its employment is attended with more danger than ether. In hot climates the use of chloroform is attended with less danger, but in experienced hands may be used in old persons with high blood-pressure and for short operations in children.

The mortality for general anesthetics is, as given by Hewitt, as follows: In 400,000 ether administrations, 1 in 16,000 cases; chloroform, 1 in 3162 cases; ethyl chloride, 1 in 3000 cases. No deaths from nitrous oxide and oxygen. In American cases the death-rate of nitrous oxide has been reported as 1 in 6905 cases. Nitrous oxide is extensively employed, and is generally given by experts which would account for the low mortality. Persons suffering from *status lymphaticus* often die suddenly during the administration of general anesthetics.

An anesthetic should never be given to a woman without the presence of a third person, as in some cases these agents give rise to erotic dreams, and it may be difficult to disabuse the patient's mind of the idea that an assault has been committed unless the evidence of eye-witnesses at the time of the anesthetization can be brought forward to prove that such was not the case.

Administration of a General Anesthetic.—The patient is placed upon his back and covered with one or more blankets to prevent the surface from being chilled, and the head should be turned to one side as in this position mucus is less apt to collect in the pharynx and interfere with breathing. The anesthetizer should confine his attentions strictly to the patient and should have at his side a table on which are placed the mask or inhaler, the anesthetic, a hypodermic syringe, a basin, tongue forceps, sponge holders, wooden screw mouth gag and a hinged mouth gag. He should assure himself that the patient has no foreign body in his mouth, such as false teeth, chewing gum or tobacco. He should examine the patient's heart and pulse before administering the anesthetic; this enables him to detect any irregular action, and at the same time has a good moral effect upon the patient if he can assure him that he is in good condition to take the anesthetic. A tactful anesthetist can do much to allay the fears of the patient. He should watch the patient closely during the administration of the anesthetic and should not have his attention diverted by the operation. He should carefully observe the pulse, respiration and color of the patient's face and be prepared to withdraw the anesthetic upon the development of any symptom of danger and to treat such symptoms should they arise.

Nitrous Oxide Gas.—This gas, by reason of its great volatility, produces anesthesia rapidly and the patient recovers quickly. It is inhaled through a tight-fitting mask. It produces deep cyanosis, due to the exclusion of oxygen from the lungs and red-blood corpuscles. It is a very safe anesthetic when given by an anesthetizer skilled in its administration. It is used in short operations, but a prolonged anesthesia may be conducted if it is combined with oxygen. It is at the present time not much used in its pure state but is combined with oxygen.

Nitrous oxide causes anesthesia by arresting the oxygenation of the blood while it is in contact with it, and, in addition, the gas produces anesthesia by direct action on the cerebral cortex. Nitrous oxide gas is contraindicated in alcoholic subjects, or in those having marked atheroma of the arteries, as apoplexy may occur, or in any condition of obstructed respiration. It should never be administered in cases of angina Ludovici, sublingual abscess or enlargement of the thymus gland. The apparatus best suited for its administration consists of a cylinder of metal in which the gas is compressed, which is attached to a rubber bag, which has a mouth-piece fastened to it; this is provided with a double valve, which prevents the expired air from passing back into the bag. The mouth-piece is adjusted over the mouth, and after removing any false teeth or foreign bodies from the mouth the patient is instructed to take deep, full breaths, and in from one-half to one minute the face becomes congested and dusky and the breathing becomes stertorous, indicating that the patient is fully under the influence of the gas. The anesthesia from nitrous oxide cannot be prolonged for more than a few minutes, unless it is given in conjunction with oxygen, so that it can only be employed in operations which take a short time for their performance, such as the extraction of teeth and the opening of abscesses. Unfortunately, it cannot be used in the reduction of fractures or dislocations, as it does not produce complete muscular relaxation. Nitrous oxide is frequently used to produce anesthesia, and when this result is accomplished the anesthesia is kept up by the administration of ether.

Nitrous Oxide and Oxygen.—The combination of nitrous oxide gas, 92 to 94 per cent, with oxygen, 6 to 8 per cent, is the least depressing of any anesthetic and is widely employed at the present time for short or prolonged anesthesia. It should be administered by a skilled anesthetist. The amount of oxygen required is guided by the occurrence of cyanosis and stertor; these call for an increase in the oxygen. To determine this cyanosis in administering this gas to negroes requires great skill. It causes no damage to the blood and is followed by the least shock, and recovery from anesthesia is very rapid. It may be given to old persons and children, but not to infants. It causes a rise in the blood-pressure and should not be used in cases of marked arteriosclerosis, emphysema, valvular disease with dilated heart or regurgitant aortic lesions. It does not produce complete muscular relaxation and if this is desired the use of a little ether may be required to bring about this result.

The anesthetic state is not produced as rapidly as by nitrous oxide gas alone, but it may be prolonged by a skilful anesthetizer for hours. It is administered by a special apparatus, by which the administrator can increase or diminish the amount of oxygen, according to the symptoms presented. The apparatus now generally employed carries two cylinders —one containing nitrous oxide gas, the other oxygen. These are held by a metal standard, to the top of which is attached a hollow double yoke supporting the gas bags at its ends and a mixing chamber at its center, to which are attached the tubing and mouth-piece. Valves are added by which the supply of gas and oxygen may be regulated.

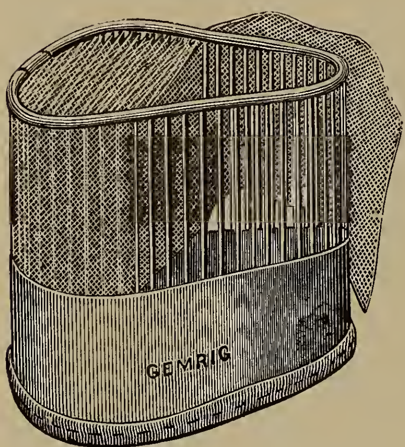
Ether.—Sulphuric ether is one of the most widely employed substances in surgery to produce anesthesia; it is probably the safest of all anesthetics, except nitrous oxide gas, and for this reason should be preferred to all others. Its effects, according to Hare, result from the action of the drug—first on the brain, then on the sensory tracts of the spinal cord, then on the motor tracts, then on the sensory side of the medulla oblongata, and finally upon the motor side of the medulla, and thereby produces death from respiratory failure if given to excess. Its administration is attended with risk in the following cases: (1) In infants, in whom it causes irritation of the bronchial mucous membrane, with profuse secretion of mucus and may cause also bronchopneumonia. (2) In aged persons a profuse secretion of mucus and bronchopneumonia may follow its use; it is also contraindicated in those subjects in whom there are rigidity of the chest and lessened respiratory power. (3) In advanced organic disease of the kidneys, and especially in nephritis of the interstitial form with urine of a low specific gravity and in diabetic subjects. (4) In disease of the heart its administration is more dangerous in myocardial than in valvular lesions. (5) In cases of obstructed respiration from swelling of the pharynx, fixation of the tongue in cancer and cellulitis of the neck, and in emphysema and abdominal distention. (6) In cases in which examination of the blood shows that the hemoglobin is diminished to less than 50 per cent. (7) When the bronchial irritation following its use may impair the result in operations for hernia and in laparotomy.

It should also be borne in mind that the vapor of ether is very inflammable, and that it is heavier than the air, so that lights brought near the patient while being etherized should be held at a higher level than the ether can or inhaler. Care also should be exercised in employing actual cautery near ether vapor.

The anesthetizer should cover the patient's eye with a compress of moist gauze and should be careful that no ether comes in contact with the conjunctiva, as severe *ether conjunctivitis* has resulted from this accident. He should also be careful in testing the sensibility of the cornea not to touch it with the finger, but should press upon it through the eyelid, for infection of the cornea, resulting in sloughing, has resulted from neglect of this precaution.

Ether produces more irritation of the respiratory tract than chloroform and its administration is sometimes followed by the development of bronchitis, pulmonary congestion or pneumonia. These complications are less likely to occur if care is taken to avoid the administration of ether in patients who are suffering from bronchial irritation and to see that a patient who has taken ether is not exposed to draughts and is not allowed to go out into cold or moist air immediately after recovering from the anesthetic.

Fig. 173.



Allis' ether inhaler.

Administration of Ether.—In the administration of ether a towel folded into a cone, a pad composed of a number of layers of gauze or one of the various ether inhalers may be employed. The best of these is Allis' inhaler, which consists of a metallic framework covered with leather or a nickel-plated case, which carries a number of folds of a roller bandage, giving a large surface for the rapid evaporation of the drug (Fig. 173). This inhaler provides the patient with a large amount of atmospheric air; at the same time it permits the anesthetizer to administer sufficient quantities of ether vapor.

If a towel folded into a cone is used a few layers of stiff paper interposed between the outer layers of the towel will keep the cone in shape and prevent the rapid evaporation of the ether from its external surface.

The *open or continuous drop* method is now very generally employed in administering ether. Although it is more wasteful of ether and requires a longer time to produce anesthesia, the patient does not receive an excessive quantity of ether vapor, and is less likely to suffer from pulmonary and renal irritation and gastric disturbances than when administered by the closed method.

In administering ether by this method a pad of gauze, consisting of about twelve layers, is held lightly over the nose and mouth of the patient, and ether applied drop by drop, the point of saturation of the gauze being constantly changed. If the gauze is not too tightly held on the nose and mouth sufficient atmospheric air is inhaled with the ether vapor.

In administering ether the drug is continuously dropped upon the gauze or inhaler placed over the nose and mouth of the patient. He is then requested to take deep breaths, or to blow the ether away, which latter procedure causes him to take deep inspirations. In the beginning of etherization the patient will resist the inhalation much less vigorously if the ether is given slowly with a plentiful admixture of air. The first effect of the inhalation of ether is to produce acceleration of the pulse and respiration; the mucous membrane of the air passages is irritated and coughing often occurs; there is also in this stage a disposition to muscular movements, and it is frequently necessary to restrain the patient; the brain also is excited and the patient is apt to cry out. These symptoms call for a continuance of the administration of the ether, and not for its withdrawal. Succeeding the stage of excitement, if the ether be pushed, profound anesthesia takes place, as is evidenced by the loss of consciousness, relaxation of the muscular system, moist skin, loss of special senses, contracted pupils and slow and deep respiration, tending to become stertorous. When the conjunctiva is insensitive to the touch of the finger anesthesia is usually profound. When the anesthesia is complete the amount of ether inhaled should be diminished, and the patient given only so much as will keep him well under its influence. It is surprising how small a quantity a careful and watchful anesthetizer will require to keep the patient fully under its effects for a considerable time. The time required to produce anesthesia varies in different cases; it is produced in children in a few minutes; in adults from ten to twenty minutes are usually required; drunkards and those who have taken ether frequently require a larger amount and a longer time to come under its influence. After the administration of the drug is stopped the patient may continue for some time in an unconscious condition, resembling a quiet sleep, or he may awake and exhibit more or less symptoms of cerebral excitement.

First Insensibility from Ether (*Ether Rausch*).—There often exists in the early course of the administration of ether a stage of primary anesthesia which lasts for a minute or more, and which may be taken advantage of to perform such a minor surgical operation as opening an abscess, reduction of a dislocation or a fracture, or extraction of a tooth. The recovery from this condition is usually very prompt, and is not followed by nausea or the after-effects which attend the prolonged administration of ether.

Accidents during Etherization.—During the administration of ether, particularly in the early stage, the patient may suddenly stop breathing, the face at the same time becoming cyanosed. This condition calls for withdrawal of the ether; and if an inspiratory effort does not quickly follow, pressure should be made upon the front of the chest, and when this is relaxed a deep inspiration usually takes place, and no further difficulty is experienced. This condition should not be confounded with the very common effort of holding the breath, the latter occurring with the chest fully expanded, the former with the chest empty.

Vomiting may occur during etherization, and the vomited matter may accumulate in the pharynx or the mouth, and obstruct the breathing or may enter the larynx or trachea and cause a like result. Vomiting is more apt to take place if solid food has been taken shortly before the administration of the anesthetic. If this accident occurs and interferes with breathing the jaws should be opened and the head turned to one side, when the vomited matter will usually escape without difficulty. If, however, food has entered the larynx, and is not ejected by coughing, it will be necessary to perform tracheotomy promptly and hold the tracheal wound open, or to introduce a tracheotomy tube and practise artificial respiration. The breathing may also be obstructed by the accumulation of *mucus* and *saliva* in the pharynx. This is less likely to occur if the head is kept to one side during the administration of the drug; if it occurs the head should be turned to one side, the jaws opened and the material removed with small sponges or pieces of gauze fixed to sponge holders.

The *tongue* may fall backward and obstruct the breathing when muscular relaxation is complete during anesthesia; this accident is also less likely to occur if the head is kept to one side during etherization. If asphyxia results from falling back of the tongue, it should be brought forward by placing the fingers on each side beneath the angles of the inferior maxillary bone, and pushing the jaw forward, at the same time overextending the neck by bending the head backward

Fig. 174.

Pushing the jaw forward.

(Fig. 174), or the mouth should be opened and the tongue drawn forward with tongue forceps. Either of these manipulations is usually sufficient to reëstablish the respiratory movements.

If, however, in any of these forms of mechanical asphyxia respiratory action is not promptly restored, some form of artificial respiration should promptly be resorted to, either Laborde's or Silvester's; and of these, Laborde's method, by rhythmical traction of the tongue, and Silvester's have yielded the most satisfactory results. Sudden arrest of cardiac action may call for *cardiac massage* (p. 236). Efforts at resuscitation in these cases should be persevered in for at least half an hour, as apparently hopeless cases have been saved by persistent use of these means.

Failure of respiration may occur also from paralysis of the respiratory centers, or spasm of the respiratory muscles; the former may occur from an overdose of the anesthetic, or from intercurrent asphyxia, syncope or morbid states of the respiratory system.

Spasmodic respiratory failure may occur before complete anesthesia, and is liable to arise in muscular and emphysematous subjects. Respiratory failure from either of these causes should promptly be treated by artificial respiration and the hypodermic use of strychnine, atropine or digitalis.

After-effects of Ether.—After complete anesthesia from ether, nausea and vomiting are very common, and both are more apt to follow in case the patient has taken food shortly before the administration of the anesthetic. They may last for only a short time or may persist for hours. If persistent, the swallowing of a few mouthfuls of hot water will often relieve the condition; or the administration of cocaine hydrochlorate ($\frac{1}{4}$ gr.) with crushed ice, repeated two or three times, or the use of crushed ice with champagne or brandy, may be followed by satisfactory results. The inhalation of oxygen, begun as soon as the ether has been suspended and continued for some time is now frequently employed with good results. Inhalation of the fumes of *vinegar* will often prevent nausea and vomiting, the vinegar being poured upon a towel or a piece of gauze, which is being held over the mouth and nose of the patient, and it should be applied as soon as the administration of the ether is stopped; it should be used continuously for some time to be followed by the best results.

Pharyngeal Insufflation.—In operations upon the mouth, face or larynx the vapor of ether may be administered through rubber tubes or catheters, introduced into the pharynx through the nostrils. The tubes are lubricated and passed through the nares into the pharynx and transfixed with a safety pin to prevent them slipping further than is desired. These are attached to a vessel containing ether and air, and the vapor mixed with air is forced into the tubes by a hand bulb or foot-pump bellows.

Intratracheal Insufflation Anesthesia.—In this method of anesthesia ether and air are supplied to the lungs through a catheter passed through the glottis into the trachea. To the free extremity of the catheter is attached a rubber tube, connected with the air-pressure apparatus, and air mixed with a definite quantity of ether is blown through the tube at a pressure of 10 mm. of mercury. After a few minutes the pressure is raised to 20 mm.

The air pressure is maintained by an electric motor or a foot bellows. This method of producing anesthesia has been advocated by Dr. Elsberg, who has also perfected a portable apparatus for supplying the anesthetic mixture at the proper pressure.

The technic is as follows: The patient is first given ether in the ordinary manner until well relaxed. The tube, in a given case, should fill about one-half of the lumen of the trachea. A No. 29 Fr. rubber catheter, which is the size required for an ordinary adult (for children an 18 to 22 catheter is required), is passed through the glottis in the trachea with the aid of the Jackson direct laryngoscope, the head of the patient being allowed to hang over the edge of the table. If one has experience in the introduction of intubation tubes he can introduce the catheter without the aid of the laryngoscope. The catheter should be marked 26 m., and not inserted beyond this depth, as this will place the tip end of the instrument about 2 inches from the bifurcation of the trachea. To prevent the catheter being compressed between the teeth, a special bit holding it is placed between the jaws.

The tube from the air-pressure apparatus is next attached to the catheter, and the anesthetic mixture of air and ether is supplied under the supervision of the anesthetizer.

By this method it is claimed there are secured: "(1) Even and sufficient oxygenation and ventilation of the lungs, with no possibility of obstruction of the upper air passages; (2) the inhalation of blood mucus (vomitus or foreign bodies are prevented by the return current of air around the tube; (3) positive pressure may be attained to any desired degree if one or both pleural cavities are opened by accident or design—the danger of pneumothorax is thus eliminated; (4) in operations upon the head and neck the anesthetist is out of the way of the manipulations of the surgeon; (5) there is no strain upon the respiratory apparatus and consequent strain and harmful effect of the anesthetic upon the cardio-vascular and central nervous systems; (6) there seems to be less shock; (7) the anesthetic is supplied with a free admixture of air, and it is practically impossible to overanesthetize the patient. After the operation is completed the ether is cut off and pure air is furnished to the lungs for a few minutes, and the patient recovers more promptly from the anesthetic state." Experience with this method has demonstrated its safety.

Ether and Nitrous Oxide Gas.—The production of anesthesia by the combined use of nitrous oxide gas and ether has been quite extensively employed both in England and this country. Hewitt considers this method of producing anesthesia far superior to any other method which we possess at the present time. A special apparatus is required which controls definitely the amount of nitrous oxide, ether and air. Anesthesia is produced first by the use of nitrous oxide gas, and, as soon as this is developed the anesthetic state is maintained by substituting the vapor of ether for the nitrous oxide gas. No air is given with the gas until anesthesia is complete, which should be in from two to three minutes. Breathing at this time is stertorous and cyanosis is well marked. After this time air is administered with the ether vapor. Anesthesia by this method is rapidly induced, there is less struggling and spasm, the quantity of ether employed is smaller and the after-effects are less marked, especially vomiting, and recovery from the anesthetic state is more rapid than when ether is used alone.

Ether and Oxygen.—The administration of ether with oxygen gas has been employed to a considerable extent. In the employment of this combination to produce anesthesia the patient is first allowed to inhale a small amount of ether from an inhaler, and a tube connected with the oxygen receiver is then introduced into the inhaler and the oxygen gas turned on, so that the patient is allowed at the same time to inhale the vapor of ether and oxygen gas. A special apparatus may also be employed which regulates definitely the amount of ether and oxygen furnished. Anesthesia produced by this combination is accompanied by less cyanosis, vomiting is rare and the patient recovers very promptly from the anesthetic state. As the ether vapor and oxygen form a highly explosive mixture care should be exercised not to bring a flame near the patient during its administration.

Oil-ether Anesthesia.—Gwathemy, who introduced this method of anesthesia, found that when oil and ether were introduced into the rectum the heat of the body liberated the ether from the oil in the form of gas; this was absorbed by the capillaries of the colon and conveyed by the blood to the liver, and thence by the greater circulation to the heart and lungs. The odor of ether can be detected in the patient's breath three or four minutes after the rectal injection. The patient should be given 1 ounce of castor oil the evening before the operation, and in the morning the bowel should be irrigated until the water returns clear. A suppository of chloretone, 5 to 10 grs., or an emulsion of the same amount of chloretone, should be introduced into the rectum. This rectal medication should be followed in a short time by a hypodermic of $\frac{1}{8}$ to $\frac{1}{4}$ gr. of morphine with $\frac{1}{100}$ gr. of atropine. This preliminary rectal medication is said to diminish the amount of oil-ether mixture required.

The apparatus required is a clamp, a rectal tube $\frac{1}{4}$ inch in diameter and 20 inches in length, a glass funnel and a double tube for washing out the bowel. The injection, which consists of olive oil, 2 ounces, and ether, 6 ounces, should be given twenty to thirty minutes before the time of operation. The tube should be oiled and passed 4 inches into the rectum, and the mixture should be allowed to pass slowly into the rectum, a minute being allowed for the introduction of each ounce of the mixture. In from ten to thirty minutes the patient should be unconscious, respiration regular and muscles relaxed. If anesthesia does not result after 6 ounces have been given, 2 ounces more may be given; more than 8 ounces should not be used. If the breathing becomes labored and cyanosis appears the mixture should be withdrawn and the rectum irrigated with warm water until the patient's condition is satisfactory.

If a satisfactory condition of anesthesia does not result a small amount of ether may be given by inhalation. After the operation the bowel should be irrigated with warm soap suds by the use of the double tube, a gallon or more being used. Bloody stools, abdominal pain and colitis have not followed the use of the oil-ether mixture, and no deaths have been reported.

This method of anesthesia has been sufficiently employed to prove that it is safe and usually efficient. It seems to act well in cases where fear is a factor, and in obese subjects, children and in cases with pulmonary disease. In cases of hemorrhoids, fistula-in-ano and colitis it is contraindicated. The time required in preparation of the bowel eliminates its use in emergency cases.

Chloroform.—This drug, according to Hare, first affects the brain, then the sensory part of the spinal cord, then the motor area of the cord, then the sensory parts of the medulla oblongata, and finally the motor portions of the medulla and produces death from failure of the vasomotor center and of the respiratory center unless, as rarely occurs, the heart has succumbed to the drug.

Chloroform is a most dangerous anesthetic, causing death by respiratory and cardiac paralysis, which may occur in the early stage of its administration, most of the recorded deaths have been in healthy middle-aged subjects at the beginning of its administration.

Chloroform is widely used in the British Islands and upon the Continent; it is not extensively used in this country except in certain districts—as in the southern and south-western districts of the United States, and here, as in India, its use is followed by fewer fatalities than in the northern districts, so that it seems that its use is safer in warm climates. The lessened death-rate from chloroform in hot climates is accounted for, according to Hare, by the fact that operations in the tropics are performed practically in the open air, where the patient receives a free supply of fresh air, while in colder climates the use of heated operating rooms diminishes the supply of fresh air to the patient. Clinical experience has demonstrated that chloroform may be used in aged and very young subjects and in puerperal patients with comparative safety; deaths from chloroform are more common in the middle period of life. It is also to be preferred to ether in patients suffering from emphysema of the lungs, bronchitis and vascular degeneration of the kidneys. It is also employed by some surgeons instead of ether in operations upon the mouth when the actual cautery is used on account of its less inflammable character.

Considerable diversity of opinion exists among different observers as to whether death resulting from chloroform is due to failure of the heart or failure of the respiration, and each has brought forward a large amount of evidence to prove his views correct. Hare states that chloroform acts primarily upon the vasomotor center, secondly upon the respiratory center, directly and indirectly, and lastly upon the heart. Although it has been demonstrated that chloroform is a direct depressant and paralyzant to the heart muscle or its contained ganglia, and that cardiac dilatation of various degrees may be brought about by the administration of chloroform, yet clinical experience shows that paralysis of the respiratory centers is probably the most important factor in causing death during chloroform anesthesia, for circulatory failure in these cases is due to embarrassed or suspended breathing, and the only method of treatment which has been found of value is that which tends to bring about respiratory action, namely, some one of the various forms of artificial respiration.

Chloroform is more dangerous in the earlier stages of the administration and the gravity of the operation appears to have little effect in increasing its danger, as statistics show that the greatest number of fatalities have occurred in minor surgical procedures, such as extracting teeth, amputation of fingers, reduction of dislocations and opening abscesses.

Preparation of Patient.—A patient is prepared for the administration of chloroform as in the case of ether (p. 220), the same precautions being taken as regards the removal of false teeth or foreign bodies from the mouth, and to see that the clothing about the chest and neck does not restrict the circulation or respiratory movements.

Administration of Chloroform.—Chloroform is administered by pouring 1 dram of the drug upon a folded towel, which is first held a few inches from the mouth and nose and gradually brought nearer, but is not allowed to come in contact with the face, as from its local irritating action it will blister the surface; the lips and anterior nares should be anointed with vaseline.

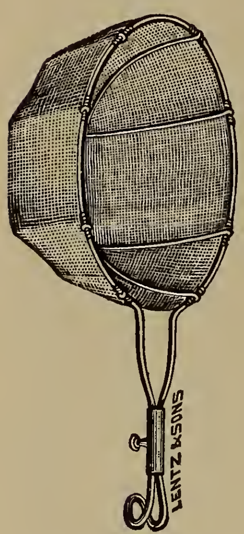
Chloroform should not be administered near the flame of a gas jet or lamp, as the chloroform vapor is decomposed by contact with the flame, producing irritating fumes composed of hydrochloric acid and chlorine, which produces intense irritation of the respiratory passages.

The anesthetizer should remember that one of the dangers in the administration of chloroform is the risk of too great concentration of its vapor, so that he should see that a sufficient admixture of atmospheric air takes place.

Chloroform may also be administered with Esmarch's inhaler, which consists of a wire frame covered with gauze (Fig. 175).

Various inhalers have been devised to regulate the amount of chloroform administered and to secure the proper admixture of atmospheric air, and the best of these probably is Mr. Clover's apparatus.

Fig. 175.



Esmarch's inhaler.

Profound chloroform anesthesia is manifested by insensibility of the conjunctiva to the touch, absence of the reflexes, complete muscular relaxation and usually contracted pupils. When this stage is reached the inhalation should be stopped, and after this time only so much chloroform should be administered as is sufficient to keep the patient fully under its influence.

Complete anesthesia should be produced before any operation is begun; if undertaken before that time syncope may be produced by reflex inhibition of the heart. If convulsive movements take place before the patient is fully anesthetized and the face becomes cyanosed the inhalation should be discontinued until these symptoms disappear. The pupils should also be watched carefully to see if they respond to light or are contracted. If the anesthesia is not complete insensibility to light or wide dilatation is a sign of danger which calls for removal of the anesthetic and active treatment to stimulate the circulation and respiration. If the inhalation has been stopped and is again in a short time resorted to, it should be given very carefully and slowly for syncope may suddenly develop from the fact that the heart or the respiration may feel the effect of the previous use of the drug.

Accidents During Chloroform Anesthesia.—*Mechanical asphyxia* may occur during anesthesia produced by chloroform, as well as that by ether, by obstruction of the respiratory passages by blood, mucus, foreign bodies or the tongue falling backward over the epiglottis. These accidents should be treated in the same manner as when occurring during etherization.

Death during the administration of chloroform may result from sudden circulatory failure or from respiratory arrest and the dangerous symptoms develop so rapidly that the greatest promptness is required to meet them. If the patient presents evidences of cardiac weakness before the administration of chloroform is begun, he should be given hypodermically $\frac{1}{100}$ gr. of atropine, which has proved clinically very active in preventing sudden circulatory collapse. The person administering chloroform should constantly watch both the pulse and the respiration, and should not for a moment have his attention diverted from the patient; great vigilance is here, if possible, more important than during the administration of ether.

Respiratory Arrest.—During chloroform anesthesia paralysis of the respiratory centers may occur, giving rise to respiratory arrest. If this dangerous symptom appears the patient's head should be lowered and artificial respiration promptly employed to reëstablish the respiratory function.

Cardiac syncope, developing during the administration of chloroform, manifested by pallor, fluttering or arrested pulse and cessation of respiration, should be treated by lowering the patient's head or inverting the patient and resorting to artificial respiration or tracheal insufflation. The use of a rapidly interrupted electric current, the hypodermic injection of atropine, gr. $\frac{1}{50}$, or strychnine, gr. $\frac{1}{10}$, hypodermically, into the pectoral muscles should also be employed for the reason that absorption from a muscle is quicker than from the subcutaneous tissues.

If the heart action is not restored by this treatment *cardiac massage* should be employed, the abdomen should be rapidly opened below the costal margin and the hand introduced and the heart grasped through the diaphragm and rhythmically pressed against the anterior chest wall, making *direct massage of the heart*. Cardiac action has been restored in a number of cases by this procedure. The transdiaphragmatic method is more rapid and equally as satisfactory as that in which the chest is opened. In young children the elasticity of the chest wall is so great that pressure upon the heart may be made by compressing it between the hands.

Adrenalin chloride solution in the proportion of ʒj of 1:1000 solution to 1 pint of hot saline solution shall also be given intravenously.

Delayed chloroform poisoning may occur after the patient has recovered from the shock of the operation and the use of the anesthetic. The symptoms of this accident are vomiting, restlessness, active delirium, followed by coma. Jaundice and albuminuria soon develop and death results in a few days. Diacetic acid and acetone may be present in the urine.

Chloroform and Oxygen.—The combined use of chloroform and oxygen is sometimes employed to produce anesthesia. A small amount of chloroform is first administered, and then the oxygen gas is introduced into the inhaler, and the two gases are inhaled at the same time; or a special apparatus may be employed, by means of which a definite amount of each drug may be administered.

C.-E. Mixture.—This consists of 2 parts of chloroform to 3 parts of ether and is highly recommended by F. W. Hewitt for general anesthesia. He considers that in general surgical cases it produces better results than any other anesthetic. And he considers it especially satisfactory in subjects over sixty years of age. Hewitt prefers to administer it by an inhaler, but it may be given by the open method.

The A.-C.-E. Mixture.—This mixture, which consists of 3 parts of chloroform, 1 part of ether and 1 part of alcohol, has been employed by some surgeons in place of ether or chloroform with the idea that the dangers of chloroform are diminished by its combination with ether and alcohol. Clinical experience, however, has not proved this view to be correct. If administered with as much care as chloroform its administration is accompanied with the same safety. It should be administered upon a gauze pad or inhaler in the same manner as chloroform, and the patient should be watched as carefully during its inhalation as during the administration of the latter drug, and any complications occurring should be treated in the same manner as those arising during the use of chloroform.

Bromide of Ethyl.—This drug was introduced as an anesthetic some years ago, but as a number of deaths followed its use, it was abandoned. The time required to produce anesthesia is shorter than for ether, but there is often induced violent muscular spasm, which renders it an unsuitable anesthetic in many cases.

Bromide of ethyl has again been revived as an anesthetic, but clinical experience has proved that its use is not devoid of danger, that it is not as safe as ether and that it possesses no advantages in point of safety over chloroform. When used it should be administered by pouring 1 or 2 drams upon an inhaler or a towel, and the patient should be watched with the same care as during the administration of chloroform.

Chloride of Ethyl or Kelene.—This drug has been employed by inhalation to produce general anesthesia. It is principally used to produce anesthesia for short operations, or may be used to bring about anesthesia which is afterward continued by the use of ether. The advantages of its use are that anesthesia can be produced in a few minutes and that recovery is rapid and unaccompanied by nausea or other unpleasant symptoms. It is administered in the same manner as ether, the spray being directed into a cone or inhaler.

Scopolamine (*Morphine Anesthesia*).—This drug, an alkaloid closely resembling hyoscine, has been extensively used in recent years. It is often given to produce rapid anesthesia and the anesthetic state is continued by the administration of ether. It has not proved as safe an anesthetic as ether as a number of deaths have been reported from its use. It is usually employed in combination with morphine, either in repeated doses without any other anesthetic or in a single dose preliminary to inhalation anesthesia, ether or chloroform being employed. In the former method the usual procedure is to give three hypodermic injections of scopolamine hydrobromate, gr. $\frac{1}{180}$ (0.0004 gm.), and morphine, gr. $\frac{1}{8}$ (0.008 gm.), at intervals of a half hour to an hour before the operation. The solution of scopolamine should be freshly made, as it decomposes rapidly if kept for more than a few days. If the drug acts well the patient becomes sleepy after the first injection, is fast asleep after the second and unconscious and insensible to pain after the third. The third injection is not usually felt by the patient. After the operation is finished the patient is returned to bed unconscious and continues to sleep for five hours after the last injection.

In the latter method a hypodermic injection of scopolamine hydrobromate, gr. $\frac{1}{100}$ (0.00065 gm.), and morphine, gr. $\frac{1}{6}$ to $\frac{1}{4}$ (0.01 to 0.016 gm.), is given about half an hour before general anesthesia is begun. The advocates of each method report very favorable results. It is probable that the second is, on the whole, the safer and more satisfactory. Scopolamine morphine alone often fails to cause satisfactory anesthesia in a large number of cases. It is a most dangerous method of anesthesia and has been responsible for a large number of deaths. H. C. Wood estimates the mortality at 4 to 1000. It certainly reduces the amount of ether or other anesthetic employed, and almost entirely abolishes the disagreeable after-effects. It should not be used in persons under sixteen years of age or in those over sixty, in cases of heart disease or persons with a tendency to pulmonary edema.

After-effects of Anesthetics.—Nausea is not common after chloroform anesthesia. The treatment of this condition following etherization has been previously described. The temperature is usually notably lowered by anesthetics, so that it is always well to apply artificial heat and keep the patient well covered. A form of mental disturbance known as *confusional insanity* is often attributed to the use of anesthetics, but as it does not usually develop until some time, often two or three weeks, after their employment, H. C. Wood was of the opinion that the relation between the mental symptoms and the anesthetic has not been clearly proved in these cases, and that it is rather the outcome of a peculiar depression of the cerebral cortex produced by the shock of the operation itself, or by the emotional strain due to the surgical illness. This view seems to be confirmed by the fact that many of the cases of emotional insanity which are observed follow injuries in which no anesthetic has been given. Albuminuria and glycosuria may follow the administration of ether or chloroform, but are usually only temporary conditions.

Patients who have been subjected to prolonged anesthesia should be carefully watched by a nurse or trained attendant until consciousness returns; it is well to have such patients turned from one side to the other at intervals to favor free pulmonary expansion. If there is any cyanosis due to the accumulation of mucus or blood in the fauces this should be removed and oxygen should be inhaled.

Postanesthetic Paralysis.—This may arise during anesthesia as the result of cerebral hemorrhage or embolism. It usually involves arms or legs and results from the nerves supplying these parts being subjected to prolonged pressure.

Paralysis of the nerves of the brachial plexus may follow prolonged anesthesia when the arm is drawn high above the head; it is not due to the anesthetic, but results from stretching of the nerves over the head of the humerus or their compression between the clavicle and the first rib. Paralysis of the musculospiral nerve may also occur from prolonged pressure of the arm upon the edge of the table. Pressure exerted in the flexure of the knees by the edge of the table, while in the Trendelenburg position, may result in paralysis of one or both internal popliteal nerves. Recovery usually follows in this variety of paralysis.

Acidosis, Acid-intoxication.—This condition arises from the accumulation of acids in the blood, the urine containing diacetic acid and acetone, and results from a lack of, or failure of assimilation of carbohydrates. It frequently develops in diabetes, and sometimes follows operation in which a general anesthetic has been given. It is said to be more frequent after chloroform anesthesia than after ether.

Symptoms.—These occur after the patient has regained consciousness. Persistent vomiting of watery fluid, restlessness, delirium, normal temperature, rapid pulse and the odor of acetone may be detected on the breath. Mild cases recover in a few days under alkaline treatment, but in severe cases a fatal issue may occur in from one to five days.

Persistent vomiting after operation demands prompt examination of the urine.

Treatment.—This consists in the use of alkalis, sodium bicarbonate, 10 to 20 grains, every two hours. If not retained it may be given by enteroclysis or intravenously. The latter method is not free from danger. In severe cases where othere means fail, Lindeman advises transfusion of blood from a donor whose blood has been rendered alkaline by taking large doses of bicarbonate of soda.

Hypnotism.—The anesthetic state of hypnotism has been utilized for the performance of surgical operations. Schmeltz and others have recorded operations done under this influence, the patient apparently suffering no pain. While there is no doubt that the anesthetic state can be obtained by hypnotism, which might be serviceable in surgical operations, yet we do not believe that it will be of general utility.

TRUSSES.

A truss for the palliative treatment of hernia is a mechanical contrivance with one or more pads and a strap: These are held in position by a spring to which they are attached, which holds the pad in contact with the skin over the hernial opening.

Trusses should only be recommended in infants and patients who, from their age or physical condition, are not good subjects for anesthesia or operation. Local anesthesia has placed some of these subjects in the operative class. The cure of a hernia in children sometimes results from the wearing of a proper truss, but rarely in adults. The only cure for hernia is operation, which should always be recommended in suitable cases. The possibility of strangulation and the limitations in exercise, which the wearing of a truss entails, often induces even timid patients to select the operative treatment of hernia.

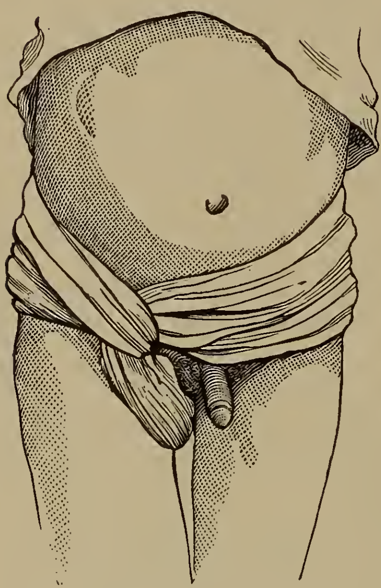
Trusses are usually applied in cases of reducible and sometimes in irreducible herniæ, and are used in the treatment of herniæ at all ages; in infants and young children the continued use of a properly fitting truss is often followed by a radical cure of the hernia. They are made with steel or rubber springs and with pads of wood, rubber, celluloid or horsehair, covered with chamois skin; their shape and the pressure which they should exert vary with the variety of hernia for which they are applied.

A firm compress applied over the inguinal canal or crural ring, secured in position by a firmly applied spica-of-the-groin bandage, forms a very satisfactory temporary means of preventing the descent of a hernia.

A properly fitting truss should be worn without discomfort to the patient—that is, should not make too much pressure upon the skin at the points where the pads are applied, and should absolutely prevent the descent of the hernia. In testing the adequacy of a truss after application, to prevent the escape of the hernia, the patient should be instructed to separate his legs, bend forward over the back of a chair and cough or strain forcibly; if this does not bring the hernia down, control of the rupture may be considered satisfactory.

Trusses should be applied after the complete reduction of the hernia, while the patient is in the recumbent posture. When first applied the truss should be worn both during the night and day; and if the skin becomes tender at the points of pressure it should be sponged with alcohol and alum, then dried and dusted with powdered starch or lycopodium. Patients at first sometimes complain of discomfort in wearing a truss, but they soon become accustomed to its presence. After a truss has been worn for some time its use at night, while the patient is in bed, may be dispensed with, but the patient should not remove it until he is in bed in the recumbent posture, and he should reapply it before he rises in the morning. In children it is better to have the truss worn continuously; and if it is removed for bathing the nurse should be instructed to place her finger over the ring to prevent descent of the hernia until the truss is applied. In applying trusses to male children care should be taken not to make pressure upon an undescended testicle.

Fig. 176.

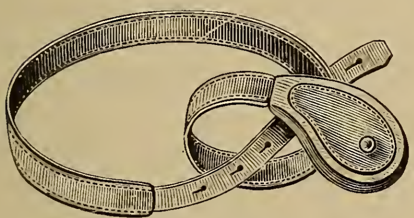


Worsted truss.

Worsted Truss.—This appliance may be used in the treatment of inguinal hernia in infants, and is made from an ordinary skein of worsted, one part of which is made to pass around the body just above the iliac crests, the other joins this in front and behind, forming a perineal band. The knot made by the two bands in front should be directly over the inguinal ring (Fig. 176).

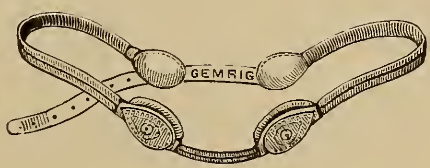
Trusses for Inguinal Hernia.—In measuring a patient for this form of truss the circumference of the body midway between the crest of the ilium and the great trochanter should be taken, and the distance from the symphysis pubis to the anterior-superior spinous process of the ilium may also be given, as half of this distance corresponds to the position of the internal abdominal ring. In reducible inguinal hernia the truss pressure should be exerted upon the inguinal canal and directly backward. To control this variety of hernia a single-spring truss (Fig. 177) may be employed, or the use of a truss having a double spring with flat pads on each side of the spine attached to the springs and a smaller pad over the inguinal canal on the unaffected side, with a full pad on the side of the hernia, will often be efficient. This, which

Fig. 177.



Truss for inguinal hernia.

Fig. 178.

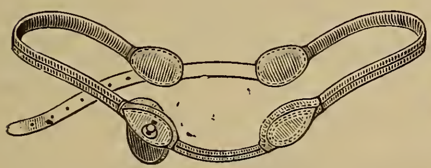


Hood's truss.

is known as Hood's truss, is one which will be found a very satisfactory instrument, both in inguinal and femoral hernia (Fig. 178).

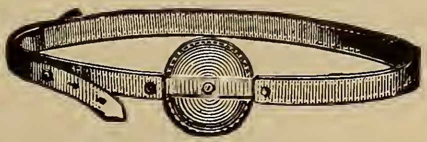
Trusses for Femoral Hernia.—In measuring a patient for this variety of truss, the circumference of the body midway between the crest of the ilium and the great trochanter should be taken; the distance of the saphenous opening from the symphysis pubis, as well as from the anterior iliac spine, should also be taken. In reducible femoral hernia the truss

Fig. 179.



Hood's truss for femoral hernia.

Fig. 180.



Truss for umbilical hernia.

pressure should be directed backward against the femoral canal, and the pad should be large enough to make pressure upon the adjacent tissues through which the hernia passes, as well as upon the relaxed tissue covering the femoral canal. As in inguinal hernia, either a single or a double spring truss may be employed (Fig. 179).

In applying a truss for femoral hernia, care should be taken to see that the pad does not rest upon the pubes, and thus remove the pressure from the crural ring and adjacent tissues and prevent the proper control of the hernia.

Trusses for Umbilical Hernia.—In measuring a patient for this variety of truss, the circumference of the body over the umbilicus should be taken. In reducible umbilical hernia the truss pressure should be directed backward and the pad should bear rather on the tendinous margins of the ring than on the hernial opening. A truss for this variety of hernia should have a flat or slightly convex pad, which is held in position over the umbilical ring by means of springs having counter pads on either side of the spine attached to their extremities; these are fastened together by a strap (Fig. 180).

A simple and satisfactory truss for umbilical hernia in infants consists of a penny covered by adhesive plaster, or a small flat compress of linen, held over the umbilical ring by one or two strips of adhesive or rubber plaster about 2 inches in width, or by a broad strip of perforated rubber adhesive plaster, which should be applied so as to cover in about the anterior two-thirds of the circumference of the body. A penny, or a small flat compress of linen, will be found much more satisfactory than the conical rubber or cork pad often recommended.

Trusses for Irreducible Hernia.—The application of a truss to this variety of hernia protects it from injury and prevents its further protrusion. Such trusses are secured in the same way as those for reducible hernia, but the pads are made concave or cup-shaped, or may have an air cushion or water cushion attached to the pad.

CATHETERS AND BOUGIES.

Catheters are hollow tubes, made either of metal, India rubber or other flexible substances.

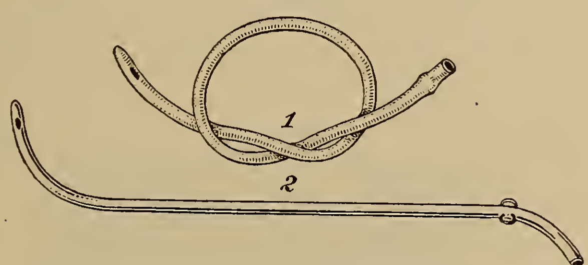
Sterilization of Catheters and Bougies.—To avoid infection of the urethra and bladder it is important that catheters and bougies should be sterilized thoroughly before being introduced (p. 429).

Infection of the bladder may occur from matter contained in the urethra so that this canal should also be sterilized. If it is possible the patient should pass the urine to wash out the urethra, and a solution of boric acid should be injected before the instrument is passed. Before passing catheter or bougies the meatus, glans penis and vulva should be washed with green soap followed by sterile water and 1 : 4000 bichloride solution.

To lubricate the instrument sterilized liquid vaseline, olive oil, lubrichondrin or (K-Y) should be employed.

Metallic Catheters.—These are made of silver or, if constructed of other metals, they should be plated with silver or nickel, to give them a smooth, bright surface which can easily be kept perfectly clean; and their shape should conform to that of the normal urethra (Fig. 183). The shape of the metallic catheter is sometimes changed to meet certain indications; for instance, for use in cases of enlarged prostate it is longer and has a larger curve than the ordinary instrument (Fig. 183). The metallic female catheter is shorter and has a much smaller curve than the instrument used for the male urethra. A female catheter made of glass is now frequently employed, and has the advantage of easy sterilization.

Fig. 181.



1, soft rubber catheter; 2, metal catheter. (Ashhurst.)

Flexible Catheters.—The most commonly used variety of flexible catheter is that known as the English catheter, which is made of linen and shellac, and is provided with a stylet; it can be moulded into any shape desired by dipping it into hot water, which renders it flexible and, after moulding it to the proper curve, this can be fixed by immersing it in cold water, which hardens it again.

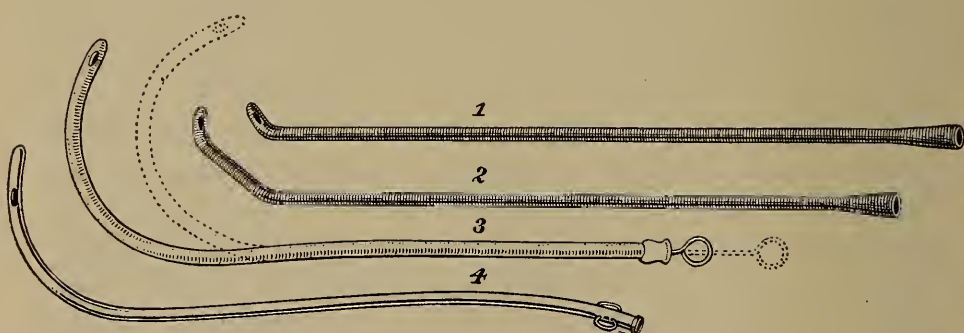
The French flexible catheter is made of India rubber, or a combination of this material with other substances. These instruments are conical toward their extremities and terminate in an olive-shaped point; they are provided with one or two smoothly finished eyes near the vesical extremity (Fig. 182).

Fig. 182.

French flexible catheter.

Another form of flexible catheter, known as the elbowed catheter, or Mercier's catheter (Fig. 183), has an angle or elbow near its vesical extremity or, at times, two elbows, (Fig. 183); these are often found satisfactory instruments to use in cases of enlarged prostate. A variety of flexible catheters made of soft India rubber is also sometimes employed.

Fig. 183.



Prostatic catheters: 1, Mercier's *coude* (elbowed) catheter; 2, *Bi-coude*, or double elbowed catheter; 3, English catheter mounted on an overcurved stylet—when the stylet is partly withdrawn the catheter assumes the form indicated by the dotted lines; 4, metal catheter with prostatic curve. (Ashhurst.)

Catheters and bougies are made according to a certain scale. The English scale runs from No. 1 to No. 12; the American, from No. 1 to No. 20; and the French, from No. 1 to No. 40.

Bougies and Sounds.—*Bougies.*—These are flexible instruments which correspond in size and shape to the English

Fig. 184.

Passing a sound from the patient's right side. Observe how the sound is held in the fingers, and note that no force can be used. (Ashhurst.)

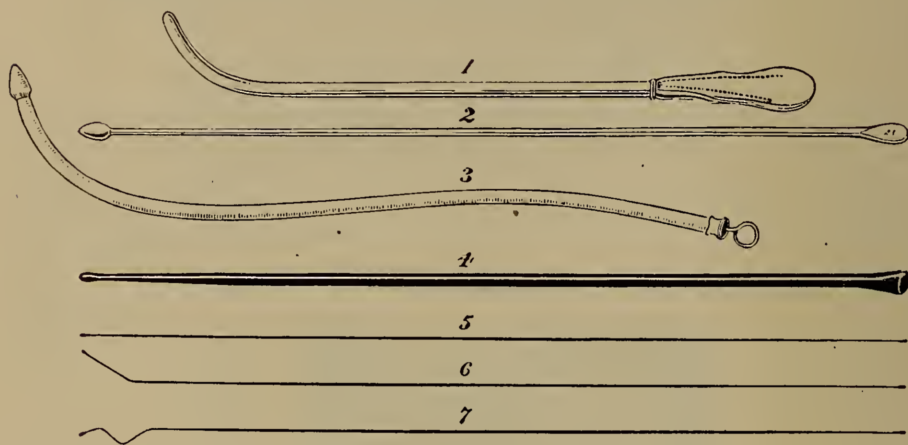
Fig. 185.

Fig. 185.—The urethral sound fully introduced. Note the angle it makes with the horizon. (Ashhurst.)

and French catheters; and besides there are the acorn-pointed bougie (Fig. 186) and the filiform bougie, which latter is made of whalebone or of the same material as the ordinary French bougie and catheter. These instruments are of very small diameter and may often be passed through strictures which will admit no other form of instrument (Fig. 186).

Sounds.—These are solid instruments, usually of steel, with a smooth surface and plated with nickel; they correspond in size and have the same curve as the metallic catheter; the handle is flattened to allow the operator to grasp them firmly; they are employed in the treatment of strictures by dilatation (Fig. 186); they should be sterilized and passed in the same manner as metallic catheters (Fig. 186). The sound

FIG. 186.



Urethral sounds and bougies: 1, steel sound; 2, bulbed sound; 3, bougie à boule; 4, olive tipped bougie, made of webbing, with a leaden core; 5, 6, 7, filiform bougies made of whalebone. (Ashhurst.)

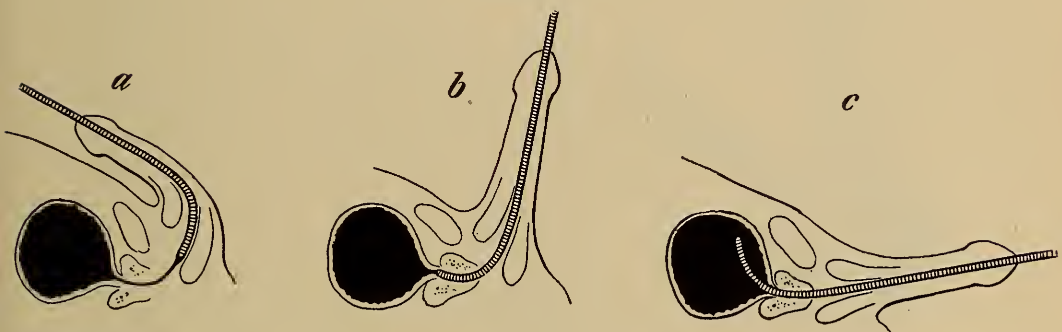
used in dilating strictures of the meatus is straight, and is shorter than the sound employed in the treatment of urethral strictures A metallic sound with a shorter curve than the ordinary sound is used for exploration of the bladder for calculus or tumor.

Introduction of a Catheter.—For the introduction of a catheter the patient may be in the standing, sitting or recumbent posture—the latter is the best in most cases; he should rest squarely on his back and have the thighs a little flexed and separated.

Before passing a metallic catheter the surgeon should see that it has been sterilized, and after warming and oiling it he stands upon the left side of the patient and grasps the penis with the left hand, and turns it over the pubis and introduces the beak of the catheter into the meatus and gently passes it along the urethra until its point passes beneath the symphysis pubis; at this point the handle is elevated and gently depressed between the thighs, when the beak will pass into the bladder (Fig. 187).

In passing a catheter in case of enlarged prostate, when the prostatic region is reached, difficulty is sometimes experienced in the further passage of the instrument; this may be overcome by introducing the finger into the rectum and guiding the catheter through the prostatic urethra; or if the prostate

Fig. 187.



Method of introducing a metal catheter. (Ashhurst.)

is found much enlarged the catheter should be withdrawn and a prostatic catheter (Fig. 183) substituted. The same manipulation is practised as in passing metallic sounds.

Flexible catheters and bougies are passed by grasping the penis and holding it in such a position that it is at a right angle to the axis of the body, and the catheter or bougie is introduced into the meatus and conducted through the urethra into the bladder by gently pushing the instrument downward. In this variety of instrument, which has no curve, the surgeon has no means of guiding the point of the instrument, and if an obstruction is met, he should withdraw the instrument slightly and make another attempt; all manipulations should be extremely gentle.

Passing the Female Catheter.—It was formerly considered important to pass the female catheter without exposing the patient. At the present time it is rarely done, as it is considered more important to sterilize the vulva and region of the orifice of the urethra to avoid infection of the bladder. After washing the vulva with soap and water, and irrigating it with boric solution or normal salt solution, the orifice of the urethra is exposed, by separating the nymphæ, and the catheter is introduced into the bladder.

Tying the Male Catheter in the Bladder.—When it is desirable to retain a catheter for some time in the male bladder, it is necessary to secure it to prevent its slipping out. Either a metallic or flexible catheter may be employed; but, as a rule, the flexible instrument is the most comfortable to the patient, and is to be preferred. There are several methods of securing it in the bladder.

Fig. 188.

Tying in catheter.

By one method, two narrow strips of tape or two or three strong silk ligatures are attached to the rings at the end of a metallic catheter, or are securely fastened around the end of the flexible instrument; these are next brought backward, one on each side of the penis, and the skin is drawn forward and a strip of adhesive plaster $\frac{1}{2}$ inch in width is passed over the strings or tapes and carried three or four times around the body of the penis just behind the glans. If the skin has been brought well forward before the strips have been applied the ligatures are tightened as it slips back and the catheter has not too much play (Fig. 188).

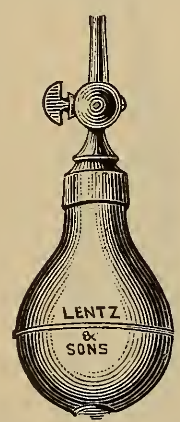
Another method consists in fastening a strong silk ligature around the catheter just in advance of the meatus; the two ends are next brought backward and tied in a knot behind the corona glandis; the ends are then carried around the penis behind the corona and tied on one side of the frænum; the foreskin is slipped forward and covers the ligatures.

A catheter may also be secured in the bladder by tying the ends of the silk ligatures which are attached to the instrument in advance of the meatus to tufts of pubic hair.

Another method of securing the catheter is to perforate the free end with a needle armed with a double ligature of silk or hemp; the needle being removed, two loops are made of the proper length, and these are passed through the ends of a T-bandage, which is secured around the waist, the tails being brought up on either side of the scrotum and secured to the body of the bandage passing around the waist.

In the female, when it is desirable to keep the bladder empty, the *self-retaining catheter* is usually employed, which consists of a catheter with a bulb at its vesical extremity, or an ordinary catheter with silk loops, and a T-bandage may be employed in the same manner as in securing a male catheter.

Fig. 189.



Rubber bag with stop-cock for irrigation of the bladder.

Irrigation of the Bladder.—This procedure may be required in the treatment of cystitis or in sterilizing the bladder, and is accomplished by passing a flexible catheter with a large eye into the bladder, or a double or two-way catheter may be employed. A syringe, or, better, a rubber bulb holding about a pint, having a nozzle and stop-cock (Fig. 189) is filled with warm water, or with any medicated solution which is desired, and it is then attached to the free end of the catheter and the contents are gently injected into the bladder; care should be taken that the bladder is not too much distended. A small metallic or glass funnel with a rubber tube attached, which is connected with the catheter in the bladder may also be used to irrigate the bladder. A glass or metal receptacle with a tube and shut-off clamp is attached to a stand about 2 feet above the bed; this may also be used in irrigation of the bladder. When the desired amount of fluid has been injected it is allowed to run out of the catheter, and the procedure may be repeated until the solution comes away perfectly clear.

The bladder may also be irrigated without using a catheter, the resistance of the compressor muscle of the urethra being overcome by the pressure of a column of water. The patient sits in a chair and a rubber or glass nozzle with a large bulbous tip, which closely fits the meatus, is inserted into it; the nozzle is connected by a rubber tube with a reservoir containing the fluid for irrigation. The reservoir is raised to a height of 3 to 6 feet above the patient. He is directed to take deep inspirations, and soon the bladder becomes filled with water, when the nozzle is removed, and the patient empties the bladder naturally. In some cases a little time is required before the column of water overcomes the resistance of the compressor muscle, or its entrance into the bladder may be hastened by directing the patient to attempt to urinate.

Fig. 190.

Shape of nozzle of urethral syringe.

Care should be taken to see that the bladder is perfectly emptied of the solution, and in cases of paralysis of the viscus gentle pressure should be made upon the abdomen over the pubis to accomplish this object. Solutions of boric acid and permanganate of potassium, and weak solutions of carbolic acid and of nitrate of silver or argyrol are often employed in washing out the bladder in cystitis.

Urethral Injections.—In the treatment of urethral inflammations the injection of medicated solutions is generally made use of; and as these injections are usually made by the patient himself, he should be shown or instructed how to employ them. A rubber syringe having a conical nozzle, and holding about 2 or 3 drams, is the best instrument to employ for this purpose (Fig. 190). The syringe having been filled with the solution, the patient sits upon the edge of a hard chair, with the thighs separated, grasps the syringe between the thumb and middle finger of the right hand, the tip of the index finger resting upon the end of the piston, and inserts its conical end from $\frac{1}{4}$ to $\frac{1}{2}$ inch within the meatus, which is held open by the thumb and finger of the left hand. After the introduction of the nozzle of the syringe the tissues should be pressed tightly around it, the pressure being made laterally, so as to narrow the urethral opening instead of broadening it, as is the case when compression is made in an antero-posterior direction. After the fluid has been thrown into the urethra in this manner the syringe is removed, and the patient is instructed to hold the lips of the meatus together for one or two minutes, to prevent escape of the fluid.

Urethral irrigation may also be practised by means of gravity, a short rubber or glass tube, or a glass urethral nozzle being connected by a rubber tube with a reservoir containing the fluid to be used, the reservoir being placed slightly above the patient.

SUTURES.

A variety of materials are employed for sutures, such as silk, catgut, linen, celluloid thread (Pagenstecher's suture), silver wire, silkworm gut, kangaroo tendon, horsehair and equisetene. The materials most frequently employed at the present time are either catgut, silk or silkworm gut, although some surgeons prefer silver wire. Catgut and kangaroo tendon are practically the only substances employed which are absorbable; the other varieties of suture require removal after their application, although some sutures, such as the silk, if absolutely sterile, when buried in wounds may be cut short, as they are apt to become encysted and remain indefinitely in the tissues. It matters little what variety of material be employed for suturing if the surgeon is careful to see that it is rendered thoroughly aseptic before being brought in contact with the wound.

Sutures of Relaxation.—These sutures are entered and brought out at some distance from the edges of the wound, and are employed to prevent dangerous tension upon the sutures which approximate the edges of the skin. This form of suture is employed in the *quilled, button* or *plate* suture.

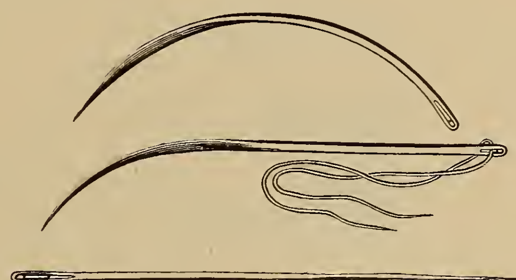
Sutures of Coaptation.—These are superficial sutures applied closely together, and include only the skin; they are employed to secure accurate apposition of the cutaneous surface of wounds.

Sutures of Approximation.—These sutures are applied deeply into the tissue to secure approximation of the deep portions of a wound; this object is accomplished by the use of the *quilled, buried, button* or *plate* suture.

Secondary Sutures.—These sutures are applied when the surfaces of the wounds are covered by granulations, when the primary sutures have failed to secure apposition of the edges of the wound, in cases of secondary hemorrhage where the opening of the wound has been necessitated to turn out the blood clot and secure the bleeding vessel, and in plastic operations where the primary sutures have failed to secure adhesions of the edges of the flaps. They are also employed with advantage in closing wounds in cases in which it was necessary to pack the wound with antiseptic gauze, or to allow hemostatic forceps to remain clamped upon bleeding tissues in the wound at the time of operation. The sutures should in such a case be introduced and loosely tied at this time, and when the packing or forceps is removed at the end of two or three days the sutures are tightened so as to secure apposition of the edges of the wound. Wounds treated by the Carrel-Dakin method as soon as they have become sterile are closed by secondary sutures.

Surgical Needles.—Needles for surgical use are of different sizes and shapes (Fig. 191); straight needles are the ones commonly employed, but curved needles will be found most convenient for the introduction of sutures in wounds in certain locations. Hagedorn needles, which are flat and have sharp cutting edges, make a narrow linear wound in the tissue, and are useful in some cases. For the introduction of sutures in the intestines or hollow viscera, the ordinary sewing needle is generally employed, as it does not cut the tissues, but merely separates them, and its puncture is not likely to bleed. Tubular needles are often employed in introducing sutures in wounds in which the use of an ordinary needle is difficult. For instance, in the operation for cleft palate, and for the introduction of sutures in deep wounds, a mounted needle will often be found very useful (Fig. 192). Reverdin's needle, which consists of a handled needle with an eye which is closed with a slide, is useful in passing deep sutures. The needle is first passed through the tissues, then threaded and withdrawn carrying the suture with it. Needles should be sharp and clean, and should be rendered thoroughly aseptic before being used. Needles should be sterilized by boiling, and may be preserved in a saturated solution of carbonate of sodium or albolene to prevent rusting. A needle holder is often required for the satisfactory introduction of sutures in wounds in certain localities (Fig. 193); if this is not at hand the needle may be held by a pair of hemostatic forceps.

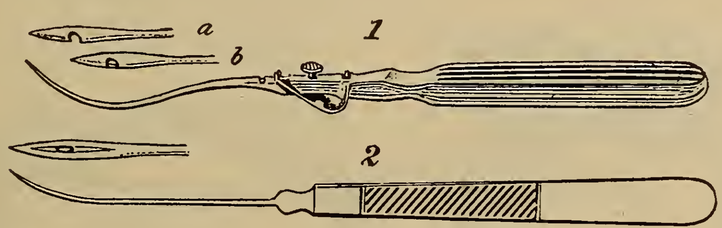
Fig. 191.



Surgical needles.

Method of Securing Sutures and Ligatures.—Metallic sutures are usually secured by twisting the ends together or by passing the ends through a perforated shot and clamping the shot with a shot-compressor, which securely fixes them.

Fig. 192.

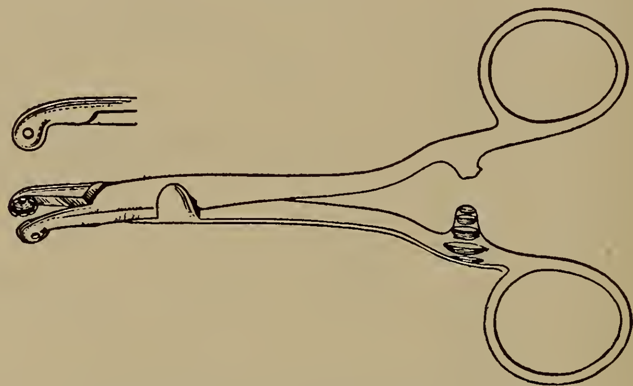


1, Reverdin's needle, showing at *a* eye opened, at *b* eye closed; 2, ordinary mounted needle. (Ashhurst.)

Sutures and ligatures of catgut, silk, silkworm gut, kangaroo tendon or horsehair are secured by tying, and several different knots are employed to secure them.

Reef or Flat Knot.—This is one of the best forms of knot to use in securing sutures or ligatures, and it is made by passing one end of the thread over and around the other end, and the knot thus formed tightened; the ends of the thread are next carried toward each other and the same end is again carried over and around the other, and when the loop is drawn tight we have formed the reef or flat knot (Fig. 194).

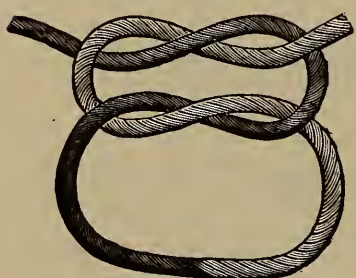
Fig. 193.



A convenient form of needle holder. (Ashhurst.)

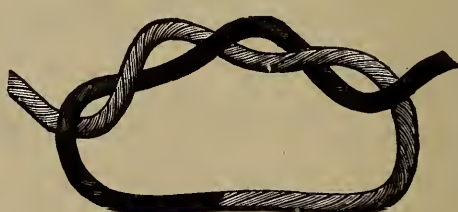
Surgeon's Knot.—This knot is formed by carrying one end of the thread twice around the other end (Fig. 195), and after tightening this loop the same is carried over and around the other end as in the case of the final knot of the reef or flat

Fig. 194.



Reef or flat knot.

Fig. 195.

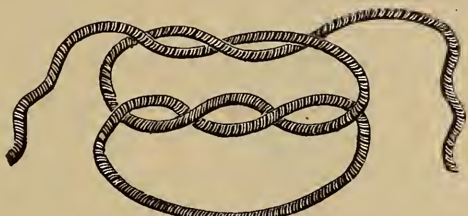


Surgeon's knot.

knot. The surgeon's knot and reef knot combined is one of the best methods of securing sutures or ligatures of catgut or silk, as the first knot is not apt to relax before the second knot is applied (Fig. 196).

Granny Knot.—This method of tying the ligature or suture should not be employed, as the resulting knot is not as secure as the reef knot and is apt to relax: it differs from the latter in the fact that one end of the thread having been carried across and around the other end, the knot is completed by carrying the same end under and around the other end of the thread (Fig. 197).

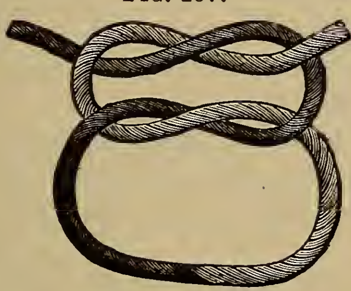
Fig. 196.



Surgeon's knot and reef knot combined.

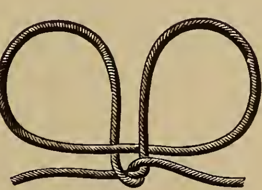
Staffordshire Knot. — This is much used to secure the pedicle in the removal of abdominal tumors, and is applied as follows: A handled needle armed with a stout silk ligature is passed through the pedicle, and then withdrawn so as to leave a loop on the distal side; this loop is drawn over the tumor, and one of the free ends is passed through it so that one end is above while the other end is below the retracted loop (Fig. 198). The ends are then seized and drawn through the pedicle; at

Fig. 197.



Granny knot.

Fig. 198.



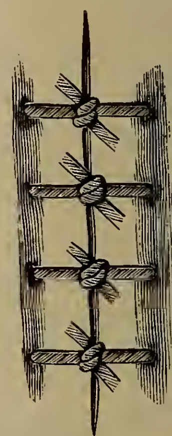
Staffordshire knot.

the same time the thumb and forefinger are pressed against it until sufficient constriction is made, and the ends are finally secured by tying as in the securing of an ordinary ligature.

Varieties of Sutures.—The Interrupted Suture.—This suture, which is the one most usually employed in the apposition of wounds, consists of a number of single stitches, each of which is entirely independent of those on either side. In applying this suture the surgeon holds the edge of the wound with the fingers or forceps and thrusts the needle, previously threaded, through the skin three or four lines from the edge of the wound. He then passes the needle from within outward through the tissues of the opposite flap at the same distance from the edge of the wound (Fig. 199). Each stitch is secured as soon as it is passed—by tying if a silk, catgut, or silkworm-gut suture be used, or by twisting if a silver-wire suture is employed.

A suture may be used with a needle threaded on each end, in which case both needles are passed from within outward. The sutures may be secured as soon as applied, or they may be left unsecured until a sufficient number have been introduced, and then they may be secured by tying or twisting. Care should be taken to see that they make no tension on the edges of the wound, and that they are so introduced as to make the best possible apposition of the parts.

Fig. 199.



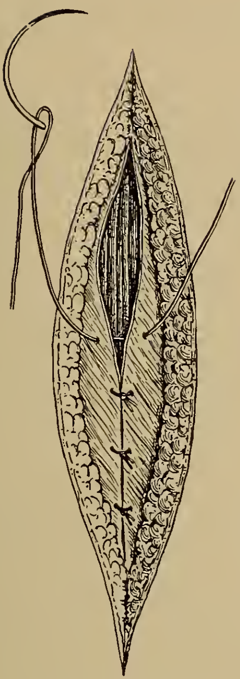
Interrupted suture.

Buried Sutures.—In extensive and deep wounds it may be found necessary to introduce both buried and superficial sutures, the former bringing about apposition of the muscles and deep fascia, the superficial layer bringing together the superficial fascia and skin (Fig. 200). These sutures may be applied so that the knot is covered by the tissues (Fig. 201).

Deep or buried sutures are often employed to unite fascia, muscles or tendons and the best material for this variety of suture is either catgut, silk or kangaroo-tail tendon.

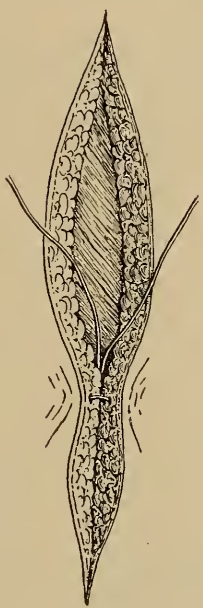
Continued Suture.—This variety of suture is applied in the same manner as the interrupted suture, but the stitches are not cut apart and tied; it is made with silk or catgut (Fig. 202), and is secured by drawing it double through the last stitch and using the free end to make a knot with the double portion attached to the needle (Fig. 204). This suture may

Fig. 200.



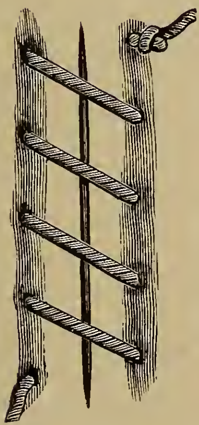
Buried sutures.

Fig. 201.



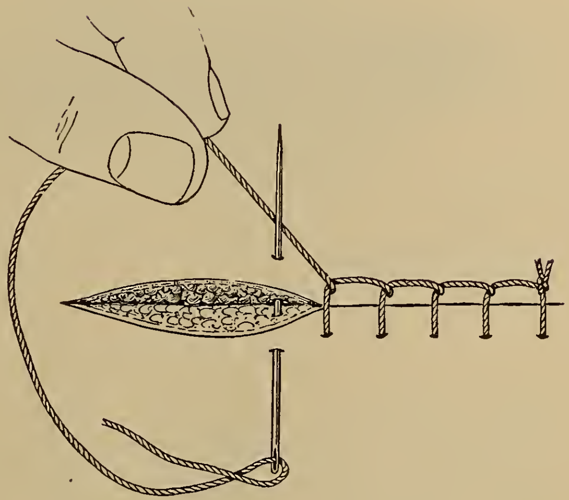
Buried suture, applied so that the knot is covered.

Fig. 202.



Continued or glovers' suture.

Fig. 203.

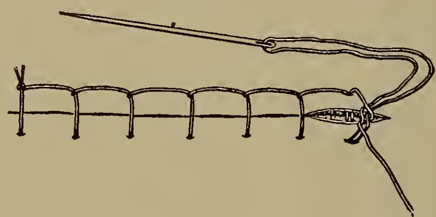


Chain-stitch or button-hole suture.

be used in intestinal wounds, but may also be employed in obtaining apposition of the edges of wounds in tissues of loose structure.

Chain-stitch or Button-hole Suture.—This is a variety of continued suture which differs from the ordinary continued suture, in that the loop is made on one side of the wound as soon as the suture has been passed (Fig. 203).

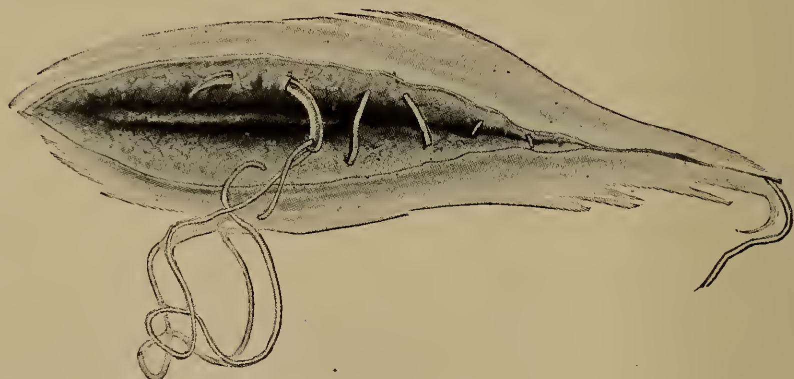
Fig. 204.



Method of securing continuous suture by tying free end and loop.

Subcuticular Suture.—Halsted has introduced a suture in which the needle is introduced on the under surface of the skin on one side, and brought out just beneath the cut edge; it is then entered in the reverse direction below the epidermic

Fig. 205.

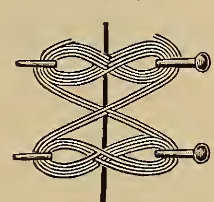


Subcuticular suture.

surface opposite; when tied it will lie wholly out of sight. The object of this variety of suture is to avoid infection of the wound by the skin coccus, which may be introduced by the suture if passed from without inward. Fine silk or catgut should be used for this variety of suture, which may become encysted, absorbed or gradually cast off after a few weeks. If employed as a continuous suture the free ends may be tied together and the suture subsequently removed by cutting the loop and drawing out the suture from one end of the wound (Fig. 205).

The Twisted or Hare-lip Suture.—This is a very useful form of suture where great accuracy and firmness of apposition of the edges of the wound are desired. It is applied by thrusting pins or needles deeply through both lips of the wound, the edges being kept in contact over the wound by figure-of-eight turns with silk or wire (Fig. 206). The ends of the pins should be cut off with pin-cutters after the sutures are applied or should be protected by pieces of cork or plaster to prevent them from injuring the skin of the patient and causing him pain. The twisted or hare-lip suture is frequently employed in plastic operations about the face and in other parts of the body where accurate apposition of the flaps is important.

Fig. 206.



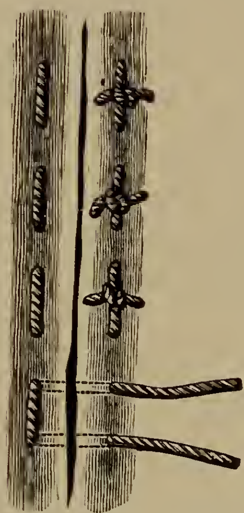
Twisted or hare-lip suture.

Mattress or Quilt Suture.—This suture is applied by carrying the needle through the two flaps and then back again, so that a loop is left on one side and the two ends of the suture project from the opposite flap (Fig. 207). This variety of suture may be applied as an interrupted or as a continuous suture; in the latter, loops are made through the flaps on each side of the wound.

Continuous Mattress Suture.—This variety of suture, known as the Cushing suture, is often employed as an intestinal suture, but does not result in as secure or close apposition of the edges of the wound as the interrupted mattress suture. It is applied as shown in Fig. 208.

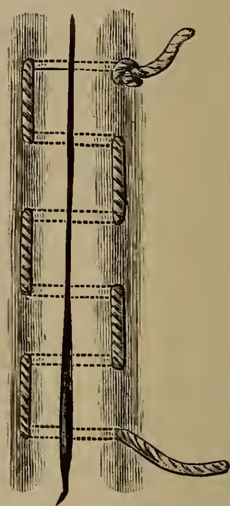
The Quilled Suture.—In making use of this suture a needle armed with a double thread of wire or silk is passed through the tissues as in applying the interrupted suture, but at a greater distance from the edges of the wound. Into the loops on one side of the wound is inserted a quill or piece of a flexible catheter or bougie, and on the opposite side the free ends of the sutures are tied around a similar object after being tightened (Fig. 209). This form of suture makes deep

Fig. 207.



Mattress suture, interrupted. (Brewer.)

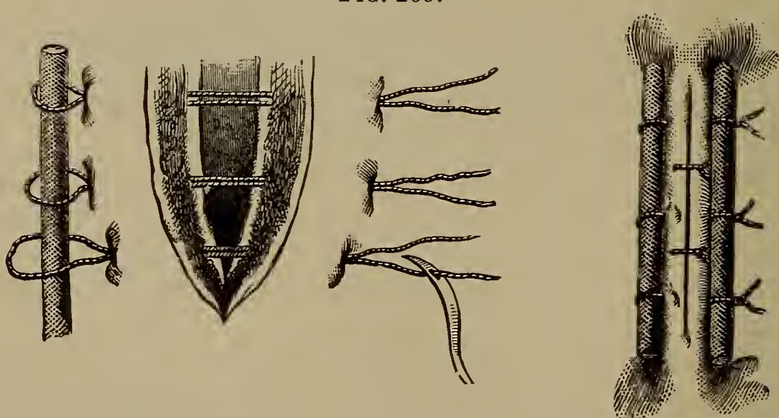
Fig. 208.



Cushing suture. (Brewer.)

equable pressure along the whole line of the wound. In applying this suture, it may be found advisable in some cases

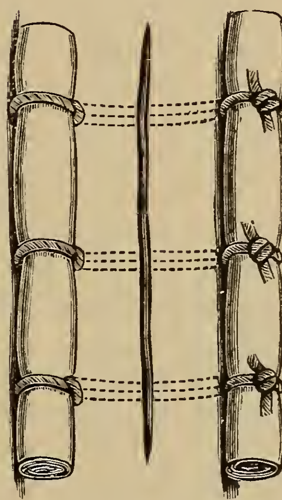
Fig. 209.



The quilled suture.

to introduce a few superficial interrupted sutures along the line of the wound to secure accurate approximation of the skin. Two small rolls of sterilized or antiseptic gauze may be used as a substitute for the quills or pieces of catheter, as shown in Fig. 210.

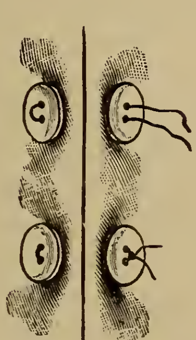
Fig. 210.



Modified quilled suture.

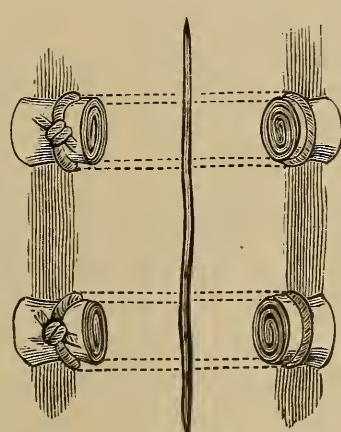
Button or Plate Suture.—This suture is applied by passing a needle armed with a double thread as in the case of the quilled suture, the ends of the suture being passed through the eyes of a button or through perforations in a lead plate before being threaded in the eye of the needle. After the suture prepared in this way has been passed through both sides of the wound the needle is removed and the free ends of the suture are passed through the eyes of a button or the perforations in a lead plate on the opposite side of the wound, and are tightened and secured (Fig. 211). In applying this form of suture small rolls of antiseptic gauze may be used instead of buttons, as shown in Fig. 212. This form of suture may be employed in deep wounds to accomplish the same purpose as the

Fig. 211.



Button suture.

Fig. 212.



Modified plate suture, using gauze pledgets.

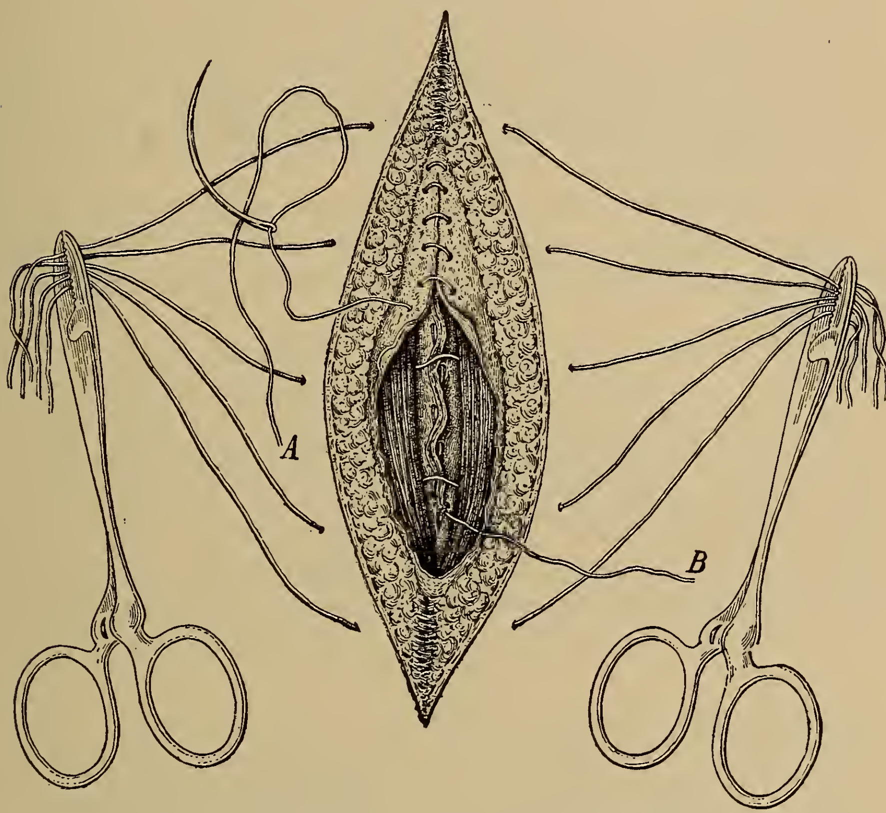
quilled suture. It allows the cutaneous margins of the wound to remain free from compression, and here, as in the case of the quilled suture, a few interrupted sutures may be introduced between the button or plate sutures to secure accurate apposition of the skin surfaces if desired.

Shotted Suture.—This suture receives its name not from any special method of application, but solely from the way in which it is secured; any of the previously mentioned varieties of sutures may be employed. The material used in applying this suture may be catgut, silver wire, silkworm gut, silk or horsehair, and after the suture has been passed the needle is removed, and the ends are passed through a perforated shot; the ends are then drawn upon to bring the edges of the wound in contact, and the shot is pressed down to the skin and clamped by means of a shot compressor. The suture is then cut off flush with the surface of the shot.

This method of securing sutures is especially useful in closing wounds in the mucous cavities, such as the vagina, rectum and mouth, where the knot or twist of the wire might cause irritation of the surface or pain to the patient; it is also a useful method of securing sutures in plastic operations; it also facilitates the removal of the sutures, as the shot is not apt to be obscured by the swollen tissue, and is easily seized by forceps when the loop is divided.

Splint Suture.—These are frequently used in closing abdominal incisions in connection with layer sutures to eliminate dead spaces and furnish additional fixation to the edges of the wound. After the peritoneum has been closed by sutures a number of interrupted splint sutures of silkworm gut or linen are introduced about 1 or $1\frac{1}{2}$ inches apart. A large curved or straight needle carrying a strand of silkworm gut is passed through the skin about $\frac{1}{2}$ inch from the edge of the wound and carried down through all the tissues of the abdominal wall to the peritoneum and carried across the wound and out through all the structures of the abdominal wall on the other side to the skin surface. A number of these sutures are passed according to the length of the wound, and their ends are clamped and not tied at the time. After the aponeurotic layer of sutures has been applied the splint sutures are pulled taut and tied without much tension; a few interrupted skin sutures may be required between the splint sutures to secure accurate closure of the wound.

Fig. 213.



The "splint sutures" have been inserted, and their ends are clamped. (Deaver and Ashhurst.)

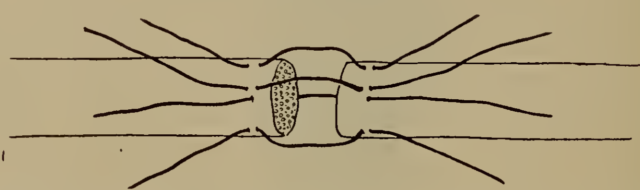
Removal of Sutures.—Where sutures are buried in the tissues or used to approximate parts in cavities which are subsequently closed, such materials should be used for sutures as will be absorbed in a few days, or will become encysted and remain harmless in the tissues—such as catgut, silkworm gut or silk—and it is needless to state that sutures used with this end in view should be rendered perfectly aseptic before being employed.

Catgut sutures, when well prepared and used for sutures in external wounds, usually undergo absorption in from ten to fifteen days; the loop buried in the tissues is absorbed, and the knot may be removed from the surface with forceps or it may come off with the dressings.

The other substance, such as silk, silkworm gut, silver wire and horsehair, are removed by cutting one side of the loop and making traction upon the knot of the suture with forceps, or in the case of the wire suture, after dividing the loop and straightening out one end of it, the wire should be withdrawn in a curved direction.

Sutures which are not causing irritation should be allowed to remain until the wound is solidly healed. The time usually required in case of aseptic wounds is from eight to twelve days.

Fig. 214.



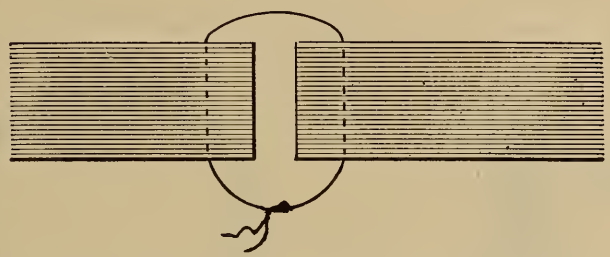
Nerve suture: One passes through the end of the nerve; the others pass through the sheath only. (Ashhurst.)

Nerve Suture.—For this suture fine chromic catgut or silk is threaded in a fine round needle and one suture is passed through each end of the divided nerve and tied just tight enough to approximate the ends of the nerve. Additional sutures should next be applied to the nerve sheath to approximate this and prevent adhesion of the nerve fibers to surrounding structures (Fig. 214).

Tendon Sutures.—The material employed for sutures may be silk, catgut or kangaroo tendon, and one or more sutures should be used, being passed through the substance of the ends of the tendon and secured by tying; the divided sheath of the tendon, if possible, should be brought together by fine silk sutures (Fig. 215). Very marked retraction of the ends of the tendon is liable to occur, and a considerable dissection is often required to bring them into view.

When there is difficulty in bringing the ends of the tendon together, and the sutures are apt to cut out, the form of suture shown in Fig. 216 may be employed.

FIG. 215.



Suture passed through the substance of the ends of a divided tendon.

Intestinal Sutures.—Sutures employed in wounds and operations upon the intestines and hollow viscera are either of fine catgut, silk or celluloid thread. A round needle such as the ordinary sewing needle is used in preference to the bayonet-pointed needle, as it does not cut the tissues and there results less bleeding from the punctures. Two layers of sutures should be used when it is possible, the deep layer of sutures including the mucosa and the superficial layer, the serous and muscular coats.

FIG. 216.

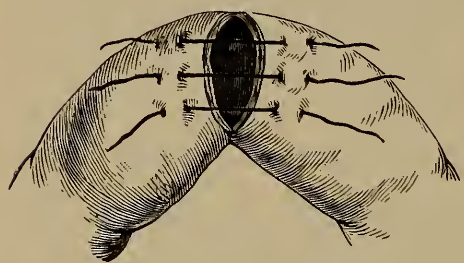
Tendon suture which does not easily tear out.

Accurate apposition of the edges of the bowel should be obtained to prevent leakage. This is especially important in wounds of the small intestine.

Care should be taken that the lumen of the bowel is not materially reduced by the sutures.

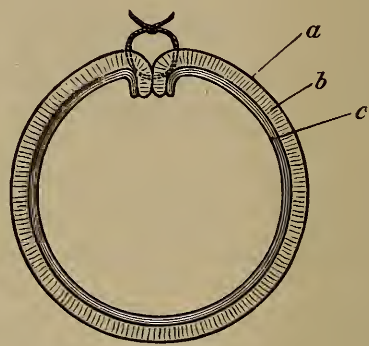
Lembert's Suture.—Lembert's suture is used in wounds of the viscera covered by the peritoneum, with the object of bringing in contact the peritoneal surfaces. This form of suture is usually employed in closing wounds of the intestine, bladder and stomach.

FIG. 217.



Lembert's suture.

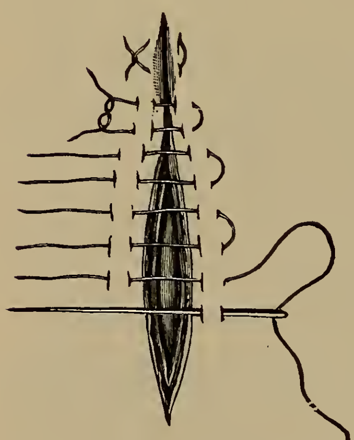
FIG. 218.



Lembert's suture. *a*, serous; *b*, muscular; *c*, mucous coat.

A needle armed with a fine catgut, silk or celluloid thread is first carried through the peritoneal and muscular coats of the intestine a short distance from the wound, and it is then carried across the wound and passed through the same portions of the intestine a short distance from the edge of the wound on the opposite side (Fig. 217), and when the suture is tightened the peritoneal surfaces of the intestine are inverted and brought into contact with each other (Fig. 218); the interrupted or continued suture may be employed in making this form of suture.

FIG. 219.

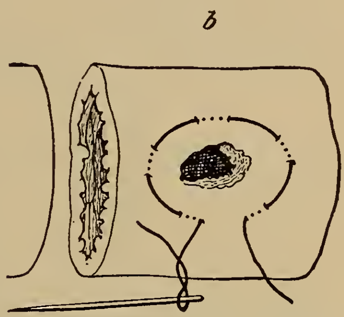


Halsted's quilt suture for intestine.

Halsted's Mattress or Quilt Suture.—This is a modification of Lembert's suture. The needle penetrates the peritoneal and muscular coats of the gut, including a small portion of the submucosa, twice on each side of the wound and is then tied (Fig. 219).

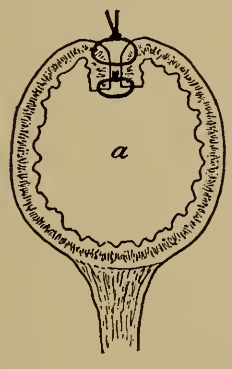
Purse-string Suture.—This form of suture is frequently used in operations upon the intestines and other abdominal viscera for covering in the stump of an appendix and in operations upon the gall-bladder and in securing the two sections of the Murphy button. It is applied by introducing a continuous suture of silk or catgut, or celluloid thread, in a circular manner at a little distance from the part to be covered in, the stitches pick up the peritoneal and muscular coats at intervals, and when the part has been circumscribed by tying the ends of the suture, the parts are puckered and bring the serous surface in contact over the part to be included (Fig. 220).

FIG. 220.



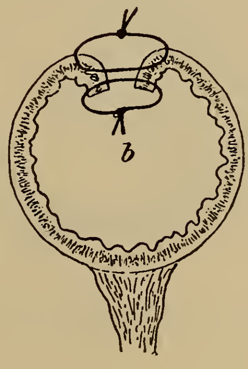
A purse-string suture to close a perforation. (Ashhurst.)

FIG. 221.



Czerny-Lembert suture. (Ashhurst.)

FIG. 222.



Albert-Lembert suture not pulled tight. (Ashhurst.)

Czerny-Lembert Suture.—This suture is a combination of the Czerny suture, which is a suture passed through all the coats of the bowel, and a Lembert suture, which includes only the serous and muscular coats of the bowel in its grasp

(Fig. 221). For the deep suture, which includes all the coats of the bowel, catgut should be used and the knots should be placed within the lumen of the bowel. Either of these sutures may be interrupted or continuous. The Albert Lembert suture, which includes all the tissues of the bowel and is knotted within the lumen of the bowel, is shown in Fig. 222. This suture may be employed in wounds or in end-to-end approximation or lateral anastomosis of the intestines.

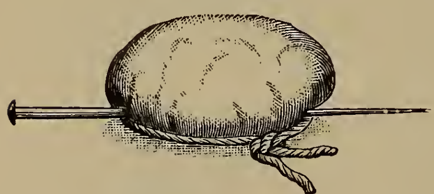
LIGATURES USED IN THE TREATMENT OF VASCULAR GROWTHS.

Vascular growths were formerly very generally treated by ligation, but at the present time excision or destruction of the growth by roentgen ray, electrolysis or carbon dioxide is more frequently employed.

Various forms of ligatures are used for the strangulation of vascular growths; the material employed is usually strong silk or hemp thread, catgut or silver wire.

The Single Ligature with a Pin.—This is applied by first inserting a hare-lip pin through the skin near the edge of the growth, passing it under the growth and bringing it out through the skin at a point opposite the place of entry; a strong silk or hemp ligature is passed under the ends of the pin surrounding the base of the tumor, and is drawn tight enough to strangulate the growth, and is secured by two knots (Fig. 223). If the growth is of considerable size it is better before applying this ligature to introduce a second pin at right angles to the first one, and then secure the ligature under the pins. In applying these forms of ligature to healthy skin the patient is saved much pain, and the separation of the mass is hastened by cutting a groove in the skin with a sharp knife at the point where the ligature

Fig. 223.



Vascular tumor strangulated with pin and ligature.

is to be applied; the ligature when tied is buried in the groove thus made.

Double Ligature.—This ligature is applied by passing a needle or a needle with a handle, armed with a double ligature,

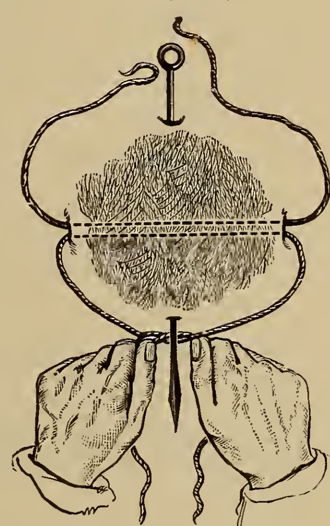
FIG. 224.

Method of applying double ligature. (Roberts.)

through the skin near the growth, and then passing it under the tumor and bringing it out through the skin at a point directly opposite the point of insertion; the ligature is then divided and the needle removed. The tumor is strangulated by tying firmly the corresponding ends of the ligature on each side of the tumor, each ligature including one-half of the growth (Fig. 224).

The double ligature may also be applied by first passing a pin under the growth and then passing a needle armed with a double thread under the tumor at right angles to the pin, and after removing the needle the ends of the ligature are tied and the tumor is strangulated in two sections (Fig. 225).

FIG. 225.



Method of applying double ligature and pin.

Quadruple Ligature. — In applying this ligature, two needles carrying a double thread are passed under the growth at right angles to each other; or if the handled needles be used, they may first be passed in this manner, and then threaded with double ligatures, which are carried under the growth as they are withdrawn. The needles being removed, the surgeon ties two ends of the ligature together, and repeats this procedure until the growth has been strangulated in four sections.

Subcutaneous Ligature.—This is applied by introducing a needle armed with a ligature through the skin near the growth, and carrying it through the subcutaneous tissues around the part to be constricted for a short distance, then bringing it out through the skin. The needle is again introduced through the same puncture, and is again brought out through the skin at some distance from the first point of exit. It is next introduced through this puncture and brought out

Fig. 226.

Method of applying subcutaneous ligature.

at a more distant point. In this way the growth is completely encircled by a subcutaneous ligature, which is finally brought out at the point of entrance; the tumor is strangulated by firmly tying together the ends of the ligature (Fig. 226).

If a needle armed with a double ligature is first passed under the growth the ligature is divided, and by passing each end of the divided ligature subcutaneously around the growth it may be strangulated subcutaneously in two sections.

Carbon Dioxide.—The use of carbon dioxide has largely supplanted the various forms of ligatures used in the treatment of vascular growths. The drug in liquid form can be purchased in large cylinders. On opening the top the liquid escapes and evaporates so quickly that intense cold is produced, which freezes the liquid into a soft snow. This is collected and pressed into a cylindrical form, and a solid stick of compressed snow results. This can be cut to the required shape, and is held firmly in contact with the growth from twenty to forty seconds. Upon removing the stick a depression is seen in the middle of the frozen area, which disappears in a few seconds when the tissues thaw. No anesthetic is required as the application is practically painless although the application is often followed by burning pain in the part. A sharp reaction follows the freezing, followed by blistering or even superficial ulceration. No after-treatment is required other than a simple dusting powder.

Injection of Hot Water.—The treatment of vascular growths by the injection of boiling water has been advocated by Wyeth. A hypodermic syringe is filled with boiling water and the needle is passed deeply into the growth and boiling water is injected. The amount of water injected depends upon the size of the growth. In large growths sections of the growth may be injected at intervals of a few days.

Elastic Ligatures.—Ligatures made of India-rubber varying from half a line to several lines in thickness are often made use of in surgery. They may be employed to strangulate growths such as moles or nevi, or in the treatment of fistulæ, and are especially useful in the treatment of those cases of fistula-in-ano in which the internal opening into the bowel is situated high up, as the division of such fistulæ by this means is accomplished without hemorrhage and with less risk than by the employment of the knife. In applying elastic ligatures in such cases the ligature, after being passed through the fistula by means of a probe, is carried out through the internal opening; the sphincter is next well stretched, and the elastic ligature is then firmly tied with two or three knots; the greater the tension made before the ligature is tied the more rapidly will it cut its way out. The smaller sizes of rubber drainage tubes may be substituted for the solid rubber ligatures.

TREATMENT OF HEMORRHAGE.

Hemorrhage may arise from wounds of arteries, veins or capillaries, or from simultaneous wound of these vessels. In arterial hemorrhage the blood is scarlet and escapes in jets from the proximal end of the vessel; the jets are synchronous with the heart beats, the stream never entirely intermits. That from the distal end is darker and does not pulsate unless the wound of the vessel is near a large collateral branch. In venous hemorrhage the blood is dark in hue and escapes in a continuous stream. In capillary hemorrhage the blood is lighter in color than venous blood and wells into the wound from numerous fine points on its surface.

Spontaneous arrest of hemorrhage is dependent upon the coagulation of blood, the retraction and contraction of the wounded bloodvessels, lowering of the blood-pressure by diminution of the volume of blood and increase in the coagulability of the blood from the progressive anemia. Women can stand the loss of a greater proportion of blood than men; children, old people and individuals exhausted by disease or sepsis bear the loss of blood badly. The loss of from 4 to 6 pounds of blood in an adult is usually fatal. The symptoms of the loss of a large quantity of blood are pallor of the face and lips, a frequent, small and fluttering pulse, the heart beats are weak and fluttering, the temperature is subnormal, the respirations are shallow and sighing and the skin is cold and clammy. Vertigo and nausea may be present. The pupils are dilated, and if the bleeding continues syncope occurs.

The surgeon may be called upon to treat the following varieties of hemorrhage: *arterial, venous,* or *capillary;* and these again are classified according to the time of their occurrence, as *primary*—that is, bleeding which occurs at the time the wound is inflicted; *intermediary* or *consecutive,* that which occurs within twenty-four or forty-eight hours after the reception of the injury, and which generally takes place during the period of reaction; and *secondary,* which usually results from a septic condition of the wound, causing a septic arteritis, and occurs usually after forty-eight hours, but may occur at any time subsequent to this period until the wound is healed. *Subcutaneous* hemorrhage may also occur from injury of arteries and veins. The blood may escape into the cellular tissue, or form a distinct tumor with fluctuation. If a large artery has been injured pulsation may be present in the tumor, producing a traumatic aneurysm. The treatment of hemorrhage is both constitutional and local.

Constitutional Treatment.—The bleeding should be temporarily arrested by pressure, sterile gauze packing, or by a tourniquet, if it arises from an accessible point, and no treatment should be given to bring about reaction until this has been accomplished. The treatment to bring about reaction consists in keeping the patient in the recumbent posture, with the head lowered. Heat should be applied to the surface of the body and the arms and legs bandaged up to the trunk to divert blood to the nerve centers. This is called autotransfusion. Hot saline solution, coffee or stimulants should be given by enema. Hot saline solution, 1 pint, to which has been added ʒi of a 1 to 1000 solution of adrenalin, should be given intravenously or by hypodermoclysis, and is most efficient. Transfusion of blood, if a suitable donor is available, is of the greatest service. The hypodermic use of morphine, $\frac{1}{6}$ gr., atropine, gr. $\frac{1}{60}$, or strychnine, gr. $\frac{1}{30}$ (the latter is not as efficient as atropine), should be employed. Stimulants and liquid nourishment should be given by the mouth carefully, as they may not be absorbed and may cause vomiting.

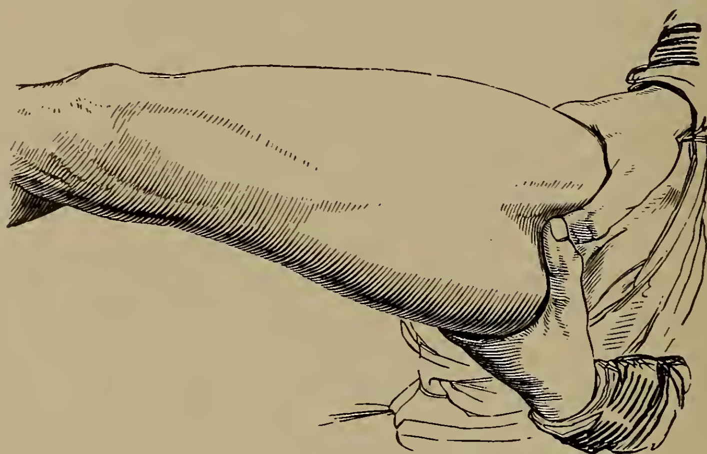
The hemostatic properties of gelatin have led to its use by subcutaneous injection in various forms of internal hemorrhage. A sterilized aqueous solution, containing 2 per cent of gelatin in normal salt solution, is injected into the loose cellular tissue of the abdominal walls or buttock, about 200 cc. being employed. It has been used in hemoptysis, epistaxis and in intestinal hemorrhage in typhoid fever.

Local Treatment.—This consists in the adoption of various local measures to control the bleeding, which may be either temporary or permanent in their action.

Temporary Control of Arterial Hemorrhage.—This may be effected by pressure applied directly to the bleeding vessel in the wound or by pressure applied indirectly to the main artery between the point of its injury and the center of the circulation, and this pressure may be made by the *fingers*—*digital compression*—by *compresses*, or by means of *tourniquets*.

Digital Compression.—This constitutes one of the most valuable means employed in the temporary control of hemorrhage: the finger is pressed directly upon the bleeding vessel, in the wound, or is used to make pressure upon the artery from which the bleeding arises at some point between the wound and the center of the circulation (Fig. 227). Control of

Fig. 227.

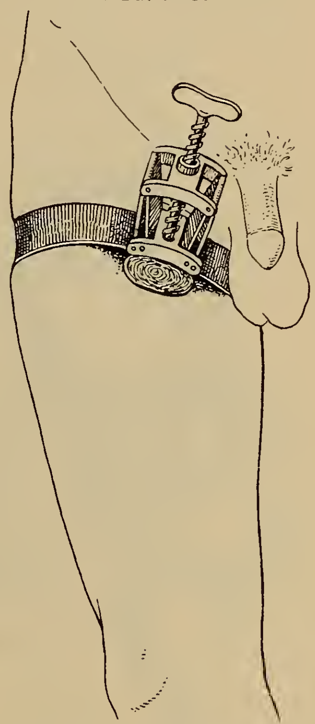


Digital compression of the femoral artery.

hemorrhage by digital pressure can be maintained only for a few minutes, for the fingers of the surgeon or assistant soon become tired, so that it is employed only until means are adopted for permanent arrest of the bleeding. Digital compression of the radial and ulnar arteries may be resorted to for the control of hemorrhage during amputations of the fingers, of the axillary, subclavian and femoral arteries in amputations at the shoulder-joint and the hip-joint. It is also used to control hemorrhage from wounds either the result of accident or those made by the knife of the surgeon, in which case the finger is placed directly upon the divided vessel or is employed to hold a sponge or compress firmly in the wound.

Compresses.—By the use of compresses placed directly in the wound or applied to the vessel between the wound and the center of the circulation, the temporary control of hemorrhage may be very satisfactorily accomplished. The compress which is applied in the wound should be made of antiseptic or sterile gauze, thereby diminishing the chances of wound infection. The compress should be held in position by a bandage firmly applied, and is generally employed only as a temporary expedient until a more permanent means of controlling the bleeding is adopted.

Fig. 228.



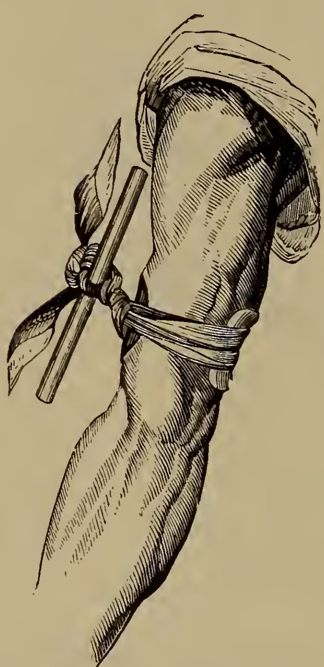
Petit's tourniquet applied to femoral artery. (Ashhurst.)

Tourniquets.—These instruments, which are employed for the temporary control of hemorrhage from wounds, are of many different kinds.

Petit's Tourniquet.—This consists of two metal plates connected by a strong linen or silk strap, with a buckle, the distance between the plates being regulated by a screw (Fig. 228). In applying this tourniquet a compress or roller bandage is placed directly over the artery to be compressed, and may be held in position by a few turns of the bandage. The lower plate of the tourniquet is placed directly over this pad, and the strap is tightly secured around the limb to keep the instrument in place. The screw is then turned so as to separate the plates and tighten the strap, thus forcing the compress or pad upon the artery and controlling its circulation. This instrument is very generally employed for the control of hemorrhage in wounds of the extremities, and is especially useful in amputation of these parts, being placed over the main artery some distance above the seat of operation.

The Spanish Windlass.—An improvised tourniquet, known as the Spanish windlass, may be employed in cases of emergency; it is prepared by folding a handkerchief or piece of muslin into a cravat and placing a compress or smooth pebble on the body of the cravat; this is placed over the artery to be controlled, and the ends of the handkerchief are tied loosely around the limb; a short stick is passed through this loop, and by twisting the stick the loop is tightened and the compress is forced down upon the artery (Fig. 229).

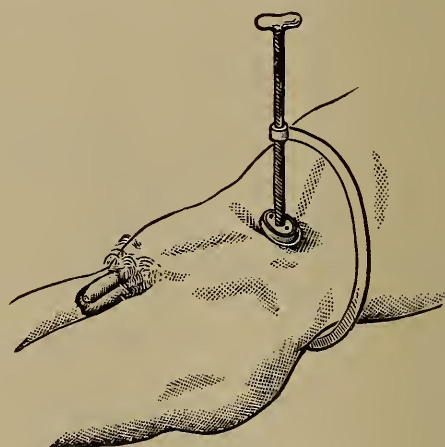
Fig. 229.



The Spanish windlass.

Many other forms of tourniquet have been devised which have the pad and counter-pad arranged to make pressure upon the vessel,

Fig. 230.

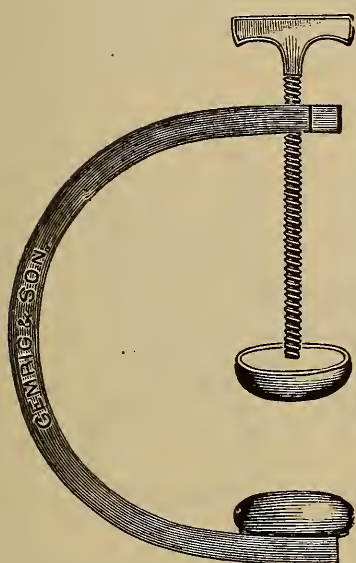


Lister's aorta compressor.

such as Lister's aorta compressor (Fig. 230), which was employed in the treatment of aneurysm of the iliac vessels and for the control of hemorrhage in amputation at the hip-joint. Signorini's tourniquet (Fig. 231) is constructed upon the same principle, and was frequently employed to control the circulation in the femoral artery in cases of operations on the thigh and leg and in the treatment of femoral or popliteal aneurysm.

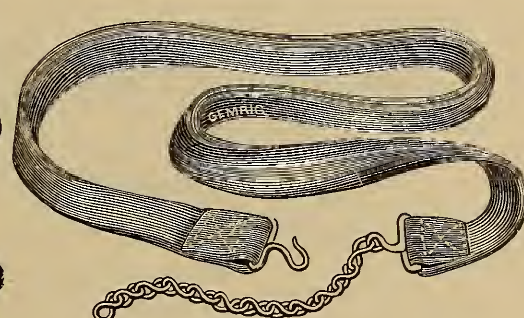
Elastic Constriction.—The elastic tube, or the strap of Esmarch's apparatus (Fig. 232), may also be employed for the temporary control of arterial hemorrhage, being applied above the wound; and if it is not at hand any strong rubber cord or a piece of large-sized drainage tube may be used as a substitute. Elastic suspenders or garters may also be employed in an emergency. In hemorrhage from wounds of the hands and feet, especially in children, and in controlling hemorrhage from wounds of the penis, a piece of drainage tube, firmly applied above the wound, may be employed with advantage. Care should be observed in applying elastic constriction, for if the elastic tube be applied too tightly the subcutaneous tissues may be divided or nerves may be so compressed that their function is destroyed. The tube or strap, although generally employed to control hemorrhage from the vessels of the extremities, may be used to control the femoral artery as it crosses the brim of the pelvis, by placing a compress over the artery in this position, and then applying the elastic band to secure it by making a figure-of-eight turn, passing under the thigh, crossing over the pad and then carrying the ends around the pelvis and securing them.

Fig. 231.



Signorini's tourniquet.

Fig. 232.

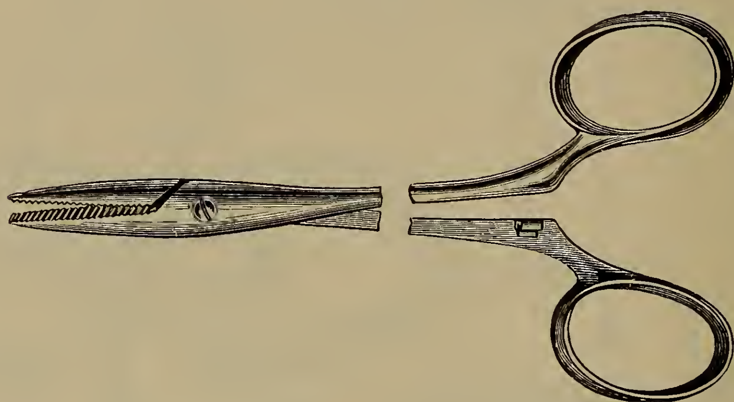


Elastic strap of Esmarch's apparatus.

To make pressure on the axillary artery a compress should be placed in the axilla, and the middle of the tube placed over this to hold it in position; the ends of the tube are then carried over the shoulder, where they are crossed and then carried to the opposite axilla and secured.

Hemostatic Forceps.—The temporary control of arterial hemorrhage by the use of hemostatic forceps is now very generally employed in surgical operations, and their use has done much to diminish the shock following operations from the loss of blood. The hemostatic forceps in general use is self-retaining; it is clamped upon the bleeding vessel, and is allowed to remain until the operation is completed, when the vessel is secured permanently by the application of a ligature, and the forceps is removed. The use of these forceps will be

Fig. 233.

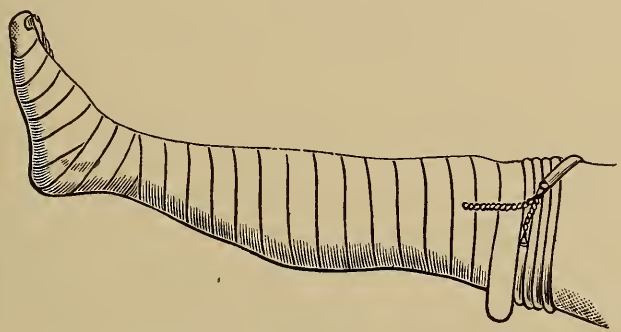


Hemostatic forceps.

found very satisfactory in controlling hemorrhage during the removal of tumors; in amputations and for the temporary control of bleeding during the operation of tracheotomy, they will be found most efficient, as also in abdominal operations, in which their utility was first demonstrated (Fig. 233).

Esmarch's Bandage and Tube.—This apparatus, which is applied to the limbs to render them bloodless during operations, consists of a rubber bandage $2\frac{1}{2}$ inches in width and 3 or 4 yards in length, and a rubber tube 2 yards in length, to one end of which is attached a chain and to the other a hook, or, better, a rubber strap, 1 inch in width and $1\frac{1}{2}$ yards in length, with a hook and chain. The bandage is applied to the extremity of the limb, and is carried up the limb to a point some distance above the seat of proposed operation; the bandage is applied firmly, each turn overlapping one-fourth of the preceding one, and when the last turn has been made the rubber tube or strap is wound firmly around the limb and secured by fastening the hook into one of the links of the chain (Fig. 234). After securing the tube or strap the rubber bandage is removed from the limb; and if the tube has been sufficiently firmly applied the limb will be found blanched, and should be free from blood during the operation. Care should be taken not to apply the tube or strap too tightly upon poorly developed limbs, or on parts of the limb where large nerve trunks approach the surface, as they may

Fig. 234.



Esmarch's bandage and tube applied.

be subjected to an amount of pressure which will interfere with their functions subsequently. I have knowledge of one case of this nature in which permanent paralysis of the limb followed the use of Esmarch's apparatus; the tube should be applied with just sufficient firmness to control the circulation. As the strap, when firmly applied, completely cuts off the circulation of the parts below, it should be applied for as short a time as possible, as gangrene has resulted from its prolonged use. After removal of the tube or strap there is generally free capillary hemorrhage, due to paralysis of the vasomotor nerves from pressure, but this in a short time stops. This appliance is of the greatest service in controlling hemorrhage at the time of operation, and in amputations and for removal of vascular tumors from the limbs will be found most satisfactory. In operations upon bones, such as resection or sequestrotomy, it is especially useful, as it allows the surgeon to inspect the parts unobscured by hemorrhage. I have found its use most satisfactory in operations for the removal of foreign bodies, such as needles embedded in extremities.

Permanent Control of Arterial Hemorrhage.—To secure this end, the surgeon may resort to the use of position, cold, heat, styptics, pressure, cauterization, ligation, torsion, suture of the artery.

Position.—In arterial hemorrhage from wounds of the extremities, elevation of the part will be found to materially diminish the amount of bleeding; in hemorrhage from wounds of the arteries of the hand, forearm, foot or leg, forcible flexion of the forearm on the arm or of the leg on the thigh will be found useful in diminishing the force of the blood current.

Cold.—The application of cold by means of a stream of cold water or an ice-bag or pieces of ice will often be found an efficient means of controlling hemorrhage from vessels of small caliber; it is especially applicable to hemorrhage from wounds of the vessels of the mouth, nostrils, vagina or rectum.

Hot Water.—Hot water will be found a very efficient means of controlling hemorrhage from small vessels, and it may be used in the form of a hot antiseptic solution. It is of special value in capillary or parenchymatous hemorrhage, and is employed in the form of a douche or by means of sponges or gauze pads dipped in the hot solution and packed into the wound. The injection of hot water is a most satisfactory method of controlling uterine hemorrhage.

Styptics.—These agents are sometimes employed to control capillary bleeding or hemorrhage from small vessels, and although their use is often satisfactory as regards the control of the bleeding, they have the disadvantage of interfering with primary union in wounds, and since the value of asepsis in wound treatment has been demonstrated they are now very seldom employed. The most valuable styptics are alcohol, alum, oil of turpentine, perchloride of iron, persulphate of iron or Monsel's solution, acetic acid, vinegar, adrenalin chloride, antipyrin and gelatin.

Adrenalin Chloride.—A solution of adrenalin chloride in normal salt solution 1:1000 to 1:10,000 is employed for the control of hemorrhage. It seems to be most serviceable in capillary hemorrhage. It is extensively employed to check bleeding during operations upon the nose, throat and larynx and to arrest epistaxis and bleeding from the uterus. It is also used intravenously in profuse hemorrhages in combination with saline solution. It is generally used by soaking a pledget of cotton or gauze in the solution and pressing it upon the bleeding surface; it may also be sprayed upon the part. Adrenalin extract, in the form of powder, may also be dusted upon a bleeding surface to secure hemostasis.

Calcium Chloride.—This drug given internally favors the coagulation of blood and tends to check oozing. The initial dose should be 10 grs., and should afterward be given in doses of 5 grs. every hour until five or six doses have been taken.

Antipyrin.—A solution of antipyrin, 5 per cent, in sterilized water possesses marked styptic action. As it also possesses antiseptic properties, and is not toxic, it may be used to control capillary bleeding from the surface of the brain, the intestines and peritoneum and from the bone cavities.

Gelatin.—This may be used as a styptic where it can be applied locally in 2 to 10 per cent solution in normal salt solution. Gelatin solution is prepared by taking 5 gm. of common salt, 1 liter of distilled water, 100 gm. of gelatin; bring the water to 80° C. and slowly stir in the gelatin until it is dissolved. Cool the solution to 40° C., add the white of one egg and stir for several minutes and then boil it; the white of egg coagulates and clears the solution. Filter through gauze and paper and put the solution in test tubes, each of which should contain 10 cc and close with a cotton plug. Sterilize by putting in a steam sterilizer fifteen minutes for three successive days. Before using a tube place it in hot water until the gelatin liquifies and it may be applied by injecting, irrigating or tamponing the bleeding area. It may also be injected subcutaneously. Intravenous injection of gelatin solution is dangerous, as it is apt to be followed by embolism. It has been employed successfully in epistaxis, hematemesis, vesical and uterine hemorrhage and in superficial wounds in patients the subjects of hemophilia.

Blood Serum.—This is obtained from human blood or that of animals; the former is to be preferred. Applied to the bleeding surface it hastens coagulation; it may also be used subcutaneously or intravenously in doses of 10 to 40 cc. It has been used with good results in hemophilia and in the postoperative oozing of jaundiced patients, or may be injected before the operation in these patients.

Pressure.—For the permanent control of arterial hemorrhage, pressure may be applied directly to the bleeding point or surface by means of a compress of aseptic gauze or by strips of gauze packed firmly into the cavity from whose surface the bleeding arises.

Compresses are used with the best results where the proximity of a bone gives a firm substance upon which the vessel may be compressed, as is the case in the vessels of the scalp. Pressure applied by means of packing with strips of gauze will be found most efficient in controlling hemorrhage from cavities, such as the nose, vagina or rectum, and in the cavities resulting from the removal of necrosed or carious bone. Pressure may be indirectly applied to an artery by flexing the joint over a compress or by firm bandaging of the limb.

In controlling bleeding from a divided artery in a bony cavity, such as the *inferior dental,* a piece of catgut ligature may be forced into the canal, and will control the bleeding in a most satisfactory manner, or it may be controlled by forcing a small piece of *Horsley's wax* into the opening in the bone; this wax is composed of wax, 7 parts; oil, 2 parts; and carbolic acid, 1 part.

Bleeding from small vessels in the bone in dense fibrous tissues may be controlled by a *muscle graft* which consists of a small fragment of muscle which is forced into the cavity or held firmly for a few seconds against the bleeding-point.

Halsted has introduced a material known as *gut wool,* which is prepared from the same material from which catgut is made. This is cut into fine shreds, and is used to control hemorrhage from bone, being pressed into the opening or cavity in the bone from which the bleeding arises.

The troublesome hemorrhage sometimes occurring after the *removal of a tooth* may be controlled by packing the alveolar cavity with a strip of iodoform gauze, or by introducing a wedged-shaped piece of cork and holding it in place by fastening the jaws together by means of a bandage.

Cauterization.—The use of cauterization by means of a hot iron is a satisfactory method of arresting hemorrhage. Care should be taken to have the iron only of a dull-red or black heat, as the result desired is not the destruction of the tissues, but the coagulating effect of heat upon them. The form of cautery-iron employed will depend upon the size and position of the vessel. Paquelin's cautery is also a satisfactory apparatus to use for the control of hemorrhage.

The control of arterial bleeding by cauterization is often resorted to in operations upon the jaws and in the removal of tumors from the mouth or pharynx or of the tonsils; it is also frequently employed to control hemorrhage in operations upon the uterus and the rectum, and also that resulting from the removal of abdominal tumors, where the application of a ligature is difficult and often impossible.

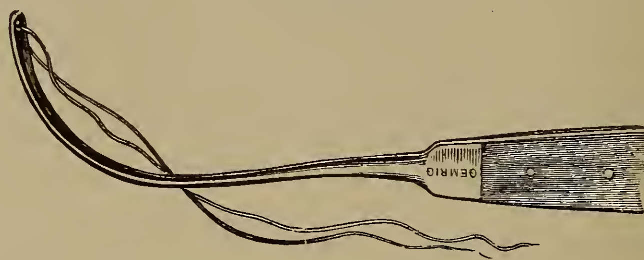
Torsion.—This method of controlling arterial hemorrhage consists in seizing the end of the artery, drawing it slightly out of its sheath and twisting it; it may be accomplished with a single pair of forceps or hemostatic forceps, or by two pairs of forceps. In the latter method the vessel is held by one pair of forceps and is twisted by the second pair. It should only be used in vessels of moderate size.

Torsion of arteries in accidental wounds is quite common, and in many cases controls the hemorrhage until surgical aid is rendered. I have seen hemorrhage from the femoral artery in Scarpa's triangle completely controlled in this manner in a case of avulsion of the thigh from a railway injury.

The Ligature.—The use of the ligature is by far the most generally employed method of controlling arterial hemorrhage. The materials used are silk, hemp thread or catgut. Catgut or silk is the material generally employed. The vessel is seized with a pair of hemostatic forceps and drawn out of its sheath, and a ligature of sterilized catgut or silk is thrown around it and secured by a surgeon's knot, or by a reef knot and a surgeon's knot combined and when firmly tied the ends of the ligature are cut short in the wound.

When ligatures are applied to vessels in their continuity, they may be threaded into an eyed probe or aneurysm needle (Fig. 235) and carried around the vessel and secured.

Fig. 235.



Aneurysm needle armed with ligature.

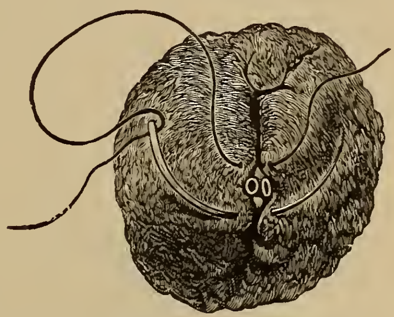
Temporary or Provisional Ligation of Arteries.—This procedure is employed when it is desired to control for a time the arterial circulation during an operation, or as a precaution in case where free hemorrhage may occur.

The artery to be temporarily occluded is exposed by a careful dissection. The sheath is not opened and a flat ligature or tape is passed beneath the sheath and is closely tied or clamped with forceps. When it is desired to occlude the vessel, an assistant lifts the vessel from its bed by the ligature, which arrests the flow of blood through the vessel. When the necessity for the control of the circulation has passed the ligature is removed and the wound is closed.

Special forceps or clamps with blades covered by rubber so that they cause no injury to the walls of the vessel may also be employed to secure temporary control of the circulation through the artery.

Ligature En Masse or Suture Ligature.—A convenient method of applying a ligature to a bleeding point, or a limited area of hemorrhage in a deep wound, or to a vessel in tissues which are of such a nature as not to permit of the isolation of the vessel, is to use a curved needle threaded with a catgut ligature, which is passed deeply into the tissues near the vessels and brought out on the opposite side; the ligature thus placed is then tied firmly enough to control the bleeding, but not so tight as to produce strangulation of the tissues; the ends are cut short in the wound (Fig. 236).

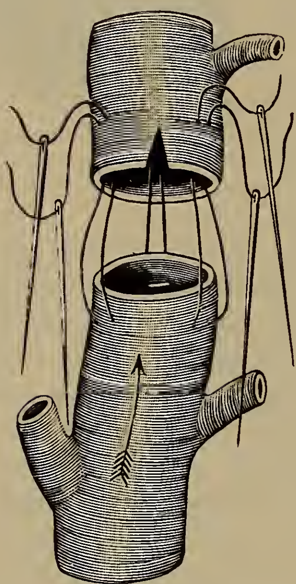
Fig. 236.



Artery occluded by suture ligature.

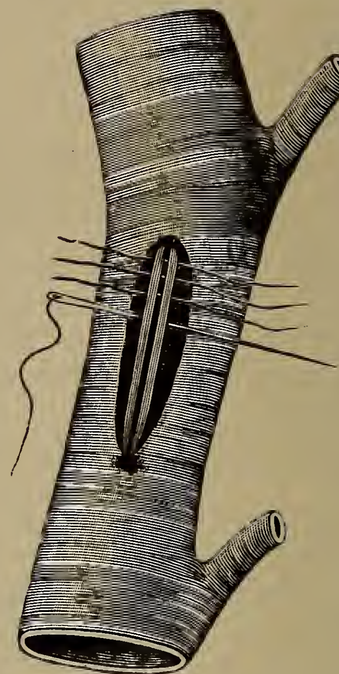
Arteriorraphy. — *Suture of Arteries.*—Wounds of arteries, both longitudinal, oblique and transverse, have been successfully closed by sutures both in man and the lower animals. It is recommended in the larger arteries, where more than two-thirds of the circumference has been divided to resect the injured portion of the vessel, where it can be done without removing more than $\frac{3}{4}$ inch of the vessel, and invaginate one end into the other, and to secure their fixation by fine silk or catgut sutures, which include all the coats of the vessel (Fig. 237). The distal end of the vessel is slit for a short distance to aid in the invagination, which is accomplished by traction upon the sutures. When this is accomplished the sutures are tied tightly with reef knots. The line of juncture is reinforced by sutures uniting the edges of the slit formed so as not to include the intima or the invaginated vessel. In longitudinal wounds the edges may be brought together by fine silk sutures, introduced by means of a fine cambric needle. The sutures should be inserted from $\frac{1}{16}$ to $\frac{1}{20}$ inch apart, and $\frac{1}{16}$ inch from the edges of the wound, and should include only the adventitia and media, not perforating the intima (Fig. 238). During the operation the circulation in the vessel should be controlled both above and below the wound by forceps covered with rubber tubing, Crile's clamps or temporary ligatures. Where a distinct sheath is present, it should be sutured over the wound; and if this is not present, muscle or fascia should be sutured over the closed wound in the vessel. The application of sutures to wounds of arteries has been advocated to secure permeability of the vessel at the seat of the wound, but it is still a mooted question whether the vessel remains ultimately permeable at the seat of the wound. If thrombosis occurs at the seat of injury occlusion of the artery may be so gradual that gangrene will be much less apt to ensue than after ligation.

Fig. 237.



Invagination of wounded artery. (Bickham.)

Fig. 238.



Suture of longitudinal wound of an artery. (Bickham.)

Closure by Plaster Tape.—Brewer, in experiments upon wounds of the arteries in animals, has secured control of the bleeding and closure of the wound by wrapping around the wounded vessel a strip of specially prepared adhesive plaster. The plaster is a variety of rubber plaster which has been thoroughly sterilized, so that it can remain indefinitely in the tissues. He has suggested that this procedure may be employed in wounds of the larger arteries in man, where for any reason sutures cannot be applied.

Rules for Ligating Wounded Arteries.—In cases of primary hemorrhage no operation should be performed upon an artery unless it is at the moment actually bleeding. The exception to this rule is in the cases where the vessel is seen to pulsate in the wound, or where the wound involves the region of a large artery and the patient has to be transported, or may be in a position not to receive surgical aid subsequently if needed; under these circumstances the vessel should be tied or the wound should be explored to ascertain the fact that no important vessel has been injured. Arteriorraphy or circular invagination should be practised in suitable cases.

In applying a ligature to a wounded artery the surgeon should cut down directly upon it at the point from which it bleeds and secure it in the wound. This rule holds good for both primary and secondary hemorrhage.

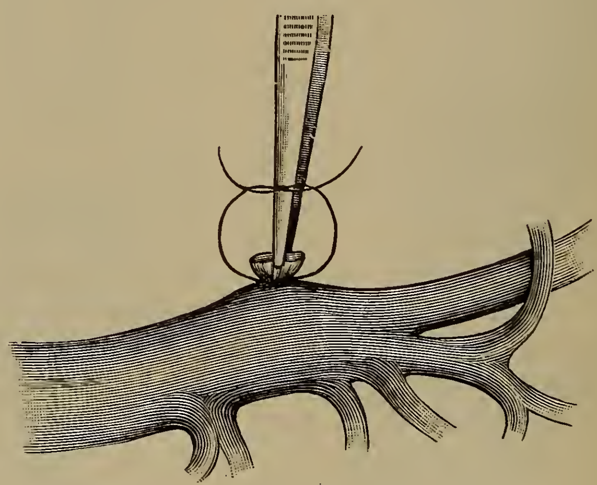
Two ligatures should be applied, one to each end of the artery if it be completely divided, and one on each side of the wound if the latter has not severed all the coats of the artery. This procedure is adopted for the reason that arterial anastomosis is so free that the proximal ligature will not always, even temporarily, arrest the bleeding; and if it does accomplish this object at the time, after the collateral circulation is established bleeding is apt to occur from the distal extremity of the divided vessel. If the coats of the artery are not completely severed their division should be completed, either before or after the application of the proximal and distal ligatures, thereby favoring contraction and retraction of the ends of the divided vessel. If a branch is present just below the ligature tie the branch as well as the main vessel. If a branch is divided very near to the main artery it should be tied; the main vessel need not be ligated.

Treatment of Venous Hemorrhage.—Bleeding from small veins often stops spontaneously unless there is pressure upon the wounded veins on the cardiac side of the wound. It is, however, very satisfactorily controlled by position or by the application of a compress and bandage. The free bleeding arising from ruptured varicose veins of the leg is easily controlled by the application of a compress and a bandage.

The Ligature.—When large veins have been divided both ends should be secured by ligatures, as in the case of divided arteries; small wounds should be treated by the lateral ligature or suture.

The Lateral Ligature.—The application of the lateral ligature to small wounds of large veins, such as the femoral, or to wounds of venous sinuses, has been recommended and employed with good results; this procedure consists in pinching up the wall of the vein so as to include the orifice of the wound with forceps and throwing a delicate silk or catgut ligature around it (Fig. 239).

Fig. 239.



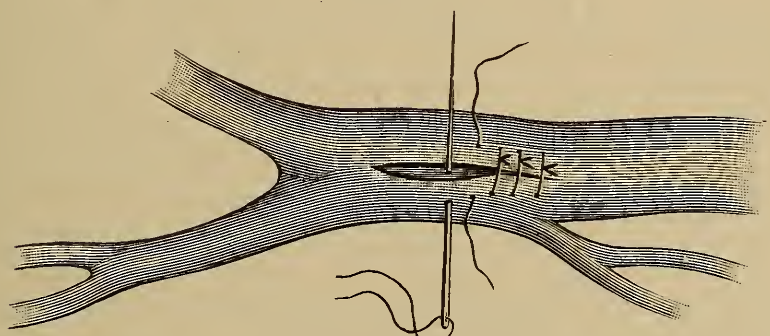
Lateral ligature. (Bickham.)

Phleborraphy.—*Suture of Veins.*—This procedure has also been employed with success in the case of longitudinal or transverse wounds of the larger veins. The bleeding should be controlled by pressure upon the vein on both sides of the wound, and the wound in the vessel should be closed by fine silk or catgut sutures applied closely together by means of a fine cambric needle (Fig. 240). The employment of sutures and lateral ligatures in wounds or veins possesses the advantage of controlling the bleeding and at the same time not causing obliteration of the vessel at the seat of injury.

The *actual cautery* may also be employed for the control of venous hemorrhage in situations in which its arrest by pressure suture or the ligature is not feasible.

Compression by means of strips of sterilized gauze is often employed to control venous hemorrhage from cavities. This is the most satisfactory manner of controlling hemorrhage for the venous sinuses of the brain.

FIG. 240.



Suture of a vein. (Bickham.)

Treatment of Capillary Hemorrhage.—Capillary or parenchymatous hemorrhage is often arrested spontaneously on exposure of the surface of the wound to the air, but the bleeding may not be controlled and may be so profuse that its arrest becomes a matter of importance. To control this form of bleeding, pressure may be applied to the bleeding surface for a short time, and if this fails to arrest it sponging the surface with dilute alcohol will sometimes prove satisfactory; but the best application to arrest hemorrhage of this nature is hot water or by hot compresses wrung out of hot water or hot saline solution.

Adrenalin chloride solution, 1 to 1000 to 1 to 10,000, may also be employed with good results.

In cases where the means mentioned above fail to control the bleeding it may be necessary to pack the wound with strips of sterilized gauze; this dressing is most serviceable when the hemorrhage comes from cavities such as result from the removal of tumors or excisions of joints, and for the control of bleeding following the removal of necrosed or carious bone. To control hemorrhage from mucous cavities, such as the nose, rectum and vagina, this method of treatment is also frequently resorted to.

Consecutive or Reactionary Hemorrhage.—This variety of hemorrhage develops during reaction from an accidental wound or operation in from twelve to forty-eight hours. It arises from vessels which did not bleed during the stage of shock or from vessels which were overlooked when the wound was dressed. It may also be due to improperly applied or prematurely softened ligatures. This form of bleeding is not often sudden or severe, the blood usually escaping by drops, and the constitutional symptoms of hemorrhage do not develop unless a considerable quantity of blood is lost.

Treatment.—Pressure applied to the wound and elevation of the part, if possible, will often control the bleeding. If, however, the bleeding persists the wound should be opened and the bleeding vessels found and secured by ligatures.

Treatment of Secondary Hemorrhage.—Secondary hemorrhage following the use of the ligature or other means of controlling bleeding usually results from a septic condition of the wound, and is due to a septic arteritis. Since the adoption of the antiseptic and aseptic methods of wound treatment it is a much less frequent complication of wounds.

The treatment of this complication is both constitutional and local. The *constitutional* treatment consists in the use of those remedies which were mentioned as serviceable in primary hemorrhage, and the drugs upon which most reliance should be placed are morphine, atropine and strychnine.

The *local* treatment of this form of hemorrhage consists in the use of the various means of controlling hemorrhage which have been mentioned, such as the ligature, hot water, pressure or the actual cautery. If possible, it is well to secure the vessel from which the bleeding arises in the wound; if for any reason this cannot be done the main artery should be ligated above the wound if the hemorrhage be arterial.

Subcutaneous Hemorrhage.—Hematoma.—Rupture of a large bloodvessel subcutaneously may give rise to a tumor and the constitutional symptoms of hemorrhage. If the source of bleeding is from a ruptured artery pulsation may be present in the tumor. Hemorrhage from a ruptured vein may cause a distinct tumor, with fluctuation but without pulsation.

Small effusions of blood are usually absorbed under rest and moderate pressure by a bandage. If the effusion is large and fluctuation persists the tumor may be aspirated or incised with full aseptic precautions, and the blood allowed to escape, the wound being closed without drainage.

Control of Hemorrhage from Special Parts.—Epistaxis.— Epistaxis, or hemorrhage from the nose, may be so profuse as to require surgical interference. To control this form of hemorrhage the application of iced compresses to the surface of the nose may first be made use of, or the injection of cold sterile water, or pledgets of cotton or gauze saturated with adrenalin solution may be packed into the nasal cavity. If this fails to control the bleeding the surgeon or the patient should grasp the cartilaginous portion of the nose with his thumb and forefinger in such a manner as to keep the nostrils tightly closed, which will prevent the passage of air through the nose and thus permit clots to form, arresting the flow of blood. Bleeding from the nose often arises from the erosion of a small artery low down upon the septum which can be freely exposed by introducing a nasal speculum, and the bleeding point may be touched with a cautery iron, thus avoiding the necessity of plugging the nares. If these simple means fail to arrest the bleeding the nasal cavity or cavities may be packed with strips of sterilized gauze introduced into the anterior nares, and pushed backward by a director or probe; this will often be found a satisfactory means of arresting the bleeding. This method may be supplemented by a plug of sterilized cotton introduced into the posterior nares with the finger. The use of a rubber tampon, consisting of a rubber bag, introduced into the nares in a collapsed state and afterward inflated, has also been recommended for the control of this variety of hemorrhage.

Plugging the nares by means of Bellocq's cannula is also employed to arrest hemorrhage from the nasal cavities; the cannula, armed with a strong ligature, is passed along the floor of the nose until it reaches the pharynx, when the spring being protruded, the ligature is seized and brought out of the mouth and secured to a plug of lint or of antiseptic gauze of the required size, and upon withdrawing the instrument the plug is brought into position in the posterior nares and the end of the ligature allowed to protrude from the mouth to facilitate its removal (Fig. 241). An ordinary flexible catheter may be employed instead of Bellocq's cannula for the introduction of the ligature.

Fig. 241.

Plugging the posterior nares. (Ashhurst.)

Hemorrhage from the Urethra.—In hemorrhage from the urethra, if profuse, the blood will trickle from the meatus; or if efforts at micturition are made the first portion of urine will contain blood, but afterward will be clear, and the last portion will contain a few drops of pure blood.

This variety of bleeding, if it proceeds from the anterior portion of the urethra, may be controlled by the introduction of a catheter and the application of a bandage around the penis applied so as to make only moderate pressure.

If the bleeding comes from the posterior portion of the urethra it will often be controlled by the application of cold or pressure to the perineum, or by the introduction of a cold steel bougie, or by the injection of a weak solution of antipyrin or of adrenalin solution.

Hemorrhage from the Bladder.—In this variety of hemorrhage the first portion of the urine may be blood stained, and the last portion will contain more blood and clots as the organ contracts, which distinguishes it from hemorrhage from the kidneys, in which admixture of blood with the urine renders it of a smoky color or dark red if the bleeding is profuse.

To control bleeding from the bladder a catheter should be introduced and the urine and clots withdrawn; the bladder should next be washed out with a hot boric acid solution. In severe cases a weak solution of antipyrin, alum or adrenalin may be employed. The application of ice to the perineum and suprapubic regions may also be employed with advantage.

Hemorrhage from the Prostate Gland.—This requires the injection of hot boric acid solution and the introduction of a large warmed bougie. A catheter should be introduced and tied in the bladder for several days.

Hemorrhage of the Kidney.—This may follow wounds of the kidney or contusion of the organ. Bleeding following contusions of the kidney is not usually profuse, and generally subsides with rest in bed, the application of an ice-bag to the loin, and the use of 10-gr. doses of gallic acid. Cystoscopic examination may be required to determine from which kidney the bleeding comes. If the bleeding continues the kidney should be exposed by lumbar incision, and the wound sutured or nephrectomy should be performed.

Hemorrhage of the Stomach.—Bleeding from the stomach should be treated by the use of ice and the administration of opium and gallic acid or gelatin solution; if it persists the stomach should be exposed by laparotomy, and if an ulcer is located it should be excised. Hemorrhage from a wound calls for laparotomy and treatment of the wound. Profuse hemorrhage from the stomach may arise from cirrhosis of the liver; in such a case operative treatment is useless.

Hemorrhage of the Rectum.—This variety of bleeding may be controlled by the injection of cold or astringent enemata. If the bleeding be profuse a speculum should be introduced, and when the source of the bleeding has been discovered the actual cautery or a ligature should be applied. If this is not feasible the rectum may be plugged with strips of antiseptic gauze, or a piece of a rubber catheter of large caliber, or a rubber tube, may be wrapped with gauze and introduced into the rectum, the end of the catheter being allowed to protrude; by using this tube flatus can escape, and if the bleeding is not controlled blood will escape through the tube, preventing the risk of concealed hemorrhage. If the bleeding arises from hemorrhoids or polypus of the rectum, operative treatment of these conditions should be undertaken to remove the cause of bleeding.

Intra-abdominal Hemorrhage.—In this variety of hemorrhage the constitutional symptoms are very marked. It may arise from contusions or wounds of the abdomen, producing lacerations or wounds of the solid or hollow viscera. The blood may gravitate to the loins, causing dulness on percussion, which changes as the patient's position is changed, or it may settle in the recto-vesical or recto-uterine pouches. In wounds of the spleen the area of dulness remains in the splenic region as the blood clots quickly. The treatment consists in an exploratory laparotomy and search for the source of bleeding. Wounds of the hollow viscera should be sutured; those of the solid viscera sutured, cauterized or packed to control the bleeding. Severe wounds of the spleen require splenectomy. Wounds of the kidney may be sutured, or may require partial or complete nephrectomy. Wounds of the mesenteric vessels should be ligated, and if a portion of the intestine is deprived of blood, resection should be performed.

Extradural Hemorrhage.—This usually arises from the middle or anterior meningeal arteries. The symptoms determine the site of the lesion. To expose the middle meningeal artery, open the skull at a point on a level with the upper orbital border and 1¼ inches behind the external angular process, and if no clot is exposed, trephine over the posterior branch on the same level and just below the parietal eminence. Remove the clot and close the wound.

Hemophilia.—This is a congenital affection in which there is an abnormal and inveterate tendency to hemorrhage from trifling injuries, such as the extraction of a tooth or insignificant wounds or abrasions; spontaneous bleeding may also occur from the mucous membranes. This condition affects males almost exclusively, but is transmitted from one generation to another only through the female; such individuals are known as bleeders and the existence of the condition is established soon after birth by the persistent oozing which occurs after minor injuries. Such slight injuries in hemophiliacs have been followed by death from acute anemia. The blood in this condition is not coagulable, or only very feebly so. Operations should be avoided in bleeders unless absolutely necessary. In such cases blood transfusion from a healthy individual is indicated in order to provide the elements of blood necessary for coagulation. The subcutaneous injection of 20 to 30 cc of suitable blood forty-eight hours before operation has been used and is said to arrest or diminish the bleeding. Hemorrhage from the larger vessels is easily arrested by ligature, but capillary oozing continues, and no local treatment seems to avail in controlling it.

Treatment.—The subcutaneous injection of horse serum and even diphtheria antitoxin has been used in some cases with apparently good results. The internal administration of calcium chloride, which increases the coagulability of the blood, has been employed. Hypodermoclysis, intravenous injection of saline solution and transfusion of blood have also been employed.

Spontaneous hemorrhage is not so common in hemophiliacs as in those in whom the hemorrhagic diathesis exists in whom the coagulation time is not retarded and there is no retardation of the clot.

Coagulation Time of Blood.—The surgeon is at the present time able to cope successfully with massive hemorrhage from large vessels, by means of hemostatic forceps, ligatures or other means of controlling the loss of blood. Still, he is largely dependent upon the natural property of coagulation or clotting of the blood for stopping oozing from small vessels. When the blood is unable to clot, any wound, operative or accidental, is dangerous, as the oozing from capillaries and small vessels may continue until the person is exsanguinated.

In the condition known as hemophilia the blood is not coagulable or only very feebly so. In long-continued jaundice, purpura, scurvy, leukemia and certain diseases of the spleen, the coagulability of the blood may be much reduced. In such cases it is advisable to estimate the coagulation time of the blood prior to operation. This may be done roughly by picking up a number of drops of blood upon a glass slide, and estimating the time necessary for coagulation, either by tilting the slide and noting when it no longer sags under the influence of gravity, or by drawing a bristle through it at intervals to demonstrate the formation of the fibrinous clot. Ordinarily clotting should occur in two to five minutes.

Wright's tubes are capillary tubes of uniform caliber, into which the blood may be drawn as far as a certain indicated point. A number of the tubes are filled and at intervals their contents are discharged, enabling one to note whether coagulation has as yet occurred.

The Brodie-Russell-Boggs coagulometer is probably the most uniform and accurate in its results. In this method a drop of blood is picked up on the small end of a truncated glass cone. This drop is placed in the cell of the instrument and observed under the microscope. By means of a bulb a fine current of air can be directed against the hanging drop of blood. While the blood is still fluid, the red blood cells are agitated and dispersed by the air current, but when coagulation occurs the cells remain in their respective places, swinging back and forth as the current is played upon them as though they were embedded in an elastic jelly. So delicate and complex are the factors involved in the coagulation of the blood that all methods yet devised lack uniformity in their results and are not entirely trustworthy for clinical purposes.

TREATMENT OF ABSCESS.

In operations for evacuation of the contents of abscesses care should be taken to observe every precaution to prevent a new infection of the wound or abscess cavity; the skin over the abscess should be carefully cleaned to make it aseptic, the hands of the surgeon and the instruments to be brought in contact with it should also be aseptic. These precautions should be especially observed in the opening of chronic abscesses when a new variety of infection is liable to be introduced if aseptic precautions are not rigidly observed. If the pus is not definitely localized the application of hot fomentations contributes to the comfort of the patient; gauze saturated with hot boric solution and covered with rubber tissue and cotton, to retain the heat and moisture, is a good dressing.

Acute Abscess.—This variety of abscess should be opened by incision, and this is best done with a straight, narrow, sharp-pointed bistoury. The incision should be deep enough to expose freely the cavity of the abscess, and should be parallel with and not across important structures, and it should also be made at as dependent a portion as possible. Abscesses of the limbs are opened by a longitudinal incision, and those in the region of the anus and breast by an incision radiating from the anus or nipple.

In incising abscesses of the face and neck due regard should he had for the resulting scars; the incisions should be in the natural folds of the skin and abscesses of the neck and jaws should, if possible, be opened through the mucous membrane of the mouth.

Pressure should not be made upon the walls of the abscess to empty it, as by so doing delicate vessels may be ruptured and cause hemorrhage, and the spread of the infection may be facilitated.

The cavity of the abscess having been emptied of pus, it may be irrigated with normal salt solution, or the irrigation of the cavity may be omitted, and if the cavity is not very large or deep no drainage tube need be introduced, and a small piece of rubber tissue may be placed between the lips of the wound to prevent their adhesion; but if, on the other hand, the cavity is extensive and deeply situated, a rubber drainage tube or a strip of moist iodoform or sterilized gauze should be introduced to the bottom of the cavity to secure free drainage, and if a tube be used it should be fixed at the surface of the skin by a safety-pin. A gauze dressing, consisting of a number of layers, which has been moistened in boric or bichloride solution, is next placed over the wound, and is covered by a number of layers of dry gauze, which are in turn covered by a piece of rubber tissue. The latter may be substituted by a few layers of sterilized gauze and cotton, and the dressing is finally secured by a roller bandage. The dressing is removed at the end of two or three days, the cavity being washed out with a mild antiseptic or saline solution, or the irrigation may be omitted. The drainage tube may then be shortened or removed, and the dressings reapplied, as at the primary dressing. Under this method of treatment acute abscesses usually heal promptly.

When there is extensive burrowing of pus it is advisable to make several incisions rather than one long incision and drain through each incision. Acute abscesses of the neck if under the deep fascia demand early incision; they may burrow extensively or cause pressure upon important structures. Retropharyngeal abscess may interfere with the breathing and deglutition, and if it ruptures may cause suffocation; it therefore demands early opening. Ischiorectal abscess, from its tendency to open into the rectum and give rise to fistula, should be treated by early incision.

Hilton's Method.—In deep-seated abscesses in the region of important structures the method of opening suggested by Mr. Hilton may be employed with advantage; it consists in making a small incision through the skin and cellular tissue; a director is next pushed through the tissues into the abscess cavity, which will be shown to have been reached by the escape of pus along the director; a dressing forceps with the blades closed is now pushed along the director into the abscess cavity, and when this has been accomplished the director is withdrawn and the forceps removed with the blades expanded so as to dilate the wound and allow the pus to escape.

Tuberculous or Chronic Abscess.—This variety of abscess occurs chiefly in connection with tuberculous disease of the bones or joints. This variety of abscess contains the degenerated products of tuberculous inflammation and true pus is only present when there has been an accidental infection with pyogenic organisms. It may be opened in various ways, the time at which this should be done depending upon the size and situation of the abscess and the amount of constitutional and local disturbance which the patient experiences from its presence.

Aspiration.—A tuberculous abscess may be evacuated by means of the aspirator; the pus being withdrawn as far as possible, the puncture is sealed with a small piece of gauze covered with collodion. Reaccumulation of pus often takes place, and the aspiration has to be repeated a number of times. The greatest difficulty in the successful removal of the contents of tuberculous abscesses by means of aspiration is the presence of cheesy masses in the pus, which occlude the cannula and often prevent complete emptying of the cavity. This may be overcome by irrigating the cavity through the cannula with saline solution.

Puncture and Injection.—This variety of abscess may also be evacuated by making a puncture through the skin and overlying tissues with a narrow bistoury, the surface having been previously sterilized with tincture of iodine; a director is next pushed through this small wound into the cavity of the abscess, and the pus is allowed to escape by stretching the wound with the director; when the cavity is emptied of pus it is washed out with saline solution or sterile water introduced into it by pushing the nozzle of a syringe into the cavity, and this is allowed to escape in the same way as the pus previously did. When all the irrigating solution has escaped the cavity may be injected with an emulsion composed of iodoform, 1 part, glycerin or sterilized olive oil, 10 parts; after this has been introduced the small wound is closed by a compress of antiseptic gauze held in place by collodion, a bandage or by strips of adhesive plaster. This procedure has to be repeated several times before a tuberculous abscess is cured. After each operation it is found that the cavity of the abscess is diminished in size. A cure depends upon the death of the tubercle bacilli or healing of the causative focus.

In evacuating tuberculous abscesses by means of the aspirator or by a small puncture there is absence of shock, and the loss of blood is insignificant, so that these procedures should generally be first employed, and the more radical operation of incision and curetting of the cavity of the abscess, which is accompanied with a certain amount of shock and hemorrhage, should be reserved for those cases in which the less severe operations have not been followed by a satisfactory result.

Incision.—Tuberculous abscesses are also treated by making a free incision into the abscess cavity with full antiseptic precautions, and after the escape of the purulent matter the walls of the abscess should be thoroughly scraped with a curette; after the cavity has been freely washed out with a carbolic or bichloride solution or sterile water, large drainage tubes are introduced and an antiseptic dressing is applied to the wound. The edges of the incision may be brought together by sutures without the introduction of drainage, or the cavity may be packed with iodoform gauze and allowed to heal by granulation. The dressings are removed as soon as they become soaked, and the drainage tubes are shortened or removed as the discharge diminishes and the cavity contracts.

Diffuse Suppuration.—This form of suppuration is treated by numerous punctures or incisions which allow the purulent matter to escape; and where sloughs are present free incisions may be required to give exit to the necrosed tissues; the introduction of the drainage tubes may also be required. The wounds and the cavities, as far as possible, should be washed out with sterile water or bichloride solution and an antiseptic gauze dressing applied. The Carrel-Dakin treatment is of great value in this variety of suppuration.

Sinus and Fistula.—These are suppurating tracts which result from abscesses or wounds. A *sinus* has only one orifice as its other extremity ends in the former abscess cavity. A *fistula* is a suppurating tract with two or more orifices which may be external or internal. A sinus or fistula may be kept from healing by the presence of a foreign body as is seen in sinuses in connection with necrosed bone, or by muscular action as is the case of fistula-in-ano or by the constant passage of the secretions of the part through the abnormal opening as in fecal, salivary or urinary fistulæ.

Treatment.—Foreign bodies should be removed, and in the case of fistula kept up by secretions from internal organs, the opening into the organ must be exposed and closed. If superficial they should be laid open freely and their surfaces scraped with a curette, and then lightly packed with strips of iodoform gauze and covered by an antiseptic dressing. Sinuses in accessible positions may be treated by dissecting out the walls of the sinus and closing the deeper parts of the wound with buried absorbable sutures, and suture of the superficial parts and the skin. If they are too deep to be treated by incision, their healing may be facilitated by the injection of stimulating solutions introduced by means of a syringe; the employment of solutions of chloride of zinc, nitrate of silver and sulphate of copper, varying in strength from 5 to 20 grains to the ounce of water, will often prove satisfactory.

Beck's Bismuth Emulsion has recently been used with good results in the treatment of deep sinuses and fistulous tracts. Two different emulsions are employed known as No. 1 and No. 2. No. 1 consists of bismuthi subnit, 30 gm., vaseline, 60 gm. No. 2 consists of bismuthi subnit., 30 gm., white wax, 5 gm., liquid paraffine, 5 gm., vaseline, 60 gm. These should be mixed while boiling.

No. 1 emulsion is not so consistent as No. 2, and is used in superficial sinuses and is apt to escape from the sinuses in a short time, while No. 2 emulsion becomes more firm upon cooling and may remain in the tissues for a long time, and healing may occur with the emulsion in the tissues.

These emulsions should be warmed in hot water until they become liquid and they can then be injected into the sinuses or fistulous tracts with a syringe, and soon become consolidated at the temperature of the body. They seem to exert a stimulating action on the walls of the sinuses favoring the growth of granulations and healing. These injections are also very useful in showing the depth and extent of sinuses connected with diseases of the bones and joints when after the injection of the emulsion, and roentgen-ray examination will show the location in which the emulsion has been deposited.

Cases of bismuth poisoning and death have been reported for the use of this emulsion.

SHOCK.

This is a condition of physical depression or prostration which develops after severe injuries or operations, or profound emotion acting on the nerve centers. It is one of the most serious conditions which falls to the lot of the surgeon. No theory of shock is entirely satisfactory. The theory generally accepted is that there is exhaustion or inhibition of the vasomotor mechanism. Overstimulation or irritation of sensory nerves causes violent impressions to be conveyed to the nerve centers, which result in exhaustion or inhibition of the vasomotor centers, producing vasomotor paralysis. The peripheral arteries and capillaries are paralyzed and nearly emptied of blood, and the blood is largely transferred to the veins, especially to those of the splanchnic area, at the same time cardiac action is impaired, the blood-pressure is lowered and respiratory action is impeded. It has recently been shown that in many cases of severe shock acidosis is present.

Crile believes that in shock there are demonstrable changes in the brain cells. He considers the most important causes of shock, fear, pain and traction, and that by eliminating these factors shock may be prevented or diminished. Fear, he holds, can be prevented by keeping the patient away from frightful influences and benumbing the association functions of the brain by the use of morphine and scopolamine. Nerve impulses may be blocked by infiltrating their trunks with an anesthetic such as novocaine. He uses a local anesthetic if possible, infiltrating the tissues with novocaine. If a general anesthetic is required he employs nitrous oxide rather than ether, as he considers it much less depressing. The term "anoci-association" is applied to this blunting of harmful association impulses.

Physiological Block.—Infiltration of the nerves with novocaine or eucaine, well above the area of operation, prevents the ascent of peripheral impressions so as to prevent shock. The use of morphine and scopolamine before operation also eliminates or diminishes shock. Nerve blocking is one of the most valuable procedures in modern surgery.

Shock may develop immediately upon or some time after the reception of the injury. Every traumatism is probably followed by a certain amount of shock, and, as a rule, its degree is proportionate to the severity of the injury received. Yet this rule is not without exception; certain classes of injuries are attended with marked shock, and the part of the body sustaining the injury will have an important influence upon the degree of development of shock. Contusions of the viscera, wounds of the testicle, contused and lacerated wounds of the trunk and extremities, if extensive and accompanied by free hemorrhage, are usually followed by marked and often fatal shock. Gunshot wounds causing perforation of important cavities of the body, injuries of the viscera, and shattering of the bones are also well recognized as giving rise to shock in a marked degree. Burns and scalds, if they involve a considerable surface of the body, are attended with severe shock.

Diagnosis.—The condition of shock resulting from purely emotional causes is usually not profound or prolonged, and can be differentiated from that resulting from corporeal injuries by the history of the case. The condition arising from excessive hemorrhage presents many symptoms common to shock, but here the nature of the injury will often assist in the diagnosis, and in doubtful cases examination of the blood may be of service, for if such an examination shows that the red blood cells are considerably diminished, being 3,500,000 or less, it is probable that the condition is due to hemorrhage rather than shock. Fat embolism may also be confounded with shock, but it should be remembered in differentiating the conditions that shock usually appears promptly, and the symptoms of fat embolism from thirty-six hours to three days after the injury.

Symptoms.—A patient suffering from shock presents pallor of the surface, paleness of the lips, dilated pupils, clammy moisture of the skin, muscular debility, occasionally relaxation of the sphincters, frequent, feeble, irregular pulse, subnormal temperature and feeble, short, sighing respiration; in many cases extreme thirst is a prominent symptom. Examination will show a marked fall in the blood-pressure. The senses are often perfectly retained. The temperature is always subnormal, and may vary from a point a little below the normal to a point below 90° F. (32° C.). A depression below 97° F. (36° C.), if it persists for a few hours, usually indicates a grave condition of shock, and reaction may not occur, although it has been observed in cases where the temperature was as low as 90° F. (32° C.).

Prophylaxis.—Unfortunately, many of the worst cases of shock are due to accidents, and here treatment can be directed only to the condition of shock itself; but the surgeon is often able to diminish to some extent the amount of shock following operations by judicious prophylactic treatment. In patients in whom shock is apt to be markedly developed, as in children or feeble or aged subjects, or in certain classes of operations, he may give stimulants before the operation, and see that the surface of the body is not unnecessarily exposed to chilling during the operation, that the operation is not needlessly prolonged, and that as little blood as possible is lost during its performance.

In anemic or exhausted subjects blood transfusion a few days before operation will often be followed by the best results.

Choice of the anesthetic is most important. Local anesthesia may be used in adults in suitable cases, but is not often satisfactory in children. Nitrous oxide, alone, or combined with oxygen, should be preferred to ether.

Shock developing during and after operations may be prevented or diminished if the operator is careful as to hemostasis, does not unnecessarily prolong the operation, avoids extensive and multiple incisions and excessive exposure and handling of the tissues; and he should bear in mind that shock in abdominal operations depends upon the length of exposure and the amount of traumatism of the peritoneum.

The *electrothermic mattress* may be used with advantage, but care should be exercised in its employment, as serious burns have followed its use. The previous administration of an ounce of whiskey and the hypodermic injection of $\frac{1}{30}$ gr. of sulphate of strychnine, $\frac{1}{60}$ gr. of sulphate of atropine, and the use of a small dose of morphine in feeble and aged patients will be followed by good results.

Treatment.—The first indication in the treatment of shock is to establish reaction. The patient should be covered with woolen blankets, the head should be kept low and dry heat should be applied to the surface of the body by means of hot-water bags, hot bottles or hot bricks; these should be wrapped in towels to prevent them from coming directly in contact with the surface; neglect of this precaution, which is most important if the patient is unconscious, often produces burns which may be followed by extensive sloughing. If the patient can swallow he should be given small quantities of whiskey or brandy, with 30-minim doses of aromatic spirit of ammonia, and, as absorption by the stomach is probably very slow in these cases, stimulants should be administered hypodermically; atropine is the most valuable stimulant that can be employed. From $\frac{1}{100}$ to $\frac{1}{120}$ gr. should, therefore, be injected and the injection repeated every hour or half hour until several doses have been given; it is especially indicated if there is profuse sweating. Caffeine citrate in doses of gr. ij may also be used with good results. Digitalin or camphorated oil may also be injected into the cellular tissues.

Strychnine was formerly widely used in shock, but its use is not now considered of great value. A stimulating enema of whiskey and warm water may be employed. Morphine is the most useful drug in shock. From $\frac{1}{6}$ to $\frac{1}{2}$ gr. should be given and repeated if necessary to insure quiet and freedom from pain. A large enema of warm saline solution may also be employed. As patients often complain of urgent thirst it is well to let them take a little black coffee, but not large quantities of water; free indulgence in water does not seem to quench the thirst, and is apt to be followed by vomiting. In cases of prolonged shock, transfusion of blood may be employed with advantage. This is especially helpful if acidosis is present. Autotransfusion may be employed in this emergency. This consists in applying muslin or rubber bandages to the limbs to drive the blood to the vascular and nervous centers. Intravenous injection of saline solution, to which is added 1 dram of a 1:1000 adrenalin chloride solution, is likely to be of most service when the condition has been preceded by the loss of a large quantity of blood. Intravenous saline solution should be given slowly, and in not too large quantities, for it should be remembered that if given rapidly and in too large quantities it may accumulate in the cavities of the right heart and arrest its function. Subcutaneous infusion (hypodermoclysis) of saline solution also has been employed with good results. Crile's method of *centripetal arterial transfusion* may be practised. In this procedure a cannula is inserted into an artery toward the heart, and saline solution is introduced, 15 to 30 minims of a 1:1000 adrenalin chloride solution is introduced in the rubber tube connected with the cannula by means of a hypodermic syringe. The injection should be made at intervals of a few minutes, introducing one or two minims at a time.

DRESSING OF WOUNDS.

Incised Wounds.—These wounds present the conditions favorable for prompt healing, and after sterilizing the surrounding skin they should first be carefully irrigated with saline solution or sterilized water to remove any blood clots or foreign bodies, or wiped with a sterilized gauze pledget; and after any hemorrhage which is present is controlled by the use of ligatures, if the wound be an extensive or deep one, provision should be made for drainage by introducing a drainage tube or a few strands of sterilized catgut at the bottom of the wound, allowing the ends to project from its most dependent portion. Irrigation of the wound with saline solution may be employed if there is reason to suppose the wound has been infected before coming under treatment. In superficial incised wounds after the hemorrhage has been controlled, it is not usually found necessary to make provision for drainage. If drainage is considered necessary a narrow strip of rubber dam, a few strands of catgut or a drainage tube should be introduced to the depth of the wound. In closing wounds the surgeon aims to approximate the various tissues accurately, so that muscle comes in contact with muscle, fascia with fascia, etc. He also strives to see that no pockets (*dead spaces*) are left, in which blood or serum may accumulate, which will serve as a culture medium for germs. If the wound be a deep one, involving the muscles and deep fascia, buried sutures of catgut or silk should be applied to approximate the muscles and fascia; and if important nerves or tendons have been divided their ends should be brought into apposition by sutures of catgut or sterilized silk. Wounds of nerves and tendons are more apt to be overlooked in incised wounds than in lacerated wounds when the exposure of the parts is greater. This seems especially the case for incised wounds of the hand and lower forearm. The superficial portions of the wound should next be brought together by the introduction of a number of interrupted sutures, catgut, silkworm gut, or silk being employed for this purpose. The accurate apposition of the edges of wounds of this variety is secured by the introduction of a number of sutures placed closely together.

After a wound of this variety has been closed the subsequent dressing is accomplished by covering the surface of the wound with a number of layers of sterilized gauze and a pad of sterilized cotton, which are held in place by a gauze bandage. Under this form of dressing prompt healing of incised wounds is the rule, and the wound need not be redressed for a week or ten days unless some indications exist for change of dressing at an earlier period. The wound may also be dressed by applying dichloramine-T over the wound and applying a dry sterile gauze dressing. If a drainage tube has been used it should be removed at the end of the second day, and the wound dressed with dry sterile gauze, and at the end of ten days the sutures should be removed. A sterilized gauze dressing is usually next applied, and allowed to remain for a few days longer.

In *superficial* incised wounds involving only the skin and cellular tissue if limited in extent, after cleansing the wound and controlling the bleeding, the edges should be approximated with sutures. The wound should then be covered with strips of sterilized gauze, over which is painted a mixture of: Tr. benzoin, ʒj; collodion, ʒvij. This forms a firm antiseptic scab which need not be removed until the wound has healed.

Lacerated Wounds.—These present edges which are torn and not sharply cut and the vitality of the injured parts is often so seriously impaired that prompt union in this variety of wounds is not, as a rule, to be looked for. Wounds of this nature should first be irrigated with saline solution, sterilized water, or a 1:4000 bichloride solution, and blood clots and foreign bodies removed. If the wounds be deep, drainage tubes should be introduced; on the other hand, if they be superficial, or if the edges are not closely approximated, provision for drainage may be omitted. Extensive lacerated wounds are often accompanied by severe shock; in such cases nerve blocking may be used to arrest the shock producing impulses. The mechanical cleaning of the wound after this procedure can be accomplished with little discomfort to the patient. The torn or irregular edges of the wound should next be brought into apposition at a few points by the introduction of catgut or silkworm-gut sutures, applied not very closely together; and if the edges are discolored and their vitality seems markedly impaired it is better not to use sutures. If the edges of the wound are so much crushed that their vitality is destroyed they may be trimmed away with scissors until a surface possessing a fair vitality is secured. The removal of devitalized tissue and foreign bodies is practically *débridement* of the wound which has recently been extensively practised in gunshot wounds. The evil results arising from the introduction of sutures into this variety of wounds, with the idea of closely approximating their edges, are so common that the surgeon who dispenses with the use of sutures entirely errs upon the safe side. The use of many sutures in wounds of this nature often causes marked tension, which is frequently followed by impairment of the vitality of the injured tissues, and sloughing results. The wound should next be dressed with sterilized gauze and cotton, or dichloramine-T may be applied to the surface of the wound and a sterilized gauze dressing laid over it. It should be dressed within twenty-four or thirty-six hours, and if it runs a favorable course it should be redressed at intervals of two or three days; the time required for repair of a wound of this nature is longer than that for an incised wound.

In lacerated wounds of the extremities continuous *irrigation* of the wound by a warm antiseptic or saline solution, applied as described (p. 133), is often followed by the most satisfactory results; wounds produced by machinery and railway accidents, in which the vitality of the tissues is much impaired, are particularly suitable cases for this method of treatment, and here the same caution should be exercised as regards the introduction of sutures.

Contused Wounds.—This variety of wounds possesses many characteristics in common with lacerated wounds: the edges are bruised and the injury of the subcutaneous tissue is often more extensive than the external wound would lead one to suspect. They are dressed in the same manner as lacerated wounds and the same objection here exists to the use of sutures as in the latter class of injuries.

Punctured Wounds.—These wounds are inflicted by sharp-pointed instruments, and it may happen that a portion of the vulnerating body remains in the wound, as is frequently the case in wounds produced by needles, splinters of wood, metal or glass. Another complication in this variety of wound is the injury of vessels, giving rise to concealed hemorrhage, or of nerves, resulting in neuritis or neuralgia. Punctured wounds may also involve the viscera and joints. I have seen a case of punctured wound of the knee-joint by the prong of a table fork result in infection of the joint which required amputation of the thigh. Simple punctured wounds should be sterilized with iodine or dichloramine-T, and covered by a sterilized gauze dressing, and if no complication exists their healing is usually very rapid.

Punctured wounds are apt to be infected and should not be closed by suture, so that discharges should have free exit. If a punctured wound shows signs of infection it should be freely opened and drained.

A very serious form of punctured wounds arises from the impaling of a portion of the body by pieces of wood or metal, the part being transfixed or simply penetrated; the penetrating object may break off, leaving a portion of it in the wound, or may retain its position in the body, so that it is difficult to separate the body from it. This accident usually results from persons falling upon sharp sticks, wooden or iron palings.

When a foreign body remains in the wound, as often happens in punctured wounds produced by needles and splinters, the punctured wound should be converted into an incised wound, and the body should be searched for and removed; in doing this in the case of wounds of the extremities the operation is much facilitated by the employment of Esmarch's bandage. The roentgen or *x*-rays may be employed with advantage in locating foreign bodies, such as pieces of glass or metal, in punctured wounds. After the removal of the foreign body the wound is treated as an incised wound, and an antiseptic or aseptic gauze dressing should be applied. When concealed hemorrhage occurs after a punctured wound, the wound should be laid open and the bleeding vessel searched for and ligated if possible, and the wound should afterward be dressed as an incised wound.

Tetanus frequently develops in lacerated and punctured wounds, the infection occurring at the time of their infliction, especially if soiled by earth. Wounds received by those working in horse stables are prone to this variety of infection. For this reason many surgeons advise that an immunizing dose of antitetanic serum be given in all these wounds.

Stab Wounds.—These wounds are caused by sharp-pointed cutting instruments, such as a dagger, knife, scissors, bayonet or sword, and partake of the nature of both incised and punctured wounds. They may be dangerous injuries from implication of the joints, bloodvessels, nerves and the thoracic or abdominal viscera. The skull may be penetrated and the brain involved. Stab wounds of the neck are dangerous and often rapidly fatal from hemorrhage. Hemorrhage and shock are prominent symptoms of these injuries. If the wound does not involve the great cavities of the body or important bloodvessels or nerves the wound should be treated as an incised wound. If large bloodvessels are injured the wound should be enlarged, the vessel exposed and ligated; if nerves have been divided they should be sutured. Penetrating stab wounds of the chest, abdomen and skull should receive appropriate treatment.

Poisoned Wounds.—These wounds are caused by the absorption, by means of a cut or abrasion in the skin, or by the sweat or sebaceous glands, of irritating or infected material from a dead body in making dissections or postmortem examinations, or in operating upon living subjects, and often result in serious consequences. Infection occurring from a living subject in operating is apt to give rise to a similar specific infection, or a mixed infection may result; whereas infection occurring from dead bodies is usually caused by the bacteria of putrefaction, as infective microörganisms retain their virulence for only a short time after death. Such wounds, as soon as possible after their reception, should be carefully washed out with a solution of bichloride of mercury, 1:2000, and the surface touched with a 30-grain solution of chloride of zinc, and then dressed with an antiseptic dressing. If, however, this precaution is not taken, or the wound has escaped notice, and in a few hours becomes inflamed and painful, and evidences of lymphatic involvement show themselves, the wound should be opened and its surface should be thoroughly sponged with a 2 per cent solution of formalin or with a 30-grain solution of chloride of zinc, and finally with a saline solution, and it should then be dressed with a moist antiseptic gauze dressing. Dichloramine-T, or the instillation of Dakin's solution, may also be used. Under these methods of dressing, the poisoned wound is often converted into a healthy one, even after the lymphatic involvement is well marked, and it usually heals promptly without further constitutional disturbance. If the infection spreads and the constitutional disturbance increases, free incisions into the surrounding tissue will be required to relieve tension and permit of the escape of serum or pus.

Scalp Wounds.—The scalp is very vascular and wounds bleed profusely, by reason of the fact that many of the vessels are in fibrous tissue and cannot contract and retract. Incised, lacerated and contused wounds are very common. Sloughing in scalp wounds is rare, by reason of its great vascularity. Extensive flaps loosened in lacerated wounds, having only a narrow pedicle, usually retain their vitality. Hemorrhage, unless arising from a large vessel, can usually be controlled by pressure as the firm bony base makes this very effective. Extensive separation of the edges of the wound does not occur in scalp wounds. In wounds of the scalp penetrating the occipito-frontalis, if infection occurs pus burrows freely under this muscle.

Treatment.—The scalp in the region of the wound should be shaved, and the skin sterilized with alcohol, tr. iodine or picric acid solution, and after the bleeding has been controlled the edges of the wound should be approximated with sutures of silk, catgut or silkworm gut. A sterile gauze dressing is next applied and held in position with a bandage. The wound may be covered by strips of gauze held in place by tincture of benzoin and collodion. Deep infected scalp wounds with abscess require numerous openings made at dependent parts of the scalp.

Contusions of the scalp are accompanied by marked swelling due to hemorrhage. *Hematoma* of the scalp, which often presents a central depression, may be confounded with depressed fracture, but in hematoma examination reveals bone on a level with the surrounding skull and the edges of the depression are smooth and circular and slightly elevated above the surface of the bone. Treatment consists in the application of moist gauze dressing and pressure; the blood is usually absorbed rapidly, but if a collection of fluid blood remains after a reasonable time, incision for its evacuation may be required. If the hematoma becomes infected and pus forms prompt drainage should be secured by incision.

Gunshot Wounds.—These in civil life result from projectiles from shotguns, rifles, revolvers and blank cartridges. The wounds resulting from gunshot missiles are of the nature of contused and lacerated wounds. The ball may penetrate the tissues, a cavity or organ, and lodge in which case it is known as a penetrating wound. If it enters and emerges it causes a perforating one; in the former there is a wound of entrance and in the latter there is in addition a wound of exit. The missile may carry into the tissues pieces of clothing and foreign matter which are certain to cause infection. The bullet of the sporting rifle is larger, softer, has no jacket, or only a partial jacket, and has less velocity than that of the army rifle, so that it is likely to lodge in the tissues rather than to perforate, and is more likely to be deflected and deformed. The ball may simply graze the surface and produce a brush-burn or contusion of the skin or a gutter; or may penetrate the tissues, injuring the bloodvessels, nerves, joints and bones, or penetrate the cavities of the body and wound the contained viscera. The principal symptoms of gunshot wounds are shock and hemorrhage; the latter may be profuse if a large vessel is injured; later, infection may develop. The bullet itself is not apt to be infected, and if this develops it is usually due to foreign matter carried into the tissues with the bullet.

In gunshot wounds from the sporting rifle the bullet may perforate the tissues without injuring large bloodvessels and nerves, or may be deflected by bone or tendon, or be deformed by striking the bones, and cause widespread laceration of the tissues. Fracture of the bone may result from impact of the bullet. Bullets penetrating the abdomen or chest, with wounds of the viscera and of the skull, produce wounds which are generally fatal. Wounds of the joints are also grave injuries. Shotgun wounds from small shot at close range produce most serious injuries, the shot and wadding entering the tissues in a mass produce extensive laceration, and may tear away fingers or toes or portions of the hands and feet or of the extremities. I have seen avulsion of the arm from a shotgun wound at close range. If the charge is received at long range a number of shot may enter the body, but the wounds are, as a rule, not serious unless the eyeball is penetrated.

Wounds from revolver or pistol balls are those most frequently seen in civil practice, and their gravity depends upon their location. Wounds of the great vessels and penetrating wounds of the joints, skull, abdomen and thorax are most serious injuries. A large number of these wounds seen in civil practice are suicidal, and usually involve the skull, thorax or abdomen. Shock and hemorrhage follow these wounds; the latter may be at first free but soon ceases unless large vessels have been injured.

Blank-cartridge Wounds.—These result from the explosion of a fulminate used in toy pistols, and cause burns and lacerations of the skin, with at times portions of the clothing, or of the paper envelope of the cartridge being driven quite deeply into the tissues. Tetanus is a quite frequent complication of these wounds.

Treatment.—Shock is a prominent symptom in severe gunshot wounds and demands appropriate treatment. The most important part of the treatment of these wounds is to prevent and control infection and not the removal of the bullet. Hemorrhage, if moderate, may be controlled by pressure; if profuse, temporary hemostasis should be secured by the use of a tourniquet or pressure, and the wounded vessel should be exposed by incision and ligated. In perforating wounds, which do not enter the great cavities of the body or injure important structures, the wound of entrance and exit should be swabbed with iodine and a sterilized gauze dressing applied.

In uncomplicated penetrating wounds the wound should be swabbed with iodine and a sterile dressing applied. The position of the bullet should not be located by probing, but by a a roentgen-ray examination, or by the fluoroscope. The removal of the bullet should be accomplished if it is in an accessible location, or if there is reason to think infective matter has been introduced with it. Balls often become encysted and remain in the tissues for years without causing any trouble. If it is found that foreign bodies have been introduced into the wound, and that the tissues have been more or less devitalized, débridement of the wound should be done, and Carrel-Dakin solution instilled, and primary, or delayed primary, suturing of the wound employed. In penetrating or perforating wounds involving the abdomen probing of the wound should not be done. The position of the ball may be located by roentgen-ray examination. In these wounds the intestines may be perforated in a number of places and the solid viscera involved. Visceral injuries are most serious. Laparotomy should be done as early as possible, and visceral injuries, if present, found and repaired. The results following laparotomy for gunshot wounds of the abdomen are generally very satisfactory. Wounds of the chest may be rapidly fatal if the heart and great vessels are involved. In wounds of the chest, the skin wounds should be sterilized, and a sterile occlusion dressing applied, and the ball should be located by roentgen-ray examination, and the question of its removal should be decided by the development of symptoms. In wounds of the skull the question of removal of the ball should be decided by the roentgen-ray findings and the development of brain symptoms.

Wounds from blank cartridges should be sterilized and foreign bodies removed, have dichloramine-T applied and a sterile dressing. The use of of antitetanic serum should be considered in all gunshot wounds. It was used as a routine treatment in such wounds during the late war, and should always be used in blank-cartridge wounds.

Carrel-Dakin Treatment.—Dakin, as the result of experimental work, concluded that a solution of sodium hypochlorite free from caustic alkali and varying between 0.45 per cent and 0.5 per cent, furnished an ideal antiseptic. Dakin's solution rapidly diminishes in strength when introduced into a wound and it is important to provide for its frequent renewal as well as a means of bringing it in contact with all parts of the wound, as it is difficult to sterilize one part of the wound while others remain septic. Carrel and Dakin devised a technic of wound treatment to accomplish this object, which has been widely and successfully employed. It requires special training to employ it efficiently.

Material and Appliances Required.—1. A solution of sodium hypochlorite prepared by the Dakin and Daufresne method.

2. A glass container holding 500 to 1000 cc.

3. Two yards of moderate sized rubber tubing.

4. Adjustable clamp to control the flow of the solution through the rubber tube.

5. Rubber instillation tubes about 25 cm. long of different diameters, the average being 16 to 18 French scale. The tubes are closed by tying at one extremity and are perforated with small holes by a punch for their lower two-thirds. The primary and secondary tubes are 7 mm. in internal diameter, the final distributing tubes are 4 mm. and the holes in these tubes are only 1 mm. ($\frac{1}{25}$ inch) in diameter.

6. Ordinary rubber drainage tubes 25 to 35 cm. long without lateral holes.

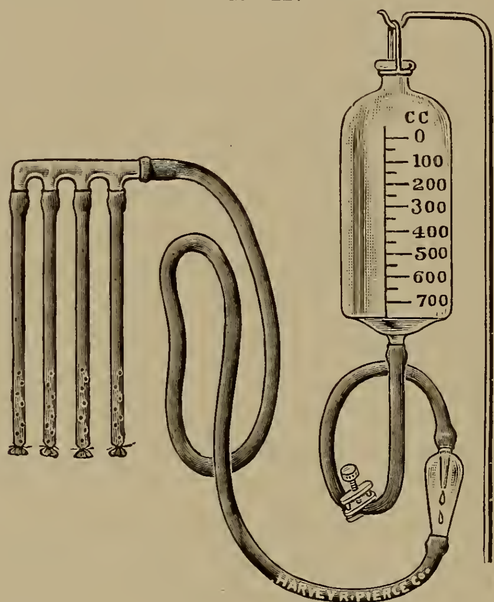
7. Glass collecting and distributing tubes.

8. Dressings consisting of pads of different sizes made of

cotton surrounded by gauze, a layer of absorbent cotton, next a thicker layer of non-absorbent cotton. These are held together by the surrounding layer of gauze secured by a few stitches. These pads should be about 3 cm. in thickness and should be of three sizes, one large enough for the thigh or leg, another to surround the arm and a third of smaller size. Webbing straps with buckles to fasten the dressing in place.

9. Sterilized strips of gauze saturated with yellow petrolatum for protection of the skin.

Fig. 242.



Instillation apparatus for Carrel-Dakin treatment.

To obtain satisfactory results by the Carrel-Dakin treatment the technic should be observed accurately. This treatment is applicable not only to wounds received in war, but also to those seen in civil practice, such as compound fractures and dislocation, lacerated, contused, punctured and infected wounds. The first requisite in the treatment of the wound is its mechanical sterilization to prepare it for chemical sterilization. The wound or infected tissues should be painted with tincture of iodine, and the cavities of the wound fully exposed by incisions if necessary. Bruised skin or tissue is likely to become necrotic and should be removed with scissors or the knife. Foreign bodies, such as pieces of clothing, fragments of metal, stone, wood or detached fragment of bone should be removed. All non-infected tissues should be carefully preserved. The object of this mechanical cleansing of the wound, débridement, is to remove everything that has been infected by the traumatism or is likely to be infected later. The same careful mechanical cleansing should be practised in the case of wounds. Comminuted fragments of bone should not be removed unless detached. Great care should be taken to secure complete hemostasis before the introduction of Dakin's solution, which has the power of dissolving recent blood clots, which may cause secondary hemorrhage if vessels are not properly secured by ligatures. The fingers and hands, even if covered by rubber gloves, should be brought in contact with the wound as little as possible. Sterilized instruments should be used in the manipulations and in handling the dressings.

The tubes should be so placed in the wound that the fluid will come in contact with all parts of the wound. The placing of the tubes will therefore vary with the nature of the wound. in *superficial wounds* a layer of gauze is applied and the tubes laid upon this and covered by another layer of gauze and the pad. In penetrating wounds the tube is introduced to the depth of the cavity and the solution is allowed to well up from the bottom. In wounds of this variety, with cavities at the depth, or those in which the point of entrance is on the posterior surface of the body or extremities, a wrapping of gauze may be securely fastened to the tube which becomes saturated with the solution and brings it in contact with the walls of the cavity. In perforating wounds the tube is passed from the lower to the upper opening and the liquid escaping from the orifices in the tube flows back alongside of the tube to the inferior opening. Wounds of the hands and feet may be immersed in the Dakin solution for ten to fifteen minutes every two hours. Instillation of the fluid is made every two hours day and night by releasing the clamp for a few seconds. The instillation of fluid is not done with the object of irrigating the wound—merely to keep the wound surface moistened with the solution. For the average wound 10 cc is sufficient. Every day the dressings should be removed and the wound inspected and flushed to see if the solution is being properly delivered. It also serves mechanically to wash away any excess of wound secretion. The average time required to sterilize a wound by this dressing is from five to ten days, but in compound fractures and badly traumatized wounds, a much longer time may be required. The sterility of the wound is proved by a bacteriological test.

Systemic bacteriological examination of the wound is made every second day to determine the number of microbes upon the wound surface. A standard loop is used to carry a portion of the secretion to a microscopic slide, and the number of microbes is counted in the microscopic field, and the results are entered upon a suitable chart. When the microbes are absent from the wound in three successive counts the wound is considered sterile. The bacteriological examination should be made one or two days after the treatment has been started and repeated at intervals of one or two days until the wound is sterile. If the details of treatment are neglected or stopped prompt reinfection of the wound is liable to occur. When the wound is sterile it is often possible to close it by sutures and secure prompt healing. If the wound is not one for suturing it may be diminished in size and the time of healing much shortened by making elastic traction upon the edges and surrounding tissues by painting the surrounding tissues with Heusner's glue and fastening canton-flannel bands, which have short hooks inserted at every 2 cm., to the tissues by this glue. When the canton-flannel bands are firmly adherent to the skin rubber bands are attached to the hooks or a rubber lacing applied which draws the edges of the wound together.

Débridement of Wounds.—This procedure, which consists of the mechanical cleansing of wounds, the removal of foreign bodies and devitalized or partially devitalized tissues, has been employed for years in the treatment of lacerated and infected wounds, but was developed into a definite technic in the treatment of gunshot wounds in the recent war. It was employed in all war wounds soiled and likely to develop subsequent infection. It was always practised in shell wounds and in bullet wounds where the tissues were tense and painful, and almost always in the case of lodgment of the bullet.

Ashhurst describes the débridement of a gunshot wound as follows: "The wound of entrance and exit are widely opened by incisions, when possible in the longitudinal axis of the limb and parallel to the main muscular masses. These débridements are frequently 25 to 30 cm. (10 to 15 inches) in length, the usual error being to make them too small. The wound area being thus slit open freely to view, the next step is excision: (1) The devitalized skin immediately surrounding the wounds is cut away (no more than is absolutely devitalized should be sacrificed); and (2) the entire mass of contused and lacerated subcutaneous tissues and muscle is cut bodily away with scissors. Accurate anatomical knowledge is required to avoid damage to important bloodvessels and nerves. All devitalized and hemorrhagically infiltrated muscle must be excised although it may not be actually invaded by bacteria at the time of operation (and probably is not until eight to twelve hours have elapsed since the injury), yet if left, it is certain to become infected. The surgeon should proceed methodically, excising piecemeal these tissues until he reaches muscle, which when cut reacts promptly by contraction. Usually in the course of débridement and excision, he comes upon shell fragments and other foreign bodies (fragments of clothing, mud, wood, etc.), and at once does extraction which is the third stage of the operation. In exceptional cases the missile enters without causing much laceration and its track has to be followed by dissection, layer by layer, until the missile is found. When the tract can no longer be followed by the eye it is justifiable to insert the finger for palpation. Usually if the missile is less than 0.5 cm. in diameter it is useless to make prolonged search for it, the missile itself being comparatively harmless after removal of the tissues liable to infection. Frequently the missile can be extracted more easily by counter-incision than through the wound of entrance. Finally, hemostasis must be secured and all complications (fractures, severed bloodvessels, tendons and nerves) should receive appropriate treatment.

"Drainage is very important. Slow healing of wounds is due to pocketing of infection, and this can only be prevented by dependent drainage. A counter-incision made for extraction may be used for drainage, but if not suitably situated for dependent drainage, another counter-incision should be made where indicated. It should be amply large and a rubber tube (1 to 1.5 cm. in diameter) should then be passed from one wound to the other; unless this tube passes easily through the wound without any bending whatsoever, the wound should be more widely opened. The entire wound surfaces are then swabbed with iodine (3 per cent), flavine (1 to 2000), picric acid (2 per cent) or Mencière's solution. If nothing else is available ether alone may be used, but this as well as Mencière's solution is apt to increase oozing of the blood.

"*Dressing the Wound.*—If débridement has been adequately done, and all devitalized tissues have been excised, it is then sufficient to provide a sewer (rubber tube) which will carry off the unavoidable wound secretions, which if dammed up in puddles would encourage the growth of bacteria. When drainage is provided it is unnecessary and harmful to stuff the entire wound with gauze. Sterile gauze and cotton in abundant quantities should be applied to the wound surfaces of the wound area and securely bandaged in place. Fixation by splints is of great value for transportation, even in the absence of fracture.

"*Primary and Delayed Primary Suture.*—If débridement is properly done within twelve or eighteen hours of injury, and the wounds are completely sutured (providing for drainage) at once, and if the patients are not evacuated but kept absolutely quiet about 85 per cent of such wounds will heal without further trouble; the remainder will require opening for infection. On the other hand, if these patients, after suturing the wounds, are evacuated at any time within a period of ten days or two weeks, at least 90 per cent of such wounds will break down or require to be opened for infection, and only 10 per cent will heal without further trouble. Hence the absolute rule that in periods of great activity, when immediate evacuation after operation is necessary, that *no wounds shall be sutured.* But when these patients, after proper débridement, reach the bases where they may be kept permanently, delayed primary suture is very successful. If all wounds, *not including bone,* are sutured immediately upon arrival at the Base, approximately 85 per cent of such wounds will heal without difficulty, and only 15 per cent of them will require opening for infection. This is so, regardless of the number and kind of bacteria present in the wounds, with the exception of the streptococcus. Almost without exception, wounds infected by the streptococcus will require reopening; and if the presence of the streptococcus can be ascertained beforehand it will be useless to attempt suture.

"*Secondary Suture.*—Many wounds, which have not been treated by primary or delayed primary suture, may be sterilized while granulating, and then secondary suture will prove successful. The best method of chemical sterilization is by the Carrel-Dakin solution. It should not be overlooked that this is efficient only when the wounds are mechanically prepared in advance; this often requires a secondary operation (débridement, sequestrotomy); and as such operation in the presence of streptococcic infection frequently cause further spread of the infection, it can be readily understood how difficult the sterilization of such a wound may prove. If such wounds continue to heal, even if slowly, it is best to pursue a conservative course.

"To perform secondary suture it is usually sufficient to freshen the skin edges, undermining them if necessary, and to close the wound not too tightly by deep sutures. It is always important not to leave any dead spaces, and for this purpose buried sutures may be necessary, but their use, as well as that of drainage, should be avoided if possible."

Powder Burns.—These result from the explosion of gunpowder, and, in addition to the burning and laceration of the tissues, are accompanied by the introduction of grains of unburnt powder into the skin, which, if not removed, leave permanent points of pigmentation. These wounds should first be washed with a 1 : 2000 bichloride solution, and upon the face, to avoid unsightly pigmentation of the skin, care should be taken to pick out the small masses of powder with a needle or the sharp point of a tenotomy knife. The surface should then be dressed with antiseptic gauze or with lint spread with an ointment of boric acid or an ointment of aristol, consisting of ½ or 1 dram of aristol to 1 ounce of vaseline, this dressing being covered by a few layers of gauze and cotton, held in place by a roller bandage.

In pigmented scars following powder burns the powder grains may be removed by electrolysis.

Contusions or Bruises.—These wounds differ from contused wounds in the fact that the skin is not broken, although in spite of this fact there may exist very extensive laceration of the subcutaneous tissues, accompanied by more or less extravasation of blood from the injured vessels. When not sufficiently severe to require operative treatment they should be dressed by applying over them several layers of lint saturated with lead water and laudanum, and over this dressing is placed a layer of waxed paper or rubber tissue, and the dressing is secured by a roller bandage. A solution which I find most satisfactory in the dressing of contusions is as follows: ammonii chloridi, grs. xx; tr. opii et alcoholis, aa ʒj; aquæ, ℥i. Several layers of lint saturated with this solution are laid over the contused tissues, and are covered with waxed paper, oiled silk or rubber tissue.

Extensive collections of blood following contusions often remain in the tissues for some time if infection does not occur, and usually are absorbed. If this result does not follow, and a large collection of fluid blood remains in the tissues, infection occurs, and an abscess forms, the blood or pus should be removed by incision with full antiseptic precautions.

Sunburn.—Prolonged exposure of the surface of the skin to the sun results in a marked erythema. This is painful, but not serious unless a large surface is involved. The condition is often spontaneously relieved in a short time by the applicatiod of vaseline or tr. benzoin comp., or a lotion composed of calamine (ʒiij), zinc oxide (ʒiij), alcohol (♏xxx) and water (℥viij) promptly relieves the irritation.

Brush-burn.—This is a form of contused and lacerated wound which is produced by violent friction applied to the surface of the body, and is often caused by coming in contact with rapidly revolving wheels, or the belting of machinery, or by the body being rapidly propelled over an uneven surface, or by a rope being rapidly drawn through the closed hands. The injury may vary from a superficial abrasion to absolute destruction of the skin. The surface of the brush-burn should be cleansed by a stream of normal salt solution, sterilized water, or 1: 2000 bichloride solution, and then dressed with dichloramine-T or a powder of acetanilid and boric acid, equal parts, and a sterilized gauze dressing applied; if suppuration occurs a moist bichloride or acetate of aluminum dressing or boric acid ointment should be applied.

Burns and Scalds.—These injuries result from the action of heat on the living tissues. It may be applied as dry heat, hot solids or flame, or may be moist, as in the case of hot liquids and steam. The former produces burns; the latter scalds. There is no pathological difference between burns and scalds. The differentiation of a burn from a scald may be made by observing that in the former the hairs on the surface of the body have been destroyed. Dupuytren classified burns according to the depth of involvement of the tissues. (1) Erythema of the skin; (2) dermatitis, with formation of vesicles; (3) partial destruction of the skin; (4) destruction of skin; (5) destruction of subcutaneous tissues and part of the muscles; (6) destruction of the whole substance of the muscles.

Symptoms.—These are local and constitutional. The *local* symptoms are pain and inflammation, varying in intensity and degree according to the extent of tissue damage. The *constitutional* symptoms are shallow respiration, feeble pulse, subnormal temperature and shock; the latter is a prominent symptom in severe burns.

Following a severe burn, in twenty-four to thirty-six hours there is elevation of the temperature and congestion of the tissues in the region of the burn, pain, internal congestion, suppression of urine, delirium, and in some cases convulsions. From the second to the eighth day there is marked inflammation and sloughing of the injured tissues. There may be also duodenal inflammation and the development of duodenal ulcer (*Curling ulcer*), the latter probably being toxic or embolic in origin.

Burns and scalds, if extensive, have a high mortality and are the most serious injuries which come under the care of the surgeon. The gravity of burns and scalds depends upon their extent and depth, and also upon their situation. Superficial burns of large extent are more dangerous than deep burns of limited extent. A superficial burn involving one-half of the body is apt to be fatal. Burns of the extremities are less dangerous than those of the head, chest and abdomen. Shock is an early cause of death in severe burns; later, infection and renal complications may also cause a fatal issue.

Treatment.—If pain is a prominent symptom morphine should be administered and stimulants should be given if indicated. As the excretion of urine is apt to be scanty, water should be given freely by the mouth, or by hypodermoclysis or enteroclysis if not retained by the stomach. Liquid diet should be given.

A great variety of dressings have at different times been employed in the treatment of burns, some of which are still employed; others have been discarded. The treatment of burns and scalds is the same. The recently introduced paraffine and dichloramine-T dressings have furnished encouraging results. The present attitude of surgeons as to the treatment of burns is well expressed by the statement of Fontleroy and Hogland, "That as burns differ widely in degree, character of tissue destruction, bacterial content and progress of healing, no one procedure as a local measure will prove equally valuable for all cases and all stages of burns."

The clothing should be carefully removed and the surface of the burn irrigated with warm salt solution. The body temperature should be maintained by the application of hot-water bags and woolen blankets, or by placing a cradle over the body and covering it with blankets. Under this canopy a 32-candle power electric lamp should be introduced, which will maintain a temperature of 100° to 105° F. Blebs, if present, should be opened to evacuate the serum, but the epidermis should not be removed. Superficial burns, in which the effect of the heat has extended only to the superficial layer of the skin, may be dressed with lint saturated with a solution of sodium carbonate (ʒj) to water (℥j). This dressing rapidly relieves the pain. A solution of acetate of aluminum (ʒiij) and water (1 pint) may be employed. Strips of lint or gauze saturated with this solution are laid over the surface of the burn and renewed each day. This dressing is a satisfactory one in the early stages of burns.

The open treatment of burns has also been employed. The surface of the burn is dusted with powdered boric acid or stearate of zinc, and exposed to the air. The use of active antiseptic agents, such as carbolic acid, iodoform or bichloride of mercury, is not to be recommended, as their absorption may be followed by grave toxic symptoms.

Continuous immersion of the burned surface in a warm bath has been employed in the treatment of burns with good results.

Carron Oil.—This mixture, which is prepared by rubbing together equal parts of linseed oil and lime water until a thick creamy paste results, was formerly extensively used in the dressing of burns. Lint saturated with this mixture is placed over the surface of the burn. This dressing is a comfortable one to the patient in the early stages of burns, but possesses no antiseptic qualities and soon becomes offensive and requires frequent renewals.

Salt Solution Dressing.—The surface of the burn is irrigated with normal salt solution; sloughs are removed and the surface is covered with strips of sterilized rubber tissue 2 inches in width. The strips should be so placed that there is a gap between the edges of each strip. Sterilized gauze is wrung out of warm salt solution and placed over the strips and held in place by a bandage. The gauze should be replaced as soon as it becomes saturated with the discharge which escapes between the edges of the strips. Fresh gauze should be applied without removing the strips, which renders the dressing much more comfortable to the patient.

Picric Acid Dressing.—Picric acid solution has been very extensively used in the treatment of burns and scalds. This dressing should not be used in extensive burns or those which involve the tissues deeply or in burns in infants and children who seem more susceptible to the action of this drug, as poisoning may result. After the surface has been cleaned and blebs have been opened, strips of sterilized lint or gauze are soaked in the solution and applied to the surface and covered with a layer of dry absorbent cotton, and the dressing is held in place by a bandage. The dressing soon dries and may be left in place for several days, when it is reapplied in the same manner. This application relieves pain and seems to diminish suppuration and leaves a healthy scar. The solution employed is as follows: Picric acid, gr. lxxv; alcohol, ℥iiss; aquæ dest., Oij. An ointment of picric acid (ʒss) to 1 ounce of vaseline is also employed.

White-lead Dressing.—This application, which consists of white lead (℥viij), powdered acacia (℥ij), sodium bicarbonate (ʒj) and linseed oil (a sufficient quantity to make a mixture of the consistency of thick cream) is extensively used in the coal regions of Pennsylvania, where severe burns are very frequent. It is spread upon lint or gauze and applied to the burned surfaces; it does not require frequent renewal, and repair of the injured surfaces is rapid under its use.

Paraffine and Ambrine Dressing.—Within a few years the dressing of burns with paraffine has been extensively employed with satisfactory results. Paraffine with 5 per cent of oil of amber, or a preparation of paraffine under the trade name of "Ambrine," the composition of which has not been given to the profession, may be employed. A paraffine preparation recommended by Hull, consisting of resorcin, 1 part, oleum eucalypti, 2 parts, olive oil, 5 parts, soft paraffine, 25 parts, and hard paraffine, 65 parts, is probably one of the best paraffine combinations for the treatment of burns. In preparing this dressing the hard paraffine is melted, and the soft paraffine and olive oil added. The resorcin, dissolved in 95 per cent alcohol, is next added, or beta-napthol may be substituted for the resorcin; and finally oil of eucalyptus is added. The burned surface should be washed with salt solution, all blisters should be opened and the surface dried by fanning or by means of an electric blower. The mixture is next heated to a temperature of 122° F., and the paraffine solution is then applied to the surface of the burn by means of an atomizer, or spread over the surface with a camel's-hair brush. At the first dressing the application of liquid petrolatum to the burned surface before applying the paraffine mixture may be used, as it seems to diminish the pain.

After applying the first layer of the paraffine mixture, a thin layer of absorbent cotton is spread over the surface of the burn, then a second layer of the paraffine mixture is next applied, and the dressing is completed by the application of a canton-flannel bandage. Dressings should be renewed at intervals of one or two days, and at each dressing blebs should be opened and dead tissue removed. Superficial burns heal more rapidly under the paraffine treatment than by any other method, but in deep burns the results are not so brilliant. The resulting scars under the paraffine dressing are softer and are less likely to be followed by contractures in burns of moderate depth, but in deep burns severe contractures may result.

Horse Serum.—Robinson has recommended horse serum for the treatment of burns, with the object of hastening the epidermization by furnishing nourishment to the cells at the wound margin, and thus stimulating them to proliferation. Normal serum, with a small percentage of tricresol, should be sprayed upon the surface of the wound several times a day for ten days, the surface of the wound in the meantime being covered with rubber tissue.

Dichloramine-T Dressing.—This preparation has been recently recommended as an efficient dressing in the treatment of burns. Dr. W. E. Lee has reported excellent results in the treatment of burns and scalds following the use of dichloramine-T. The dichloramine dressing is as follows: The devitalized tissue should be softened by soaking in saline solution and removed as far as possible. The surface of the wound should be dried by fanning or a hot air blower. When this has been accomplished the wound is painted over with a $\frac{1}{40}$ of 1 per cent dichloramine, and a layer of wide-meshed paraffine gauze applied, extending in all directions, a little beyond the edges of the wound. A number of layers of sterilized gauze are next applied, and held in contact with the wound by a gauze bandage or strips of adhesive plaster. The dressings should be changed daily or with intervals of a day. The strength of the dichloramine should be gradually increased from $\frac{1}{40}$ of 1 per cent up to 1 or 2 per cent if its application is painless. Another method consists in applying the dichloramine and paraffine gauze and allowing the wound to remain exposed to the air.

If the wound is relatively aseptic the healing progresses rapidly, and subsequent contractures are avoided or diminished.

Burns and Scalds of the Tongue, Pharynx, Glottis and Epiglottis.—These may result from taking hot liquids into the mouth, or from the inhalation of steam, hot vapor or steam; the introduction of caustic alkali in the mouth produces similar lesions. There is great swelling of the tongue and mucous membranes, the formation of vesicles, shock, pain, dysphagia, dyspnea and edema of the glottis.

Treatment.—Shock should receive appropriate treatment, vesicles should be punctured, ice should be held in the mouth, and if the tongue is greatly swollen multiple longitudinal incisions of the dorsum of the tongue should be made. If edema of the glottis is present, as evidenced by dyspnea, scarification should be employed and if, in spite of this procedure, dyspnea is increasing, tracheotomy should be done. Intubation is not likely to be of service as the edematous tissues would occlude the opening in the tube.

Burns of Esophagus.—These are seldom caused by hot liquids, which rarely pass beyond the pharynx, but are more apt to result from the swallowing of caustic alkali or acids. As the result of this accident there will be shock, pain, severe thirst, vomiting of blood, and there often follows severe gastritis. After the acute symptoms subside, sloughs are cast off, ulcers form, and cicatrization takes place, with the development of signs of stricture of this organ.

Treatment.—If a caustic alkali has been swallowed, use mild acidulated drinks, wash out the stomach with acidulated water to counteract the alkali. If acids have been swallowed alkaline drinks, such as lime water, should be employed—also for lavage. Treat shock, if present. Give morphine for the relief of pain. Feed the patient by the rectum until he shows signs of failing strength, then give concentrated nourishment by the mouth—beef tea and soft-boiled eggs. Start the use of bougies early, in second or third week, to limit contracture of the organ and prevention of stricture.

Burns of the Hands and Fingers.—The contracture and deformity following burns of the hands and fingers often result in so much loss of function as to render the members useless. With this possibility in view, proper dressing should be selected, and the greatest care should be observed to keep the parts in proper position by the use of splints during and after the healing of the burn. Care should be taken to prevent adhesion of raw surfaces, especially in the fingers, resulting in webbing of these members. By dressing each finger separately to prevent contact of the raw surfaces, and the early resort to skin grafts, much can be done to prevent this crippling deformity. Burns of the feet and toes should receive the same attention.

Contractures from Burns.—The amount of scar tissue produced in the healing of burns and the consequent contractures are in direct relation to the severity and duration of the infection. In burns and scalds involving the face, neck, hands, feet and the region of the joints, the possibility of serious deformities from contraction of the tissues should not be lost sight of, and position, extension, splints and bandages should be employed to prevent as far as possible this complication. The use of braces in the case of burns in the region of joints and the neck is, even after healing has occurred, most useful in preventing deformity.

Skin Grafting.—This procedure should be resorted to early in the ulcerated surfaces resulting from burns, as soon as the surface is in condition to receive grafts. By so doing both the time of repair and the tendency of contracture of the scar tissues is diminished.

Ulcers resulting from separation of the dead tissues should be touched with a solution of nitrate of silver, 5 grains to 1 ounce of water, and dressed with lint spread with an ointment of boric acid, aristol or ichthyol. Repair in the chronic ulcers following burns and scalds is often very slow. In such cases the use of an ointment of *scarlet red* will be found most effective in hastening the healing: Scarlet red, grs. viij; ac. boric, ʒss; ungt. petrolatum, ℥j.

Effects of Cold.—The results of exposure of the body to cold depend more on the length of the exposure than upon the intensity of the cold. Moist cold produces more serious results than dry cold. Hunger, fatigue and alcoholism render the subject more susceptible to the effect of cold. Prolonged exposure to cold causes pain in the limbs, lassitude, somnolence, coma and death if the patient is not actively treated. Death may result from cerebral anemia, from sudden and progressive chilling, or cerebral congestion from slow and continuous chilling or embolism in cases when the patient is exposed to sudden warmth.

Frost-bite.—This is most frequently seen in the fingers, toes nose, ears, cheeks and chin, but may involve the penis, feet, legs, hands and arms. The local effect of cold is analogous to that of heat, erythema, vesication and sloughing. Cold causes a primary contraction of the vessels and pallor and numbness of the part which is followed by dilatation of the vessels with redness, swelling and burning pain in the affected part. In a moderate frost-bite the swelling and redness disappears in a few days. In more severe frost-bites the part becomes purple and covered with vesicles, the cuticle is destroyed and infection follows and painful ulcers develop; local areas of gangrene form or large portion of the limbs may become gangrenous.

Treatment.—In the milder varieties of frost-bite, in which the skin is livid but not gangrenous, friction with snow or rubbing with towels should be employed until sensation is restored and the parts should then be wrapped in cotton. In severe cases, when localized or extensive gangrene occurs, the parts should be covered with warm antiseptics to favor the suppuration of the sloughs. When this has occurred the resulting ulcers require appropriate treatment. In gangrene of the limbs amputation is required which should not be done until the line of demarcation is well established.

Pernio or Chilblain.—This is a vasomotor disturbance which is characterized by burning, pain and redness of the skin which follows frost-bite of moderate degree. This may disappear and afterward recur on exposure to slight cold. The parts most frequently involved are the feet, fingers, toes, heels, cheeks, nose and ears. The patient should wear woolen stockings in cold weather if the feet or toes are affected, and not bring the parts near a fire. The local treatment by painting the parts with tincture of iodine or tincture of belladonna often relieves the condition; friction with alcohol or camphorated soap liniment may do good or an ointment of emp. plumbi and petrolatum, equal parts, or one composed of pulv. camphoræ (ʒj), ichthyol, (ʒiss) lanolin (ʒss) and petrolatum (℥iv) often relieves the pain and itching; the parts should be wrapped in cotton after applying this dressing.

Injuries from Electricity.—Since the extensive introduction of electricity in the arts, injuries from contact with heavily charged wires are of frequent occurrence. If the current be a strong one, death may be instantaneous, or the patient may be knocked down, become unconscious and present severe burns at the point of contact, then regain consciousness and subsequently suffer from numbness in the extremities, traumatic neuroses and in rare cases true paralysis. If the skin be dry at the time the current is received there will be more burning, less penetration and less shock and less danger of death. The burns are not painful, but are apt to be followed by extensive sloughing. Alternating currents are more dangerous than continuous currents; a continuous current of 1000 volts is not apt to be followed by serious consequences, whereas an alternating current of the same strength is likely to produce death.

Death from exposure to strong alternating currents is considered by Hedley to be caused by destruction of the tissues or by arrest of respiration producing asphyxia. Exposure to a strong electric current may produce burns or ecchymoses, and occasionally wounds; the latter bleed freely and are apt to slough. A burn from electricity presents a dry blackened surface and is surrounded by an area of pale skin. They are not as painful as ordinary burns, but healing in electric burns is usually slow. Inflammation and suppuration of the tissues usually develop in a few days, and are often followed by the development of an extensive area of moist gangrene, a small burn being followed by extensive and deep destruction of the surrounding tissues.

If the body of the person receiving the electric current is still in contact with the wire it should be removed as quickly as possible. It is not wise to lift the body with bare hands. Rubber gloves, if available, should be worn; if not, the hands should be covered with dry woolen cloths before lifting the body.

Treatment.—The treatment of a person who has been exposed to a strong electric current, even if apparently lifeless, consists in practising artificial respiration. If the heart's action can be detected there is a chance of resuscitation; if both cardiac action and respiration are present the prognosis is favorable, Laborde's or Silvester's method being employed; also friction to the surface of the body and enemata of hot saline solution or infusion of saline solution with adrenalin into a large artery, as recommended by Crile; in some cases venesection has been employed with advantage. Hedley records a case of apparent death in a man who received an alternating current of 4500 volts short-circuited through his body for many minutes, who showed no signs of life for thirty minutes. In this case, after the employment of Laborde's method of artificial respiration for some time, normal respiratory action was restored and the patient recovered. Artificial respiration should be practised in all cases, and should be continued until it is certain that the patient is dead. At the same time strychnine should be used hypodermically.

The burns should be treated by the application of antiseptic dressings, but these often fail to arrest the sloughing. DaCosta recommends in the early stage of these burns the use of fomentations of hot saline solution, which facilitates separation of the sloughs, and in the subsequent dressing of the wounds peroxide of hydrogen followed by irrigation with saline solution. After sloughs have separated dry sterilized dressings should be employed.

Lightning Stroke.—This results from the discharge of atmospheric electricity, and injuries from this cause are more frequent in the summer season. In this form of electric injury a person may be struck directly or may be shocked by an induced current, the lightning having struck some object near at hand. The results of lightning stroke upon the body differ according as the electrical or the burning action predominates. There may be present severe burns or extensive lacerations, involving the muscles, bloodvessels and bones; or sudden death may result from paralysis of the respiration and circulation. Upon regaining consciousness, the patient may complain of disturbance of vision, and may suffer from paralysis of the nerves of motion or sensation; paralysis of the lower limbs is said to be more common than that of the upper limbs.

Treatment.—The treatment of the stage of shock following lightning stroke consists in the application of external heat, heat, the employment of artificial respiration and the administration of stimulants. If burns exist upon the surface of the body they should be treated like burns arising from artificial currents. If paralysis persists for some time after recovery from the immediate effects of the shock the use of galvanism and the administration of strychnine may be followed by good results.

Roentgen-ray Burns.—A peculiar lesion of the skin and subjacent tissues, following prolonged exposure to the roentgen rays, resulting in inflammation, dermatitis or ulceration of the skin and loss of the nails and hair in the damaged area, is described as an roentgen-ray burn. This lesion differs from an ordinary burn in that it may not appear for several days or weeks after the exposure, and that the inflammatory or gangrenous process arises in the tissues and finally involves the skin. Chronic roentgen-ray burns give rise to indolent ulcers, which in time undergo malignant change. These lesions are very painful and slow in healing; and if an extensive surface be involved they may result in serious consequences: amputation of the fingers or a limb has been demanded by reason of a burn of this nature. The lesion is probably due to trophic changes.

Treatment.—The dressings employed in ordinary burns have not proved satisfactory in these injuries. Where dermatitis with intense itching is present a paste composed of boric acid, ʒj; zinc oxide, ℥j; starch, ℥j; bismuth subnitrate, ℥j; olive oil, ℥j; lime water, ℥iij; lanolin, ℥iij; rose water, ʒxij is spread on lint or gauze and applied to the part. Dry sterilized dressings may be employed and skin grafting when the ulcerated surface is extensive may be of service. The latter procedure is found most efficacious after exclusion of the base of the ulcer. When a small area only is involved, and healing fails to occur, Powell recommends excision of the ulcerated tissues. Amputation may be necessary.

Bed Sores (Decubitus).—The local failure of nutrition in a subject with tissues of low vitality from age, disease, or injury may result in the development of a bed sore. Development of a bed sore in the aged is favored by their arterial condition.

Bed sore, in favorable subjects, results from continued pressure upon a part, aided by slight injury or irritation which may be caused by contact with urine, feces, sweat or foreign bodies.

Vascular tone is diminished by pressure; stasis results, thrombosis occurs and gangrene results. They are also a frequent and troublesome complication in spinal injuries, in which cases they result from trophic disturbances.

The parts most subject to bed sores are the sacral region, buttocks, scapulæ, heels, trochanters and elbows. Their formation may be prevented in many cases by the use of air cushions or of a water mattress, and by keeping the parts exposed to pressure scrupulously clean and frequently bathing them with stimulating lotions, such as alcohol, olive oil and alcohol (equal parts) or soap liniment. The parts should also be protected from pressure by the use of small pads or pillows so arranged as to relieve the part of pressure. When a bed sore has actually formed—and in many cases its formation is very rapid and the slough will be found to involve a large surface of the skin over the sacrum, and to extend down to the bone—we have present a very serious complication, and one which requires most careful treatment.

The dressing of a bed sore before separation of the slough consists in relieving the part from pressure by the use of an air cushion placed under the buttocks, and the application of a moist antiseptic dressing until the slough has separated.

When the slough has become detached the ulcer remaining should be well irrigated with a 1:2000 bichloride solution, and the granulations touched with a 5-grain solution of nitrate of silver; and aristol, or boric acid ointment spread upon lint, should be applied to the surface of the ulcer or dichloramine-T may be used. This dressing should be renewed every day or every other day, and means should be adopted to protect the parts from further pressure, and the constitutional condition of the patient should be improved by the administration of a nutritious diet, tonics and stimulants. The application of the galvanic current has been employed to promote healing of the ulcer in obstinate cases.

INJURIES OF JOINTS.

Contusion of Joints.—This injury results from force directly applied to the surface of the joint, or from force transmitted through the adjacent bones, as is not infrequently observed in the knee-joint after fracture of the femur. The part becomes swollen and tender, and the joint assumes that position in which there is the least tension. The swelling is due to effusion and hemorrhage in the joint and the contusion of the soft parts. The swelling and tenderness usually subside in a short time under the application of cold-water dressing, or an ice-cap, and fixation of the joint for a short time with a splint. Pressure by a firm bandage, hot-air baking and massage may be useful.

Hemarthrosis.—This condition, in which blood has escaped into the joint, resulting from a subcutaneous wound or severe contusion or sprain, is most frequently observed in the knee-joint. The joint becomes swollen and painful and there is loss of function. Cold-water dressing and fixation of the joint should be applied and later pressure by a bandage. If, in spite of treatment, the swelling remains and is painful, arthrotomy, with the removal of the blood, should be practised. The wound should be closed without drainage.

Sprains of Joints.—A sprain is caused by a sudden wrench or twist of a joint, which stretches or lacerates the ligaments, contuses or crushes the synovial membranes, and may loosen or separate the cartilages. The joints most frequently involved are the knee, elbow and wrist, but the smaller joints may also be involved. The ball and socket joints are less frequently involved than the hinge joints. In the foot the subastragular joint often presents this injury. A careful examination should be made to eliminate the presence of fracture. As the swelling appears early and is often marked, it may be difficult to obtain this information unless a roentgen-ray examination is made. *Sprain-fracture,* which was described by Callender as the tearing of a ligament or tendon from its point of insertion, with the detachment of a thin shell of bone, often complicates sprains of joints.

When seen early, strapping of a sprained joint and the application of a firm bandage is the most satisfactory dressing, as it gives the parts support and limits the swelling If the sprain is seen late and the parts are much swollen and painful wet dressing and a firm bandage should be applied for a few days, and as soon as the swelling has diminished strapping should be employed. I have found that with this form of dressing the patient has restoration of function much sooner than with any other form of dressing. With a properly applied strapping of the ankle or knee-joints patients are able to walk without discomfort in a few days. The application of strapping to a sprain of the ankle-joint is seen in Fig. 243).

The strapping should be renewed in five or six days, and may be dispensed with in two or three weeks. Absolute fixation of the sprained joint with a plaster-of-Paris dressing was formerly much used in the treatment of sprains, but as it tends to promote stiffness and interferes with the circulation it is now seldom employed. In severe sprains induration and tenderness often persists for some time. In such cases baking and massage should be employed.

Wounds of Joints.—As joints are very susceptible to infection, any wound which opens the joint is a most serious lesion. Penetrating joint wounds may result from incised, lacerated and gunshot wounds and fractures of adjacent bones. All wounds of joints are attended with danger, but those of the knee and vertebral joints are the most dangerous; the great risk in these wounds is infection. If proper treatment is not promptly undertaken infection of the joint develops rapidly, followed by septicemia and death. When a joint is opened by a wound there is a flow of synovial fluid; this also occurs in wounds of bursæ in the neighborhood of the joint. In punctured wounds, if small, the escape of synovial fluid is not apt to occur. When a joint is opened by the

Fig. 243.

Strapping applied to ankle-joint.

surgeon with full antiseptic precautions it usually heals under rest and aseptic dressings without untoward symptoms. In accidental penetrating wounds of joints infection is likely to occur.

Treatment.—Small punctured wounds of joints by instruments which are not likely to introduce infection, may be treated by painting the wound and surrounding skin with tr. iodine and applying a sterile gauze dressing. The joint should be put at rest upon a splint, the patient being carefully watched for symptoms which point to infection of the joints. If infection occurs radical treatment should be promptly undertaken. In wounds in which it is likely that infection has been introduced—incised, lacerated, gunshot and punctured wounds—the wound should be packed with sterile gauze, and the limb surrounding prepared as for an aseptic operation. The wound should be enlarged if necessary, foreign bodies extracted and blood clots removed, and devitalized tissues trimmed away with the knife or scissors. The joint should be next irrigated with warm saline solution, and the capsule sutured. Primary flushing of the wounds with ether was practised during the late war, with apparently good results. After providing for drainage of the overlying soft parts the wound is sutured and covered by a sterile gauze dressing. The joint is immobilized by a splint or plaster-of-Paris dressing, elevated and surrounded by ice-bags, and in the larger joints weight extension should be applied. If there is absence of pain and fever the drainage should be removed at the end of the second day, and fixation of the joint kept up for two weeks. At this time, if the wound is healed, passive motion to restore the function of the joint should be practised. Unfortunately, the joint wound may not take the course described above. A few days after the first dressing signs of infection may appear, as evidenced by swelling, pain, fever and marked leukocytosis, indicating the development of septic arthritis. The dressings should be removed and drainage instituted, either by opening the original wound or by making counter-incisions. Fixation of the joint should be continued, and it should be irrigated two or three times a day through the openings with saline solution, or instillation of Dakin's solution may be employed. Free incision of the joint and chemical sterilization has also been employed in these cases. Wilms, in cases of suppurative arthritis, recommends opening the joint by one or more incisions, and have the patient make active movement of the joint every few hours, claiming that movements of the joint force the pus from all crevices of the articulations, thus securing the best drainage. In applying this treatment to septic arthritis of the knee-joint the part is surrounded by a copious gauze dressing, and is kept upon a splint with extension. At intervals of a few hours the splint and extension are removed, and the patient makes active movement of the joint for a few minutes; this procedure is repeated every few hours. This method is still under trial. Good results have been recorded in a number of cases. My experience in a limited number of cases has been favorable.

In spite of the above treatment, if the septicemic symptoms continue or increase, the question of excision or amputation has to be considered, and it is well not to postpone these radical operations too long, for if done late in the disease, even they may fail to save the patient's life.

Sprain-fracture.—Under this name Mr. Callender has described an injury which consists in the separation of a ligament or tendon from its point of insertion into a bone, with the detachment of a thin shell of the bone; this injury is apt to occur about the ankle-joint, knee-joint, elbow-joint and wrist-joint, and the treatment is the same as that of an ordinary fracture in the same locality. This injury is probably much more common than is generally supposed in connection with sprains of the joints and is, I think, in many cases the cause of tardy restoration of the function of sprained joints, this injury being overlooked, simply being treated as a sprain, and the patient being encouraged to use the part before union of the bone has been accomplished. The frequency of sprain-fracture has in recent years been demonstrated by roentgen-ray examination.

Strains of Muscles and Fascia.—These vary in severity from simple stretching of the fibers to absolute rupture, and should be treated by putting the parts at rest and by the application of pressure by means of adhesive straps or of a bandage; in strains of the muscles and fascia of the back the use of broad strips of adhesive plaster, applied as in cases of fracture of the ribs, will be found most satisfactory. In the treatment of the later stages of these injuries the employment of baking and massage will often be followed by good results.

VACCINE THERAPY.

The bodily resistance to an infection may be increased by the injection of a vaccine. Vaccines are prepared by taking a culture of the infecting organism from the local focus of inflammation, the wound, or the blood, and a pure culture is made. If several organisms are present cultures of the most pathogenic type are grown; this occurs in thirty-six hours. The organisms which are made into an emulsion with salt solution, known as bacterins, are destroyed by heat and are injected with aseptic precautions into the subcutaneous tissues or muscles of the patient.

The work of Wright and Douglas led to the discovery of substances in the blood known as opsonins, whose function is to act upon bacteria in such a way as to make them more easily destroyed by phagocytes. The injection of an emulsion of bacterins increases the opsonic power of the patient's blood, presumably by stimulating the opsonic power of the patient's blood by stimulating the opsonic forming elements of the body.

This treatment is based on the principle of exciting the formation of antibodies in the system and the destruction of bacteria by them and the leukocytes. Antibodies which destroy most bacteria exist constantly in the blood, and their formation is actively stimulated by antigens such as bacterial toxins. A vaccine made from a certain variety of organisms is valuable only in infections caused by that variety of organism. Stock cultures are sometimes employed, but it is better to use, whenever possible, bacteria obtained from the infected person, and make the vaccine from them. This is known as an *autogenous* vaccine. In cases of emergency stock vaccines may be used until an autogenous vaccine can be prepared.

Mixed vaccines are also used, with excellent results in cases of mixed infection, prepared by combining the vaccines of staphylococci, streptococci and colon bacilli, etc.

The dosage of bacterins varies with the organism, the nature of the disease and the resistance of the patient. The injections of vaccines appear to be free from danger. Staphylococcic vaccines give better results than streptococcic. It is better to begin treatment with a small dose rather than a large one. A moderate dose of staphylococcic vaccine is from 50,000,000 to 200,000,000; streptococcic vaccine is given in doses of 15,000,000 to 50,000,000. A moderate reaction often follows the injection of bacterins, such as slight rise in temperature, headache, backache and languor.

There is no doubt of the value of this form of treatment in certain cases; in acne vulgaris, furunculosis and carbuncle, their use seems to be especially effective. They are also employed with good results in septicemia following wounds and abscesses, joint infections, osteomyelitis, endocarditis, pericarditis and meningitis.

DISEASES COMPLICATING WOUNDS.

Septicemia or Sepsis.—This is a febrile affection caused by the introduction into the blood of pyogenic organisms, their toxins, or those of saprophytic bacteria, staphylococci, streptococci or pneumococci may be the causative agent. The absorption of septic matter by the lymphatics is an important agent in its production; a wound is the usual portal of entry. We recognize three forms of septicemia: (1) Septic infection which may be mild in type, and progressive septicemia in which there may be a true bacteriemia; (2) pyemia; and (3) sapremia.

Septic infection is manifested by elevation of temperature, rise in pulse-rate, headache and nausea. These symptoms may be present for a few days and recovery takes place. The severe form of progressive septicemia may follow the milder form and is ushered in by a chill followed by high fever, rapid, weak, compressible pulse, delirium alternating with stupor and coma usually develops before death in this form of infection. A true bacteriemia may be demonstrated by blood culture. The prognosis is not good if bacteriemia exists.

Treatment.—The wound should be sterilized by the use of Carrel-Dakin treatment or dichloramine-T and the patient should be given tonics and stimulants with a supporting diet, and if improvement does not promptly occur vaccines or polyvalent serum should be employed. Hooker has in such cases recommended the transfusion of immunized blood, the donor being immunized by progressively increasing doses of a freshly made vaccine from the causative organism.

Pyemia.—This affection is characterized by fever of an intermittent type, recurring chills and the development of metastatic abscesses as the result of septic thrombophlebitis. The entrance into the blood of clots filled with toxins or clots infected with streptococci or staphylococci from an infected wound is the usual cause of this infection. Suppuration in contact with a vein may cause thrombophlebitis and clot formation if no wound exists. Portions of the infected clots are carried by the blood stream to different parts of the body and lodge in the smaller vessels giving rise to embolic, secondary or metastatic abscesses. This affection may arise from the infection of superficial or deep wounds, the medulla of bone or erysipelas.

Symptoms.—A severe chill, followed by high fever and profuse sweats usually ushers in the disease. The chills and sweats recur at intervals, during the sweating the temperature may drop to the normal, jaundice may occur and there may be suppuration of the parotid gland or purulent arthritis. Acute pyemia may prove fatal in a few days; the chronic condition may last for months.

Treatment.—This is similar to that of septicemia—abscesses if accessible should be evacuated and vaccines should be employed as soon as the disease declares itself.

Sapremia (*Putrid Intoxication*).—This arises from the absorption of poisonous ptomaines from putrefying tissues.

Symptoms.—There is often a chill; the temperature rises to 103° F. or higher; headache, dry coated tongue, nausea, vomiting, rapid and weak pulse and jaundice may be present; petechial spots may appear upon the skin; leukocytosis may be marked. Visceral complications, nephritis, cholecystitis, pleuritis, pericarditis or endocarditis may occur, which require appropriate treatment.

Treatment.—The wound should be drained, antiseptic dressings applied and attempts to render the wound aseptic should be made. Carrel-Dakin treatment should be employed. The patient should be given stimulants. Alcohol, strychnine and digitalis, a nourishing diet, purgatives, diuretics and diaphoretics should be administered to aid in removing the toxins. Hypodermoclysis or the intravenous use of saline solution may be helpful.

Erysipelas.—This is an inflammation of the skin and subcutaneous cellular tissues caused by infection of the small lymphatics by streptococci. The infection occurs through an ulcer wound or scratch, which in some cases is difficult to locate. Many different varieties of erysipelas have been described, but for practical purposes that involving the skin and that in which the skin and subcutaneous cellular tissue are both involved need only be considered; the latter may result in the formation of abscesses (phlegmonous erysipelas).

The skin in the region of a wound, in the course of lymphatic vessels draining the region of the wound, becomes red and slightly elevated. The disease may show itself on parts of the body where no wound can be located. The face and bridge of the nose is a frequent seat of origin. Here the lesion may be in the scalp or the mucous membrane within the nose. The redness, whose margin is sharply defined, spreads rapidly, and may involve a large portion of the skin of the body and blebs may form on the surface. The ears are not often involved on account of the close adhesion of the skin to the cartilage.

Symptoms.—There is burning pain and swelling in the involved area. The lymphatic glands are enlarged, the pulse is increased and the temperature elevated. If the disease ceases to spread the redness and swelling gradually abate and desquamation occurs. On the other hand the area involved may become more swollen and edematous and dusky in color and areas of softening may be found, pointing to the development of abscess. In young and strong subjects the symptoms of cutaneous erysipelas are often slight, but in old and debilitated subjects serious symptoms develop, rapid pulse, dry brown tongue, high temperature, delirium and death. Pneumonia, meningitis, endocarditis, arthritis and albuminuria may develop as serious complications.

Treatment.—If a wound is present it should be rendered aseptic if possible. The patient should be isolated. Wet dressing, boric acid or magnesium sulphate may be applied over the inflamed area or the surface should be frequently painted with ichthyol, 25 parts, olive oil, 75 parts, or an ointment containing ichthyol and lanolin or vaseline, equal parts, should be applied. The dresser should wear rubber gloves to prevent transferring the affection to other subjects.

To arrest the spreading of disease, painting the skin outside of area with a broad band of tincture of iodine has been recommended. Constitutional treatment appropriate for the inflammatory condition should be given. Tincture of chloride of iron and quinine, the former given in the form of Basham's mixture, have long been used in this affection with good results. In phlegmonous erysipelas, with purulent infiltration of the subcutaneous tissues, free incisions should be made for drainage and wet antiseptic dressings applied. The grave constitutional symptoms call for the use of strychnine, quinine, digitalis and alcohol. Antistreptococcic serum may be employed.

Cellulitis.—This results from a streptococcic or staphylococcic infection of the subcutaneous cellular tissues, with involvement of the lymphatic channels, which appear as red lines upon the skin, with enlargement of associated lymphatic glands. The skin is not often involved; there may be redness, but less marked than in erysipelas. In mild cases the lymphatics dispose of the infection, and there are few symptoms. Pain of a throbbing character is often present. If the infection is more severe there may be symptoms of infection, rapid pulse and rise in temperature and suppuration in the lymphatic glands.

Treatment.—The constitutional treatment should be that employed in septic infection: Rest of the affected part and hot antiseptic dressings applied to the wound; the area about the wound should be painted with tincture of iodine, or covered with ichthyol ointment. If suppuration involves the lymphatic glands, incision and removal of the broken down glands should be practised.

Air Embolus.—Air may enter a vein during operations or be accidentally injected in giving hypodermic injections or in saline hypodermoclysis or intravenous infusion. It was formerly considered a very fatal accident, but recent investigation has shown that a certain amount of air can enter the veins without causing grave symptoms. The danger depends upon the amount of air and the rapidity of its entrance. The cause of death in air embolism is supposed to be due to the mixing of air with the blood in the right side of the heart, interfering with the normal action of the valves and the propulsion of blood into the lungs.

Symptoms.—These develop with great rapidity; extreme failure of circulation, with a churning sound on cardiac systole, marked pallor or cyanosis, gasping for air and convulsions.

Treatment.—Suspend the anesthetic, compress with the finger, or clamp the divided vein, lower the head and make artificial respiration. Give strychnine hypodermically, and normal salt solution and adrenalin intravenously.

Fat Embolism.—Fat may be forced into open veins in wounds by muscular action. Wilms believes it enters the veins by way of the lymphatics and thoracic duct. Fat in the blood is quite a common condition and seldom produces serious symptoms. Fat embolism may occur in fractures of long bones, in extensive bruises and crushes, amputations, excisions and rupture of the liver.

Lipemia probably results when laceration of the vessels occur in fatty tissues, and the presence of fat in the urine—*lipuria*, is not uncommon after fractures, especially of the long bones. The presence of fat in the urine after fracture should warn against early movements of the fragments.

If numerous emboli block the capillaries of a vital organ, or large emboli lodge, marked symptoms arise.

Symptoms.—Restlessness, dyspnea, rapid weak pulse, rapid respiration, contracted pupils, pallor followed by cyanosis, edema of the lungs and exhaustion.

Treatment.—Complete immobilization and infrequent dressing of the injured or diseased part. External heat, strychnine, alcohol and nitroglycerin. If respiration is much embarrassed artificial respiration may be useful. Drainage of the region of fracture or injury should be made, as fat enters the vessels gradually under pressure.

Thrombosis.—This consists in coagulation of blood in a vessel partially or completely occluding it, the clot or coagulum remaining at the point of origin. The clot or thrombosis consists of red and white corpuscles, fibrin and platelets; it forms gradually, being deposited layer by layer, and may occur in arteries, veins or capillaries. Thrombosis occurs from chemical alterations in the blood, changes in the interior of the vessel by bacterial infection, changes in the inner coat of the vessel and slowing of the circulation. In arteries, changes in the coats and embolism are the chief causes of thrombosis. The essential cause of all intravascular thrombi is damage to the endothelial coat usually effected by bacteria and therefore is infectious. An excess of fibrin forming elements in the blood, and slowing of the circulation also favor thrombosis. By testing the coagulability of the blood the danger of thrombosis and embolism may be suspected. Wounds, fractures, ligation or wounds of vessels, pressure of splints, foreign bodies in a vessel, suture of vessels and atheroma of arteries are all active causes of thrombosis. Thrombosis may follow abdominal operations and general infections as in cases of pneumonia, typhoid fever and appendicitis. Mesenteric thrombosis, either arterial or venous, causing gangrene of the intestine, is also occasionally observed.

Treatment.—If an aseptic thrombosis develops in a large vessel of a limb the part should be handled very carefully to avoid detachment of fragments (emboli) which may be swept into the circulation. Lift the limb, cover it with cotton and apply a bandage from the lower extremity; keep in slightly elevated position and apply heat to favor development of the collateral circulation as gangrene is in imminent danger in thrombosis. The part should be kept at rest for five or six weeks. An infected thrombosis in an accessible vessel should be removed after ligating the vessel on each side of the clot, the wound sterilized and dressed. In gangrene of the intestine from mesenteric thrombosis, if not too extensive, resection of the gangrenous gut is often followed by recovery.

Embolism.—This consists in the occlusion of a vessel by a foreign body usually a blood clot which has been brought from a distant part of the vessel. This body is called an embolus and may consist of a fragment of a thrombus atheromatous material from a distant artery, a shred of fibrin or portion of a tumor. An embolus is arrested when it reaches a vessel whose diameter is less than its own, or at the bifurcation of a vessel. An aseptic embolus may lodge and become organized, while an infected one is apt to soften and give rise to a number of smaller emboli, which escape into the blood stream and may cause metastatic abscesses. Collateral circulation may be established after the lodgment of an aseptic embolus.

Symptoms.—These depend upon its situation, the organ involved and its freedom from infection. Embolism of the cerebral arteries or of the pulmonary artery are often fatal. If the main artery of a limb is involved there is pain at the seat of the embolus, the limb becomes cold and swollen and discolored, and the pulse is absent below the seat of the obstruction of the vessel.

Treatment.—The limb should be elevated, kept at rest and heat applied to favor the development of the collateral circulation. If gangrene occurs amputation is demanded as soon as a line of demarcation is established. Emboli, either septic or aseptic, have been successfully treated by exposure and removal.

Gangrene.—This term is used to describe the process of death of the soft parts in mass, the dead portions being large enough to be visible. Ulceration is caused by *molecular death* of the tissues; the dead parts are cast off in the form of pus. The term *necrosis* is usually confined to the death of bone, although it is often used to describe the death of soft parts, forming necrotic masses at some depth from the surface.

The causes of gangrene are *direct,* where the death of the tissues is caused by crushing or pulpefaction of the parts, or destruction by caustics, heat, cold or electricity or virulent bacterial infection; or indirect, where the condition arises from interference with the blood supply.

Gangrene is usually described as *dry,* when the condition arises where the arterial supply is cut off gradually by disease of the artery, arteriosclerosis, or suddenly by an embolus; *moist*, which is usually due to venous obstruction, thrombosis, pressure of tumor or splints, or a tight bandage, and occasionally results from the sudden occlusion of an artery by embolism, wounds or ligature; *microbic*, in which bacteria or their toxins may cause gangrene by developing endarteritis, phlebitis and thrombosis.

Dry Gangrene.—This usually develops in subjects well advanced in years, and is also known as senile or anemic gangrene, and is due to feeble action of the heart and a slowly

Fig. 244.

Dry gangrene from embolism. (Ashhurst.)

progressing arterial occlusion from endarteritis and atheroma. The part involved becomes black, dry and mummified. The vessels in this condition do not carry a normal amount of blood and at any time may be occluded by thrombosis. Dry gangrene sometimes follows the sudden occlusion of an artery by an embolus (Fig. 244). A man with the above vascular condition is generally in feeble health, suffers from cold and numbness in the feet, and frequently complains of burning pain in the feet, especially at night. The arteries are felt as rigid tubes, like pipe stems. Gangrene usually appears upon one or more of the toes, and may follow a trifling injury, such as a bruise, cutting a corn too closely, or the rubbing of a shoe, or there may be no history of injury. A small purple anesthetic spot appears and is followed by a vesicle, which ruptures and discharges a small amount of bloody serum, exposing a dry floor. The tissues around this area show retarded and stagnated circulation, being purple in color, and those beyond the area are hyperemic. The part becomes black, dry and wrinkled and the process may be limited to one or more toes, or may gradually extend so that in time it involves the greater part of the foot, or even the leg. In senile gangrene the distal portion is dry, while that near the body is somewhat moist. As it spreads the area of hyperemia at the margin advances and the area of stasis follows. A line of demarcation may or may not form; if it does a spontaneous amputation may take place. Coincident with the development of the gangrenous process, the patient complains of severe pain, and if the area is extensive, develops fever from septic absorption and death may occur from renal, pulmonary or cardiac complications, or from exhaustion caused by sleeplessness, pain, septic absorption or embolism.

Treatment.—If the gangrene is limited to one or more toes, and shows no tendency to spread to the foot, no operative treatment need be considered. To prevent injury or infection the part should be wrapped in dry sterile cotton. If the patient has no fever, nor exhausting diarrhea, and sleeps and takes nourishment well, formal amputation may never be required, as Nature will be able to remove the dead tissue at the phalangeal joints with less constitutional disturbance than would result from operation. If a line of demarcation forms and the parts are not separated spontaneously the surgeon can remove them with forceps and scissors and apply a dry antiseptic dressing. If, on the other hand, gangrene spreads to the foot and continues to extend, and the patient presents symptoms of septic infection, fever, diarrhea and sleeplessness, amputation should be done at the knee-joint, or just above the condyles of the femur. Some surgeons recommend amputation of the leg, but in my experience the disease is more apt to recur in the stump if the operation is done below the knee.

Lejars, to determine at what level the limb should be removed, places an Esmarch bandage on the limb to exsanguinate it, then applies the rubber band and removes the elastic bandage. The band should be removed in five minutes. It will be observed that the hyperemic blush which follows, will extend only so far as healthy circulation is present, and amputation may safely be done at this point. I have made use of this ingenious procedure, but its employment seems to be accompanied by a definite risk of injuring the artery and the formation of a thrombus at the seat of application of the rubber band. For this reason, in amputation of the thigh for senile gangrene, I never use the rubber band to secure hemostasis, but prefer to secure the arteries in the wound before they are cut.

In many cases of senile gangrene the patient's condition is so poor that any operation would only hasten the fatal termination. Under such circumstances, of course, only palliative treatment is admissible. In dry gangrene following immediately the occlusion of an artery by an embolus, the surgeon should wait for the formation of line of demarcation and separation before resorting to amputation.

Fig. 245.

Gangrene following carbolic-acid dressing. (Ashhurst.)

Moist or Acute Gangrene.—In this form of gangrene the tissues may be actually destroyed by the traumatism, by strangulation of the tissues as seen in strangulated hernia, tumors with twisted pellicles or volvulus, or by the action of heat and cold or chemical irritants. Gangrene following the continued application of carbolic acid to wounds is frequently seen. It is used in more or less diluted solutions as a household remedy. It generally involves the fingers and toes (Fig. 245).

Moist gangrene may follow lacerated or contused wounds, compound fractures, burns and frost-bite, wounds of veins and arteries, or the ligation of arteries, or thrombosis or embolism. It usually results from venous obstruction (thrombosis), pressure of tumors or constricting bands, the parts being surcharged with venous blood. When moist gangrene develops the part swells, the skin is first pale, cold and sensation is lost, and becomes livid, mottled and purple or greenish in color; blebs form beneath the epithelium which contain a reddish-brown fluid. The epithelium is loosened and may be slipped from the derma with little pressure. At the point where the resistive powers of the patient are able to overcome the destructive lesions producing the gangrene, a red line encircling the gangrenous structures forms, known as the line of demarcation. In this region the usual phenomena of inflammation occur, and as the process continues a line of granulations is formed, known as the line of separation. During this process the patient develops fever, due to sapremia from absorption from the gangrenous area.

Treatment.—In moist gangrene the treatment should be directed to the prevention of infection and hastening the separation of the sloughing tissues. Warm antiseptic dressings should be applied, or the Carrel-Dakin treatment may be employed. In moist gangrene exposure of the part to sun or electric light is said to be valuable in preventing infection. The patient should be given morphine for relief of pain, tonics, nourishing food and stimulants. After the dead tissue has been separated the resulting granulating surface should be protected by antiseptic dressings. If the gangrene involves a limb, amputation should be done as soon as the line of demarcation and separation is established, at a point just above this line.

Microbic Gangrene.—This is also described as gas gangrene or traumatic spreading gangrene. It frequently occurs in lacerated or gunshot wounds and compound fracture, and is due to a mixed infection with virulent streptococci and organisms of putrefaction, or to infection by the bacillus of malignant edema or Bacillus aërogenes capsulatus. Within twenty-four hours after the injury the tissues of the wound swell, become painful and bluish-green or purple in appearance. The process extends rapidly and the tissues surrounding the wound become emphysematous; crackling can be elicited by palpation. There is no tendency to the formation of a line of demarcation. The patient develops symptoms of overwhelming sepsis, high fever, delirium and coma, and death often occurs in from twenty-four to forty-eight hours.

Treatment.—Free incisions may be made in the surrounding tissues and antistreptococcic serum administered, but are not often of value. If a limb be involved prompt amputation at a point well above the infected area is often a life-saving procedure.

Diabetic Gangrene.—The diabetic condition seems to have a special tendency to necrotic processes. It seems probable that this form of gangrene is due to infection of tissues predisposed to infection by the presence of sugar and a lessened amount of oxygen. This variety of gangrene may be of the dry or moist variety. Diabetic gangrene is most frequently observed in the feet and legs of elderly people, and a trifling injury is apt to be the exciting cause. It may start as spreading cellulitis, which eventuates in a moist gangrene.

As diabetics are bad subjects for operation, preliminary treatment of the diabetic condition is of the first importance, and operation should be postponed if possible until the patient becomes sugar free. If the toes or foot are involved amputation above the knee is the most satisfactory operation. If done at a lower point the disease is apt to recur in the flaps.

Embolic Gangrene.—This may follow the lodgment of an embolus in an important artery. This itself may be due to some infective process, typhoid fever, pneumonia, influenza, etc. The embolus which causes gangrene probably not only occludes the artery, but also vessels of the collateral circulation. When an embolus lodges and gangrene occurs there is severe pain at the seat of impaction, and there is pulsation above, but not below, the seat of the embolus. The skin is white and anesthetic, and in thirty-six hours becomes purple, green or black, and gradually becomes dry, shrivelled and hard, having the appearance of smoked bacon skin; in time a line of demarcation forms. Gangrene does not extend up to the point of occlusion, but only to a region in which the anastomotic circulation is sufficiently active to establish a line of demarcation and separation. Moist gangrene is sometimes seen after arterial occlusion by an embolus. The sudden loss of the *vis a tergo* in the arterial system, venous reflux and engorgement of the vessels with venous blood accounts for its occurrence. A thrombus in an artery rarely causes gangrene except in old subjects, as the collateral circulation gradually adjusts itself. If gangrene occurs it develops slowly and is of the dry variety.

Treatment.—The limb should be slightly elevated and wrapped in cotton, and the area should be dusted with antiseptic powders and kept dry. Hot-air baking is often useful. Incision of the artery and removal of the embolus has been practised, as well as arteriovenous anastomosis. Up to the present neither of these procedures has been very satisfactory. If there is constitutional reaction supporting treatment should be given. If the disease involves the extremities when the line of demarcation is well established amputation should be done well above this line.

Presenile Gangrene.—This disease occurs in young male adults, and usually involves the legs; first one leg, but in time the other leg becomes involved. It is rarely seen in women. It starts with severe pain in the toes, foot or leg, and the part feels cold. No pulse can be felt in the anterior or posterior tibial arteries. If the part is warmed some color returns. Walking is painful and difficult from severe pain in the calf muscles. If the foot hangs down it becomes red or cyanotic. After some months a bleb or ulcer appears upon the toes or foot and dry gangrene develops. This does not not usually occur until the disease has existed for a year or more. It has been ascribed to an obliterative endarteritis of all the arteries of the leg. Buerger regards the condition as a thrombo-angiitis obliterans of the larger arteries and deep veins of the leg. It has been attributed to improper diet, occupation and excessive use of tobacco and to typhus fever. Buerger considers infection the cause.

Treatment.—A great variety of different methods of treatment has been employed; many have failed and others have proved only palliative. In the early stage of the disease Ringer's solution, 500 cc by hypodermoclysis every other day until fifteen or twenty have been given, has been reported to have given relief of pain and to have arrested the spread of the gangrene. Intravenous injection of 2 per cent solution of sodium citrate has also been employed. Arteriovenous anastomosis has been practised, as well as reversal of the circulation by end-to-end anastomosis of the femoral vein to the femoral artery. Stratton collected 136 operations of this kind in different forms of gangrene which showed a direct mortality of 30 per cent and absolute failure in 72 per cent.

Sooner or later these cases come to amputation, which should be through the tubercle of the tibia or above the knee. I amputated both legs in a young man, aged twenty-one years, with an interval of a year between the operations, with entire relief of pain and improvement in his general health. Ten years after the last operation he was well and doing laborious outdoor work.

FIG. 246.

Noma following measles; duration one week. (Ashhurst.)

Noma, Gangrenous Stomatitis, Cancrum Oris.—This is a rapidly spreading gangrenous process which begins on the mucous membrane of the gums or cheek, but may occur in the genitals, noma pudendi or noma vulvæ. It occurs in children from three to ten years of age, and is apt to follow the exanthemata, especially measles. Various bacilli have been found by different observers, certain forms of leptothrix being there most frequently present. A mixed infection, including saprophytes, almost always exists. The disease usually starts upon the mucous membrane of the mouth, gums or genitals, and in a few hours a gangrenous ulcer may be present. A shiny red spot on the exterior of the cheek may be the first thing to attract attention. At an earlier stage fetor of the breath may be detected. In a few hours the gums or cheek becomes gangrenous and the cheek perforated, and a large portion of the jaw bones may become necrotic. I had under my care in the Children's Hospital a child with noma of the cheek, who recovered after cauterization, and later had all of the necrotic lower jaw removed, except one ascending ramus and its condyle. The constitutional disturbance is not marked at first, but soon the pulse becomes rapid and the temperature elevated, and the patient is apt to die of exhaustion, pyemia or septic pneumonia.

Treatment.—The patient should be given an anesthetic, a mouth gag introduced and the gangrenous surface of the cheek or gums curetted, and the base and edges thoroughly cauterized with nitric acid or acid nitrate of mercury, or the Paquelin cautery may be used. If the cheek has been perforated it is better to excise the gangrenous tissue and at the same time necrotic portions of the jaw should be removed. Similar treatment should be employed in the case of noma pudendi or vulvæ. The mouth should be frequently washed with saline solution or boric solution, and the patient should be given stimulants and a nourishing diet. The mortality is high, from 70 to 95 per cent. If recovery takes place later plastic operations are required for the resulting deformities.

Tetanus.—This disease is characterized by spasm of the voluntary muscles, which invariably results from the infection of a wound or focus of infection by the Bacillus tetani. This bacillus is anaërobic and is frequently found in the refuse from barnyards or stables and in earth or dust. The infection may occur in punctured or lacerated wounds, compound fractures, ulcers and burns, or through an abrasion of the mucous membrane or skin. A wound infected with pyogenic organisms or saprophytic bacteria, which being aërobic absorb all available oxygen, provides an anaërobic condition favorable for the growth of Bacillus tetani if brought in contact with it. It is claimed that the Bacillus tetani normally infests the intestinal canal of horses and cattle, and has been found in the intestines of human beings ingested with uncooked food. The occurrence of tetanus after operations upon the rectum has been explained by Matas as due to contact with feces containing Bacillus tetani. The development of tetanus in wounds received about stables is quite common.

The incubation period of tetanus is about ten days. Cases have been reported in which it developed in a few days, and others in which it did not appear for a month or longer. The duration of the period of incubation is said to be due to the distance of the wound from the spinal cord. The disease is a pure toxemia. Bacillus tetani may be present in a wound without producing any definite reaction, but the toxins they produce are alone responsible for the symptoms of the disease. Toxins are absorbed directly by the motor nerves of the injured part, and are transported by them through the perineural lymph sheaths to the spinal cord and medulla, and becoming fixed in the nerve cells of the spinal cord and medulla produce the symptoms of the disease. Toxins also enter the circulation, but cannot reach the central nervous system except when carried to the peripheral ends of motor nerves and absorbed by them. The toxins are said to enter into chemical combinations with the nerve tissue. The irritation of the motor cord produces tonic contraction of the muscles, while irritation of the sensory portion of the cord is responsible for clonic convulsions.

Symptoms.—In acute cases of tetanus, which develops within ten days, the patient may complain of pain in the wound or chilliness, but he usually first complains of stiffness in the jaws and a painful contraction of the extensor muscles of the neck. He occasionally complains of spasm of the muscles in the region of the wound. The fixation of the jaw is known as *trismus*. In a few hours generalized cramps occur, and as a general rule the extensor muscles overcome the flexors. The contraction of the muscles of the back is so powerful that the patient's body is bent into a curve, so that the entire body is supported on the occiput and the feet (*opisthotonos*) (Fig. 247). If he is bent in the opposite direction it is called *emprosthotonos*, and when lateral deviation of spine occurs it is known as *pleurothotonos*. Tonic spasms are more or less continuous, and clonic spasms develop as the disease progresses, and arise from peripheral irritations, such as exposure to bright light, jarring of the bed, attempts at swallowing, etc. The jaws remain persistently stiff and the neck arched. The temperature is usually normal but may be slightly elevated, and always rises just before death. The respiratory movements are rapid and shallow, because of muscular rigidity. When clonic spasm involves the thoracic

Fig. 247.

Opisthotonos in third day of tetanus. (Ashhurst.)

muscles cyanosis develops and asphyxia is frequently threatened in the clonic convulsions. The spasms are very painful and extremely exhausting. Retention of urine frequently occurs and constipation is marked. Sleep is disturbed by the recurring convulsions, and it is difficult to give the patient sufficient nourishment.

The diagnosis is based upon the presence of a wound, retraction of the head and stiffness of the jaws, the tonic and clonic convulsions and the absence of delirium. The conditions which may be confused with tetanus are strychnine poisoning, hysteria with tetany or hydrophobia. The prognosis in tetanus is bad. The mortality from tetanus, according to Jacobson's statistics, is 83.1 per cent for acute cases and 43.6 per cent in subacute cases. The longer the period of incubation and the longer life is preserved after the symptoms develop, the greater is the probability of recovery.

Treatment.—The development of tetanus may be prevented by the most scrupulous care in treating wounds in which tetanus is liable to occur. Septic, punctured and contused wounds should be opened, foreign bodies and sloughs removed and swabbed with a 3 per cent alcoholic solution of iodine. The same application should be made to lacerated wounds: 1500 units of tetanus antitoxin should be injected into the tissues or into any nerves exposed in the wound; this injection should be repeated in eight or nine days. The immense experience in the use of antitetanic serum during the late war has proved its prophylactic value. The efficacy and harmlessness of immunizing injections of tetanus antitoxin is generally accepted, and it should be employed in all soiled, punctured, lacerated and contused wounds. In gunshot wounds and those resulting from blank cartridges an injection of antitetanic serum of 1500 cc is given when the wound is first seen; a second injection at the same amount is given at the end of seven or eight days, and at the end of seven or eight days more a third injection should be employed. The injection is made slowly, and at the second injection the patient should be watched for the slightest sign of anaphylaxis; if this is noted the injection should be promptly stopped.

The treatment recommended by Ashhurst is as follows: When the disease has once developed active treatment should be promptly instituted. The principles of treatment according to Ashhurst are: (1) To remove the source which supplies the toxin (*i.e.*) bacilli which are still in the wound; (2) to neutralize the toxins already formed; (3) to depress the functions of the spinal cord; and (4) to sustain the patient by nourishment. The patient should be isolated in a quiet, cool, darkened room, and a special nurse should be placed in charge. The dressing of the wound should be that employed for the prevention of tetanus. The toxins should be neutralized by injections of antitoxin into the subarachnoid space. It was pointed out by Ashhurst and John that, used in this way, it acts directly upon the nerve roots, and that repeated intraspinal administration has been followed by immediate and favorable effects.

Anesthesia is not necessary, but often desirable. If employed chloroform is better than ether.

Spinal puncture is made with a hollow needle between the second and third lumbar spaces, and a few cubic centimeters of the subarachnoid fluid removed, and from 3000 to 10,000 units of antitoxin, diluted with warm saline solution, are slowly injected by syringe or gravity. If the site of inoculation is on the upper extremity or head, the foot of the table may be raised to allow the antitoxin to gravitate toward the medulla. If no marked improvement follows the subarachnoid injection within six or eight hours, 18,000 to 20,000 units of antitoxin should be administered intravenously. The intraspinal and intravenous injections should be repeated daily until the disease is definitely controlled. Since the adoption of intraspinal therapy there has been less reason for intravenous injections; all the nerves may be reached simultaneously by the spinal route.

To depress the function of the spinal cord drugs may be given by the mouth if the patient can swallow, or by the rectum; hypodermic administration is best when possible. These drugs should be administered in doses sufficient to produce some effect. Ten to 20 grains of chloral hydrate and 20 to 40 grains of bromide of potassium should be given as often as every two or three hours; more should be given if the patient requires it, and less if it proves sufficient to relieve the pain and diminish the rigidity. Chloretone has given gratifying results in doses of 30 to 60 grains administered by the mouth or rectum, dissolved in whiskey or hot olive oil.

Nursing of the patient is very important. Clear the bowels by a brisk purge early in the disease. Watch for retention of urine; guard against bed sores. Enforce feeding by the stomach tube, passed under a general anesthetic if necessary.

Cephalic Tetanus.—This is a rare form of tetanus, sometimes called hydrophobic or head tetanus. It follows head injuries and the muscular contractions are confined to the face, neck and pharynx, although the abdominal muscles may also be rigid. There may be paralysis of the facial nerve, the oculomotor or the hypoglossal nerve, or there may be no paralysis. The treatment is similar to that employed for acute tetanus.

Chronic Tetanus.—This disease develops from ten days to several weeks after a wound. The symptoms are less severe than in acute tetanus. The muscular spasm is widespread, but it may not be persistent. Intervals of relaxation occur which permit the patient to sleep and take nourishment. The disease may last for weeks. Chronic tetanus had a mortality of 40 to 50 per cent, but under modern methods of treatment it is claimed that it has been reduced to 35 to 50 per cent.

REMOVAL OF FOREIGN BODIES.

Foreign bodies may enter the body through the normal openings or by means of wounds. The location of these bodies may be made by palpation, a probe or by a roentgen-ray examination.

Foreign Bodies in the Urethra.—These are generally introduced into the urethra for purposes of sexual excitement and often slip from the grasp of the individual and pass within the meatus or into the bladder. If lodged in the urethra they may be removed with delicate forceps, firm pressure being made upon the base of the penis to prevent it slipping into the bladder. A pin lodged in the urethra with its point toward the meatus may have its point pushed through the urethra and skin, and being reversed the head may be made to present toward the meatus when it can be removed with forceps or by manipulation. Pins, needles, pencils, hair-pins and many other objects are often removed from the urethra.

Foreign Bodies in the Bladder.—If there is doubt as to the nature of the foreign body in the bladder a cystoscopic or roentgen-ray examination should be made. In the male a small body may be grasped with a lithotrite and crushed and removed or may be removed without crushing. In the female dilatation of the urethra will often permit the introduction of the female urethroscope and inspection and removal of the body with forceps. If the body is irregular in shape or is encrusted with urinary salts it should be removed through a suprapubic incision into the bladder.

Metallic rings are sometimes slipped over the penis, or strings may be tied lightly around the organ, and if they fit tightly the resulting congestion quickly swells the glans and tissues beyond the ring so that it becomes buried and it is impossible to remove it. If the constriction is not promptly removed gangrene results. A flat director should be carefully passed under the ring to prevent injury of the skin, and it should be divided at one or two points by a file or small steel saw, when it can be removed without difficulty. Strings can be removed by cutting them.

Foreign Bodies in the Rectum.—These may consist of objects introduced into the rectum to excite sexual feeling or to assist in defecation, or masses of fecal matter may be allowed to remain in the rectum until they become so firm that they require the same treatment for their removal as foreign bodies. Hard fecal masses may sometimes be grasped with forceps and removed or be broken up with the finger, and removed by the finger or by a stream of water. It is usually well after locating the position of the foreign body to anesthetize the patient and dilatate the sphincter muscle. The body can then be removed with the finger or forceps. If the body is irregular in shape a speculum may be introduced or the body may have to be broken or cut into fragments before it can be removed. Care should be taken to do the least possible damage to the rectal mucous membrane in order to avoid infection.

Impaction of the Rectum.—This condition often occurs in cases of severe illness when a milk diet is used and is frequently observed in aged subjects suffering from fractures which confine them to bed. The condition is frequently overlooked as the impacted mass produces enough irritation to cause frequent thin fecal evacuations which escape around the mass. The patient complains of frequent bearing-down pains with rectal tenesmus and the escape of slight watery stools and is usually credited with having diarrhea. These symptoms with the absence of formed stools are significant of impaction of the rectum.

Digital examination of the rectum reveals a firm, putty-like mass which may be as large as the closed fist.

Treatment.—This consists in introducing the finger and breaking up the fecal mass, or introducing a speculum and removing the mass with a dull curette, and giving rectal enemata until the rectum is clear of fecal matter.

Foreign Bodies in the Vagina.—Foreign bodies are frequently introduced into the vagina to produce sexual excitement, or they may consist of bodies introduced to prevent uterine displacement. Pessaries often are found whose presence had been forgotten by the patient. If the body becomes buried in the vaginal walls difficulty in urination and purulent discharge are the prominent symptoms. The vagina should first be irrigated and an antiseptic solution and a speculum introduced to locate the position of the body. Neglected pessaries can usually be removed without difficulty, but if embedded for a long time it may be necessary to divide them at one or two points with cutting forceps. They can then be removed with forceps, care being taken to do the least possible damage to the vaginal walls.

Foreign Bodies in the Pharynx.—Small foreign bodies, such as pins, fish bones, pieces of bone, pieces of straw, jack stones, etc., may become lodged in the pharynx and soon become embedded by swelling of the mucus membrane. The sensation of the patient will often assist in locating the position of the body.

The pharynx should be inspected with the aid of reflected light and explored by the finger. When the body is located it can usually be removed with forceps. I have seen a jack stone embedded behind the larynx, which was removed with great difficulty.

Foreign Bodies in the Esophagus.—Foreign bodies may be arrested at any point of the esophagus; but are apt to lodge opposite the cricoid cartilage or near the cardiac orifice of the stomach. A great variety of objects have been found lodged in the esophagus—coins, buttons, pieces of bone or meat, pins, safety pins and plates with artificial teeth, etc. The body should be removed as soon as possible to prevent ulceration and perforation of the esophagus. A soft, smooth body may be dislodged and pressed downward into the stomach with a bougie. The body may be located and removed by the use of Jackson's esophagoscope and forceps. If, however, the body is of considerable size and irregular in shape like a tooth plate it is better to remove it by operation, external esophagotomy; if low down in the esophagus it may be necessary to perform thoracic esophagotomy.

Foreign Bodies in the Stomach.—Bodies which have entered the stomach often pass into the intestines and escape from the rectum. If the body is of such a shape that it is apt to be arrested in the stomach or intestines it should be located by a roentgen-ray examination and should be removed by gastrotomy.

Foreign Bodies in the Intestines.—Bodies usually pass with great facility through the intestinal tract and escape from the rectum. Purgatives should not be given; rather a diet which produces an increase in the bulk of the fecal matter. Intubation tubes are frequently swallowed and pass without difficulty. A roentgen-ray examination taken at intervals will show the change in the position of the body in the intestinal tract.

If arrested at any point and symptoms of obstruction are present it should be removed by abdominal section and enterotomy.

Foreign Bodies in the Trachea and Larynx.—Bodies lodged in the larynx and trachea produce violent coughing effects and soon dyspnea develops. The bodies most commonly found are grains of corn, seeds, pins, safety pins and fragments of bone. They are often dislodged by coughing and expelled. They may be removed by using the laryngeal mirror and forceps or by the use of Jackson's laryngoscope and forceps. If the dyspnea is urgent tracheotomy should be performed and the body removed through the tracheal wound or later by tracheal forceps.

Foreign Bodies in the Bronchi.—A foreign body which has passed below the trachea usually lodges in one of the larger divisions of either bronchus, usually the right bronchus. If the breathing is much embarrassed a low tracheotomy should be performed and the body may be grasped with forceps through the tracheal wound and removed. Bronchoscopy by Jackson's method has been used successfully for the removal of bodies impacted in the bronchi (p. 193).

Foreign Bodies in the Eye.—Bodies such as particles of sand, cinders, fragments of steel often lodge in the eye, and may be adherent to the conjunctiva or embedded in the cornea. The eye should be inspected with a good light and the lids turned if necessary.

The body may be removed if in the conjunctiva or cornea by touching it with a wisp of cotton twisted on a probe or match stick, if embedded in the cornea a few drops of a 2 per cent solution of cocaine should be dropped into the eye and the body removed with an eye spud.

If the body has penetrated the cornea the case should be referred to a specialist.

After removing the foreign body the eye should be frequently douched with boric acid solution.

Foreign Bodies in the Nose.—Foreign bodies, such as peas, grains of corn, beans, buttons, beads and pencils are often introduced into the nasal canals, especially by children. Their presence often causes no marked symptoms, but if ulceration takes place, purulent and blood-stained discharges occur; a persistent unilateral nasal discharge in a child should always suggest the possibility of an impacted foreign body. The body may pass backward and lodge in the nasopharynx.

A dry body, like a pea or bean, may absorb moisture and swell so that it becomes very firmly imbedded; the impaction in all cases becomes firmer from the swelling of the surrounding mucous membrane. It is well to give an anesthetic before attempting to remove foreign bodies from the nose.

The nasal cavity should be inspected through a speculum and the body grasped with forceps and removed; a small curette is sometimes useful. When the body is in the nasopharynx the removal is very difficult. A mouth gag should be used and the finger should be passed into the nasopharynx from the mouth when by manipulation and forceps it may easily be removed by way of the nasal cavity or by the nasopharynx. An antiseptic spray should be used after the removal of the body.

Foreign Bodies in the Ear.—Hardened wax, beads, seeds and insects are often found in the ear. These may be removed by syringing the ear with warm water, and if this fails to remove them their removal may be accomplished by delicate angular forceps, with which the body is grasped. Live insects may be killed by dropping a little olive oil in the ear, and they then may be removed by syringing the ear with warm water.

FURUNCLE OR BOIL.

This consists of a localized inflammation of the true skin and subcutaneous cellular tissue. The infection is caused by the entrance of the Staphylococcus pyogenes aureus through a hair follicle or sebaceous gland, and gives rise to limited tissue necrosis. A hard papule surrounded by induration appears upon the skin and gradually increases in size and may soften in the center and open, discharging a few drops of pus and a small mass of necrotic tissue known as a core.

Treatment.—In the early stages of the affection, sterilization of the area may be accomplished by first injecting a few drops of a 2 per cent novocaine solution into the center of the inflammatory mass, and introducing a red hot needle into the hair follicle or sebaceous gland; or the central soft spot may be incised and a match stick, tooth pick or swab saturated with carbolic acid may be bored into the softened tissues. If these procedures fail to arrest the spread of the infection excision or circular incision around the indurated area should be made and a dressing of dichloramine-T applied. In cases of recurrent furuncles an autogenous vaccine may be used with good results.

CARBUNCLE.

This is an inflammation of the skin and subcutaneous tissues with multiple foci of necrosis arising from an infection of the hair follicles, the causative organism being the

Staphylococcus pyogenes aureus. The most common sites of this affection are the skin of the back of the neck and of the upper part of the back, but it may occur on other parts of the body, the lips, face, thighs and trunk (Fig. 248).

Carbuncle should be regarded as a serious affection in debilitated subjects and those suffering from diabetes and nephritis. I have seen a number of fatal cases in diabetics. Carbuncle of the upper and lower lip is occasionally observed and is considered especially dangerous from the risk of infective thrombosis of the venous sinuses of the brain.

Fig. 248.

Carbuncle of the neck in a diabetic.

Warren explains the spread of the infection in carbuncle by the fact that the hair follicles extend only a short distance into the true skin; columns of fatty tissue (columnæ adiposæ) run from the subcutaneous tissue in an oblique position to join the point and sides of the hair follicle and each contain a sweat gland. When pus forms it runs down one of the columns and works its way to the deeper tissues and from one to another interspace and finds its way to the surface by other fatty columns. Thus, numerous foci of pointing appear over the surface of the carbuncle.

Symptoms.—An inflammatory area appears at the site of infection; a papule develops with an indurated base; the latter spreads rapidly and in a few days a number of pustules appear over its surface, each pustule marking the site of a focus of necrosis. At the beginning of the infection there may be a chill, and there is always fever and pain. In a few days some of the pustules rupture and necrotic tissues may be discharged. The induration ceases to spread and the case progresses slowly toward a cure. In other cases the tissues being honeycombed with areas of necrotic tissue, infection spreads, extensive sloughing of the tissues occurs, and if the patient does not succumb from hemorrhage or infection recovery may follow after many weeks.

Treatment.—The patient should be given supporting treatment—nourishing food, tonics and stimulants—and if he is also suffering from diabetes or Bright's disease appropriate treatment for these affections should be administered. Crucial incisions through the indurated tissues was formerly practised, followed by the application of hot antiseptic dressings; but in spite of these the infection often continued to spread. The Carrell-Dakin treatment should be used after incisions have been made. I have also seen favorable results follow dichloramine-T dressings.

The treatment which is now considered most effective in carbuncle in favorable locations, is complete excision of the indurated tissue and packing the wound loosely with strips of gauze saturated with dichloramine-T. If hemorrhage is free vessels should be tied where possible, or packing of the wound should be employed. It is surprising how rapidly these extensive wounds heal; skin grafting may also be employed to hasten healing when the surface of the wound is in condition for grafts. In carbuncles of the face and lips excision is not applicable; here incisions planned to avoid important structures should be employed and subsequent dressings with dichloramine-T applied. If the upper lip be involved, free longitudinal incisions down to the mucous membrane should be made and if the spread of infection is not arrested by these incisions, the facial vein should be ligated to prevent infective thrombosis of the lateral sinuses of the brain.

Vaccine Treatment.—In patients who have a succession of boils or carbuncles or multiple infections, vaccination with an autogenous vaccine of the causative organism or a mixed vaccine may be employed with good results.

VARICOSE VEINS.

This is a condition in which the veins become elongated, dilated, tortuous and pouched. This may affect the superficial or deep veins, in any part of the body. The veins of the lower extremities, especially the saphenous veins, are those most frequently involved. The cause is said to be a predisposition to the growth of vein tissue which leads to valve failure, and regurgitation of the blood from the deep veins into the superficial venous channels. Varicose veins develop during and after pregnancy, and in those who stand on their feet for long periods and in those who make great muscular efforts. The valves become incompetent, the blood stagnates, hypertrophy and sclerosis of the vessel walls occur and thrombosis may finally obliterate the diseased vein. The most prominent symptoms in varicose veins of the lower extremities are pain, thickening of the perivascular tissue and edema. Poor nutrition of the skin may upon slight injury produce an abrasion which fails to heal and varicose ulcer results. On the other hand, one sees many subjects who have well-developed varicose veins who present no disabling symptoms and are actively employed in laborious work. A varicose vein may rupture externally and give rise to profuse hemorrhage, which is easily controlled by pressure—a compress fixed over the wound by a bandage. Rupture of a deep vein causes sudden sharp pain followed by extensive ecchymosis. The *palliative treatment* should always be tried first, and consists in emptying the veins and reducing the edema by elevating the limbs and applying an elastic bandage or elastic stocking. These appliances give temporary relief and prevent further dilatation of the veins. The *operative treatment* should be considered when palliative measures fail to give relief. If varicosity of the superficial veins results from thrombosis of the deep veins and edema exists, ligation or excision of superficial veins should not be undertaken, as its performance might cause permanent edema. If elastic support with obliteration of the varicosities gives relief it shows that the collateral circulation is efficient. The operations for the cure of varicose veins are not unattended by risk. *Schede's operation* is sometimes done, which consists in a circular incision of the tissues below the knee down to the deep fascia, dividing all of the superficial veins; both ends of the denuded veins are ligated and the wound is closed with sutures. This operation has the disadvantage that it divides also the superficial lymphatic and sensory nerves, and may be followed by edema, paresthesia or neuralgia or trophic changes in the skin. *Trendelenburg's operation* has furnished a fair number of recoveries. It consists in exposing the saphenous vein by an incision just below the saphenous opening and dividing the vein between two ligatures, the object being to break the column of blood, thus relieving pressure symptoms. The saphenous vein may be removed by one long incision, or it may be removed by a number of incisions by subcutaneous tunneling of the skin. Multiple phlebectomy is considered by some surgeons the most satisfactory operation. It consists in removing sections of the vein from 7 to 10 cm. in length at the saphenous opening and other parts of the thigh and leg, where the main trunks or their branches are most dilated. The intervening portions become thrombosed, contract and produce no further symptoms.

ULCERS.

An ulcer is a loss of substance due to molecular death of the superficial tissues which results from bacterial infection. Repair of ulcers occurs by granulation and cicatrization. When an ulcer is healing the discharge of pus diminishes, the edges become firmer and granulations appear upon its surface. At the edges of the ulcer the epithelium proliferates, gradually covering the granulations; the fibroblasts become converted into white fibrous connective tissue and the surface of the ulcer contracts, decreasing the area, which must be covered by the surrounding epithelium.

Simple or Healthy Ulcer.—The tendency of this ulcer is to heal. The best example of this ulcer is that following superficial incised wounds or burns; it may heal under a scab. Protection of the surface of the ulcer from injury by a dressing of lint spread with boric acid ointment and a few layers of gauze is the only dressing required.

Inflamed Ulcer.—This form of ulcer may present active inflammatory symptoms from the start, or they may occur in a healthy ulcer from local irritation or from constitutional causes. It often develops in drunkards or debilitated subjects whose resistance is low. The tissues surrounding the ulcer are red and inflamed, the surface of the ulcer is covered by grayish sloughs, the discharge becomes thin and irritating and pain is a prominent symptom. The formation of sloughs indicates that the tissue death is progressing rapidly. When the ulcer spreads with great rapidity and becomes deeper and of greater surface area it is known as a phagedenic ulcer.

Treatment.—The patient should be confined to bed and given calomel or blue mass, followed by a saline. The limb should be elevated and surface surrounding the ulcer painted with tincture of iodine and alcohol, equal parts. Hot antiseptic should be applied to the surface of the ulcer and changed frequently. Dichloramine-T dressing or Carrel-Dakin treatment may be used with advantage. Under this treatment the inflammatory symptoms often subside rapidly and the ulcer assumes a healthy appearance, when the dressings for a healthy ulcer may be applied.

Edematous or Weak Ulcer.—This presents large flabby granulations of low vitality and easily detached from the surface of the ulcer. This condition results from improper dressing or the prolonged use of poultices or wet dressings. The granulations should be cauterized with pure carbolic acid, or the solid stick of nitrate of silver, or may be cut away with scissors. The surface should next be dressed with stimulating ointments, scarlet red (8 grains) to vaseline (1 ounce), used only for a few days and followed by ichthyol ointment, balsam of Peru or 25 per cent argyrol solution.

Irritable Ulcer.—This is usually small and situated near the ankle, or over one of the malleoli. The surrounding skin is thickened, there is little discharge and its surface is glazed and extremely painful. The condition is probably due to exposure of sensory nerve filaments of the musculo-cutaneous or internal saphenous nerves. The patient should rest in bed with the foot elevated, and the surface of the ulcer should be touched with the solid stick of nitrate of silver or carbolic

Fig. 249.

Irritable ulcer. (Ashhurst.)

acid, or the application of a 20-gr. solution of chloral hydrate may temporarily relieve the pain. This should be followed by a boric ointment dressing. If this treatment fails to give relief the affected nerve may be divided from 2 to 3 inches above the ulcer.

Indolent or Callous Ulcer.—This is one of the commonest forms of leg ulcer. It occurs in adults on the lower portion of the leg over the tibia or fibula. The surface of the ulcer is comparatively dry, the granulations are poorly developed and the edges of the ulcer are indurated, giving the surface of the ulcer a concave appearance. This form of ulcer usually develops after a slight injury, a contusion, scratch or abrasion which receives no attention, in patients who are compelled to be on their feet from their occupation, and who often present edema of the limbs from poor circulation of blood and lymph in the parts.

Fig. 250.

Indolent or callous ulcers. (Ashhurst.)

Treatment.—If a patient with indolent ulcer is put to bed, attention paid to the condition of the bowels and kidneys, the leg elevated and wet antiseptic dressing applied the ulcer is soon converted into one of a healthy type, and healing occurs. As many patients with this type of ulcer cannot afford to stop their work, it is important to apply a dressing which will allow them to continue their work during the course of treatment. The most satisfactory dressing for these cases is strapping with resin or Z. O. adhesive plaster, and support of the tissues of the foot and leg to the knee by a well-applied muslin bandage. If possible it is well to keep the patient at rest for a few days, and apply warm antiseptic fomentations, which diminish the induration surrounding the ulcer. The surface of the ulcer may be dressed for a day or two with ointment of scarlet red (gr. viij), boric acid (gr. xx), petrolatum (℥j), and the skin surrounding the ulcer should be

Fig. 251.

Strapping an ulcer of the leg.

sponged with alcohol. Straps of resin plaster or Z. O. adhesive plaster $1\frac{1}{2}$ to 2 inches wide, and long enough to extend two-thirds of the distance around the limb, are required. If the portion of the limb is covered with hairs it should be shaved before the straps are applied. The surface of the ulcer should be touched with a solution of nitrate of silver

(15 grs. to water 1 oz.) and the surrounding skin dried. The first strap being heated, if resin plaster is used, it is applied transversely to the long axis of the leg and carried two-thirds of the distance around the limb. Care should be taken to see that the straps are so applied as not to cover the entire circumference of the limb, as by so doing edema and injurious

Fig. 252.

Strapping an ulcer of the leg.

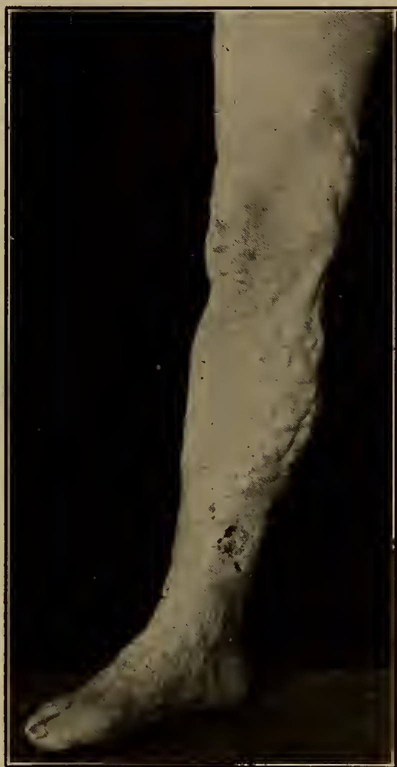
circular compression might result. Another strap is applied to a corresponding point of the skin above this one, so that it overlaps one-third of the strap first applied, and is carried two-thirds of the way around the limb. Additional straps are then applied until the ulcer is covered in, and the straps are carried several inches above the ulcer.

Strapping of ulcer of the leg may also be accomplished by using straps of plaster $1\frac{1}{2}$ inches in length. The ends of two straps are placed upon each side of the limb some distance below the ulcer and the straps are brought up and made to cross each other so as to draw the tissues toward the point of crossing. A number of imbricated straps are applied in this way until the ulcer and surrounding tissues are covered in and supported (Fig. 252). A muslin bandage $2\frac{1}{2}$ inches in width is next firmly applied from the base of the toes to the knee. The patient returns in a few days or a week, the straps are removed, the skin cleansed with alcohol and the the ulcer touched with silver solution, and the strapping is reapplied in the same manner. The patient returns at intervals of a week until the ulcer is healed. Chronic ulcers in other parts of the body may be strapped in the same manner. It is surprising to see how rapidly ulcers heal under this method of dressing which have often existed for years.

After the ulcer is healed the patient should wear an elastic webbing bandage for some time. He soon learns to apply this to furnish the proper amount of support. In some cases in which repair is slow in spite of treatment radiating incisions through the indurated edges of the ulcer may be made with advantage.

Varicose Ulcer.—This ulcer is associated with varicose veins of the leg. Varicosity of the veins causes stagnation of blood. This impairs nutrition and a slight traumatism in this area of impaired nutrition becomes infected and ulcer results (Fig. 253). A slight traumatism in this form of ulcer is often followed by profuse hemorrhage. Rest in bed with elevation of the leg, and the application of an ointment of ichthyol or boric acid will often be followed by a prompt cure. If the patient cannot go to bed he may be treated as a walking case. The ulcer and surrounding skin are cleansed, the surface touched with a solution of nitrate of silver and strapping and a supporting bandage applied, as used in the treatment of indolent ulcers. After the ulcer is healed if he wears an elastic webbing bandage to support the varicose veins the ulcer is less likely to recur. In persistent cases excision of the neighboring varicose veins may be practised, but this should not be done in the presence of active phlebitis; or if the veins are thrombosed the excision should be done at a point where this condition is not present.

Fig. 253.



Varicose ulcer of leg. (Ashhurst.)

Syphilitic Ulcers of the leg are usually situated above the middle of the leg, and may be associated with disease of the underlying bone. These ulcers respond promptly to anti-syphilitic treatment, and the local application of an ointment of iodoform or calomel.

Warty Ulcer, known also as the ulcer of Margolin, is one which develops upon a scar of a wound of the soft parts or bone or a burn, many years after the injury has been received. The surface of the ulcer presents fine wart-like granulations, and the discharge from the surface is free and very offensive. This form of ulcer is malignant, and when it involves an extremity, amputation is the safest treatment.

PART III.

ASEPSIS AND ANTISEPSIS.

SURGICAL BACTERIOLOGY.

Bacteriology is the science of microörganisms. The discovery and study of these organisms in recent years has revolutionized surgical practice.

The microörganisms associated with disease in man are bacteria, spirochetes, certain yeasts and moulds, filamentous fungi and protozoa. In addition to these varieties there is a group of disease-producing organisms which have never been isolated. The causative agent is known as a filtrable virus, because it is able to pass through the pores of a filter too small to allow passage of known bacteria. Almost all infectious diseases may under certain circumstances possess surgical importance, but practically, surgery is concerned chiefly with bacteria.

Bacteria are minute unicellular organisms representing the lowest order of plant life. They are classified primarily according to their shape into: (1) The cocci or round organisms; (2) the bacilli or straight rod-shaped organisms; and (3) the spirilla or curved rod forms. Only a comparatively small number of known varieties of bacteria are capable of producing disease. These are known as the pathogenic bacteria. Organisms which are incapable of producing disease are known as non-pathogenic bacteria or saprophytes. Many of these bacteria are most useful, such as the nitrifying bacteria which abstract nitrogen from the air, thus enriching the soil. Fermentation and putrefaction are the result of microorganismal action and in fact it was the investigations of Pasteur concerning the cause of spoilage of wines and beers that laid the foundation of modern bacteriology.

Koch's Law.—To prove that a certain bacterium is the cause of a disease, the following rules have been laid down by Koch: (1) The bacterium must first be found in the diseased person or animal; (2) it must be cultivated outside of the body; (3) when inoculated in pure culture in a healthy animal it must produce the original disease; (4) from the body of the animal the original microbe must be capable of again being isolated.

Bacteria multiply by the simple process of division, which under favorable circumstances may occur with incredible rapidity. Fisher has stated that the colon bacillus and the spirillum of cholera may divide in about twenty minutes. If this rate of multiplication could be maintained it is easily calculated that a single organism would have about sixteen hundred trillion descendants in twenty-four hours. Lack of food and other inhibitive influences tend to prevent such excessive rates of multiplication. Many bacteria are motile, being able to propel themselves through fluid by means of whip-like prolongations known as flagella. Non-motile organisms have no such method of locomotion, but are transferred passively by wind, water or moving objects.

The study of bacteria is made possible by the microscope and the development of special technical methods whereby they may be artificially cultivated and isolated in pure culture and their characteristics noted. Certain dyes are employed to stain bacteria in order to make them more easily visible under the microscope and to reveal their finer structure. Common stains employed for this purpose are methylene blue, gentian violet and carbol-fuchsin. The majority of bacteria are able to multiply in the presence of atmospheric oxygen which they employ in their metabolic processes very much as the higher plants and animals. Such bacteria are known as aërobes. Certain other bacteria can thrive only when oxygen is excluded, and these are known as anaërobes. Many varieties are able to multiply under both conditions, being known as facultative aërobes or anaërobes.

Spores.—An interesting phenomenon of great practical importance is the formation by certain bacteria of what are known as spores. These are round or oval bodies, developed in the substance of the bacteria and apparently represent a resting stage. These spores are much more resistant to sterilizing agents of all varieties than the growing or vegetative form of the organism. According to Hiss and Zinsser, a 10 per cent solution of carbolic acid will kill the vegetative forms of anthrax bacilli within twenty minutes, but anthrax spores are able to resist the same disinfectant for a much longer period in a concentration of over 50 per cent. Although the vegetative forms of the same bacilli are killed at once by live steam, the spores will withstand its action over ten to fifteen minutes. Whenever the spores of a microörganism are put into a suitable environment as to temperature, moisture and food, the spores will develop into vegetative forms which then multiply by division in the ordinary manner. Important examples of sporulating forms are the tetanus bacillus and the gas bacillus. Methods of preparing surgical materials in order to be safe must kill spores as well as the vegetative forms.

The bacteria of greatest importance surgically are the Staphylococcus albus, Staphylococcus aureus, Streptococcus pyogenes, pneumococcus, gonococcus, the colon and typhoid bacillus, the pneumobacillus, tetanus bacillus, gas bacillus (Bacillus aërogenes capsulatus), tubercle bacillus, diphtheria bacillus and the Bacillus pyocyaneus. The spirochete of syphilis possesses great surgical importance. Of the diseases due to the higher bacteria, actinomycosis due to actinomyces is the most important. Rare instances of ulcerations and occasional generalized infections due to yeasts or blastomycetes are reported, and moulds occasionally produce lesions of the mucous membranes, the most common and best known of which is the disease, thrush, due to the Oïdium albicans. Diseases due to filtrable virus, such as hydrophobia, smallpox and typhus fever only rarely possess surgical significance, with the exception of anterior poliomyelitis or infantile paralysis, which is the most important in this connection because of the paralyses and deformities which result from it.

Pathogenic Action.—Bacteria produce disease by the formation of toxins or poisons which damage the tissues of the host. These toxins may be excreted by the bacteria and conveyed in soluble form by the blood and lymph, thus affecting regions at a distance. These are known as exotoxins. Other toxins are the result of decomposition of the bacteria themselves and are not set free until the organism dies and undergoes solution. These are endotoxins. Lodgment and multiplication of bacteria at any point within the body produce inflammation which is Nature's defense reaction. The phenomena of infectious diseases are the result of such local damage plus the general or systemic reaction to the absorbed products of the infection.

A sterile wound is one in which no microörganisms are present. This constitutes complete asepsis and is the aim of surgical technic in so-called clean operations carried out upon non-infected tissues. It is not always possible to obtain absolute asepsis, but the presence of a few microörganisms derived from the skin or air will not prevent the wound from healing without inflammation or suppuration. Formerly the air was thought to be an important avenue in the conveyance of infection to wounds, but it is now known that the bacteria carried in the air are usually non-pathogenic and not numerous, unless the air is in violent motion and carries along with it obvious particles of dust and dirt. It is possible, therefore, to operate with practical immunity from infection by employing a technic which permits no contact of unsterile or contaminated objects or materials of any kind with the fresh uncontaminated tissues of the wound, since for all practical purposes it is only by this means that clean wounds become infected.

Contamination means the soiling of clean tissues by microorganisms or substances which are carriers of bacteria. Every article and material of any sort whatever, which has not been previously sterilized and maintained in a sterile condition must be regarded as a potential source of contamination.

Infection is the state or condition which results from contamination and lodgment of pathogenic microörganisms within the tissues. There is a certain latent period between contamination and the onset of inflammation or disease during which time mechanical cleansing of a wound may obviate infection. In the recent war this mechanical disinfection was widely practised, with the most beneficial results. The method consisted of complete removal of contaminated surfaces, devitalized tissues and foreign material, and was known as "débridement." This state of contamination for practical purposes may be considered to have terminated at the end of about eight hours. After this time the lodgment and multiplication of bacteria has occurred and the phenomena of inflammation have begun. This is the stage of infection, and mechanical efforts at removal of the infection are of no value and often dangerous. Bacteria may gain entrance into the body through any wound or abrasion of the skin or mucous membrane, or in certain instances make their way unaided through the integuments. Not infrequently they get into the lymph vessels or into the blood stream and are transported to distant regions. The point of entrance is known as the portal of entry and may be very insignificant in comparison with the results.

The role of insects in the spread of infective agents is now known to be a very important one in certain diseases. Various blood-sucking insects may harbor microörganisms, and by their bite introduce these germs into the body. Examples of such infections are malaria and yellow fever, carried by the mosquito, bubonic plague by the flea and sleeping sickness by the tse-tse fly. Organisms tend to become more virulent after passage through a susceptible animal. The resistance to infection varies in different individuals and is affected by many circumstances. It is well known that some people are susceptible to infections and also that conditions which depress vitality predispose to infection. Such factors are exposure, malnutrition, excessive fatigue, debilitating disease, age, confinement, unhygienic surroundings and bodily excesses. Local conditions which favor infection in wounds are the presence of foreign material, pockets or so-called dead spaces into which blood or serum may accumulate, lacerations and devitalization of tissues by injury or chemical action, and interference with the blood supply by constriction, tight sutures, direct damage to blood-vessels, etc.

Immunity.—Certain organisms are pathogenic to man but not to lower animals and *vice versa.* Some affect only certain species. When man or animal is entirely insusceptible to infection with a certain organism he is said to possess a natural immunity. An acquired immunity may be produced by a previous attack of the disease, by vaccination, or by the introduction into the body of a serum which has a neutralizing or antagonistic action against the infection or its toxins. Active immunity is the result of measures which heighten the resistance of the individual against infection. The best examples of this are vaccination against smallpox and typhoid fever. Passive immunity is that which is conferred by the injection into an animal of the serum obtained from another animal which has been previously immunized. Active immunity usually lasts for a considerable length of time, while passive immunity is only temporary. The substances in the body fluids which confer immunity are of two main varieties. Those which attack the bacteria directly causing their death and disintegration are known as bactericidal substances. Some infections, especially those which produce the soluble exotoxins, cause the body to form substances which combine with and neutralize these toxins, thereby gaining the name antitoxins.

Antitoxins.—The production and use of antitoxins depends upon the above principles. The best known example is in diphtheria. A horse may be so immunized against diphtheria toxin by successive injections of ascending doses of toxin that the animal's serum becomes able to neutralize an enormous amount of this poison. By introducing this antitoxic serum into a susceptible person, a passive immunity is conferred which temporarily protects against the disease, or after the disease is established it will neutralize the toxemia and assist in recovery.

Tetanus, hydrophobia, anthrax and infections with the pneumococcus, meningococcus, streptococcus and staphylococcus are often treated on these principles.

Phagocytosis and Opsonic Treatment.—Certain cells of the body have the power of engulfing bacteria and causing their destruction. Cells which possess this property in the highest degree are the polymorphonuclear leukocytes of the blood and certain endothelial cells which line the vascular channels and serous cavities. These cells are known as phagocytes. Certain substances may be present in the blood which by their previous action upon the bacteria greatly assist the phagocytes in this process of devouring the invading bacteria. Their action is to render the organisms more susceptible to phagocytosis and for this reason they are called opsonins, after a Greek word meaning to prepare a meal. The formation of opsonins may be stimulated by the injection of killed bacteria into the body.

Bacterial Vaccines.—Bacteria after artificial cultivation may be suspended in salt solution, and either killed by heat or so devitalized by other means that their power of multiplication is abolished. They are then no longer able to produce disease and may be introduced in proper amounts into the body by means of hypodermic or intravenous injection. Bacterial vaccines or bacterins are such suspensions standardized to contain a known number of bacteria per cubic centimeter. By beginning with small doses and increasing at intervals, the active immunity of the body against a certain organism or organisms may be considerably increased. This immunity is highly specific and does not, as a rule, confer additional resistance against other organisms or even against other strains of the same organism. It is best, therefore, to use the organism isolated from the disease when it is desired to employ this treatment. Such a vaccine is said to be autogenous. When this is impracticable or impossible vaccine may be made from an organism which is identical so far as can be determined. This is a stock vaccine. At times mixtures of bacterial suspension are employed which are known as mixed vaccines. Not all infections are amenable to this kind of treatment. The best results have been obtained in chronic pyogenic infections, such as acne and furunculosis. It is valuable also in chronic infective conditions of the pulmonary and urinary tracts. The results are less satisfactory in acute infections.

Leukocytosis.—This consists in a marked increase in the number of the polynuclear leukocytes over the normal, about 8000, in the circulating blood which is frequently observed in local inflammatory processes, in most acute infectious diseases and in some toxic conditions. A slight rise in the leukocyte count may be observed during the height of digestion, but this is usually trivial. The leukocytosis of inflammation is caused by chemotaxis which is an attraction exerted by the products of bacterial activity upon the blood-making organs which are probably stimulated to an increased rate of production. Leukocytosis is generally much more marked if pus exists than if the exudation is serous or fibrinous.

The number of leukocytes per cubic millimeter of blood may be increased in inflammation from 8000, the normal, to 15,000 or 50,000, the amount not necessarily indicating the severity or extent of the focus of inflammation. It is found in suppurative and gangrenous inflammations, in acute articular rheumatism, scarlet fever and pneumonia, and is frequently observed after copious hemorrhage. Cases of rapidly growing sarcoma often show this condition. It is absent in typhoid fever, tuberculosis, malaria and influenza.

The degree of leukocytosis may be considered a general index to the intensity of the infection and to the strength of the patient's resisting powers in reacting against it. Intense infections in individuals, whose resisting powers are great, produce marked leukocytosis, while the presence of an infection of similar intensity in one whose resisting powers are weak fails to cause decided leukocytosis.

If a sudden overwhelming septicemia accompanies the beginning of an inflammation, as in peritonitis, caused by intestinal perforation, leukocytosis may fail to develop, and may be absent when an abscess exists, which is well encapsulated.

From these facts it is evident that leukocytosis is a symptom which may be very useful in diagnosis, but it must be interpreted with care.

The determination of the percentage of polymorphonuclear leukocytes by a differential count possesses some value in surgical infections, as it has been shown that very severe infections may show an abnormally large percentage of these cells even when leukocytosis is slight or absent. Normally, the polymorphonuclear cells form about 70 per cent of the leukocytes in the circulating blood. In severe infection they may be as high as 90 to 98 per cent.

The same man should make all of the counts on one patient as the individual equation is very important in this procedure.

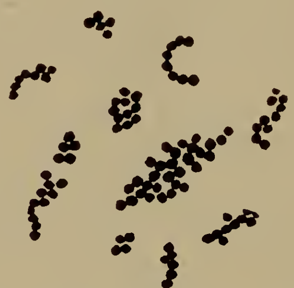
Varieties of Bacteria.—Bacteria of Suppuration.—*Pyogenic Bacteria.*—A large number of bacteria are capable of giving rise to suppurative inflammation, but the most important are the staphylococcus, especially the Staphylococcus pyogenes aureus, and the Streptococcus pyogenes or Streptococcus erysipelatis, they being identical. Besides these, as rarer causes, we have the Bacillus pyocyaneus, the Bacillus coli communis, the typhoid bacillus, the gonococcus, the Diplococcus pneumoniæ and the Bacillus pneumoniæ (Friedländer).

Staphylococcus Aureus.—This is so named because of the golden pigment which it produces in artificial culture. It is the common cause of boils, carbuncles and usually of acute osteomyelitis. It may gain entrance into the circulation, giving rise to bacteriemia, and being transported to various parts of the body may there set up abscesses or other inflammatory conditions. It is widely distributed, often being found on the normal skin and mucous membranes. It is not an uncommon cause of wound infection. (Fig. 254).

Apparently closely related to this organism, but of lower pathogenicity are the Staphylococcus albus and the Staphylococcus citreus. The first is always found on the skin where it seems to be a normal and usually an innocuous inhabitant. Occasionally it is the cause of stitch abscesses or other suppurative processes in the skin, and rarely its virulence is quite as great as that of the aureus. It is called the albus or white coccus because its colonies are white on artificial media. The second, the lemon colored coccus, is less common than the preceding varieties and its pathogenicity is usually low, but like the others, on occasions it is virulent enough to cause severe infection and even death. These cocci grow in masses, are readily cultivated and thrive best in air, but are able to grow in the absence of oxygen.

Streptococcus Pyogenes.—This is one of the most important of pathogenic organisms. It is found widely distributed throughout the animal kingdom (Fig. 255). Certain varieties are devoid of pathogenic properties while others are so deadly as to be almost uniformly fatal when infection occurs. It may affect practically any tissue of the body. It shows a special tendency to spread by means of the blood and lymph streams. It is the usual cause of so-called blood poisoning, and it causes the most dangerous variety of puerperal fever. It may itself produce or act as a serious complicating infection in such conditions as pneumonia, empyema, scarlet fever and

Fig. 254.



Staphylococcus pyogenes aureus.

Fig. 255.

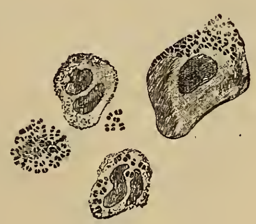
Streptococcus pyogenes.

smallpox. A large proportion of deaths in the great epidemics of the World War were due to this organism as well as many which resulted from wounds complicated by streptococcus infection. Erysipelas is one of its manifestations. It is not a spore-producing germ, and is readily killed by heat or exposure to antiseptics for a sufficient length of time, but its ubiquity makes scrupulous technic necessary to avoid contamination.

Diplococcus Pneumoniæ.—This organism commonly called the pneumococcus is the most common cause of pneumonia. It is frequently found in the human mouth and throat. The most common surgical complication of pneumonia is empyema which is a collection of pus within the pleural cavity; abscesses of the lung itself may occur. This organism is capable also of producing bacteremia and septicemia and may attack the joints, the meninges, middle ear and mucous membranes. Several varieties of this organism have been distinguished, a fact which must be considered in connection with treatment by vaccines or serum. It is a small oval organism usually growing in pairs or sometimes in short chains and possesses a mucoid capsule which aids in its differentiation.

Gonococcus.—This, the germ of gonorrhea, is a kidney-shaped coccus, arranged in pairs, with the concave edges toward each other; the diplococci usually inhabit the pus cells, but are occasionally free (Fig. 256). Besides specific urethritis, it causes salpingitis, oöphoritis, arthritis, endocarditis, conjunctivitis, proctitis and other lesions.

Fig. 256.

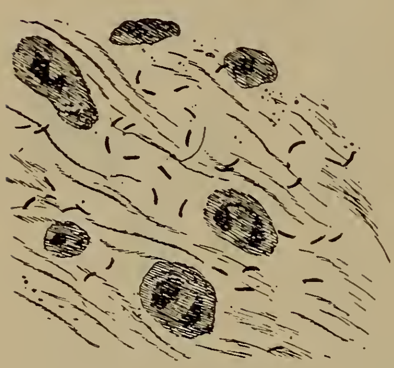


Gonococcus.

Bacillus Coli Communis.—The colon bacillus is an invariable and apparently a normal inhabitant of the intestinal tract. In appearance and cultural reactions it closely resembles the bacilli of typhoid fever and dysentery and certain other members of the intestinal group of organisms. It is the most common cause of peritonitis, being capable of causing suppurative inflammation of the peritoneum to which it gains entrance from an injury or disease of some intra-abdominal organ, notably the appendix. The pus caused by this infection possesses a characteristic foul odor. It is a common cause of wound infections, particularly after abdominal operation. It is often responsible for cystitis, pyelitis and infections of the kidneys. It is a common secondary infection in conditions which may have been due in the first place to other microörganisms. It is rod shaped, usually short and does not form spores.

Bacillus Tuberculosis.—This is probably the most important single pathogenic microörganism. Its only serious rival is the Streptococcus pyogenes and its close relative, the pneumococcus. It may attack practically any tissue in the body but is most common in the lungs, the lymph nodes, the bones and the intestines. In the skin and mucous membranes it produces ulcerations which are very resistant to treatment. The unit lesion in tuberculosis is the tubercle, which is a colony of bacilli within the tissues about which certain characteristic tissue reactions take place, forming a nodule or tubercle (Fig. 257). The center of the tubercle usually undergoes necrosis, giving rise to a cheesy or caseous material and the process is known as caseation. These tubercles may coalesce to form larger foci. Infection of the peritoneum results in tuberculous peritonitis; of the pleura, tuberculous pleurisy; of the meninges, tuberculous meningitis. Slowly progressive glandular enlargements in the neck of the young are usually tuberculous, the tubercle bacilli gaining entrance through the tonsils or mucous membranes. Disease of the spine, causing the common hunchback deformity, is due to tuberculosis of the vertebræ. Disease of the hip and knee, such as "white swelling," are often tuberculous. Softening of the caseous foci produces thin yellowish pus, which often forms without pain, heat or other signs of inflammation, and is therefore known as a "cold abscess." The organism does not form spores and may readily be killed by heat but is resistant to antiseptics, probably on account of a fat-like envelope.

Fig. 257.



Tubercle bacilli.

Bacillus Typhosus.—The typhoid bacillus closely resembles the colon bacillus. It is the specific cause of typhoid fever. Surgical conditions are not infrequently complications or sequelæ of typhoid fever, such as perforation of the intestine, cystitis, inflammations of the kidney, periostitis and cholecystitis. Gallstones frequently result from typhoid infection of the gall-bladder.

Influenza Bacillus.—This is a very minute organism which causes true influenza. Influenzal infections are prone to be complicated by secondary or associated infections, especially with the streptococcus and pneumococcus. It is a factor in the production of certain chronic pulmonary diseases such as bronchiectasis.

Diphtheria Bacillus.—This is the causative organism in diphtheria which occasionally demands surgical interference in the form of intubation or tracheotomy, owing to occlusion of the larynx and upper trachea by the membrane and the inflammatory swelling peculiar to this disease. It is capable of growth upon the surface of wounds and mucous membranes other than those of the throat. Such infections are recognized by the serious constitutional symptoms, by the necrotic and adherent membrane which forms on the surface and by the results of culture made from the suspected tissue and incubated for twelve to twenty-four hours. The organisms have a characteristic morphology and staining reaction which may be recognized microscopically.

Fig. 258.

Tetanus bacillus.

Tetanus Bacillus.—This is a spore-forming anaërobe which causes the disease commonly known as lock-jaw. It is widely distributed, its principle and natural habitat being in the intestinal tract of vertebrates (Fig. 258). It is common in fertilized soil, street dirt, surface water, gun wads, wearing apparel, etc. Methods of sterilizing catgut, which is made from the intestines of sheep, must be capable of killing the resistant spores which are produced by this organism. A considerable number of cases of postoperative tetanus are believed to be due to the neglect of such precautions. The organism thrives in lacerated, devitalized or punctured wounds, danger being much increased by gross contamination with soil or dirt. This organism does not invade the general circulation, but produces a toxin which is absorbed chiefly through the motor nerves. Owing to the firm union which takes place between the toxin and the cells of the central nervous system when the symptoms begin it is often too late to save life by treatment.

Bacillus Aërogenes Capsulatus.—The gas bacillus is a strict anaërobe and forms spores. It also is widely distributed. It is a characteristic invader of war wounds, but is encountered occasionally in civil life, especially in lacerated, devitalized wounds and those containing foreign material. Together with certain closely related organisms it is the responsible cause of gas gangrene. It attacks chiefly the muscles, and unless interrupted pursues an extremely rapid and fatal course. It is characterized by production of gas within the tissues which imparts a crackling sensation on palpation. Other organisms are usually present, and the pus is sanguineous and foul. Prostration is early and extreme. Treatment must be made on discovery and consists of wide excision of the infected tissues and in the case of the extremities amputation may be indicated. Protective serums have been produced, but they are not so efficacious as antitetanic serum in the prevention and treatment of tetanus. It is a large bacillus which takes a positive Gram stain and is provided with a capsule. These characteristics are of assistance in early diagnosis.

Fig. 259.

Threads of Bacillus anthracis containing spores.

Treponema Pallidum.—The spirochete of syphilis is shaped like a corkscrew, usually showing eight to twelve turns. It is motile and does not produce spores. It is an obligate anaërobe and produces a great variety of lesions. It may affect any tissue in the body and may simulate many surgical diseases. The possibility of its presence should never be lost sight of, principally to avoid errors in diagnosis and treatment.

Actinomyces.—This is a filamentous organism, standing in an intermediate position between the bacteria and the higher fungi. It is also known as the ray fungus on account of the star-like structure of its growth in tissues (Fig. 260). The larger of its colonies are visible as minute yellowish nodules resembling sulphur granules, and are characteristic of the pus produced by this infection. The microscopical picture is characteristic. It produces lesions particularly in the lower jaw and tongue, characterized by a woody swelling which breaks down at various point discharging pus. It most often affects cattle, causing the condition known as "lumpy jaw." Its normal habitat is believed to be in grain, particularly in barley. It may affect man and has been known to occur in many different locations. The lesions should not be confused with malignant growths.

Fig. 260.

Actinomyces.

The *blastomyces* or *yeasts* usually affect the skin or mucous membranes. Characteristic examples are blastomycetic dermatitis due to a specific yeast and parasitic stomatitis, or thrush, due to the Oïdium albicans. Occasionally yeasts cause general infection.

The *hyphomycetes* or *moulds* are filamentous fungi and are a higher form of life than bacteria. Examples of human infection with moulds are the various types of ringworm and sporotrichosis.

Putrefactive Bacteria.—Putrefaction is the result of the action of living organisms upon organic material, the process being due to digestion of the substance by the germs, which thus obtain their nutriment. Such organisms may possess little or no pathogenic properties, but when they complicate infections by other bacteria the end-products of their digestive activities may be absorbed and prove toxic to the individual. Proteus vulgaris and many anaërobes are especially important in the process of putrefaction but a large number of bacteria possess the ability to break down organic materials.

Protozoa.—These are minute unicellular organisms representing the lowest form of animal life. Malaria, due to the Plasmodium malariæ and amœbic dysentery, due to the Entamœba histolytica, are the most important. Examples of surgical complications of these conditions are chronic splenomegaly resistant to antimalarial treatment, and liver abscess which is a common complication of ulcerative amœbic dysentery.

THEORY OF ASEPSIS AND ANTISEPSIS IN WOUND TREATMENT.

Before the introduction of Lister's method of treating wounds it was the rule in accidental and operative wounds to have profuse suppuration, fever, pain and in many cases such wound complications as septicemia, pyemia, erysipelas and hospital gangrene and the mortality following operative and accidental wounds was very high. The mortality in compound fractures from sepsis was formerly great, but by modern methods of wound treatment has been diminished to an insignificant percentage. The same diminished mortality has followed amputations and other wounds, accidental or operative.

Lister's method of wound treatment was largely based upon the idea that the infection of the wound occurred from contact with the air, which contained spores and germs, and his method of treatment was chiefly directed to their destruction. The air may be a medium of wound infection to a certain extent, for it has been demonstrated that dry air contains dust in which spores and bacteria are present in much larger numbers than in moist air, and such air coming in contact with an open wound deposits there numbers of bacteria which may set up inflammatory changes. Koch later demonstrated the fact that atmospheric microbes were chiefly of an innocuous character, and that wound infection was generally caused by bacteria or spores being brought in direct contact with the wound by the clothing and skin of the patient, the instruments and the hands of the surgeon and assistants and unclean surgical dressings.

Cheyne has shown that the relative number of bacteria entering the tissues is an important factor in producing suppuration and septic infection, for we know that bacteria may exist in an aseptic wound and yet the wound heal and remain aseptic, the antiseptic qualities of the blood serum and the cell activity in healthy tissues being sufficient to destroy or remove a certain number of microörganisms, and suppuration or septic infection occurring only when the tissues are overwhelmed by the number of organisms or when their power of resistance is diminished by injury or disease. This explains the satisfactory behavior of wounds which pursue an aseptic course where very imperfect details of aseptic or antiseptic treatment have been employed. It may, therefore, be assumed that infection does not necessarily depend upon the presence of a few microbes, but rather upon the quantity and quality of the germs which are present in the wound.

Pyogenic microörganisms under different conditions may produce a series of different diseases, for it is now generally accepted that Fehleisen's Streptococcus erysipelatis is identical with Streptococcus pyogenes, which is recognized as the cause of very different inflammatory affections.

Sepsis.—Sepsis is due to the entrance and multiplication of microörganisms, or the absorption of their products in the body, and is characterized by local inflammation of the wound, and marked constitutional symptoms, such as fever, disorders of the nervous system and inflammation of the viscera. Microbic infection sets up a pathological process which causes serious wound complications, and differs materially from that process which attends the repair of wounds that run an aseptic course. Suppuration in a wound is considered clinically to be due to the presence of bacteria, for their exclusion will prevent its occurrence.

Asepsis.—Asepsis aims at thorough sterilization of the field of operation and of all objects brought in contact with the wound, and the exclusion of microörganisms by occlusive sterilized dressings.

Antisepsis.—Antisepsis, on the other hand, has in view the destruction of microörganisms by keeping germicidal agents constantly in contact with the wound. The object of antisepsis is, therefore, to produce asepsis.

No surgeon should undertake the performance of an operation or the treatment of an open wound without having clearly impressed upon his mind the important part that pyogenic and specific microörganisms may play in the subsequent course of the wound.

Methods of Disinfection or Sterilization.—Since the majority of wound complications are due to the presence in the wound of microörganisms, it is the duty of the surgeon to prevent their contact with it, or to employ means for their destruction. We must, however, employ means of disinfection or destruction of these microörganisms which will not have any injurious effect upon the tissues with which they come in contact. *Mechanical disinfection or sterilization* is applicable to wounds only to a moderate extent, but is employed to remove any microörganisms which may be present upon the objects which are to come in contact with the wound, namely, the hands of the surgeons and assistants, instruments and the skin surrounding the wound. Mechanical disinfection is accomplished by the use of friction with a brush, soap and water. Chemical sterilization by means of *germicidal solutions* may be used for disinfection of wounds, but are most useful in the disinfection of the hands of the operator, the skin of the patient, the instruments and the dressings. If these have been carefully employed before the wound is made, their subsequent use in the wound is usually unnecessary. The recently adopted method of débridement of wounds followed by Carrel-Dakin treatment represents both their mechanical and chemical sterilization.

Some forms of *bacilli* contain spores which resist the action of germicidal substances, while the bacilli themselves are readily destroyed by these agents; the surgeon should, therefore, employ that means of disinfection which is generally applicable to the destruction of both bacilli and their spores. The bacilli of *anthrax* and *tetanus* contain spores; hence to destroy these organisms is a matter of more difficulty than to render harmless such microörganisms as Staphylococcus pyogenes aureus, albus and citreus, Streptococcus pyogenes and Streptococcus erysipelatis and the bacilli of diphtheria and glanders, which contain no spores.

Heat when used as a germicide cannot be applied to the wound itself, except in cases where a limited surface of the wound may be touched with the hot iron. Heat can, therefore, be used only for the disinfection of substances coming in contact with the wound, and for this purpose it is employed in the form of *steam, dry heat* or *boiling water.*

Wounds may be treated by using either the *aseptic method* or the *antiseptic method,* and at the present time these two methods are to a certain extent combined—that is, it is impossible to be strictly aseptic without employing means of disinfection by the use of antiseptics. The aseptic method, which employs germicidal substances only for the purpose of sterilization of objects coming in contact with the wound when their disinfection by heat is impossible, is the method which has generally been adopted.

Antiseptic Method.—In the antiseptic method the sterilization of the field of operation, the hands of the surgeon and assistants, which for surgical purposes should also include the forearms, the instruments, ligatures, sponges and sutures, is accomplished by mechanical sterilization as well as the use of germicidal solutions, and, in addition, the wound is irrigated frequently during the operation with germicidal solutions, and is afterward covered with dressings impregnated with germicidal substances. The antiseptic method was that first employed, and, recognizing its value in surgical procedures, some surgeons still continue to employ this method; but it has certain disadvantages. Recent investigations have shown that many germicidal substances have not the power which was formerly attributed to them, as they only arrest bacterial development; many chemical germicides cause the formation of a dense layer of coagulated albumin when applied to the tissues, and also fail to destroy microörganisms associated with fatty or oily substances. Germicides may also form chemical combinations with the tissues with which they come in contact, seriously impairing their germicidal action. Antiseptic substances which are active as germicides often cause irritation of the surface of the wound, interfering with its repair.

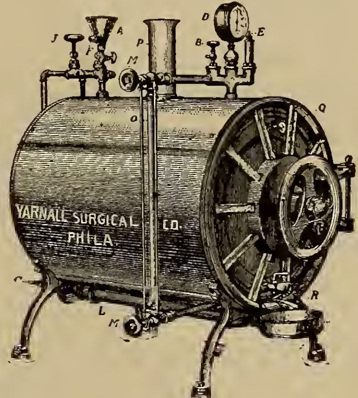
It has been shown that irrigation of a fresh wound with a 1:10,000 solution of bichloride of mercury is followed by distinct evidence of superficial necrosis of the tissues. Antiseptic irrigations of wounds is apt to cause very free oozing of serums which necessitates the use of drainage, and makes frequent dressing of the wound necessary. Many antiseptic substances produce marked toxic effects upon the patient, and also cause severe irritation of the skin with which they come in contact.

Aseptic Method.—In employing the aseptic method in the treatment of wounds, the field of operation, the hands of the surgeons and assistants, the instruments, ligatures, sponges and suture are sterilized mechanically with soap and water and by the use of germicidal solutions and heat, and after this has been accomplished, relying upon the completeness of the sterilization, no germicidal substances are brought in contact with the wound, sterilized water or sterilized salt solution being used if it is necessary to flush the wound, and the dressings employed are those only which have been sterilized by moist or dry heat. The advantages of the aseptic method are as follows: The method is applicable to all parts of the body; wounds treated by this method heal more promptly and do not require frequent dressing; there is no risk of toxic effects and there is no irritation of the skin by the dressings. *Dry sterilized dressings* are efficient to produce absorption, and at the same time the dryness may be a factor in the destruction of germs, for depriving bacteria of moisture robs them of one of the conditions necessary to their existence. The aseptic method is, therefore, to be preferred to the antiseptic method in the treatment of wounds wherever it is possible.

The aseptic method has steadily increased in popularity and has largely supplanted the antiseptic method in surgical practice.

Agents Employed to Secure Asepsis.—A great variety of agents possessing more or less germicidal properties have been at different times employed in the practice of aseptic or antiseptic surgery; those most employed at the present time are heat, bichloride of mercury, carbolic acid, iodoform, formalin, iodine, picric acid, formaldehyde, chloride of zinc, acetate of aluminum, peroxide of hydrogen, creolin, permanganate of potassium, sulphocarbolate of zinc, salicylic and boric acids, acetanilid, aristol, nitrate of silver, argyrol, protargol, Carrel-Dakin solution, chlorazene, hychlorite and dichloramine-T, flavine, B. I. P. P., and mercurochrome.

Fig. 261.



Steam sterilizer.

Heat.—The most reliable and universally available agent for the destruction of microörganisms is heat, either dry or moist; many forms of bacteria are rendered inert at a temperature of 140° F., and none can withstand the application of moist heat at 212° F. *Spores* which will resist the action of powerful germicides for a considerable time are destroyed by boiling for a few minutes. Dry heat is not as efficient for sterilization as moist heat, for some spores will resist dry heat of 284° F. for three hours. As moist heat is the most efficient sterilizer it should be preferred and can always be made use of for this purpose by boiling the instruments and dressings for a few minutes; and if for any reason it is thought advisable to employ dry heat as a sterilizer, this may be made use of by baking the instruments or dressings in a hot oven. The best results may be obtained by the use of moist sterilizers (Fig. 261). By the use of these, surgical supplies can be subjected to the action of steam under pressure, thus increasing its penetration and sterilizing effect. An improvised sterilizer may be made by placing a perforated metal stand inside a large kettle, so that only the steam comes in contact with the instruments and dressings.

Bichloride of Mercury.—This is employed as an antiseptic in watery solutions varying in strength from 1:1000 to 1:10,000.

The solution of 1:1000 to 1:1500 is used only for the irrigation and disinfection of the hands and skin; for the irrigation of wounds, a solution of 1: 2000 or 1: 4000 may be employed. At the present time bichloride solutions are not frequently used in fresh wounds on account of their irritating effects. Where continuous irrigation is kept up, or where it is employed in large cavities, a still weaker solution, 1:5000 to 1:10,000, should be employed.

In using bichloride solutions the surgeon should watch the patient carefully for signs of poisoning due to absorption of bichloride of mercury; the symptoms denoting this are vomiting, fetid breath, salivation, inflammation of the gums, diarrhea, blood-stained stools and bleeding from the mouth and nose. Locally the use of moist bichloride dressings may cause well-marked dermatitis. The continuous application of bichloride solution to the hands of the surgeon causes the skin to become roughened and blackens the nails.

In preparing solutions of bichloride of mercury for use, it will be found convenient to have a concentrated solution of the salt in alcohol, 1 part of the bichloride to 10 parts of alcohol; this can be kept in a well-stoppered bottle, and to it should be added one teaspoonful of common salt, which prevents disintegration of the mercuric compound. One teaspoonful of this solution added to 1 quart of water makes a 1:2500 solution.

A 10 per cent bichloride solution may be made as follows:

Bichloride of mercury	2 parts.
Sodium chloride	1 part.
Dilute acetic acid	1 "
Aquæ dest.	16 parts.

Or the solution may be prepared with tartaric acid in the proportion of 5 parts of the acid to 1 part of bichloride of mercury, the following formula being employed:

Hydrarg. chlor. corrosiv..	grs. xv.
Ac. tartaric	grs. lxxv.
Aquæ dest.	Oij.

Pellets containing a definite amount of bichloride of mercury compounded with a few grains of common salt or muriate of ammonium, which, when dissolved in a definite quantity of water, make a solution of 1:1000 or 1:2000, will also be found very convenient for the preparation of solutions. The pellets should also contain a little coloring matter, which gives a faint color to the solution and serves to distinguish it from other solutions. Bichloride solutions cannot be used to sterilize instruments on account of their corrosive action on ferrous metals.

Biniodide of Mercury.—This drug possesses germicidal properties equal to or greater than the bichloride of mercury; it is used in the same strengths as the latter; it is less irritative, does not form a mercuric albuminate and does not tarnish metal instruments.

Carbolic Acid.—This drug is employed in solutions of 1 : 20 or 1 : 40. The stronger solution, 1 : 20, is usually employed to sterilize instruments, the latter being allowed to remain in this solution for thirty minutes before being used. As a carbolic solution of this strength benumbs and cracks the skin of the hands of the operator, it should be diluted just before the instruments are required, by adding an equal quantity of boiled water, making it a 1:40 solution. The rusting of steel instruments and the dulling of the edges of knives by exposure to carbolic acid may be prevented by the addition of 5 per cent of sodium carbonate to the solution.

The 1 : 40 or 1 : 60 solution is used for the irrigation of wounds and the washing of sponges. As carbolic acid in strong solutions is a local caustic and coagulates albumin, it should not be used in fresh wounds. A ready method of making a 5 per cent carbolic solution is to add one tablespoonful of carbolic acid to one pint of hot water.

In using carbolic acid solutions continuously, the surgeon should be on the watch for symptoms of poisoning, which will be manifested by dark-colored urine, headache, dizziness, vomiting and in severe cases bloody diarrhea, hemoglobinuria and death from collapse. Carbolic acid solutions should be used with great caution in young children, as they seem to be more susceptible than adults to its constitutional effects.

The use of weak solutions of carbolic acid seems to involve more risk of toxic action than does the employment of the pure drug, the superficial layer of tissue being coagulated by the latter, so that absorption of the drug is prevented. *Gangrene* of the skin and subjacent tissues has frequently been observed to follow long-continued use of quite dilute solutions of carbolic acid or of ointments containing small quantities of the drug. Cases of gangrene of the fingers and toes from this cause are not infrequently seen.

Iodoform.—Iodoform has been shown by experimental research to possess little direct germicidal action, but in spite of this fact clinical experience has proved that it possesses powerful antiseptic properties, due, as shown by Behring and De Ruyter, not to the destruction of germs, but to its undergoing decomposition in their presence, thus inhibiting their activity. It may be rendered absolutely sterile by exposing it to heat, and, as it is easily decomposed, fractional sterilization may be employed, or by washing it in a 1:1000 bichloride solution; it should then be dried and kept for use in closely stoppered bottles. Iodoform is often employed in the form of a powder as an application to wounds, and is frequently used in aseptic wounds which are liable from their position to become infected, such as those about the mouth, rectum and vagina, and is especially useful as a dressing in infected wounds and in tubercular or syphilitic ulcers and in bone cavities. In operations upon the mouth, anus, rectum, uterus and abdominal cavity iodoform gauze packing is largely employed, and serves to keep the discharges from becoming foul, thus often preventing septic intoxication; it must, however, be used with caution in the mouth. *Iodoform collodion,* made by adding iodoform (gr. xlviij) to collodion (f℥j) is a useful dressing in superficial wounds. Iodoform may also be employed in the form of an *ethereal solution,* iodoform (gr. xv) and ether (f℥j), as an application to wounds or ulcers. An *emulsion of iodoform* in iodoform (ʒj) and sterilized glycerin (ʒx), or an emulsion of iodoform made by adding sterilized iodoform (ʒj) to boiled olive oil (ʒx) is much employed as an injection in the treatment of tubercular abscesses and joints. For packing cavities a 5 per cent gauze is best; a 10 per cent gauze is too strong except in small amounts. For large cavities a *Mikulicz* pack, consisting of a bag of iodoform gauze stuffed with sterilized gauze, may be employed.

Numerous cases have been reported in which toxic symptoms have followed the use of iodoform, such as urticarial eruptions, dermatitis, headache, depression, delirium, mania, debility and sleeplessness. Elderly persons and infants are very susceptible to the toxic action of iodoform.

Iodine.—This drug possesses marked germicidal properties. It may be used in a solution of 0.5 to 1 per cent for irrigation and 0.25 to 1 per cent for dressings. It is extensively used for the sterilization of catgut ligatures and in the form of an alcoholic solution it is frequently employed to sterilize the skin before operations. The skin should be perfectly dry when the iodine is applied.

Picric Acid.—This drug may be used in 1 per cent aqueous solution; gauze saturated with this solution is used in the treatment of burns. A 2 per cent alcoholic solution is employed for the sterilization of the skin.

Formaldehyde.—This is a pungent, penetrating gas, possessing valuable antiseptic properties, which is principally used for the disinfection of clothing, instruments, bedding and rooms. Acids may be generated by boiling commercial formalin or by pouring formalin over crystals of potassium permanganate in the proportion of 16 ounces of formalin to $6\frac{3}{4}$ ounces of permanganate.

Formalin.—This is a 40 per cent solution of formaldehyde gas in water, and has valuable antiseptic properties. A solution of this strength is a powerful irritant, and should not be used in the treatment of wounds. It may be used in a 2 per cent solution to disinfect wounds or instruments, or in 0.25 per cent solution for irrigation. Brewer recommends a 1 per cent solution applied for three minutes to disinfect the skin, a 2 per cent solution applied under anesthesia to sterilize infected tissue and 0.3 per cent solution for gauze.

Dakin's Solution.—This is a solution of sodium hyperchlorite, free from caustic alkali and varying in strength of 0.45 and 0.5 per cent. It was found by Dakin to fulfill the requirements of an ideal antiseptic. In contact with wound exudate the solution gives off nascent chlorine which forms highly germicidal chloramine. If the solution is of less strength than 0.45 or 0.5 of 1 per cent it is too weak to be efficient. If used in a strength of more than 0.5 of 1 per cent it will be too strong and will irritate the wound and adjacent skin. In using this solution of the normal strength, the skin surrounding the wound is protected by covering it with strips of gauze, saturated with sterilized yellow vaseline. It has been demonstrated that the hypochlorites are detergent rather than bactericidal, especially acting upon dead tissues. For this reason sutures and ligatures of silk, linen or catgut may be dissolved and secondary hemorrhage result. Chromicized catgut is less likely to be dissolved. It is a very unstable solution and should not be heated or exposed to light and should be prepared fresh daily, and should be kept in dark-colored glass bottles. In large quantities it is prepared by passing chlorine gas through a solution of sodium bicarbonate. Daufresne's modification of the original solution is more stable and if kept from exposure to light in a cool place may retain its active qualities for several weeks. It is wiser, however, to use only a freshly prepared solution. It is prepared by placing 200 gm. of chlorinated lime (bleaching powder) which has been proved by test to contain 25 per cent active chlorine in a 12-liter flask and adding 5 liters of water. This mixture should be shaken vigorously for some time and allowed to stand for six hours. In another flask 100 gm. of dry sodium carbonate and 80 to 90 gm. of sodium bicarbonate is added to 5 liters of water, and added to the chlorinated lime solution. This mixture is actively shaken for a few minutes and then the calcium carbonate is allowed to settle. In half an hour the supernatant liquid is siphoned off and passed through double filter paper. The solution should be neutral; if it contains free alkali it should not be used. The alkalinity may be corrected by passing CO_2 through the solution. The technical details of its employment in the treatment of wounds, elaborated by Carrel and Dakin are given on page 317.

Dichloramine-T or Dakin's Oil.—When hypochlorites react with proteins free chlorine is changed into non-irritating germicidal substances known as chloramines. Chloramines can be prepared synthetically and are known as *chloragene.* It can be used in an aqueous 2 per cent solution in much greater strength than Dakin's fluid without irritating the wound or skin, but in contact with wound exudate the chloramine disappears rapidly and must be renewed frequently. It has been found that if dichloramine-T is dissolved in chlorinated oil the strength of the solution is from 5 to 10 per cent and that when applied to a wound the germicide will be liberated over a period of eighteen to twenty-four hours. The following formula is often employed: Dichloramine-T powder (grs. 156), chlorinated paraffine oil (chlorinated eucalyptol ʒiij). This makes a 7.5 per cent solution.

Dakin's oil is more stable than the Carrel-Dakin solution, does not irritate the skin and retains its potency for twenty-four hours, thus avoiding frequent dressing, and does not require the complicated technic of the former. It is used in solutions in strength from 1 to 5 per cent in the treatment of wounds, abscesses and burns; in the latter much weaker solutions are employed. It may be sprayed or dropped on the surface of a wound, or introduced into deep wounds by wicks of gauze saturated with the oil to bring it in contact with all parts of the wound area. After its application the wound should be covered with a light gauze dressing held in place by a bandage. Its use should follow thorough débridement and drainage of infected wounds.

Chlorcosane.—This is a recently introduced solvent for dichloramine-T. It is prepared by melting hard paraffine wax with a melting-point of 50° C. and passing chlorine gas at a temperature of 120° to 140° C. through it. The melted wax absorbs from 45 to 55 per cent of chlorine, the resulting straw-colored liquid will absorb 8 per cent of dichloramine-T. It is used in a 5 per cent solution and is applied to wounds by means of a spray, syringe or cotton swab.

Flavine.—This is a chlorine compound also known as acriflavine, prepared from coal tar and is an antiseptic which possesses the property of destroying bacteria without injuring the tissue cells. It is highly efficient as an antiseptic in a watery solution of 1:1000. It may be used pure or in a 1:100 solution for irrigation.

Mercurochrome-200.—This is a red powder insoluble in water, but readily soluble in sodium hydroxide. It has marked antiseptic properties and is used in solutions of 1:1000

B. I. P. P.—This is known as Morison's paste and consists of: Iodoform (2 ounces), bismuth subnitrate (1 ounce), paraffine and petrolatum to make a thick creamy mixture. This paste is decidedly antiseptic and is employed in the treatment of wounds and in bone cavities.

Dakin's Solution.—See p. 317.

Chlorazene.—This antiseptic was studied by Dakin and occurs in a white crystalline powder freely soluble in water, in which it makes a faintly alkaline solution. It has the same germicidal power as sodium hypochlorite but is much less irritating. It is usually employed in a 1:1500 solution.

Hychlorite.—This is a solution of chlorinated soda; each 100 cc is said to contain 4.05 gm. of sodium hypochlorite, 3.2 gm. of sodium chloride, 0.25 gm. of calcium hydroxide and 0.92 gm. of inert salts. It contains more chlorine than the solution of chlorinated soda of the U. S. P. One volume of hychlorite diluted with 7 volumes of water is isotonic.

Both of these preparations are more stable than Dakin's solution and may be substituted for the latter when it is not possible to get freshly prepared Dakin's solution.

Silver Nitrate.—This drug has marked antiseptic action and is frequently used in solutions of varying strengths in the treatment of infected mucous membranes. In the form of the solid stick, lunar caustic, it is a most satisfactory application to wounds to destroy exuberant granulations. A solution of nitrate of silver, 1:16,000 to 1:24,000, is one of the most satisfactory solutions for irrigation of an infected bladder.

Argyrol.—This is an organic silver salt which is less irritating than nitrate of silver, but not as efficient as an antiseptic. It is used in a 10 to 15 per cent solution as an application to mucous membranes. It stains the tissues and clothing and the stains may be removed from the latter by soaking in a 1:500 bichloride of mercury solution.

Protargol.—This is a silver salt containing 8.3 per cent of silver which occurs in a yellowish powder, soluble in hot or cold water It is used in a 1 to 5 per cent solution. It is also employed in inflammation of the mucous membranes.

Acetanilide.—This preparation possesses antiseptic properties and is frequently used as a substitute for iodoform. It may be used in the form of powder as an application to suppurating or ulcerating tissues, but in tubercular conditions is not as satisfactory as iodoform.

Chloride of Zinc.—Chloride of zinc in a solution of 30 to 40 grains to water (f℥j), is a very powerful antiseptic. When employed upon raw surfaces it produces marked blanching of the tissues; it is especially useful in wounds which are infected or which have been exposed to infection. I have found it by all means the best application for the poisoned wounds which are received in dissecting dead bodies and in operating. In such cases the whole cavity or surface of the wound should be swabbed with a 30-grain solution, and then the wound should be dressed with moist sterilized gauze.

Acetate of Aluminum.—This drug is used in solution, and is prepared as follows: aluminis, ʒvj (24 gm.); plumbi acetatis, ʒixss (38 gm.); aquæ, Oij (1000 gm.). Mix, and filter after standing twenty-four hours. It has decided germicidal qualities, is employed for irrigation and moist dressing where carbolic or bichloride solutions cannot be used, and is by all means the safest and best antiseptic substance for wet dressings.

Peroxide of Hydrogen.—Peroxide of hydrogen is employed in what is known as the 15-volume solution. It may be used in this strength or may be diluted. It is an excellent agent for cleaning purulent areas, but has no distinct germicidal action. It is frequently employed in the sterilization of sinuses or suppurating cavities, such as remain after the opening of abscesses or result from diseases of or operations upon the bones. It is injected into the sinuses and cavities by means of a glass syringe, or may be applied to open wounds in the form of a spray. Its action is shown by the escape of gas and purulent material and it should be used as long as these continue to escape. It must be used with caution in sinuses and deep cavities as the sudden generation of gas may produce pressure and force its way into adjacent tissues, thus spreading infection.

Creolin.—This substance is obtained from English coal by dry distillation, and has been found to possess powerful germicidal properties; it is non-irritating and practically non-toxic. It is insoluble in water, but forms an emulsion with it which possesses marked antiseptic properties. It is especially useful as a deodorant in offensive malignant ulcers. It may be employed for the same purposes as carbolic acid. It is used in an emulsion, in strength of from 2 to 5 per cent, and is employed in the irrigation of large wounds or cavities of the body, and has been most favorably recommended in gynecological practice.

Boric Acid.—This drug has not very marked antiseptic qualities and is usually unirritating even in saturated solutions; but occasionally it produces marked irritation of the skin. It is frequently employed in a 5 per cent solution for most dressings or fomentations and to cleanse and disinfect mucous surfaces and large cavities. It is often employed to wash out the bladder before the operation for the removal of calculi or growths from that organ. In the dressing of superficial wounds, or in wounds in which the bichloride or carbolic acid dressing produce irritation, an ointment of boric acid, 1 part, to petrolatum, 5 parts, will be found very satisfactory.

Boro-salicylic Powder.—This powder, which consists of 4 parts of boric acid to 1 part of salicylic acid, is used as a dusting-powder and as a dressing for wounds. It has been recommended highly by Senn in the treatment of fresh wounds.

Salicylic Acid.—Salicylic acid does not have very marked antiseptic qualities, but possesses much less toxic action than carbolic acid, and is used for somewhat the same purposes. Its antiseptic power is said to be increased by the addition of boric acid and a boro-salicylic lotion (Thiersch's solution) is prepared by adding salicylic acid, 1 part; boric acid, 6 parts; to hot water, 500 parts; making a bland solution, which, when reduced to 25 to 50 per cent of the original strength, may be used for irrigation of the bladder.

Permanganate of Potassium.—This drug, owing to its oxidizing action, acts as an antiseptic, and is often employed for the disinfection of foul wounds and ulcers. It is practically non-irritating, and may be used in quite concentrated solutions, but is usually employed in the following strength: Permanganate of potassium, ʒj; water, f℥j. One fluidram of this solution to 1 pint of water makes a 1:1000 solution.

Aristol.—Aristol, which is a compound of iodine and thymol, possesses germicidal properties, and has been introduced as a substitute for iodoform. It has the advantage over iodoform of not being poisonous, and is also without disagreeable odor. It may be employed for the same purposes as iodoform and it seems to be particularly useful as a dressing to chronic and specific ulcers.

Xeroform.—This is a combination of bromine, carbolic acid and bismuth. It possesses marked antiseptic properties and is frequently used as a drying powder in the treatment of wounds or may be combined with petrolatum and used as an ointment in the dressing of ulcers.

Sodium Chloride.—This salt has no direct antiseptic action, but is used in the preparation of normal salt or saline solution, the strength of which is 0.6 to 0.9 per cent.

Saline Solution.—This is prepared by adding 6 drams of sterilized sodium chloride to 1 liter of distilled water, which is contained in a sterilized oval glass flask. The mouth of the flask should be plugged with sterilized cotton and a piece of gauze fastened over the mouth and neck of the bottle. The solution should be exposed to steam sterilization one-half hour on two successive days. Saline solution is non-irritating, and is frequently used in the irrigation of fresh wounds, to remove foreign bodies or blood clots and for the cleansing of mucous and serous surfaces. Its utility by intravenous injection or infusion is well recognized (see page 157). In emergencies a solution prepared by adding 1 dram of common salt to 1 pint of water which has been sterilized by boiling may be employed.

Sterilization of Water.—Water may be rendered absolutely sterile by boiling from fifteen to thirty minutes. It should be distilled or filtered before being boiled to remove any inert matter which is not desirable in wounds. After being boiled it should be placed in sterilized glass flasks and corked with sterilized cotton, the mouths of the flasks also being covered with several layers of gauze. It is employed for the irrigation of wounds and of mucous and serous surfaces.

Preparation of Materials used in Aseptic Operations.— **Dakin's Pads.**—See p. 318.

Gauze Sponges or Pads.—On account of the difficulty in satisfactorily sterilizing marine sponges, as well as of their expense, folded gauze sponges have largely superseded them.

Gauze Sponges.—These are prepared by cutting a piece of gauze, composed of from twelve to sixteen layers, in pieces 6 inches square; the four angles of these pieces are then tied together or secured by a few stitches. Sponges may also be made by folding a piece of gauze 18 inches by 18 inches composed of two layers so that the cut edges are turned in, the resulting sponge being about 4 inches square.

Gauze Pads.—Gauze pads are made from a piece of gauze composed of from sixteen to twenty layers cut the desired size, the different layers in each pad being quilted together by a few stitches and the edges loosely whipped with a thread to prevent them from fraying. Gauze pads are used as a substitute for the flat sponges formerly employed in abdominal surgery, and for the drying of wounds. Where pads are used in abdominal operations, to prevent them from being lost in the abdomen, it is well to have sewed to each pad a piece of tape 12 inches in length, which is allowed to protrude from the wound and to which a hemostatic forceps is attached Gauze sponges and pads are put in packages, a definite number in each package, and marked before being sterilized. The pads or sponges may be sterilized by boiling or by exposure to steam in a sterilizer, and afterward dried by dry heat. They are wrapped in a sterilized covering; if not used within twenty-four hours they should be resterilized before being used. Warm moist pads should be preferred to dry pads for use in the abdominal cavity.

Silk Sutures and Ligatures.—Silk for sutures or ligatures, either the plaited silk or the Chinese twisted silk, should be sterilized by boiling from ten to thirty minutes, the time of boiling depending upon the thickness of the threads; frequent boiling renders the silk weak. It should then be placed in stoppered bottles and covered with a 5 per cent solution of carbolic acid or with absolute alcohol, or in 1:1000 bichloride and alcohol solution.

As boiling diminishes the strength of the silk, it may be rendered sterile by being wound upon a glass spool and placed in a test-tube plugged with cotton; the tube should be placed under 10 pounds pressure in an autoclave for thirty minutes on three successive days. Silk ligatures and sutures are extensively used in abdominal surgery for the ligation of pedicles and suturing of the viscera.

Silkworm Gut.—Silkworm gut is an excellent material for sutures, and may be sterilized by boiling it for fifteen minutes, or by placing it for one-half hour in a 5 per cent carbolic solution; after being sterilized it should be kept in 95 per cent alcohol. There has recently been introduced an iron-dyed black silkworm gut which makes the sutures more prominent and thus facilitates their removal.

Silver Wire Sutures.—Fine silver wire was formerly very extensively used as a suture material. The heavier grades of silver wire are still used as bone sutures. This material is sterilized by boiling.

Aluminum Bronze.—This material in the form of wire has recently been extensively used for bone sutures. It is sterilized by boiling.

Horsehair Sutures.—This material is frequently used for sutures; it is more pliable than silkworm gut and is often used for skin sutures. It should be sterilized by boiling for fifteen minutes in a 4 per cent solution of carbonate of sodium.

Equisetene.—This is a fine silk suture material which has been recently introduced and is frequently used where horsehair sutures were employed.

Catgut Ligatures and Sutures.—Catgut is the ideal material for ligatures and sutures, but has the disadvantages of difficulty and uncertainty in its sterilization. Raw catgut is often infected with microörganisms and, therefore, thorough sterilization alone can render it a safe material for ligatures and sutures. It is furnished in threads of different sizes, 00 being the smallest, then 0, 1, 2, 3, 4; the greater the diameter of the catgut the more difficult is its sterilization.

Catgut sutures should be secured by a square knot; if the catgut is so stiff or wiry that it is difficult to tie it should be soaked for a few moments in salt solution, which renders it pliable. The ends should not be cut too short, and in apply- it to large vessels it is better to secure it by three knots.

Von Bergmann's Catgut.—This method of preparing catgut consists in winding the catgut loosely upon glass rods or spools; these spools are placed in ether for twenty-four hours; the ether is then poured off and they are placed in the following solution: bichloride of mercury, 10 parts; absolute alcohol, 800 parts; distilled water, 200 parts. Remove from this solution after twenty-four hours and place them in a similar solution for forty-eight hours; then place in absolute alcohol. If soft catgut is desired add 20 per cent of glycerin to the absolute alcohol. To make the sterilization absolutely certain it has been found advantageous to soak the catgut for thirty minutes in a 1:1000 aqueous bichloride solution before placing it in the alcoholic solution of bichloride.

Boiled Catgut.—Catgut may also be sterilized by boiling in alcohol under pressure. The most satisfactory method is that devised by Fowler, which consists in placing a number of strands of catgut in an ordinary test-tube which is filled with 95 per cent alcohol to within half an inch of the top; a wad of cotton is next pushed into the mouth of the tube and a cork is introduced. The tubes thus prepared are placed inverted in a fruit jar filled with 95 per cent alcohol; the jar is then closed and placed in a water bath, and kept at a boiling temperature for an hour. Or the catgut may be loosely wound upon glass rods and spools and placed in a metallic cylinder or jar having an accurately fitting screw top. The catgut is then covered with absolute alcohol, the top is screwed down and the cylinder or jar is immersed in boiling water for an hour.

Formalin Catgut.—This is prepared by winding catgut loosely on glass spools and keeping them for forty-eight hours in a vessel containing equal parts of alcohol and ether. They should next be washed for a few minutes in alcohol and placed in a jar containing equal parts of alcohol and formalin and allowed to remain for several days. The excess of formalin should then be washed away with alcohol and the catgut kept for use in 95 per cent alcohol.

Cumol Catgut.—The catgut is rolled loosely on glass spools which are placed in a glass beaker having a layer of cotton in the bottom; the beaker is covered by a piece of cardboard having a hole in the center through which a thermometer is introduced and is placed on a sand bath heated by a Bunsen burner. Heat is applied until the temperature is raised to 176° F.; this is maintained for one hour, and removes all moisture from the catgut. Cumol, at a temperature of 212° F., is next poured into the beaker, completely covering the catgut, and the temperature is then raised to 329° F. and maintained for one hour. The cumol is next poured off and the catgut is allowed to dry in the beaker on the sand bath at a temperature of 212° F. for two hours; it is then transferred to sterile jars or tubes which should be air-tight.

Iodine Catgut.—This variety of catgut has recently been extensively used with most satisfactory results. The catgut is soaked in a 1 per cent solution of iodine for seven days, when it is ready for use. The solution is prepared by dissolving iodide of potassium, 1 part, and iodine, 1 part, in 100 parts of water. The solution is prepared by dissolving the iodide of potassium in a small quantity of water, to which the iodine, finely powdered, is added and the concentrated solution is diluted to a 1 per cent solution.

The catgut may be kept in the sterilizing solution or in a mixture consisting of absolute alcohol, 950 parts, glycerin, 50 parts, and iodoform finely powdered, 100 parts.

Chromic Acid or Chromicized Catgut.—Catgut, after being soaked in ether for twenty-four hours and washed in alcohol, is placed for twenty-four hours in a 4 per cent aqueous solution of chromic acid; it is then removed and dried in a hot oven, and placed in closely stoppered jars, or may be preserved in absolute alcohol. Catgut thus prepared will resist the action of living tissues for several weeks, the time of its absorption depending upon the size of the gut. Before being used it should be sterilized by either the cumol, alcohol or formalin method.

Owing to the fact that it undergoes very slow solution in the tissues, chromicized catgut is often employed for sutures or for the ligation of the larger vessels in their continuity, and for bone sutures.

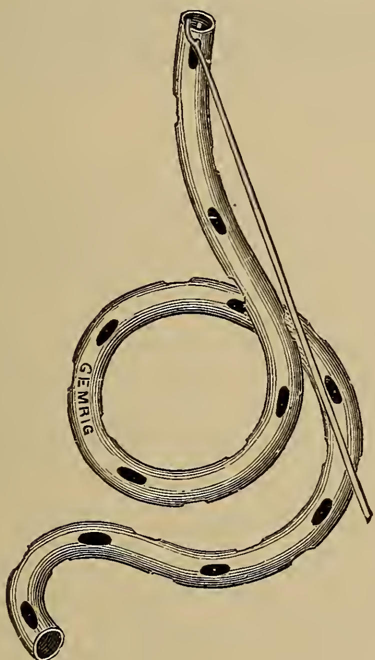
Bartlett's Catgut.—Coils of catgut are strung upon a thread for convenience of handling and are dried for four hours at temperatures of 160°, 180°, 200° and 220° F. The coils are next placed in liquid albolene and allowed to remain for several hours. The vessel containing the catgut and albolene is next placed upon a sand bath and the temperature raised to 320° F. which is maintained for two hours. The coils are then taken out of the oil with sterile forceps and placed in a mixture of iodine crystals, 1 part, and deodorized methyl alcohol, 1000 parts. The catgut is ready for use in twenty-four hours and may be stored in the same solution.

Kangaroo Tendon Sutures.—This material is obtained from the tendons in the tail of the kangaroo. The dried strands of tendon are prepared as is catgut and should be chromicized. It is a very strong material and undergoes very slow absorption in the tissues, often remaining for sixty days. It is used for buried sutures.

Celluloid Thread.—This is a linen thread introduced by Pagenstecher. It is prepared by boiling the thread for thirty minutes in a 1 per cent solution of sodium carbonate. It is then dried between sterile compresses and soaked for some hours in celluloid solution. It may be kept dry or in an alcoholic solution of bichloride of mercury. It may be resterilized by boiling or under steam pressure. It has proved a satisfactory material for sutures and ligatures, and may be used in place of catgut or silk.

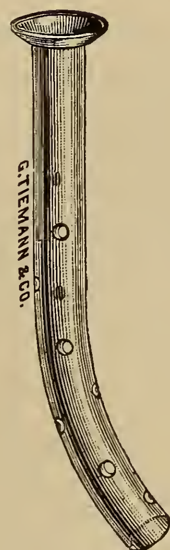
Drainage Tubes.—The drainage tubes usually employed are prepared from rubber tubing of different sizes perforated at short intervals; the black-rubber tubes are softer and more pliable than the red-rubber or white-rubber tubes, and are generally preferred (Fig. 262). In using rubber drainage tubes in contact with organs on which they may exert injurious pressure it is sometimes found of advantage to split the tube for its entire length which does not alter its shape or interfere with its function unless it is subjected to severe pressure. Drainage tubes are also made of glass, straight or curved (Fig. 263), which are almost exclusively used in abdominal surgery, and also of decalcified bone. The tubes should be well washed and sterilized by boiling water for a few minutes before being used. They may be kept in a 5 per cent carbolic solution.

Fig. 262.



Rubber drainage tube.

Fig. 263.

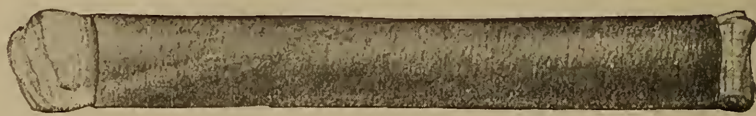


Glass drainage tube.

Gauze Drainage.—Strips of gauze, either sterilized or iodoform gauze, are often used for drainage, and are preferred by some surgeons to the various kinds of drainage tubes. This form of drainage is very much employed; it will be found that the drainage is more prompt if the gauze is wet with saline solution or any antiseptic solution preferred before being introduced. Gauze drainage suffers from the disadvantage of contracting firm adhesions to the surrounding tissues and when its meshes become filled with thick exudate it may act as a plug rather than a drain.

Cigarette Drain.—This consists of a roll of sterilized or iodoform gauze covered by rubber protective tissue (Fig. 264). It may be prepared in lengths of 12 inches and a sufficient amount cut off as is required by the depth of the wound to be drained. It is a very satisfactory form of drain in abdominal wounds.

Fig. 264.



Cigarette drain.

Mikulicz Bag or Tampon.—This consists of a roll of gauze surrounded by rubber tissue, which is used especially in abdominal operations where we desire to obtain pressure to arrest hemorrhage and also to secure drainage.

Catgut and Horsehair Drainage.—Catgut as ordinarily prepared for ligatures may be used to secure drainage in small and superficial wounds; a number of strands are placed in the bottom of the wound and the ends are allowed to project from one or both extremities of the wound.

Horsehair or silkworm gut may be employed for the same purpose, a number of strands being placed in the wound in the same manner. Before being used it should be well washed with soap and water and then sterilized by boiling.

Protective.—Protective is employed to prevent the wound from being irritated by the antiseptic substances with which the gauze is impregnated or by its irregular surface. The great objection to the use of protective is that it sometimes interferes with drainage and permits of the accumulation of serum beneath it, which may become infected.

Various materials are employed as protectives; one of the best is Lister's oil silk, rubber dam, rubber tissue or silver foil, the principal requirement being that they can be readily rendered aseptic and do not absorb irritating materials from the dressings.

Silver Foil.—The inhibitive action of metallic silver on the growth of microörganisms is utilized in the employment of silver foil to cover the surface of wounds. The foil is sterilized by dry heat and placed directly on the surface of the wound after it has been closed by sutures. It is claimed that the foil prevents infection of the wound from the exterior and also destroys microörganisms which may come in contact with it.

Rubber Dam.—This is a thin, pure rubber tissue, which may be cleansed and sterilized with greater facility. It is often attached to the drainage tube in abdominal wounds to shut off the opening of the tube from the abdominal wound. Before being used it should be washed with soap and water, rinsed and then placed in a bichloride or carbolic solution for a time sufficient to sterilize it. Cut into strips it is a useful material for drainage of abscesses and sinuses, especially in infections of the fingers and hands.

Rubber Tissue.—This consists of a very thin sheet of India rubber with glazed surfaces which can be obtained from the rubber manufacturers; it is employed to cover moist dressings and, as previously stated, may be used when properly sterilized instead of protective for covering the wound.

Gauze Dressing.—The most convenient and cheapest material for wound dressing is a material known to the trade as cheesecloth or tobacco-cloth, and for surgical use should contain no sizing. From the fact that it has a very open mesh, it absorbs well either the materials with which it is prepared or the discharges from the wound, and is soft and pliable, so that it is a comfortable form of dressing to the patient.

Gauze containing various antiseptic substances was formerly much employed in surgical dressings, but at the present time it has been largely superseded by sterilized gauze.

Bichloride or Corrosive Sublimate Gauze.—Bichloride or corrosive sublimate gauze is prepared by placing cheesecloth in a washing kettle and covering it with water to which is added 2 pounds of washing soda or 1 pint of lye; the latter is added to dissolve any oily matter which the cheesecloth contains, thus making it more absorbent. The gauze is boiled in this solution for an hour, and is then removed and washed in boiled water and passed through a sterilized clothes wringer; it is then immersed in a 1:1000 bichloride solution for twenty-four hours; the excess of fluid is then squeezed out of it, and it may be packed in air-tight jars and preserved as a moist gauze, or may be dried in a warm oven and packed in sterilized jars and kept as a dry gauze. Dry bichloride gauze, unless freshly prepared, possesses little antiseptic properties.

In using the sublimate gauze on delicate skins a dermatitis sometimes results which is known as mercurial eczema; this is particularly apt to occur if the gauze is moistened or covered with rubber tissue. If this condition develops the parts covered by the gauze should be rubbed over with boric acid ointment or vaseline before it is reapplied, or a sterilized gauze dressing should be substituted.

Iodoform Gauze.—This may be prepared by soaking sterilized gauze in a mixture containing iodoform, 5 parts, glycerin, 20 parts, and alcohol, 75 parts. This furnishes the 5 per cent iodoform gauze; if 10 per cent gauze is desired the quantity of iodoform should be doubled. When the gauze is thoroughly saturated it should be of a uniform yellow color. It should then be thoroughly wrung out with sterilized hands to remove the alcohol and packed in sterilized jars with tight-fitting covers.

Iodoform gauze may also be prepared by saturating sterilized gauze with a mixture of ether and iodoform, and then allowing the ether to evaporate, the iodoform being distributed evenly through the gauze.

Carbolized Gauze.—In preparing carbolized gauze, cheese-cloth which has previously been boiled and dried is soaked for a few hours in the following solution: resin, 16 ounces; alcohol, 5 pints; castor oil, 24 ounces; carbolic acid, 12 ounces. The gauze is removed from this solution and passed through a sterilized clothes wringer, and is then cut into pieces from 4 to 6 yards in length, which are folded and packed in air-tight jars for use.

Improvised Aseptic or Antiseptic Dressings.—Aseptic dressings in cases of emergency may be improvised, where the ordinary gauze dressings cannot be obtained, by tearing muslin or mosquito netting into pieces ½ yard square and placing them in boiling water for a few minutes; they are then removed, the excess of moisture is wrung out and they are applied to the wound.

If it is desirable they may be used as antiseptic dressings by soaking them for a few minutes in a 1 : 1000 or 1 : 2000 bichloride solution, or in a 5 per cent carbolic solution. This dressing will keep the wound aseptic until a more elaborate dressing can be obtained.

Sterilized Bandages.—Sterilized bandages are prepared by tearing or cutting gauze into strips from 2½ to 3 inches in width, and forming these strips into rollers which are sterilized by steam or dry heat. They should be used soon after being prepared, or, if kept for any time, should be resterilized before being used.

Sterilized Towels, Operating Suits and Gowns.—These are wrapped in muslin covers and sterilized by steam under pressure and dried in the same manner as gauze dressings.

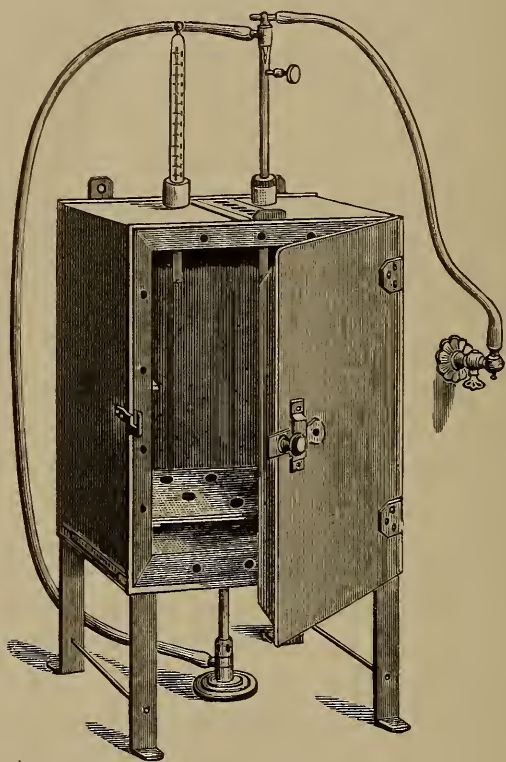
Bichloride Cotton.—This material is prepared by soaking absorbent cotton in a 1:1000 bichloride solution for twenty-four hours and allowing it to dry, or it may be dried in a hot oven; when dry it is packed in jars or in air-tight boxes. It was formerly much used, but has now been superseded by sterilized cotton.

Sterilized Cotton.—Sterilized cotton is prepared by placing absorbent cotton, enclosed in perforated metal cans, in a steam sterilizer and allowing it to remain for half an hour under ten pounds' pressure. If kept for a short time it should be resterilized before being used.

Moist Sterilized Gauze Dressings.—Moist sterilized gauze dressings may be prepared by subjecting gauze which has been boiled in soda solution to the action of boiling water or of steam for thirty minutes. Gauze thus treated should be used as soon as prepared.

Sterilized Gauze.—This is prepared by cutting pieces of gauze the desired size, wrapping them in a towel and placing them in wire baskets; or the gauze may be placed in cylindrical tin boxes, 3 inches in diameter and 8 inches in height, with perforated metal covers, covering the gauze at each end with a layer of cotton before putting on the covers. The gauze is next placed in a steam sterilizer and subjected to 10 pounds' pressure of live steam for half an hour. The steam is then shut off from the sterilizer and allowed to circulate in the jacket of the apparatus without pressure for half an hour to dry the dressings. If the gauze has been sterilized in metal cases it may be kept for some time and still remain sterile. Cotton may be sterilized in the same manner.

Fig. 265.



Hot-air sterilizer.

Dry Sterilized Gauze Dressing.—Dry sterilized gauze dressings are prepared by cutting gauze into proper lengths and packing it loosely in wire cages or perforated metal cans, which are next placed in a dry sterilizing oven for several hours, and upon removal it is placed in air-tight jars or metal boxes. In using dry sterilized gauze dressings it is safer to have the dressings freshly sterilized immediately before each operation. A convenient form of sterilizing oven is shown in Fig. 265. Towels and operating gowns may be sterilized in the same oven.

Paraffine Gauze.—This is prepared by impregnating white coarse-meshed mosquito netting with a mixture of paraffine, 2 parts, petrolatum, 2 parts, and stearin, 1 part, and 0.5 per cent of carbolic acid may be added. This is a non-adherent dressing, which provides good drainage through the meshes of the gauze. One or two layers of this gauze are laid over the wound and covered by an absorbent gauze dressing. It is useful in the dressing of burns and scalds, and is a most satisfactory dressing to apply over skin grafts before a gauze dressing is applied.

Resterilization of Used Gauze Dressing.—Formerly all gauze dressing which had been used was thrown away. This resulted in an enormous waste of material. In most hospitals the used gauze if not soiled with pus is resterilized and is perfectly safe. The gauze is first soaked and washed to remove blood or stains, then boiled for thirty minutes in a steam laundry machine and dried in a centrifugal drier, and next placed in a drier heated to a high temperature by pipes carrying superheated steam. The gauze is then sterilized for two or three successive days. By this treatment it has been found that gauze, even if soiled with pus, is rendered absolutely sterile.

Methods and Dressings Employed to Secure Asepsis in the Treatment of Wounds.—To prevent infection of wounds the various chemical sterilizers and dressings are employed in different ways and the principal types of dressings are as follows:

The primary sterilization of the wound should be done with tincture of iodine or dichloramine-T before the dressings are applied.

Method by Simple Drying.—This method is employed in small and not very deep wounds. The edges having been brought together by sutures, the surface of the wound is dusted with powdered iodoform, the serum and blood forming with this, as it dries, a scab, which protects the wound from infection from without, repair taking place promptly under this scab. Treves employs this method of dressing in compound fractures. A few layers of gauze or a thin layer of absorbent cotton saturated with iodoform collodion or tr. benzoin (ʒj) and collodion (ʒvij) may be employed instead of iodoform. Dry sterilized gauze and cotton dressings may also be employed in this method of dressing.

Method of Drying and Chemical Sterilization.—The object of this method of dressing is to provide a means of sterilizing the blood or serum which escapes from the wound, and at the same time to insure the sterilization of the air coming in contact with the discharges from the wound. It is employed in large or deep wounds, where there is always more or less escape of blood or serum, and is accomplished by applying a number of layers of sublimate or iodoform gauze and sublimated cotton over the wound. Evaporation not being interfered with, the whole dressing becomes hardened and the wound is surrounded by a large antiseptic crust made up of the dressing and serum or blood.

Moist Dressings.—In this method of dressing the wound is covered by layers of moist antiseptic gauze which are kept moist and evaporation prevented by applying over them some impervious material, such as mackintosh or rubber tissue. This method of dressing is not at the present time often employed.

Modified Moist Dressing.—In using this method the wound itself is covered by a piece of protective or rubber tissue; over this is placed the sublimated or iodoform-gauze dressing and some layers of sterilized cotton. In this way the wound itself is kept in a moist condition favoring particularly the organization of blood clots; the external dressings become dry as the discharges which have escaped into them evaporate, forming an antiseptic crust or covering over the wound.

Preparation for Aseptic Operation.—**Preparation of Patient for Operation.**—Where it is possible the patient should have two or three days' rest in bed before a severe operation, and at the same time he can be taught to use the bed pan and to urinate in the recumbent posture. The condition of the heart, lungs, blood and kidneys should be investigated. If the blood examination shows a percentage of hemoglobin under 50 with a corresponding reduction in the red corpuscles in cases not associated with hemorrhage operation should be postponed until there is an improvement in this respect or blood transfusion may be done. The urine should be carefully examined for sugar, albumin, casts, acetone and diacetic acid; presence of the latter forbid any but an emergency operation. The presence of sugar and granular and fatty casts should point to the abandonment or postponement of operative procedure, except in urgent cases.

The presence of valvular disease of the heart with fair compensation is not a contraindication to operation, while evidence of myocardial changes always renders the result of serious operations uncertain.

The results following the examination of the urine and the circulation enables the surgeon intelligently to select the proper anesthetic. The condition of the bowels should also be investigated. If constipation exists it should be relieved by mild cathartics; free purgation should be avoided. It is customary to give a laxative the night before operation and a saline or an enema in the morning. Emptying the bowels lessens the liability of wound infection, and an empty lower bowel is of great value if it becomes necessary to give stimulants by enema during or after the operation. In operations upon the anus, rectum or colon I prefer to have the bowels opened freely on the day preceding the operation, for if it is postponed until the day of operation the manipulations are often followed by fecal discharges, which soil the wound and cause unnecessary delay. The diet should be regulated so that bland and nutritious articles of food only are allowed. It is customary in most hospitals to put a sterilized operating suit upon the patient before going to the operating-room. This is usually made of canton flannel. If the patient has been in the habit of wearing woolen underwear it is well to apply a freshly laundried woolen undershirt to protect the chest rather than to change to a muslin one, for I am confident that many of the pulmonary complications attributed to the operation and anesthetic are due to neglect of this precaution.

Preparation of Room.—In hospital practice suitable operating-rooms are provided; in private practice, however, the surgeon is often called upon to select a room and give directions as to its preparation. A well-lighted room should always be selected and all unnecessary articles of furniture, such as ornaments, pictures and curtains, should be removed. The carpet should be taken up and the floor scrubbed. A few small tables and a large wooden table should be placed in the room, having previously been dusted and wiped off with a bichloride solution. All preparations should be made, if possible, upon the day before the operation, as the stirring up of dust incidental to the change in furniture in cleaning the room on the day of operation immediately before the time set is more dangerous than no cleaning of the room whatever, since the principal contamination of the wound is likely to come from germs contained in the dust. In cases of emergency the floor may be well moistened by sprinkling with water to lay the dust or covered by sheets wrung out of bichloride solution. The preparation of the room is not, in my judgment, a matter that affects the results of operations as much as does the exercise of great care in regard to aseptic details of the operation itself.

Preparation of Field of Operation.—The skin always contains microörganisms, which develop upon it and are constantly being deposited upon it from the air. We can scarcely hope to obtain absolute sterilization of the skin under these circumstances, but by careful preparation seek to obtain that relative sterility which enables us to obtain primary union. The patient should be given a general bath the night before the operation, and the skin surrounding the site of operation should be thoroughly scrubbed with a brush and soap and water; or a soap poultice may be applied to the part for a few hours before the final sterilization with alcohol and bichloride is made. In scrubbing the skin a soft brush should be used, since too forcible scrubbing may cause irritation or dermatitis. After this scrubbing has been continued for a few minutes the skin is washed with alcohol and ether, then douched with sterilized water, and there should be applied to the surface a folded towel or gauze dressing saturated with a 1:1000 bichloride solution; or if a moist dressing is uncomfortable to the patient a few layers of sterilized gauze should be placed over the surface and held in place by a bandage. A similar washing and preparation of the seat of operation should be made the next morning, a few hours before the time fixed for operation.

Sterilization of the skin by *tincture of iodine* is now frequently employed. In emergency cases, where the preparation of the field of operation is made in the operating-room, the skin is first rubbed over with benzine or alcohol and ether, which dissolves oily substances and evaporates rapidly, leaving the skin dry for the application of the iodine. The skin should be dry shaved, should be dry, and in emergency cases 3 to 5 per cent of tincture of iodine in alcohol is painted directly over the field of operation without preliminary washing of the skin. Where there is time the surface is painted with iodine some hours before the operation, and another application is made just before the operation is undertaken. At this time the area covered with iodine may be freed of iodine by wiping it with a gauze pad saturated with alcohol.

Tincture of iodine should not be used upon the genitals or the scrotum.

The skin may also be sterilized by formalin. It should first be scrubbed thoroughly with soap and water, and then a few layers of gauze saturated with a 1 per cent solution of formalin should be laid over it and covered by an impermeable dressing. This solution should be kept in contact with the skin for twenty-four or thirty-six hours, the compress being changed every twelve hours. Picric acid in a 2 to 5 per cent alcoholic solution may also be used to sterilize the skin.

It is well to remember that regions of the body which contain hair and numerous sweat glands, such as the axilla, navel, scrotum, groin and the creases about the joints, are those in which microörganisms grow with the greatest activity. All the surrounding hair should be shaved off; and if the operation be upon the skull it is well to shave the scalp completely.

Sterilization of the Feet.—There is usually present upon the feet a large amount of thickened epidermis which renders their sterilization difficult. The feet should be washed thoroughly with soap and water and scrubbed vigorously with a brush; or a soap poultice should be applied to the whole surface of the feet for some hours and held in position by a bandage. A moist dressing favors separation of the superficial layers of the epidermis, and after it has been worn for a few hours it is possible to remove a large amount of the latter by the use of the brush. After having been washed thoroughly with a 1:1000 bichloride solution they should be be wrapped in a towel or a few layers of gauze saturated with bichloride of mercury solution, 1:1000. Or after being washed with green soap and water they are dried and a dry gauze dressing is applied for some hours. When the skin is perfectly dried it may be sterilized by painting it with tincture of iodine.

Sterilization of the Vagina.—The vagina and external genitals require great care in their sterilization. According to Schimmelbusch, the best method of sterilizing the vagina is to dilate it fully with a speculum and to scrub it thoroughly with pads of gauze saturated with green soap and water, and after this cleansing, to irrigate it with a 1:2000 bichloride solution or a 1 per cent solution of creolin.

Sterilization of the Bladder and Urethra.—It is impossible to sterilize completely the mucous membrane of the bladder. The bladder should be emptied by catheter and irrigated with sterile water or normal salt solution. The best means we have at our disposal at the present time of sterilizing the mucous membrane of the bladder consists in irrigating the organ frequently with a 15-grain to the ounce solution of boric acid in boiled water. In operations upon the urethra the same care should be taken to render the urethra sterile by free irrigation with normal salt solution or boric acid solution.

Sterilization of the Stomach.—The stomach should be sterilized by thorough lavage with normal salt solution or boric acid solution. This is important, not only in operations upon the stomach itself, but also in operations upon the pharynx, to diminish the risk of infection by vomited matter. In cases of intestinal obstruction with vomiting, lavage of the stomach should always be employed before operation.

Sterilization of the Rectum.—When an operation is to be performed upon the anus and rectum the patient should be given a purgative and an enema the day before the operation to remove any fecal matter which may be in the rectum. The region of the anus should be shaved, disinfected with soap and water and thoroughly scrubbed, and after the patient has been anesthetized the sphincter should be well stretched and the rectum irrigated with a boric acid solution, or a 1 to 3 per cent creolin solution. A tampon of sterilized gauze, with a string attached, may be packed into the rectum above the seat of operation to prevent the wound from becoming soiled with feces during the operation. The tampon can be removed by means of the string after the operation has been completed.

Sterilization of the Scalp.—Great care should be observed in sterilizing the scalp before operations on the scalp or brain, as the scalp is often covered by dense masses of epidermis. The entire scalp should be shaved and a soap poultice applied for twelve hours, or the application of sweet oil for twenty-four hours before the use of the soap poultice may be of use in softening the epidermis. It should be rubbed thoroughly with soap and water and finally with a 1:1000 bichloride solution or a 2 to 5 per cent alcoholic picric acid solution may be employed.

Sterilization of the Mouth and Nasal Cavities.—To render the mouth as far as possible sterile the teeth should be thoroughly brushed with tooth powder and the cavity of the mouth frequently rinsed with a solution of peroxide of hydrogen, 1 part to 6 parts of water, or with a saturated solution of boric acid. The nasal cavities and the postnasal region should be sterilized by spraying them with the same solution or with Dobell's or normal salt solution.

Sterilization of the Hands.—The difficulty of completely sterilizing the hands has been shown by bacteriological tests, for it has been demonstrated that after great care in the process complete sterility could be obtained only in about 95 per cent of the tests. The hands of the surgeon, unless properly sterilized, may be the most efficient agents in producing infection of the wound; the region of the *finger-nails* and the *interdigital folds* are locations where germs are particularly abundant. The hands and forearms of the surgeon, assistants and nurses, who are to take part in the operation, may be sterilized by first rubbing them with spirit of turpentine, and then thoroughly scrubbing them with Castile soap and water, using a nail-brush freely. Care should be taken that the brush is sterilized. This scrubbing should be employed for several minutes (five to ten minutes); the hands and forearms are then rinsed to remove the soap and are soaked for two minutes in a 1:1000 bichloride of mercury solution. If turpentine has not been employed before washing with the soap strong alcohol, benzine or ether should be rubbed well over the hands before they are immersed in the bichloride solution. When the hands have been sterilized they should not be brought in contact with anything that is not sterile.

Harrington's Method.—Harrington, after washing the hands thoroughly with green soap, immerses them in the following solution for a few minutes: alcohol (94 per cent), 640 cc; hydrochloric acid, 60 cc; water, 300 cc; corrosive sublimate, 0.8 gm. This solution has been found to be a most efficient sterilizing agent.

Chloride of Lime and Carbonate of Sodium.—Weir recommends the following method of sterilizing the hands. After washing them with green soap put a tablespoonful of commercial chloride of lime and an equal amount of crystalline carbonate of sodium (washing soda) in the hand with enough water to make a paste. Rub this into a thick cream, which should be rubbed into the hands until the grains of lime disappear and the skin feels cool. The hands are then rinsed in sterile water. This method of sterilization of the hands has, in my experience, been most satisfactory. If employed several times a day irritation of the skin may result.

Sterilization of Instruments.—The sterilization of instruments may be accomplished by dry or moist heat; they should be placed in a hot-air sterilizer or baked for twenty minutes in a hot oven. Sterilization of instruments by dry heat or baking is not often employed, as it is apt to spoil the temper of the steel. Instruments may be sterilized by the method suggested by Schimmelbusch, now almost universally employed, which consists in boiling them for fifteen minutes in water to which a tablespoonful of washing soda (carbonate of sodium) has been added for each quart of water; this prevents the rusting of the instruments, and also makes the water a better solvent for any fatty matter which may be upon the instruments, thus increasing the sterilizing effect of the heat. If wooden-handled instruments are used (it is better not to use instruments of this kind), which would be injured by boiling, they should first be thoroughly scrubbed with soap and water and a brush, and after having been rinsed in sterilized water they should be placed in a tray and covered with 1:20 watery solution of carbolic acid, and allowed to remain in this solution for at least half an hour; before being used they should be transferred to a bath of sterilized water, which will prevent the benumbing effect of the carbolic solution upon the surgeon's hands.

A frequent boiling injures the cutting edge of knives; they may be rendered sterile by first thoroughly washing them and placing them in pure *carbolic acid* for from three to five minutes, then transferring them to a vessel containing alcohol.

Instruments may also be sterilized by formalin: The latter is generated by heating pastilles of paraform with Schering's formalin lamp. The instruments are placed in racks in a metal case, and by burning from 10 to 15 grains of paraform the instruments may be rendered sterile in fifteen minutes.

Instruments which fall upon the floor or come in contact with the clothing of the surgeon or of the patient during the operation should again be sterilized before being brought in contact with the wound.

Sterilization of Catheters and Bougies.—These, if made of metal or glass, may be sterilized by boiling for ten minutes in a 1 per cent solution of sodium carbonate. If constructed of gum prolonged boiling destroys them; these may, however, be sterilized by first washing them with soap and water, and then placing them for fifteen minutes in a 1 per cent solution of sodium carbonate, heated nearly to the boiling-point; they are next placed in a 1:1000 bichloride solution until required. They should, on being removed from this solution for use, be soaked thoroughly in hot sterile water to remove all the bichloride solution. Rubber catheters may be sterilized by boiling, they may also be sterilized by soaking them for an hour in a 2 per cent solution of formalin. For lubricating catheters and bougies sterilized olive oil, liquid vaseline or K. Y. should be employed.

Rubber Gloves.—These gloves are now extensively employed in operative work, and the results following their use have been most satisfactory; they protect both the patient and the surgeon from infection. They are made of very thin rubber, so that there is little interference with tactile sensation, and from their elasticity they fit the hands accurately. They can be rendered absolutely sterile, and as they are impervious to moisture there is no risk of wound infection if the hand is not completely sterilized unless the gloves have been torn or punctured during the operation. A punctured rubber glove is more dangerous than the bare hand, from the fact that moisture or sweat from the hand may escape through the puncture. To avoid this possibility of infection the hands should be sterilized as completely as possible before they are applied. They may be sterilized by first washing them with soap and water, and then wrapping them in a towel and boiling them for thirty minutes in a 1 per cent solution of carbonate of soda. They may be applied by filling them with sterilized water or salt solution, and then introducing the hand. In operating upon patients with infected wounds or in dressing infected wounds rubber gloves should always be worn. If properly cared for a pair of gloves will withstand a number of sterilizations. A freshly sterilized pair of gloves should be used for each operation. At the present time the use of gloves which have been sterilized and dried is considered safer; the gloves and hand are dusted with sterile talcum powder before they are applied.

Clothing of Surgeon and Assistants.—The surgeon and his assistants should wear sterilized linen or muslin suits, or be provided with gowns with sleeves reaching to the wrists for the protection both of the patient and of their clothing. The operating gown should be made of muslin or linen with sleeves reaching to the wrist, which can easily be sterilized by boiling or heat; a variety of linen known as butchers' linen is very serviceable for this purpose. As a matter of additional precaution, many surgeons and their assistants wear during the operation closely fitting skull caps of linen or gauze, and wear over the nose and mouth a mask or a pad composed of a number of layers of sterilized gauze to prevent infection of the wound by the expired air. The surgeon and assistants will often find it convenient to wear under their linen gowns India-rubber aprons to prevent soiling of the clothing by blood or solutions. The nurses should wear sterilized linen or muslin operating gowns and dresses of washable goods. An *operating apron* may be improvised from a clean sheet folded so as to be $1\frac{1}{2}$ yards in width and from 5 to 6 feet in length, by turning in about 10 inches of one end of the sheet over the upper part of the chest and placing a strip of bandage in this fold, which should be secured around the neck and tying a second strip of bandage over the sheet at the waist.

The number of instruments, gauze sponges and pads allotted for each operation should be recorded, and before the wound is closed they should be counted. This is especially important in abdominal operations. The care of sponges and pads is the special duty of one nurse.

Details of an Aseptic Operation.—The patient being prepared for operation as described, and having been anesthetized, is placed upon the operating table, the surgeon, assistants and nurses also being prepared for the operation as previously described. If the operation be one upon the face, neck or chest it is well, before the dressings covering the seat of operation are removed, to cover the patient's hair with a rubber bathing cap or a towel or handkerchief bandage made of several layers of sterilized gauze. The portions of the patient's body which it is not necessary to expose in the operation should be covered with a woolen blanket, and this covered with a sterilized sheet. Some surgeons prefer to have the patient wear a *sterilized gown* which is ripped or cut to expose the part to be operated upon. The region of the wound and the operating table are next protected with sterilized sheets and towels. Black sheets surrounding the wound have been recommended by some surgeons with the idea that the glare from white sheets interferes with accurate inspection of the wound during the operation. The surgeon having assigned the assistants and nurses their duties, the dressing is removed from the part to be operated upon, and the operation is begun. Hemorrhage is controlled by the use of hemostatic forceps and sterilized gauze sponges are employed to keep the wound free from blood. When the operation is completed the vessels are ligated, the hemostatic forceps are removed and the wound is dried with gauze sponges. If, for any reason, the surgeon deems it advisable to irrigate the wound, it may be done with hot sterilized water or with sterilized salt solution. In operations involving the abdominal cavity the greatest care should be taken to see that no instrument, sponge or gauze pad is left in the cavity before the wound is closed. If the surgeon decides that drainage is not necessary the deeper parts of the wound may then be brought together with buried sutures of catgut or silk to approximate tissues and eliminate dead spaces, and the edges of the superficial wound next approximated by sutures of catgut, silk or silkworm gut. If the surgeon decides to use drainage before closing the wound a few strands of catgut, a strip of sterilized gauze, a tent of rubber tissue or a rubber drainage tube is introduced into the deepest portion of the wound and brought out at its most dependent part. The wound is then dressed with a number of loose masses or pads of sterilized gauze placed so as to cover the wound and extend beyond it in all directions. Over the gauze dressing are placed a few layers of sterilized cotton, extending on all sides well beyond the gauze, and the dressings are held in place by a sterilized gauze bandage or adhesive straps. The dressings should be voluminous; it is always a mistake to apply scanty dressings. In redressing the wound the same care should be exercised as regards asepsis as was observed at the primary dressing.

Postoperative Treatment.—Recovery from a general anesthetic is considered on p. 239. After the patient has recovered from the anesthetic he should be kept quiet and free from excitement and encouraged to sleep. If pain is present it should be relieved by the judicious use of codeine or morphine. The dressings should be inspected to see that they are in place and that there is no bleeding. Patients often complain of thirst, but if given water by the mouth are apt to vomit; so it is better allayed by giving water by the rectum for the first twelve hours. As a rule, no food is required for twelve or twenty-four hours, and then liquid diet, albumin water, broth or milk may be given. Persistent vomiting of sour liquid after operations call for an examination of the urine for acetone. Postoperative retention of urine is not uncommon in males but is rare in women. If no urine is passed in twelve hours the condition of the bladder shall be investigated. If the bowels are not moved spontaneously in forty-eight hours an enema or a laxative should be administered.

The *redressing* of the wound if drainage has been employed should be done on the second day and the drainage removed at this time if there is no further indication for its use. It is well not to bring even the gloved hands in contact with the wound or dressings, but to use forceps to handle the dressings. If drainage has not been used and the wound is running an aseptic course it need not be dressed for from eight to ten days, and at this dressing the sutures should be renewed.

Details of an Antiseptic Operation.—The region of the wound being previously sterilized and the patient being anesthetized and placed upon the table, the clothing is so arranged as to expose freely the part to be operated upon; the clothing or skin surrounding this region is next covered with towels wet with a 1:1000 bichloride solution. If any considerable surface of the patient's body is covered by these towels, to avoid chilling the surface and adding to the shock which naturally follows the operation, they should be wrung out in a hot bichloride solution, and should be replaced as they become cold by hot towels prepared in the same manner.

During the operation the wound may be irrigated with a 1:2000 to 1:4000 bichloride solution. In prolonged operations, or in those in which a large wound is made, it is especially important that the irrigating solutions should be used as warm as can comfortably be borne by the hands of the surgeon; warm solutions, it has been shown by recent investigations, possess a greater germicidal power than those of the same strength when used cold, and they also possess the advantage of preventing chilling of the patient, and thus diminish the shock of the operation.

Hemorrhage during the operation is controlled by the use of hemostatic forceps. After the operation has been completed, and all hemorrhage has been controlled, the wound is thoroughly irrigated with a 1 : 4000 to 1 : 2000 bichloride solution.

Drainage is provided for by the use of perforated rubber drainage tubes or strips of gauze.

The rubber tube may be laid in the wound, the ends being allowed to extend from the extremities of the wound, or it may be so introduced that one end of the tube rests in the deepest part of the wound and the other extremity is brought out of the wound at its most dependent portion; in large or irregularly shaped wounds a number of tubes may be required to secure free drainage. The ends of the drainage tubes are transfixed with safety pins which have been sterilized or secured by a suture to the skin, and should next be cut off close to the pins or suture so as to be as nearly as possible flush with the skin.

The wound being closed by sutures, a final irrigation of its deepest parts should be made by injecting a stream of bichloride solution, 1 : 4000 to 1 : 2000, into the end of the drainage tube. Over this is laid the deep dressing, which consists of a pad of bichloride gauze from eight to sixteen layers in thickness, and large enough to overlap the wound 2 or 3 inches in all directions. This should be dipped in a 1 : 4000 to 1 : 2000 bichloride solution, and wrung out as dry as possible before being applied. The superficial bichloride gauze dressing is next applied, and consists of sixteen layers of gauze, which should be large enough to extend from 3 to 6 inches beyond the wound in all directions; this gauze is applied dry. Over the superficial gauze dressing there is next applied a number of layers of sterilized cotton, so arranged as to extend a little beyond the margin of the gauze dressing. These dressings are next secured in position by the application of a gauze bandage or adhesive straps. Iodoform, carbolized or any other variety of medicated gauze may be used in place of the bichloride gauze.

The dressing of the wound should be made with the greatest care as to asepsis. The bandage should be cut and removed and dressings removed by forceps, and the skin surrounding the wound covered with sterile towels. Rubber gloves should be worn and the dressings should be handled with forceps. The drainage tube is usually required for some days, but if there is no further indication for drainage it should be removed.

Redressings of the Wound.—If the wound is not running the typical course of an aseptic wound, constitutional symptoms will be developed, as evidenced by a rise in the temperature and pulse-rate and other constitutional disturbances. In this event the wound should be redressed as soon as possible, and if the cause of the disturbance can be found it should be removed; for instance, hemorrhage may have taken place into the wound, and the blood not being able to escape through the drainage tubes may have caused so much distention of the wound that the vitality of the skin covering the wound is threatened, or the sutures may be found to be causing irritation or suppuration may be present.

If, on exposure of the wound, it is found that it is distended with blood clots, and that blood is escaping from the wound, the sutures should be removed, the clots turned out and the bleeding vessel or vessels sought for and ligatured, and the wound, after a thorough irrigation with saline solution, should be drained and closed with sutures and dressed as previously described.

If, however, on exposure of the site of the operation, and upon the removal of a portion or all of the sutures, the wound is found distended with a blood clot, and no evidence of hemorrhage at the time exists or of suppuration in the wound, the clot may be allowed to remain in place and the wound should be redressed as in the original dressing, trusting to the organization of the blood clot if it has remained aseptic. If the patient's condition improves after the dressing, and the temperature and pulse-rate become normal it is an indication that the wound is still aseptic, and it need not be redressed for some days.

If, on the other hand, examination of the wound shows that the drainage is insufficient, or that the drainage tubes are occluded by blood clots, these should be removed by washing out the tubes with saline solution by means of a syringe, and introducing additional drainage tubes if it is deemed necessary; the wound should then be redressed.

When it is found on examination of the wound that suppuration is present the sutures should be removed, the wound opened up and Carrel-Dakin treatment applied. If the constitutional symptoms improve it may be assumed that the wound has been rendered aseptic.

Antiseptic Treatment of Infected Wounds.—It often happens that the surgeon is called upon to treat a wound which is septic when it comes under his care, as evidenced by the inflamed state of the wound, inflammation of the lymphatic vessels and skin, foul discharges and sloughing of the tissues, and the coexistent constitutional symptoms of sepsis. In such a case it would at first sight appear that the surgeon or his assistants could not introduce any infection worse than that which already existed in the wound, but he should bear in mind the fact that it is possible to introduce a new form of infection in addition to that already existing. With this possibility in view he should observe the same precautions as regards the sterilization of his hands, the region of the wound, the instruments and dressings, as he would employ in treating a perfectly fresh wound.

The most important part of the treatment of infected wounds is free drainage. The skin surrounding the wound should be dried by washing it with ether or benzene and tincture of iodine should next be applied. Free drainage is secured by the introduction of rubber drainage tubes or gauze wicks. The wound before the drainage is introduced should be flushed with peroxide of hydrogen followed by saline solution or 1: 2000 bichloride solution. Moist antiseptic dressing, gauze saturated with saline solution or bichloride solution, should next be applied and changed every three or four hours. The constitutional condition of the patient should also receive attention. Formerly the use of a 30-grain solution of chloride of zinc swabbed over the surface of the wound or a 2 per cent solution of formalin followed by moist antiseptic dressings was often employed with good results. At the present time the instillation of Dakin's solution by the Carrel-Dakin method is the treatment generally employed and is most efficient in these cases. The dichloramine-T dressing may also be used with good results. By these methods of treatment it is often possible to convert a septic wound into the aseptic one and have rapid improvement follow both in the local condition of the wound and in the constitutional condition of the patient.

PART IV.

FRACTURES.

In the following section the author has endeavored to confine himself simply to a description of the varieties of fracture and to their dressing and treatment, and he has tried as far as possible to avoid the multiplication of dressings, being satisfied to describe a few of the methods of dressing most frequently employed. He has also avoided the description of complicated splints and dressings, by the use of which in certain fractures most excellent results are obtained, but has preferred to recommend the employment of simple splints and dressings, which can be obtained by physicians practising in districts remote from large cities, where the services of an instrument maker cannot be obtained to construct special apparatus for the treatment of these injuries. The recently introduced suspension traction treatment of fractures of the long bone is described.

Varieties of Fractures.—Complete Fracture.—This is a fracture in which the line of separation completely traverses the bone, involving its entire thickness.

Incomplete Fracture.—This is a fracture in which there is only a partial separation of the bone fibers (Fig. 266), under which name is included *partial* or *"green-stick" fracture,* in which some of the bone fibers have given way, while the remaining fibers have been bent by the force, but have not been broken (Fig. 267). *Fissured, punctured, indented* and *perforating* fractures are also included in the class of incomplete fractures (Fig. 268).

Subperiosteal Fracture.—This is a fracture in which the fibers of the bone are ruptured but the periosteum remains untorn; it is seen in infants and young children.

Gunshot Fractures.—The nature of the injury to the bone depends upon the density of the latter, and upon the size, shape, composition and velocity of the ball. In gunshot

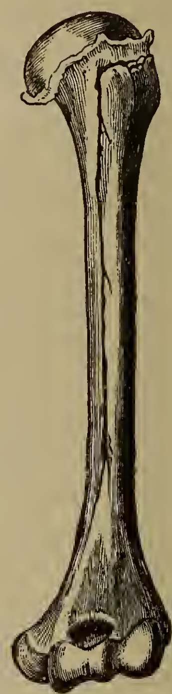
Fig. 266.

Incomplete fracture of femur.

Fig. 267.

Partial or green-stick fracture of radius.

Fig. 268.



Fissured fracture of the humerus.

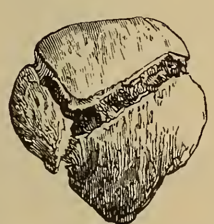
injury of the spongy bones the cancellated structure yields to pressure, and the striking energy is not transmitted in lateral directions, producing explosive effects; while in the dense bones, such as the submaxillary bones or the shafts of the long bones, extensive comminution and fissuring are apt to result. In the articular ends of the long bones clean perforations are often observed, except at close range, when more or less comminution of the cancellated structure may occur. The tissues from the wound of entrance to the bone are usually injured only in the line of perforation, but those beyond the seat of injury are often extensively lacerated and contused, not only by the ball, but also by the splinters of bone driven into the tissues and acting as secondary missiles.

Simple or Closed Fractures.—This is a fracture in which there are but two fragments, and the seat of injury in the bone does not communicate with the external air by a wound in the soft parts.

Compound or Open Fracture.—This is a fracture in which the seat of injury in the bones communicates with the external air by a wound in the soft parts.

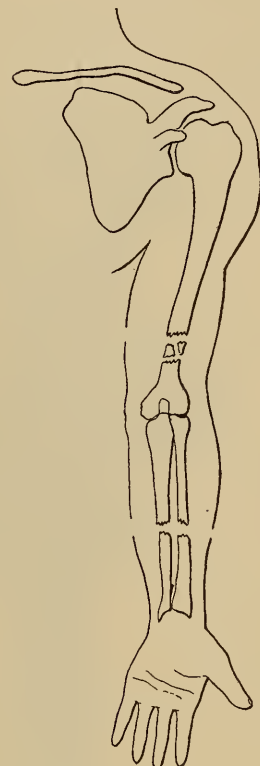
Comminuted Fracture. — This is a fracture in which there are more than two fragments, the lines of fracture intercommunicating with each other (Fig. 269).

Fig. 269.



Comminuted fracture of patella.

Fig. 270.



Multiple fracture of the upper extremity. (Ashhurst.)

Multiple Fracture.—This is a fracture in which a bone is the seat of two or more distinct fractures at different points, the lines of fracture not necessarily communicating with each other. (Fig. 270).

Complicated Fracture.—This is a fracture accompanied by some serious injury of the parts in the region of the fracture—as, for instance, the laceration of important bloodvessels or nerves, contusion or laceration of the muscles or dislocation of a neighboring joint.

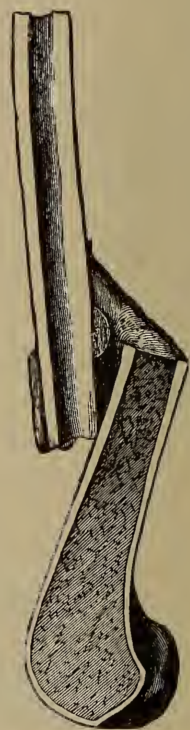
Impacted Fracture.—This is a fracture in which one fragment is driven into and fixed in the other, the impaction taking place at the time of fracture, or being caused by a force subsequently applied (Fig. 271).

Transverse Fracture.—This is a fracture in which the general line of division of the bone is at right angles with the long axis of the bone (Fig. 272). Transverse fractures of the long bones are rarely met with, the line of fracture usually being more or less oblique.

Fig. 271.

Impacted fracture.

Fig. 272.



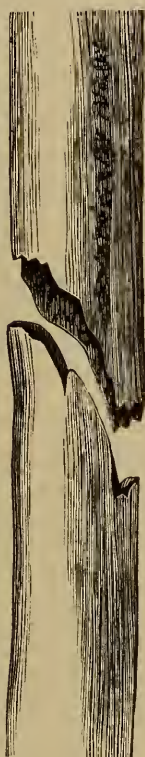
Transverse fracture of femur.

Oblique Fracture.—This is a fracture in which the line of separation is oblique to the long axis of the bone. This is one of the most common directions of the line of fracture (Fig. 273).

Longitudinal Fracture.—This is a fracture in which the line of separation runs in the general direction of the long axis of the bone (Fig. 274). This form of fracture is rare, but is sometimes met with in the long bones as the result of gunshot injury.

Symptoms of Fracture.—The most prominent symptoms of fracture are loss of function, deformity, preternatural

Fig. 273.



Oblique fracture of humerus.

Fig. 274.

Longitudinal fracture of tibia.

mobility, pain, crepitus and muscular spasm. In impacted fractures, crepitus and preternatural mobility are absent.

Prognosis of Fracture.—This is good as far as the patient's life is concerned; the general mortality in a large series of statistics is about 2.5 per cent. Compound and complicated fractures have a much higher mortality, about 25 per cent.

Death following fractures may result from shock, hemorrhage, visceral injuries, embolism, delirium tremens and fat embolus and in the aged from exhaustion.

Deformity.—The deformity or displacement in fractures is either *angular, transverse, longitudinal* or *rotary.*

Examination of Fractures.—In examining a case of fracture to locate the nature and seat of the injury the clothing should be removed from the part with as little disturbance as possible, and it is better in most cases to cut or rip the clothing rather than to attempt to remove it in the ordinary manner. The surgeon should first inspect the injured part and where possible compare it with its fellow, as in the case of injuries of the extremities; much valuable information is also derived from the patient or his friends as to the manner in which the injury was produced. The part should next be carefully examined by the surgeon; if it be one of the extremities which is injured it should be gently lifted, firm extension being made at the same time, the surgeon by his touch and by gentle movements seeking to locate the seat of fracture; and he may, by his manipulation, at the same time develop crepitus.

All manipulations should be made with care, and with the greatest gentleness, not only to save the patient from pain, but also to prevent the soft parts in the region of the fracture from being injured by the rough or sharp fragments of the bone. Rough handling of fractures may increase the muscular spasm by the irritation caused by the sharp fragments of the bones and may also result in the injury of important vessels and nerves, and indeed a simple fracture may easily be converted into a compound one by forcible and injudicious manipulations.

The sooner the examination is made after fracture has occurred the better, for at this time there is less swelling in the region of the injury, and the surgeon can locate the bony prominences with much more ease and often discover the exact seat of the fracture with the least amount of manipulation of the parts. When a case of suspected fracture is not subjected to examination for several days after reception of the injury, the parts in the region of the supposed fracture are often so much swollen that it is impossible to accurately locate its seat, and in such a case a roentgen-ray examination should be made.

Anesthetics in Examination of Fractures.—These may be employed to relieve the patient from pain and to obliterate muscular spasm in the examination of fractures. Their employment is often of the greatest service in the diagnosis of obscure or complicated fractures, especially those in the neighborhood of joints; but the surgeon should remember that all manipulations should be made with the same gentleness as when the examination is conducted without anesthesia, for there is the same risk of injury to the surrounding structures by the fragments; this precaution is often neglected when an anesthetic has been given, the surgeon being inclined to handle the parts more roughly than he otherwise would; such practice cannot be too severely condemned.

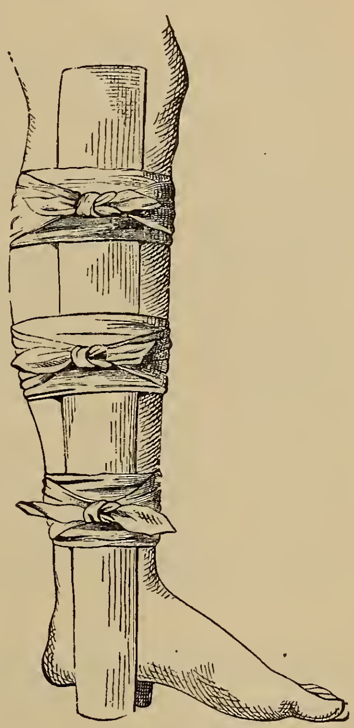
Ether is the most satisfactory anesthetic for this purpose as by its use complete relaxation may be obtained, but nitrous oxide may be used.

Roentgen-ray Examination.—This method of examination is now very widely employed in fractures. The use of the fluoroscope or of a roentgenograph taken by the roentgen rays has proved a valuable means of ascertaining the existence, location and nature of the fracture in obscure cases. It is advisable in every case of fracture where it is possible to have an roentgen-ray examination and if possible to have another examination after the case has been under treatment for a short time to ascertain if the fragments are in good position. This form of examination has done much to increase our knowledge of fractures. By this method of examination we have learned that comminution is much more common in fractures than was generally supposed. Distortion of the image sometimes occurs from the direction in which the rays are applied, and this fact should not be lost sight of in examining roentgen-ray plates.

Repair of Fractures.—Bone reacts to injury or disease in much the same way as the other tissues, but the phenomena of inflammation and repair are less active and slower than in the soft tissues. When a bone is fractured the surrounding soft parts are more or less damaged and react to the injury by the process of inflammation. A blood clot forms in the medullary cavity, between the broken ends and under and outside of the periosteum. Various cellular tissues in the injured region; bone cells from the marrow and periosteum, muscle cells, connective-tissue cells and leukocytes proliferate and aid in removing débris and cause organization in the mass of inflammatory lymph which is formed. The intercellular substance of the bone is temporarily absorbed on removal from the fractured ends by osteoclasts and the exudate forming between the fragments, which is known as callus, is analogous to the inflammatory lymph which surrounds it or with which it is continuous. During the regeneration the bone ends soften and are partly absorbed by osteoclasts. This callus is derived largely from the medulla of bone by proliferation of osteoblasts. In the course of two weeks the callus, after passing through a cartilaginous stage, becomes impregnated with lime salts. The callus as organization proceeds gradually becomes condensed, the central callus is not entirely absorbed and complete restoration of the medullary canal is rare. The process of repair begins a few days after the occurrence of fracture. In simple fractures union is usually firm in four weeks, but in compound and comminuted fractures union is often much delayed.

Provisional Dressings of Fractures.—It generally happens that fractures occur at localities more or less distant from the point where the treatment of the fracture is to be conducted and the transportation of the patient and the temporary dressing of the fracture are, therefore, matters of the first importance. In fractures of the *upper extremity,* if the fractures be simple, the clothing need not be removed, and the arm should be bound to the side by some article of clothing, or supported in a sling made from handkerchiefs or the clothing, and the patient can usually walk or ride for a short distance without much injury to the parts in the region of the fracture or inconvenience to himself. When the bones of the *lower extremities* or the trunk are the parts involved, the transportation of the patient is a matter of more difficulty. When the bones of the *trunk* are involved, the part should be surrounded by a binder firmly pinned or tied, made from clothing or from towels or sheets or other strong materials which are at hand. When the bones of the *lower extremity* are involved, if the fracture be a simple one the clothing need not be removed, and the motion of the fragments should be prevented by applying to the sides of the limb, extending above and below the seat of fracture, strips of wood, shingles, pasteboard, bundles of straw, strips of bark taken from trees or bundles of twigs, these being held in place by handkerchiefs or strips torn from the clothing (Fig. 275). Umbrellas or canes or broomsticks applied in the same manner may be employed, the object of all of these dressings being to secure temporary fixation of the fragments of bone during the transportation of the patient.

Fig. 275.

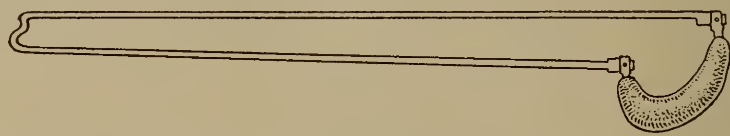


Provisional dressing for fractreu of the leg.

Transportation of Fractures of the Extremities. — The use of Thomas' splints for the transportation of fractures of the upper or lower extremity is most satisfactory. For transporting a fracture of the lower extremity the Thomas knee splint (Fig. 276) is employed and for those of the upper extremity the Thomas humerus splint (Fig. 277) is used. Temporary extension at the same time may be made by applying a band around the wrist or ankle and securing it to the loop at the end of the splint. The results following this method of temporary fixation and extension have been so satisfactory that the majority of hospital ambulances are equipped with these splints.

If the fragments are not fixed in some way, but are allowed to move about during the transportation of the patient, much damage may result to the soft parts surrounding the fractured bones, and simple fractures may become compounded ones by the bones being forced through the skin, the discomfort of the patient at the same time being much increased.

Fig. 276.



Half-ring modification of Thomas' splint for transport of fractures of the lower extremity. (Ashhurst.)

Having applied a dressing to bring about fixation of the fragments, the patient should next be placed upon a broad board or settee; if a mattress cannot be obtained the fractured limb should be laid upon a mass of clothing, or upon straw, and he should be placed in a wagon or carried to the point where the subsequent treatment of the fracture is to be conducted.

Fig. 277.

Hinged Thomas' splint for transport of fractures. (Ashhurst.)

Reduction or Setting of Fractures.—This should be effected as soon as possible after the occurrence of the injury and as soon as the surgeon is prepared to apply the dressings to keep the parts in their proper position; reduction at an early period is less painful to the patient, and is accomplished with more ease to the surgeon than at a later period, when marked inflammation and swelling are present at the seat of fracture. Reduction consists in bringing the fragments by manipulation, as nearly as possible in their normal position; this is accomplished by extension and manipulation with the hands, care being taken to use as little force as possible to attain the object. Very little force is required if the surgeon places the part in such a position as to relax the muscles which produce the displacement; when this is accomplished, the fragments can usually be pressed into position by the fingers without the application of considerable force. A roentgen-ray examination should be made after these manipulations to show satisfactorily that the reduction has been accomplished. When the reduction of a fracture has been accomplished the fragments are retained in position by the application of various splints or dressings which serve to prevent their displacement.

Materials and Appliances Used in the Dressing of Fractures.—The Fracture Bed.—Many ingenious forms of beds have been devised for the use of patients suffering from fractures of the bones of the trunk and lower extremities, with the object of permitting the patient to have fecal evacuations without disturbing his position; but a simple bedstead provided with a firm hair mattress is usually more satisfactory than the complicated form of bed.

It will be found more convenient in handling the patient to use a single bed not over 32 or 36 inches in width, and it is not essential that the mattress be perforated, as a bed-pan can usually be slipped under the patient. The use of an ordinary shallow tin pie-plate covered with a piece of old muslin to receive the fecal evacuations may be substituted for the bed-pan, and will be found in many cases more satisfactory, especially in the case of children suffering from fracture of the lower extremities.

Splints.—After the reduction or setting of the fragments in cases of fracture, they are usually retained in position until union occurs by the use of splints held in position by means of bandages or strips of muslin. Splints may be made of wood, or of tin, lead, copper, or wire, binders' board, leather, felt, paper, gutta-percha or plaster of Paris.

Wooden Splints.—The simplest splints are made from wood—white pine, willow or poplar being the best material to employ for their construction, being sufficiently strong to give fixation to the parts and at the same time being light. Splints made from smooth white pine, willow or poplar boards from $\frac{1}{8}$ to $\frac{1}{4}$ inch in thickness may be employed in the form of straight or angular splints, and their preparation is a matter of little difficulty.

Wooden splints before being applied to the part should be well padded with cotton, oakum or hair; and where lateral wooden splints are employed in the treatment of fractures of the lower extremity it is usual to place bandages or junk bags between the limb and the splint. The carved wooden splints which are sold by the instrument makers are not to be recommended, as a rule, for unless the surgeon has a large number to select from, it is rare that a splint can be obtained to accurately fit any individual case.

Binders' Board Splints.—Binders' board is an excellent material from which to construct splints; it is first soaked in boiling water, and when sufficiently soft is padded with cotton or a layer of lint and moulded to the part. It may be secured in position by a bandage; as it becomes dry, it hardens and retains the shape into which it was moulded.

Undressed Leather Splint.—Undressed leather is a good material from which to construct splints; it is applied by first soaking the leather in boiling water, and after padding it with cotton or lint it is moulded to the part and retained in position by a bandage.

Felt Splints.—These are made from wool saturated with gum shellac and pressed into sheets. This material is prepared for application to the surface by heating it before a fire until it becomes pliable or by dipping it into boiling water.

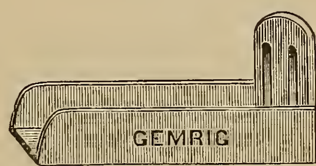
Gutta-percha Splints.—These are made from sheets of this material from $\frac{1}{16}$ to $\frac{1}{5}$ inch in thickness, and may often be employed with advantage. The splint is prepared for use by immersing it in hot water; when it becomes soft it can be moulded to the surface. Care should be taken that it is not allowed to become too soft by long immersion, as it then cannot be conveniently handled.

Paper Splints.—These are made from layers of Manila paper stiffened with starch and constitute a very fair substitute for some of the varieties of splints previously mentioned.

Plaster of Paris, Starch, Chalk and Gum, Silicate of Potassium or Sodium Splints.—These may be employed for the construction of splints, either movable or immovable, in the treatment of fractures; their methods of preparation and application are described on page 93 *et seq.*; the plaster-of-Paris dressing is the one which is most generally used at the present time.

Fracture Box.—This is a form of splint used in the treatment of fractures of the lower extremity, and consists of a board 18 to 20 inches in length, with a foot board firmly secured at its lower extremity; the sides are secured by hinges which allow them to be raised or lowered (Fig. 278). A fracture box of greater length is required for the treatment of fractures about the knee-joint.

FIG. 278.



Fracture box with movable sides.

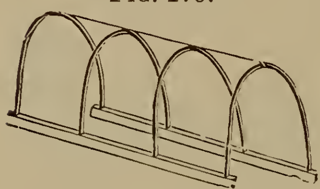
Bran, Sand or Junk Bags.—These are constructed by taking a piece of unbleached muslin 5 feet in length and $14\frac{1}{2}$ inches in width, doubling it, and securing the free margins, except at the mouth, by stitches so as to form a bag; the bag is then inverted so that the edges of the seams are brought on the inner surface of the bag. The bag is next filled with dry sand, bran, hair or straw and the mouth of the bag is closed by stitches or by being tied with a string. Bran bags with splints or sand bags are frequently employed in the treatment of fractures of the femur.

Bandages.—These are made of muslin and are used to retain splints in the treatment of fractures and are also sometimes applied directly to the injured part before the application of splints to control muscular spasm and limit the amount of swelling; when a bandage is so used it is known as *primary roller.* The use of the primary roller is sometimes of the greatest service in the dressing of fractures, but its use in inexperienced hands has so often been followed by unfortunate results in the early treatment of fractures, or in cases which are not under constant observation, that I think it a safe rule of practice to discard entirely the use of the primary roller.

Compresses.—These are made from a number of folds of lint, or of cotton or oakum, and are often employed to retain fragments in position or to make localized pressure upon certain points in the treatment of fractures. The compresses are held in position by strips of adhesive plaster, by a few turns of a roller bandage or by the splints. Compresses are sometimes employed to protect bony prominences of the skeleton from the pressure of the splints, but this purpose is often better effected by the use of small pieces of soap plaster spread on chamois skin fitted over the prominent points.

Rack or Cradle.—This is made of wire or wooden hoops, and is often employed to support the weight of the bed-clothes in the treatment of fractures of the lower extremity (Fig. 279).

Fig. 279.



Rack for supporting bed-clothes in fractures of the lower extremity.

Evaporating Lotions in Fracture.—The employment of evaporating lotions such as lead-water and laudanum, or muriate of ammonium and laudanum or a solution of magnesium sulphate, to the skin in the region of fractures is highly recommended by many surgeons, especially in fractures involving or situated near joints. They are here employed to relieve pain, to limit inflammatory swelling and to hasten absorption of the blood and serum at the seat of fracture. Many surgeons, on the other hand, think that their use causes irritation of the skin and delays the process of repair in the union of the fracture, and strongly condemn their employment. Personally, I have never seen bad results from their use, and have generally employed them in fractures near or involving the joints; but I do not consider their employment essential, and when I use them I do so for only two or three days. In cases of fractures accompanied with much pain and swelling, when the surgeon does not wish to use any of the lotions named, an ointment of ichthyol, 1 part, lanoline, 3 parts, spread on lint and wrapped around the limb, will often prove a satisfactory dressing, or a layer of cotton may be simply wrapped around the part before the application of the splints.

Massage in the Treatment of Fracture.—Lucas-Championnière advocates and practises immediate and continuous massage in the treatment of fractures, and holds that by its use pain is diminished, repair of the bone hastened by the profuse deposit of callus, and atrophy of muscles and stiffening of joints avoided.

Massage is employed as soon as possible after the fracture has occurred, and consists in manipulations with the thumb, the fingers, or the whole hand. The limb is held by an assistant and extension is made, or it is placed upon a firm pillow or a sand cushion. The manipulations should be made in the direction of the muscular fibers and of the blood current, and firm pressure should not be made directly over the seat of fracture.

Massage should be practised for from fifteen to twenty minutes daily, and no retention apparatus should be applied in the intervals unless there is marked tendency to displacement of the fragments, when some form of retention apparatus or splint may be used. These manipulations should be continued for some weeks, until union is firm at the seat of fracture. Massage has also been combined with the ambulatory method of treatment of fractures of the lower extremity. This method of treating fractures by massage may be said to be still on trial, sufficient experience not yet having accumulated to prove that it possesses marked advantage over the generally adopted method of treatment by immobilization.

Operative Treatment of Simple Fractures.—Since the comparatively safety of operations under strict aseptic precautions has been demonstrated, the operative treatment of simple fracture attracted much attention. The advantages claimed by this method are accurate apposition of the fragments, and their fixation by plates, nails, screws or sutures, thus favoring prompt repair and diminishing the risk of non-union and deformity.

There is no doubt that exposure of the fragments enables the surgeon to reduce the deformity and fix them accurately by means of mechanical appliances; but it should not be forgotten that the conversion of a simple fracture into a compound one entails a definite risk of infection in spite of the strictest precautions. At the present time the operative treatment of simple fractures is not employed as frequently as it formerly was. There are certain simple fractures where this method of treatment is to be most strongly recommended; for instance, in those fractures where it is impossible to reduce the deformity by manipulation and in those in which the deformity persistently recurs after reduction, and in fractures where it is evident that the soft tissues are interposed between the fragments.

In fractures of the patella the functional results of this method of treatment are so superior to those following the non-operative method that the former procedure is now generally employed.

The surgeon making use of this method of treatment of fractures should have in mind the value of perfect aseptic technic.

SEPARATION OF THE EPIPHYSES.

This lesion consists in a separation of the epiphysis of a bone from its diaphysis. The epiphyses are entirely cartilaginous in infants, but ossification occurs later at various periods for different bones. The separation may occur at any time from birth up to the twenty-first year. The age at which traumatic separation of the epiphyses has been most observed is from the twelfth to the fifteenth year. Epiphyseal separations may be *simple* or *compound.*

Simple Separations.—Traumatic separations of the epiphyses may result from direct and indirect violence, from traction or torsion and in rare cases from muscular action. The injury is always accompanied by stripping of the periosteum from the end of the shaft of the bone, but it generally remains firmly attached to the epiphysis. Separation of the epiphyses in children results from the application of considerable force; according to Poland, an injury which would be able to produce a dislocation in an adult will in a child usually result in a separation of an epiphysis. Separation of the epiphyses may result from disease, as in tuberculous and syphilitic ostitis and acute infective ostitis. Suppuration in the region of an epiphysis may result in its separation.

Compound separations of the epiphyses are frequently met with, being most common at the lower epiphysis of the femur and the upper epiphysis of the humerus. These are grave injuries, from the fact that infection is apt to occur, resulting in suppurative osteomyelitis and necrosis, followed by arrest of growth of the limb and shortening.

Symptoms.—These are mobility, deformity, crepitus, loss of function, pain and swelling. Mobility, which exists at a point where it should not be observed, is a most important symptom, and is most marked if the separation of the periosteum be extensive. Deformity is also more marked than in fractures, the smoothness of the separated surfaces permitting of displacement; this varies with the amount of displacement of the diaphysis and the amount and mode of application of the force. Crepitus is soft and muffled; loss of function is usually marked and pain and swelling at the seat of injury are soon followed by extravasation of blood.

Diagnosis.—Separations without displacement are difficult to diagnose and are often considered as sprains of joints. In infants this lesion is difficult to recognize, and often escapes detection, but may be followed in a few weeks by swelling, suppuration and symptoms of chronic osteomyelitis.

Separation of the epiphyses is most apt to be confounded with fracture or dislocation; the diagnosis is made from fracture by observing the line of separation, shape of the displaced epiphyseal fragment, the deformity (which is very characteristic in certain separations), and the soft character of the crepitus. From dislocation, the diagnosis is based upon the following signs: Dislocations are rare in infants and children. In separations of the epiphyses if the displacement is reduced it tends to recur upon removal of the force; while in dislocation if reduction is accomplished it is not likely to recur when the force is removed. Rigidity is present in dislocation, while preternatural mobility is marked in epiphyseal separation. In many joints the epiphysis will still be found to be connected with the joint and to retain its normal relations with the surrounding articular structures. In compound separations of the epiphyses the diagnosis may be made by observing that the displaced end of the bone is not covered by articular cartilage. A roentgen-ray examination is valuable in the diagnosis of this injury.

Prognosis.—Union of the separated epiphyses occurs by the same process as that of a fracture. The amount of callus, which is formed largely by the periosteum uniting the fragments, varies with the completeness of their reduction. Non-union has never been observed in this injury. Anchylosis of the neighboring joint may result in spite of the greatest care in the reduction of the deformity and in the treatment, yet permanent deformity may be present and interfere very little with the function of the limb. Arrest of growth of the limb after this injury in young subjects may be observed, but is not a necessary result, for the epiphyseal cartilage may perform its function as completely as before the injury, but is more apt to occur if the separation takes place between the epiphyses and the epiphyseal cartilage or the cartilage itself is severely injured. Arrest of growth is not marked in many cases, for the reason that the injury occurs at a period when the growth of the skeleton is almost complete.

Treatment.—This consists in reduction of the deformity, which in many cases is difficult unless an anesthetic be administered, and fixation of the parts after reduction by the use of splints and bandages, the dressings employed being similar to those used in fracture at a corresponding portion of the bone. Muscular wasting should be prevented by the early employment of massage. Compound separations of the epiphyses are treated in the same manner as compound fractures, great care being taken to render the wound aseptic and to maintain it in this condition. The treatment of special epiphyseal separation is considered under fracture of these parts.

DRESSING OF SPECIAL FRACTURES.

Fracture of the Nasal Bone.—Fractures of the nasal bones are often accompanied with fractures involving the septum, the nasal process of the maxillary bone and the nasal spine of the frontal bone (Fig. 280).

Treatment.—This consists in replacing the fragments, if displacement exists, by manipulation with the fingers over the seat of fracture and by pressure made from within the nostrils by a probe or a steel director. When the displacement is once corrected it is not apt to recur, and in the majority of cases no dressing is required. Before resorting to any manipulation within the nasal cavities the mucous membrane should be thoroughly cocainized to render the operation painless. When there is a return of the depression of the fragments or displacement of the septum after correcting the deformity by raising the depressed fragment, or bending the septum into place with a director, the parts may be held in position by packing the nasal cavity firmly with a strip of antiseptic gauze or by the use of Asch's tubes. These are curved and perforated flattened vulcanized rubber tubes moulded to fit the nasal passages.

Fig. 280.

Fracture of nasal bones, eighteen hours after injury. (Ashhurst.)

In lateral displacements of the nasal bones from fracture, after reducing the displacement a small compress held over the fragment by strips of adhesive plaster will be the only dressing required. Narrow strips of gauze, fastened to the nose by collodion and drawn toward the cheek and fastened by collodion may be used to correct the deformity and hold the fragments in place.

Profuse hemorrhage sometimes occurs after fracture of the nasal bones, and may require plugging of the nares to control it. Fractures of the nasal bones are usually quite firmly united in two weeks and dressings may be dispensed with after this time.

Fractures of the Malar Bone and Zygoma.—These fractures are usually the result of direct force; the displacement is upward or backward, and when the zygomatic arch is broken the fragments from pressure upon the masseter muscle or on the tendon of the temporal muscle may interfere with the movements of the lower jaw in mastication (Fig. 281). This displacement is corrected by cutting down upon the fragment and elevating it or by passing a tenaculum into the fragment and raising it. Outward displacements may be corrected by pressure and the application of a compress.

Treatment.—The dressing of these fractures after the correction of the deformity consists in the application of a compress of lint over the seat of fracture, held in position by strips of adhesive plaster or a bandage. There is little tendency to recurrence of the deformity after it has been corrected, and union at the seat of fracture is usually firm at the end of three weeks.

Fig. 281.

Fracture of right malar bone. (Ashhurst.)

Fractures of the Upper Jaw.—These fractures may involve the *body*, the *nasal processes* or the *alveolar processes*.

Treatment. — The deformity should be corrected, and if any teeth have been displaced they should be replaced; if there is comminution of the alveolus the teeth in the separate fragments may be fastened together by fine wire to fix the fragments and hold them in place; the teeth of the lower jaw should be brought up in contact with those of the upper jaw, and the jaws should be secured together by the application of a Gibson or a Barton bandage (Figs. 282 and 283). Interdental splints, made of silver or aluminum with grooves to fit the teeth, or of gutta-percha, are also employed in the dressing of these fractures. The patient should not be allowed to move the jaw in mastication, and should be nourished by liquid and semisolid food, which may be taken without removing any teeth to give space for its introduction. The bandage should be removed every second or third day, and it should be reapplied in the same manner. Union is usually firm at the end of four or five weeks, and dressings may be dispensed with at this time.

Fractures of the Lower Jaw.—Fractures of the lower jaw may involve the body, ramus, the condyle or the coronoid process, the most usual seat of fracture being near the mental foramen; it is often broken at two places at once; if these fractures be one on each side of the symphysis, the tongue may fall back and interfere with the patient's respiration. These fractures are in many cases rendered compound by laceration of the mucous membrane, or the injury may consist in a separation of a portion of the *alveolar process* of the bone.

Fig. 282.

Dressing for fracture of the upper jaw.

Fig. 283.

Dressing for fracture of the lower jaw.

Fracture through the neck of the condyle is a serious injury which leads to anchylosis. The external pterygoid muscle rotates the condyloid fragment forward. Fracture of the coronoid process is a very rare accident and difficult to detect except by roentgen-ray examination.

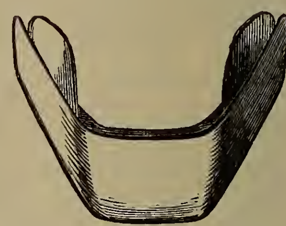
Treatment.—The dressing of a fracture of the lower jaw, after reducing the displacement and replacing any loosened or detached teeth, consists in applying a pad of lint under the chin and bringing the jaw up against the upper jaw, holding the compress in place and securing the jaws firmly in contact by applying a Barton (Fig. 283), a modified Barton or a Gibson bandage. The bandage should be removed and reapplied at the end of the second or third day, and at like intervals during the course of treatment. The patient should be fed upon a liquid or semisolid diet, not being allowed to chew solid food until union at the seat of fracture has become firm. A very satisfactory temporary dressing for a fracture of the lower jaw consists in the application of a four-tailed sling.

Some surgeons prefer to use an external splint moulded from pasteboard or gutta-percha fitted to the chin in the dressing of this fracture (Figs. 284 and 285), this being padded with cotton and held in place by a Barton or Gibson bandage.

Fig. 284.

Shape of splint before being fitted to chin. (Roberts.)

Fig. 285.



Splint moulded to fit chin. (Roberts.)

Where there is much difficulty in keeping the fragments in position wiring together of the teeth may be employed, or the fragments may be perforated with a drill and held in place by a strong silver wire suture. In double fractures on each side of the symphysis if the tongue falls back the fragments should be fixed by wiring. In fracture of the condyle, as it is difficult to correct the deformity by manipulation, operation is indicated. Interdental splints of metal or gutta-percha are also sometimes used for this purpose. The best results in fractures of the jaw with marked displacement are obtained by the use of interdental splints; a plaster cast of the teeth is first made and from this is constructed a gold, silver or aluminum splint, which fits the teeth accurately. The splint may be cemented to the teeth in one jaw or may be worn between the jaws, being held in position by holding the jaws together by a Barton bandage. During the course of treatment of fracture of the jaws the mouth often becomes very offensive from fermentation of the saliva and discharges, and it is well to use frequently a mouth wash of chlorate of potassium and tincture of myrrh or boric acid solution.

The dressings for fracture of the lower jaw are applied for four or six weeks, the union usually being quite firm at the end of this time.

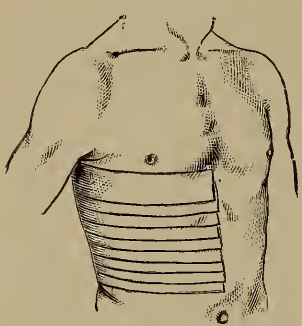
Fracture of the Hyoid Bone.—In fracture of the hyoid bone if displacement exists its reduction is facilitated by pressure made with the finger in the pharynx.

Treatment.—This consists in enforced quiet and the use of opium if cough is a prominent symptom, and the inflammatory symptoms may require the employment of active local treatment. A dressing may sometimes be employed with advantage, consisting of a splint of pasteboard or leather moulded to the anterior portion of the neck.

Fractures of the Larynx or Trachea.—In fractures of the larynx or trachea where there is little displacement and dyspnea is not marked, the parts should be supported by the application of compresses of lint held in place by strips of adhesive plaster. In fractures of larynx the thyroid cartilage is the one most frequently involved, and serious asphyxia may develop from edema of the glottis. If, on the other hand, the respiration is embarrassed or there is free expectoration of blood, tracheotomy should be performed, and if the injury be seated in the larynx the displacement of the fragments may be overcome by manipulation with the finger or a director through the tracheal wound, or the larynx may be packed with a strip of antiseptic gauze to control hemorrhage or hold the fragments in position, the patient in the meantime breathing through a tracheotomy tube secured in the tracheal wound; the packing should be removed in a few days, the tracheotomy tube being permanently removed as soon as the patient can breathe comfortably through the larynx with the tracheal wound closed. In fracture of the trachea the opening into the trachea should be below or at the seat of injury.

Fractures of the Ribs.—Fractures of the ribs are more frequent than fractures of any other bones of the trunk; this injury is extremely rare in children and most common in male adults; the ribs most commonly broken are those from the fourth to the tenth; the most common seat of fracture is near the anterior or posterior portion; the displacement is usually not marked unless a number of ribs be broken, being prevented by the intercostal muscles and aponeuroses. The marked symptoms are pain on forced inspiration and upon sudden motion, localized tenderness and sometimes distinct mobility and crepitus; this can often be detected by the use of a stethoscope. Visceral injuries are not usual, but may be serious; subcutaneous emphysema, from rupture or puncture of the lung, hemothorax and traumatic pneumonia.

Fig. 286.



Adhesive plaster dressing for fracture of the ribs.

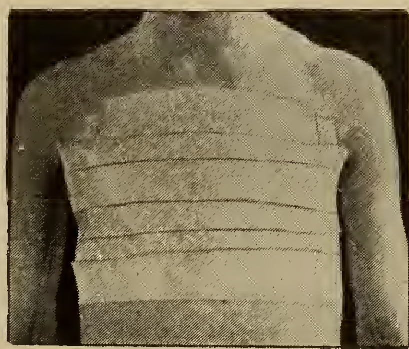
Treatment.—The dressing of fractures of the ribs is best accomplished by enveloping the side of the chest on which the rib or ribs are broken with broad straps of adhesive or rubber plaster. The adhesive straps should be $2\frac{1}{2}$ inches in width and sufficiently long to extend from the spine to the middle of the sternum. The straps are warmed and the first strap is firmly applied at the base of the chest, extending from the spine to the midsternal line; a number of ascending straps are applied in this way, each strap overlapping the preceding one by about one-third of its width until half the chest is covered in (Fig. 286). This dressing usually gives the patient much comfort, and the straps need not be renewed until they become slightly loosened, usually at the end of a week or ten days; they should then be renewed in the same manner. The dressings are usually dispensed with at the end of three or four weeks, as repair of the fracture is generally well advanced at this time.

A satisfactory temporary dressing consists in surrounding the chest by a broad binder of stout linen or muslin; indeed, some surgeons prefer to employ this dressing during the course of treatment but, as a rule, I think it is not as good a dressing as the adhesive plaster dressing, as the former confines the movements of both sides of the chest.

Fractures of the Costal Cartilages.—These fractures often take place at the junction of the cartilages with the ribs or in the body of the cartilages, and the union of the fracture usually takes place by the production of a mass of bone at the seat of fracture.

Treatment.—It consists in the application of strips of adhesive plaster applied in the same manner as for fracture of the ribs and the dressings should be retained for about the same time.

Fig. 287.



Adhesive plaster dressing for fracture of the sternum.

Fractures of the Sternum.—Fractures of the sternum are rare injuries, but diastasis of the bones of the sternum is a more common accident. This injury usually results from crushing force; inward displacement of the fragments may produce visceral injury as evidenced by hemoptysis, dyspnea, cyanosis and subcutaneous emphysema. Fracture of the ensiform process with backward displacement may cause gastric symptoms.

If inward displacement of the fragment is marked, its reduction can sometimes be accomplished by making hyperextension over a small pillow and drawing the arms backward.

Treatment.—The treatment for both fracture and diastasis is the same and consists in the application of a compress over the seat of fracture held in place by a broad bandage, or, better, by strips of adhesive plaster (Fig. 287) applied so as to cover and fix the anterior portion of the chest, covering the entire length of the sternum. This dressing should be retained for at least four weeks, being renewed if it becomes loose at the end of a week or ten days.

Fractures of the Pelvis.—These fractures are usually caused by direct violence and may involve the *ilium, ischium, pubis* or *sacrum.* Vertical fractures, either single or double, may occur; the latter break the pelvic ring and are not uncommon. Separations of the pelvic bones from their junctions may also occur as well as fracture of the rim of the acetabulum from force transmitted through the femur, and are often serious injuries from implication of the pelvic viscera. Visceral injuries from fracture of the pelvic bones occur in about one-sixth of these cases, and have a mortality of 30 per cent.

Treatment.—The reduction of the displacement should be first accomplished as far as possible by external manipulation, together with internal manipulation by the fingers introduced into the rectum, or into the vagina in the female. The patient should be placed upon a firm bed on his back, with the knees slightly flexed over a pillow, and the parts should be kept at rest by surrounding the pelvis with broad straps of adhesive plaster or a stout muslin binder, or by a firmly applied padded pelvic belt. The hip-joints should be kept at rest by the application of pasteboard splints or by sand bags. Fractures and diastases of the pelvic bones may also be satisfactorily treated by the application of a plaster-of-Paris dressing. The parts being well padded with cotton, a plaster dressing is applied to include the upper portion of both thighs, the pelvis and a portion of the trunk. The dressings should be retained for a period of at least six weeks.

When these fractures are complicated by injury of the pelvic viscera various operative procedures may be required, which will compel the surgeon to modify the method of dressing.

Fractures of the Sacrum and Coccyx.—The dressing of fractures of the *sacrum,* after effecting reduction of the fragments as far as possible by pressure from within the rectum, consists in the application of broad adhesive straps around the pelvis, the patient at the same time being kept at rest in bed.

When the *coccyx* is fractured, after reduction of the displacement, which may sometimes be accomplished by manipulation with the finger in the rectum, the patient should be confined to bed and the bowels kept at rest by the use of opium by suppository. The patient should remain in bed for two or three weeks.

Fractures of the Vertebræ.—Fractures of the vertebræ are always most serious injuries, not only from the damage to the bones themselves, but also from that to the spinal cord, membranes and nerves which often accompanies them. These injuries are often associated with dislocations of the vertebræ, so that the term *fracture-dislocation* is used to describe them. This combined lesion occurs in 60 per cent of cases of injury of the spinal column, while isolated fractures and dislocations form each about 20 per cent of these injuries. In transporting or turning in bed a patient suffering from fracture of the vertebræ great care should be exercised, for rough or sudden motions may cause a displacement of the fragments which might, by injury of, or pressure upon, the spinal cord, rapidly prove fatal. The prognosis is always bad in vertebræ fractures; as a rule, the higher the injury the graver is the prognosis. Recovery without loss of function may follow fractures of the lower lumbar vertebræ.

Treatment.—If the deformity is marked, effort should be made to reduce it by extension and counter-extension; and the result may be successful, especially if the fracture be associated with a dislocation of the vertebræ. In some cases the use of permanent extension by means of weights attached to the legs, shoulders and chest by adhesive plaster and bandages has been successful in reducing the deformity. Laminectomy may be practised in certain cases—where it is probable that pressure symptoms are due to some extramedullary lesion, displaced bone or blood clot.

The patient should be placed upon his back upon a bed with a hair mattress, or better, if it can be obtained, a water bed, which consists of a rubber mattress filled with water which distributes the weight of the patient's body evenly over the surface. Whatever form of bed be used, the greatest care should be exercised to keep the patient absolutely clean, and the parts of the body or limbs which are exposed to pressure should be frequently bathed with alcohol or soap liniment; and to distribute the pressure small pads should be placed under the parts and changed at intervals. These precautions are necessary to prevent, if possible, the formation of extensive bed sores, which are a frequent and troublesome complication of these injuries.

The *bowels* should be carefully watched, and, if constipation is present it should be relieved by the use of enemata; and, as it is not desirable to lift the patient to slip a bed pan under him the discharges may be received in a flat tin plate pushed under the thighs and buttocks or on pads of oakum or old muslin.

The care of the *bladder* is also a matter of the greatest importance; the retention which at first exists should be relieved by the use of a flexible catheter carefully sterilized and introduced with great gentleness, and when incontinence supervenes a catheter which has been thoroughly sterilized should also be used at intervals; the employment of a soft instrument, if used with care, is not apt to produce injury to the urethra or bladder.

The employment of a plaster-of-Paris jacket has been followed in some cases by good results, and it may be applied early in the case or after the patient has been kept in the recumbent posture for some weeks; by its use it is often possible to get the patient out of bed and allow him to sit in a chair.

In fractures involving the *cervical vertebræ* care should be exercised in lifting or moving the head; it is often of advantage in these cases to apply short sand bags to the sides of the neck and head, to give additional fixation to the parts while the patient is in the recumbent posture, or, if he is allowed to get out of bed, to apply a moulded leather or pasteboard splint to the neck, shoulders and back of the head for the same purpose.

The course of treatment in cases of fractures of the vertebræ, if the patient does not succumb to the injury in a few days or weeks, often extends over many months, and recovery is often more or less incomplete as regards the function of the parts below the seat of fracture.

Fractures of the Skull.—The injuries may result from the application to the skull of a bending, bursting or explosive force; they may be simple, compound, depressed or punctured. The fracture may involve either the vault or base or both. Fractures of the skull are most serious injuries when accompanied by intracranial complications.

Treatment.—This depends largely upon the nature of the injury—whether simple or compound—and the condition of the cranial contents. In simple fractures unaccompanied with cerebral symptoms no special dressing is required, but in compound fractures where loose fragments are present these should be removed; and if there is no depression of the fragments, and if no cerebral symptoms are present, the wound should be drained, carefully closed and dressed antiseptically, the dressings being held in place by a recurrent bandage of the head. The patient should be put to bed, and the use of an ice cap to the head is often of service. The diet should be restricted, while calomel and opium or bromide of potassium should be administered, or urotropine which has the property of rendering the cerebrospinal fluid bactericidal. It is well to keep the patient for a few weeks in a quiet and darkened room. Where cerebral symptoms are present, either in simple or compound fractures, and trephining is resorted to, the dressing of the wound is similar, and the same general treatment should be adopted. In all cases of fracture of the skull, whether subjected to operative treatment or not, it is well to keep the patient at rest in bed for three or four weeks, and he should be cautioned to avoid excesses afterward and should not resume active work for some months.

Fractures of the Clavicle.—Fractures of the clavicle may very frequent both in children and adults and may be complete or incomplete; in the former the deformity is marked while in the latter variety of injury, the deformity is not usually very marked (Fig. 288). The indications for treatment in complete fractures of the clavicle are to relax the sternocleidomastoid muscle, to prevent the weight of the arm on the injured side from dragging down the outer fragment of the clavicle and by fixing the scapula, to carry the attached external fragment outward and backward. A large variety of dressings have been devised and used to accomplish these objects.

Dressing by Position.—The treatment of fractures of the clavicle by position is accomplished by placing the patient in bed on his back upon a firm mattress with a low pillow under his head, and the arm on the side of injury should be fastened to the side of the chest by a few circular turns of a bandage passing around the arm and chest; the deformity is usually very satisfactorily reduced upon the patient assuming this position, and after three weeks' rest in this position the union is generally sufficiently firm to allow the patient to get out of bed and be about with the arm bound to the side

Fig. 288.

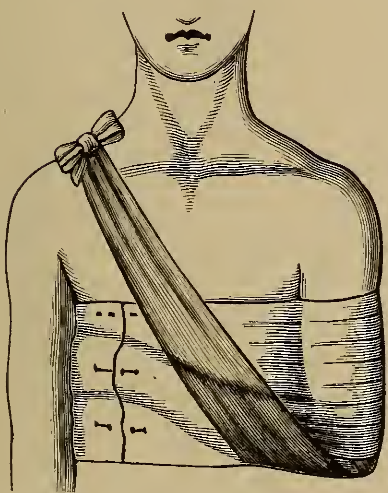
Deformity in fracture of left clavicle. (Ashhurst.)

or carried in a sling or with a Velpeau bandage applied, without any recurrence of the deformity.

Temporary Dressing.—A satisfactory temporary dressing for fractures of the clavicle consists in the application of a four-tailed bandage; the bandage is made from a piece of muslin 2 yards in length and 14 inches in width; a hole is cut in its center about 4 inches from its margin, to receive the point of the elbow; the bandage is then split into four tails in the line of the hole and to within 6 inches of it; the body of the bandage should be applied so that the point of the elbow rests in the hole, and a folded towel being placed in the axilla, the lower tails should be carried, one anteriorly, the other posteriorly, diagonally across the chest and back, to the neck on the side opposite the seat of fracture and secured; the remaining tails are next carried around the lower part of the chest and secured so as to fix the arm to the side of the body (Fig. 289).

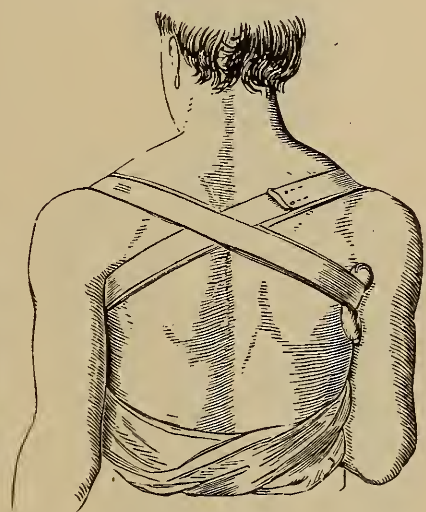
In some cases the deformity is corrected by the application of a posterior figure-of-eight bandage, the forearm on the side of injury being carried in a sling (Fig. 290).

Fig. 289.



Four-tailed bandage for fracture of the clavicle.

Fig. 290.

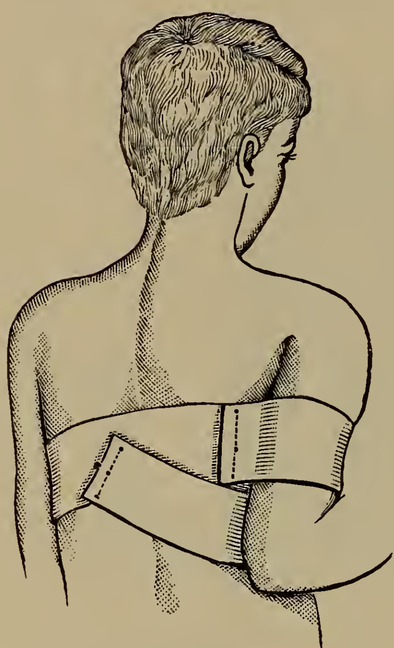


Posterior figure-of-eight dressing for fracture of the clavicle.

Sayre's Dressing.—This consists of two strips of adhesive plaster $3\frac{1}{2}$ inches wide and 2 yards in length. The first strip is looped around the arm just below the axillary margin, and is pinned or sewed with the loop sufficiently open not to constrict the arm. The arm is then drawn downward and backward until the clavicular portion of the pectoralis major muscle is put sufficiently upon the stretch to overcome the action of the sternocleidomastoid muscles, and in this way draws the sternal fragment of the clavicle down to its place.

The strip of plaster is then carried completely around the body and pinned or stitched to itself on the back (Fig. 291). The second strip is next applied, commencing upon the front of the shoulder of the sound side; thence it is carried over the top of the shoulder diagonally across the back, under the elbow, diagonally across the front of the chest to the point of starting where it is secured by pinning or sewing. A slit is made in this strip to receive the point of the elbow. Before

Fig. 291.



Sayre's dressing for fracture of the clavicle. First strip applied.

Fig. 292.

Sayre's dressing for fracture of the clavicle. Second strip applied.

the elbow is secured by the plaster it should be pressed well forward and inward (Fig. 292).

Velpeau's Dressing.—This may also be used in the treatment of fractures of the clavicle (Fig. 293). A compress may also be secured by the vertical turns of this bandage over the seat of fracture if needed. The application of the bandage is described on page 66.

In any form of dressing in which the arm is held against the side of the chest it is well to apply a folded towel or piece of lint between the arm and chest to prevent the skin surfaces from becoming excoriated.

Modified Velpeau's Dressing.—A modified form of Velpeau's dressing for fracture of the clavicle is applied as follows: A soft towel or piece of lint is placed against the side of the body and over the front of the chest, and held in position by a strip of adhesive plaster; the arm is next placed in the Velpeau position, a good-sized pad of lint is next applied over the scapula and this is held in place by a strip of adhesive plaster $2\frac{1}{2}$ inches in width and $1\frac{1}{2}$ yards in length; this strip is continued downward and forward so as to pass over the point of the elbow and is carried diagonally across the chest to the shoulder of the opposite side and is secured, a slit being cut in it to receive the point of the elbow; a compress of lint is next placed over the seat of fracture and held in place by a strip of adhesive plaster; an additional strip of plaster is next carried from the spine around the arm and chest and secured on the opposite side of the chest; circular turns of a roller bandage are then passed around the chest, including the arm from below upward until the arm is securely fixed to the body, and the dressing is finished by making one or two turns of the third roller of Desault (Fig. 294). Or the turns of the third roller of Desault may be applied first and the dressing may be finished by circular turns of a roller passing around the arm and chest, extending from the elbow to the shoulder.

Fig. 293.

Velpeau's dressing for fracture of the clavicle.

The removal of dressings and their reapplication will depend upon the comfort of the patient and the manner in which they keep their position. As a rule, in fractures of the clavicle the dressings are removed at the end of the second or third day, the parts are inspected and the skin is sponged with dilute alcohol; the dressings are then reapplied, and if the patient is comfortable and the parts are in good position the dressings are made at less frequent intervals until union is completed at the seat of fracture.

Fig. 294.

Modified Velpeau dressing for fracture of the right clavicle.

Union in cases of fracture of the clavicle is generally quite firm at the end of four or five weeks, and at this time the dressings may be removed, and the patient should carry the arm of the affected side in a sling for several weeks, and should not undertake any work requiring forcible movements of the arm until eight or ten weeks have elapsed from the receipt of the injury.

Fractures of the Clavicle in Children.—In the treatment of fractures of the clavicle in children the Velpeau or modified Velpeau dressing will be found to be the most satisfactory dressing to employ; and as these patients are particularly apt to disarrange the dressings, it is well to render them additionally secure by applying a few broad strips of adhesive plaster over the turns of the roller bandage, the strips following the turns of the bandage.

The time required for union in fractures of the clavicle in children is somewhat shorter than in adults; the dressings may be removed at the end of three weeks.

Fractures of the Scapula.—Fractures of the scapula usually occur from direct violence and may involve the *body, neck, acromion* or *coracoid* process of the bone. Fractures of this bone are rare, those of the acromion process being most common. As an exact diagnosis of these injuries is often difficult a roentgen-ray examination should be made.

Fracture of the Body of the Scapula.—*Treatment.*—If deformity is present it is reduced by manipulation and compresses of lint are placed above and below the seat of fracture and held in place by adhesive strips; the arm is next fixed to the side of the body by spiral turns of a roller bandage passing around the arm and chest and the forearm is supported in a sling.

Fracture of the Neck, Acromion or Coracoid Process of the Scapula.—In fracture of the surgical neck of the scapula the line of fracture passes through the suprascapular notch, detaching both the coracoid and glenoid processes. Fracture of the acromion process is the most common fracture met with in this bone and may be compared with separation of the epiphysis; that of the coracoid process is very rare and is generally produced by muscular action.

Treatment.—The treatment of these fractures consists in reducing the displacement by manipulation and placing a pad of lint or a folded towel in the axilla and binding the arm to the body by spiral turns of a roller bandage passing around the arm and chest and supporting the forearm in a sling. These fractures may also be dressed by first placing a pad of lint or a folded towel in the axilla and then securing the arm in the Velpeau position by the application of a Velpeau bandage (Fig. 293). Fractures of the scapula may also be treated by the application of a plaster-of-Paris bandage, the deformity being reduced, the arm is placed against the chest, a fold of lint being interposed; a flannel bandage is next carried over the shoulder and around the chest and arm, and this dressing is covered by the turns of a plaster-of-Paris bandage (Fig. 295). In fractures of the acromion or coracoid processes the union is usually fibrous. In the treatment of fractures of the scapula the dressing should be retained for about four weeks.

Fractures of the anatomical neck are rare and may be largely intra-articular. The semiglobular fragment is displaced toward the axilla and may tear the capsule and escape into the axilla.

Fig. 295.

Plaster-of-Paris dressing for fracture of the scapula.

Fractures of the Humerus.—Fractures of the humerus may involve the *upper extremity*, the *shaft* or the *lower extremity* of the bone.

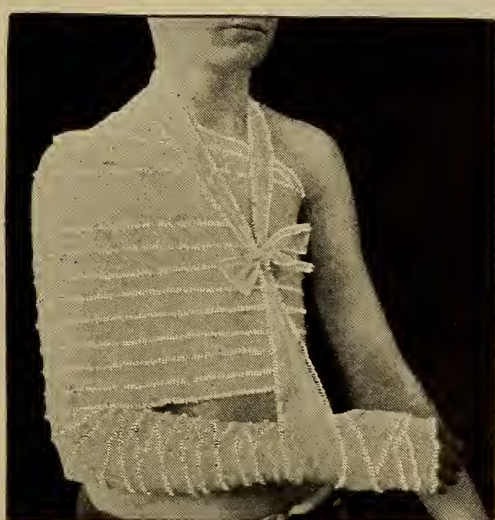
Fractures of the Upper Extremity of the Humerus.—These include fractures of the *head* and *anatomical neck* of the bone. Fractures may separate the tuberosities, the greater tuberosity being the one usually involved, resulting from muscular action and rarely from direct violence, or they may involve the *surgical neck* of the humerus; and, finally, separation of the upper epiphysis of the humerus; this is a very frequent fracture.

Treatment.—The most satisfactory dressing for all fractures of the humerus above the upper third of the bone is applied as follows: A primary roller should be evenly applied from the tips of the fingers to the seat of the fracture, the arm being flexed at the elbow before the bandage is carried above this point, to prevent the dangerous constriction which might result if the bandage were applied with the arm in the straight position, and it were afterward flexed at the elbow. A folded towel or a thin pad of lint should next be placed in the axilla and over the outer surface of the chest to furnish a firm basis of support for the humerus, and also to prevent excoriation from the contact of the skin surfaces. A splint of pasteboard, felt or leather (Fig. 296) is next moulded to the shoulder and arm; this should be long enough to extend some distance below the seat of fracture and wide enough to cover in about one-half of the circumference of the arm, and is padded with cotton and fitted to the shoulder and arm. The splint and arm are next secured to the side of the body by spiral turns of a roller bandage, including the arm and chest in its turns and applied from the elbow to the top of the shoulder. The forearm is carried in a narrow sling suspended from the neck (Fig. 297). This dressing should be removed at the end of twenty-four or forty-eight hours, and after the parts have been inspected and sponged with alcohol the dressings should be reapplied in the same manner, and if the patient is comfortable they need not be disturbed again for three or four days, subse-

Fig. 296.

Moulded splint for shoulder and arm.

Fig. 297.



Dressing for fracture of the upper extremity of the humerus.

quent dressings being made at the same intervals. Union in fractures of the upper extremity of the humerus, except in those within the capsule, in which bony union is the exception, is usually quite firm at the end of five or six weeks, and the dressings can be dispensed with at this time.

Separation of the Upper Epiphysis of the Humerus.—This accident is not uncommon in patients under twenty years of age, and may be confused with fracture of the neck of the humerus. The displacement is due to muscular action; the diaphysis can be felt under the anterior fibers of the deltoid. There is usually a marked projection of the upper extremity of the lower fragment in front of the shoulder (Fig. 298).

Fig. 298.

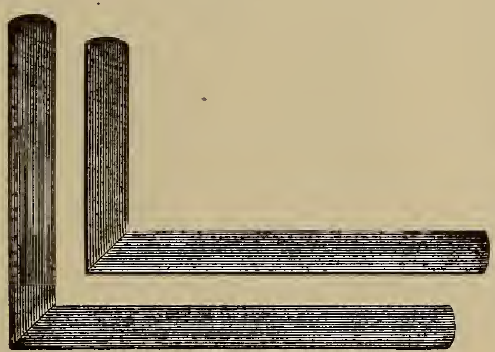
Separation of upper epiphysis of the humerus.

Treatment.—This consists in reducing the displacement by manipulation and the dressing is similar to that employed in fracture of the neck of the humerus (Fig. 297). In some cases, after the deformity has been reduced under anesthesia, the reduction is maintained by fixing the arm in the abducted position by a plaster-of-Paris bandage for a few weeks. The functional result following this injury is usually very good.

Fracture of the Shaft of the Humerus.—This fracture may occur at any point between the surgical neck and the condyles of the humerus; the line of fracture is usually oblique. In fractures of the shaft above the insertion of the deltoid the lower fragment is carried upward and outward by action of this muscle, while the upper fragment is pulled inward by the axillary muscles. In fractures below the insertion of the deltoid the displacement is reversed.

Treatment.—This consists in the application of a primary roller from the tips of the fingers to the seat of fracture; a short, well-padded, wooden splint extending from the axilla to a point a little above the internal condyle is next placed on the inner surface of the arm and against the chest; a moulded pasteboard or felt splint, fitted to the shoulder and outer side of the arm and extending a short distance below the seat of fracture, is padded with cotton and applied to the shoulder and arm. The splints are held in position by the turns of a bandage and the arm is secured to the body by spiral turns of a roller bandage carried around the chest and arm, and the forearm is carried in a sling suspended from the neck. The dressing is much the same as that for fracture of the upper part of the humerus, with the addition of the short internal splint.

Fig. 299.

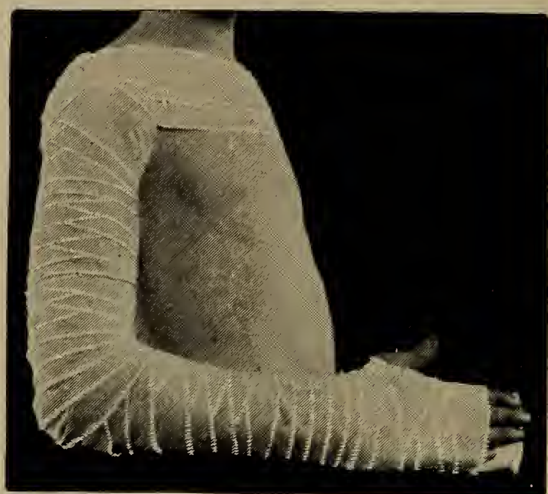


Internal angular splints.

This fracture may also be treated by the use of three narrow coaptation splints of wood or binders' board, extending from the axilla to a point just above the elbow, being well padded these are placed one anteriorly, one posteriorly and one externally. These are held in position by a bandage; a shoulder cap is next applied and the arm is firmly bound to the side of the chest by circular turns of a bandage.

Fracture of the shaft of the humerus may also be dressed by first applying a primary roller and then placing the forearm and arm upon a well-padded internal angular splint (Fig. 299). Care should be taken to see that the end of the splint extends only to the axilla and does not press upon the brachial vein. A pasteboard or felt moulded splint is next applied to the shoulder and outer side of the arm, and should be long enough to extend below the seat of fracture. The splints are held in position by turns of a roller bandage beginning at the fingers and carried up to the shoulder, and finished with a few spica-of-the-shoulder turns (Fig. 300). If there is great overlapping of the fragments producing marked shortening the patient should be kept in bed and the elbow flexed and weight or elastic extension made by adhesive strips

Fig. 300.

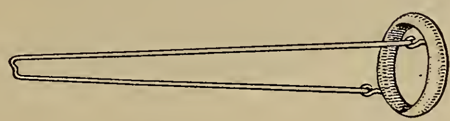


Dressing for fracture of the shaft of the humerus with internal angular splint and external splint of binders' board.

applied to the arm, short coaptation splints also being applied. If the patient is treated as a walking case the same result can be accomplished with a bag of shot or weight fastened to the arm so as to hang below the elbow. The arm is supported by a sling applied at the wrist and sometimes for additional security the arm is bound to the side of the body by spiral turns of a bandage carried around the arm and chest. The after-treatment of these fractures as regards the removal and renewal of the dressings is the same as in cases of fracture of the upper portion of the humerus; the dressings should be retained for five or six weeks.

Extension, with adhesive straps and a weight, with the use of a Thomas arm splint (Fig. 301) is often employed with advantage where the shortening and deformity are marked, and it is found impossible to keep the fragments in good position with the ordinary dressing. The use of this method requires the patient to be in bed on his back.

Fig. 301.

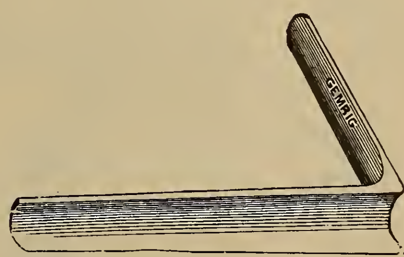


Thomas' arm splint. (Ashhurst.)

Fractures of the Lower Extremity of the Humerus.—These include fractures at the *base of the condyles, splitting fracture* between the *condyles* or those of the *internal* or *external condyle* and *epiphyseal separation* of the lower epiphys's of the humerus

Treatment.—The displacement is reduced by extension and manipulation, and before applying any splint it is well in many cases to apply over the region of the fracture several layers of cotton wadding. An anterior angular splint (Fig. 302) well padded with cotton or oakum is next applied and held in position by the turns of a roller bandage applied from the fingers to the upper portion of the splint (Fig. 303). Great care should be taken to see that the angular edge of the splint does not press too firmly upon the tissues in the bend of the elbow, as sloughing of the skin and damage to the nerves has resulted from neglect of this precaution. These fractures may also be dressed with a well-padded internal angular splint, this splint being substituted by an anterior angular splint at the end of ten days or two weeks.

Fig. 302.



Anterior angular splint.

Some surgeons prefer to dress fractures of the condyles of the humerus with the arm in the *extended* position upon a

Fig. 303.

Dressing for fracture of the lower extremity of the humerus with anterior angular splint.

Fig. 304.

Gunstock deformity after fracture of the condyle of the humerus.

straight anterior splint, or with short, narrow pasteboard splints applied around the joint, as favoring more accurate coaptation of the fragments, and diminishing the tendency to what is known as gunstock deformity and loss of the carrying angle (Figs. 304 and 305). If this position is employed a straight wooden splint is applied to the anterior surface of the arm and forearm, or moulded splints of pasteboard may be used, and after the union is moderately firm, at the end of two weeks the elbow should be flexed and kept in this position during the remaining time of the treatment.

Treatment by Acute Flexion (Jones' Method).—In this dressing of fractures of the condyles of the humerus the displacement of the fragments is corrected by manipulation and the forearm is placed in a position of acute flexion at the elbow (Figs. 306 and 307), and the hand of the injured arm is brought up and is supported by a sling carried around the neck (Fig. 308). The flexion of the forearm on the arm may also be rendered more secure by passing broad strips of adhesive plaster or bandage around the arm and forearm. The arm is kept in the position of acute flexion for about two weeks and it is then dressed in a position of less flexion, and at the end of three or four weeks is simply carried in a sling. After this time the arm is gradually extended. This method of dressing seems to be followed by the best results in fractures of the condyles of the humerus in children. By this method of dressing the fragments are firmly held in position, better motion is obtained and the tendency to gunstock deformity is diminished. The more extended use of this method of dressing fractures of the condyles of the humerus has shown that the practical results obtained are most satisfactory.

Fig. 305.

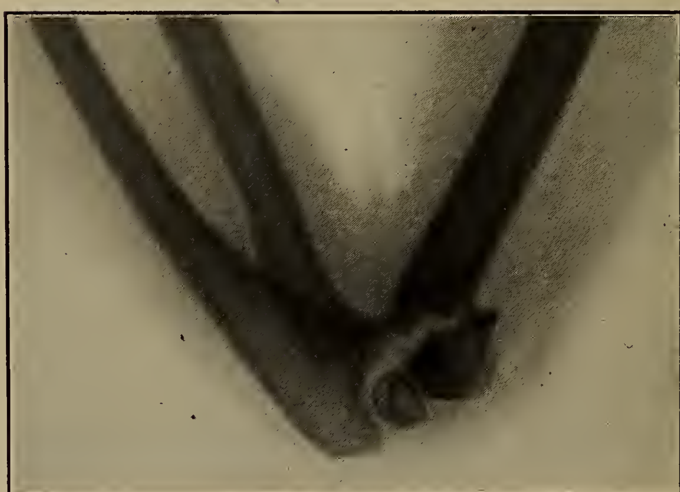
Showing loss of carrying angle after fracture of the condyle of the humerus.

When fractures of the lower extremity of the humerus involve the elbow-joint a certain amount of impairment of

Fig. 306.

Fracture of the condyles of the humerus before reduction.

Fig. 307.



The same case after reduction with the elbow in acute flexion.

joint motion is apt to occur either from anchylosis or from displacement of the fragments, giving rise to gunstock deformity and loss of the carrying angle, which in many cases it is impossible to reduce completely, so that flexion and extension of the joint are restricted. Bearing these facts in mind, it is well to make passive motion in these cases as early as the second or third week. It is well to explain to the patient or his friends that impairment of joint motion may

Fig. 308.

Dressing for fracture of condyles of humerus in acute flexion.

result in these fractures in spite of the greatest skill and care in the treatment. In a case of fracture in the region of the condyles of the humerus the dressings should be removed in twenty-four hours, and should be redressed in the same manner, and if the swelling does not increase and the dressing is comfortable to the patient it should afterward be dressed at less frequent intervals; the union is generally quite firm at the end of four weeks and the splint may be removed at this time. Fractures of the condyles of the humerus are very common in children, and *epiphyseal separations* of the lower epiphysis of the humerus are also met with; the dressing of these injuries in this class of patients is similar to that described for fractures of the condyles of the humerus.

Fractures of the humerus, simple or compound, with marked deformity may also be treated by the Thomas splint with suspension and traction. This method is of special value in those about the surgical neck of the bone. Another apparatus and method of extension and suspension are shown in Fig. 335).

Fractures of the Olecranon Process of the Ulna.—Fractures of the olecranon may consist in simply a separation of the cortical layer of bone over the summit of the process to which the triceps is principally attached or the line of fracture may pass through the sigmoid fossa.

Fig. 309.

Adhesive straps applied in fracture of the olecranon.

Treatment.—This fracture is dressed with the arm slightly flexed at the elbow or with it completely extended; the former position is a little less irksome to the patient. The separation of the fragment by the action of the triceps muscle is usually not very marked; but, if the displacement is considerable it may in a measure be overcome by the use of a compress above the fragment, over which figure-of-eight strips of adhesive plaster are fastened to draw it down into position (Fig. 309). The ends of the strips are then attached to a well-padded straight splint which should be long enough to extend from the upper third of the arm to the ends of the fingers, and is secured in position by the turns of a roller carried from the fingers to the upper extremity of the splint, with figure-of-eight turns at the elbow to reinforce the action of the strips of plaster (Fig. 310).

This fracture may also be dressed by first applying a primary roller to the elbow, and then placing over the arm a well-padded anterior obtuse-angled splint, or a straight splint with a good-sized pad of lint or oakum fastened at a point corresponding to the position of the flexure of the elbow. When either of these splints is placed upon the arm a position of moderate flexion is obtained. A compress of lint is next placed above the fragment if there is a displacement, and one or two narrow strips of adhesive plaster are fastened over this and passed obliquely downward and attached to the

Fig. 310.

Fracture of olecranon dressed in the extended position.

splint on either side. The splint is then securely fastened to the arm by the turns of a roller bandage applied from the fingers to the upper end of the splint.

The dressings should be removed at the end of twenty-four or thirty-six hours, or sooner if there is evidence of swelling of the tissues in the region of the fracture, and they should be reapplied in the same manner. If the dressing is comfortable to the patient, and there is no evidence of swelling, the subsequent dressings should be made at less frequent intervals; the dressings are usually retained in this fracture for five or six weeks. In *compound fractures* of the olecranon process and in simple fractures where it is found impossible to keep the fragment in apposition fixation of the fragments should be secured by suture. Passive motion should not be made until this time, as flexion of the elbow tends to separate the fragments, unless union has taken place. The union of a fracture of the olecranon is in most cases fibrous, but in a few instances bony union has been observed.

Fracture of the Coronoid Process of the Ulna.—Fracture of the coronoid process is an extremely rare injury.

Treatment.—This is accomplished by placing the arm in a hyperflexed position and applying a well-padded internal acute-angled splint, or an anterior acute-angled splint, and securing it to the arm by the turns of a roller bandage. This may also be secured by placing the arm in the Jones' position. After two weeks the arm should be gradually brought into the extended position. A moulded pasteboard or leather gutter may be substituted for the angular splint. The dressings should be changed at intervals, and after their removal, at the end of three or four weeks, passive motion should be practised.

Fracture of the Shaft of the Ulna.—This is a very disabling injury, as the ulna forms the main part of the elbow-joint, and is often associated with a dislocation of the head of the radius. The displacement may be backward or forward, and is often difficult to correct. The treatment consists in the use of a straight splint, applied to the hand and forearm with compresses adjusted to correct the displacement of the fragments.

Fractures of the Head and Neck of the Radius.—These fractures are also quite rare.

Treatment.—This consists in reducing the fragments by manipulation by flexing the elbow and keeping it in this position, and by the application of a well-padded anterior right-angled splint, the splint being firmly secured in position by the turns of a roller bandage applied from the tips of the fingers to the upper end of the splint (Fig. 303). The splint should be changed at intervals and should not be permanently removed for four weeks, at which time passive motion, consisting in flexion and extension at the elbow and pronation and supination of the forearm should be made.

An internal angular splint applied to the inner surface of the forearm and arm may also be used in the treatment of these fractures (Fig. 299). The Jones' position also is excellent.

Fractures of the Ulna and Radius.—These fractures are often met with as the result of direct or indirect violence.

Treatment.—After reducing the displacement, which is always marked when both bones are broken, by making extension from the hand and by manipulation, the forearm is placed in the supine position or in a position between pronation and supination. The supine position is, as a rule, to be preferred in any fracture of the radius, as the upper fragment is supinated by the action of the biceps and supinator brevis muscles, and, therefore, unless the lower fragment be

Fig. 311.

Dressing for fracture of both bones of the forearm.

placed in the supine position, union with rotary deformity will almost inevitably ensue.

Two straight wooden splints, well padded, a little wider than the forearm, are employed. The anterior splint should be long enough to extend from the elbow to the tips of the fingers, and the posterior splint should extend from the elbow to the wrist. A primary roller should never be applied to the forearm in dressing these fractures, as its application diminishes the interosseous space, and its use has been followed by gangrene of the hand and forearm. In applying the anterior splint to the palmar surface of the forearm and hand, care should be taken that the upper end of the splint does not press upon the brachial artery and basilic vein at the elbow when the forearm is flexed; the posterior splint is next applied from the elbow to the wrist and the splints are held in position by the turns of a bandage carried from the fingers to the elbow (Fig. 311).

In dressing this fracture a posterior splint equal in length to the anterior splint may be used in place of the short posterior splint extending from the elbow to the wrist.

In fracture either of the shaft of the radius or of the ulna alone, the deformity is usually not so marked as when both bones are broken at the same time, the unbroken bone acting as a splint; the dressing for these fractures is the same as for fracture of both bones of the forearm.

In cases where displacement of the fragments and shortening is very marked and difficult to correct or maintain, extension applied to the forearm and the use of a Thomas splint will often prove satisfactory, the patient being confined to his bed when this dressing is employed. In some cases exposure of the fragments and suturing is the only procedure which offers a fair prospect of a good result.

The extension traction method with a Thomas splint and the Balkan frame may be employed in cases where the deformity is marked and there is difficulty in maintaining the correction. The extension bands are fastened to the wrist, lower part of the forearm or hand and fingers.

The dressing should be removed in twenty-four or thirty-six hours, and after inspecting the parts and sponging them with dilute alcohol the splints should be replaced in the same manner and secured. The dressings should be renewed at intervals of two or three days for two weeks at least, and after this time the dressings should be made at less frequent intervals. The time required for union in these fractures is usually five or six weeks and the splints should be retained for this time.

Incomplete Fractures of the Ulna and Radius.—Green-stick Fractures.—In children these fractures are very common.

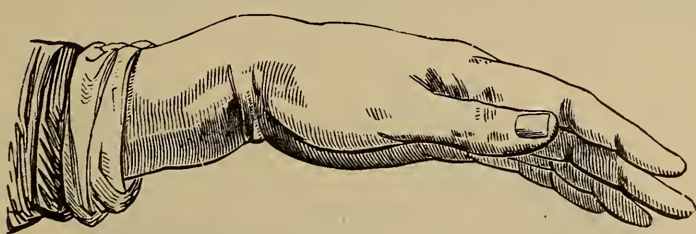
Treatment.—The deformity is reduced by bending the bones back into place, often converting the incomplete fracture into a complete one. After reduction of the deformity the treatment adopted is the same as that described above. In these patients there is a great tendency to displace the splints or rather to draw the forearm out of the splints, and to prevent this I often employ an anterior angular splint in place of the straight anterior one, the upper portion of which, being fastened to the arm, prevents the child from dragging the arm out of the dressings.

Fig. 312.

Green-stick fracture of ulna and radius. (Ashhurst.)

Fracture of the Lower End of the Radius.—The most common fracture of the radius is one situated from $\frac{1}{2}$ to $1\frac{1}{2}$ inches above the lower articular surface of the bone (Colles' fracture), the line of fracture being more or less transverse, although it may in some cases be slightly oblique; the characteristic deformity in this fracture is represented in Fig. 313. Numerous roentgen-ray studies of this fracture have shown that it is a much more complicated injury than was formerly supposed, being often comminuted or impacted and associated with a fracture of the styloid process of the ulna or of the scaphoid or semilunar bones.

Fig. 313.



Fracture of the radius near its lower extremity.

Treatment.—The most important point in the treatment of this fracture is to effect complete reduction of the fragments before the application of any splint; this is done by making extension from the hand, and, at the same time, by over-

FIG. 314.

Reduction of Colles' fracture of left radius. (Ashhurst.)

extending and then flexing the wrist and by manipulation (Fig. 314); the deformity can usually be completely reduced. The arm should then be brought into the position of supination, and a firm compress of lint is next placed over the lower end of the upper fragment on the palmar surface of the forearm; a second compress is then placed over the upper end

FIG. 315.

Position of compress in Colles' fracture.

of the lower fragment (Fig. 315), and a well-padded Bond splint (Fig. 316) is applied to the palmar surface of the arm and held in place by the turns of a roller bandage (Fig. 317).

Many surgeons treat this fracture with the hand in a position between pronation and supination, the thumb pointing upward. A substitute for Bond's splint may be prepared by fastening a roller bandage obliquely upon a straight wooden splint as suggested by Dr. Hays (Fig. 318).

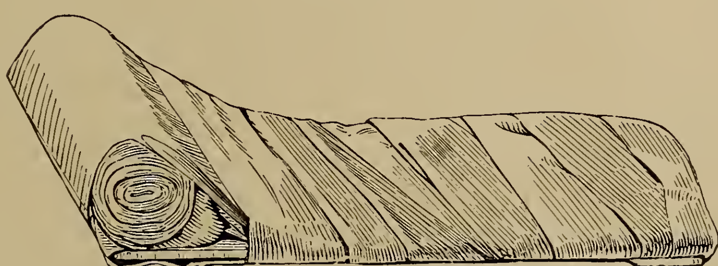
Fig. 316.

Bond's splint.

Fig. 317.

Dressing for fracture of the lower end of the radius.

Fig. 318.



Substitute for Bond's splint.

Jopson reduces impacted Colles' fractures under anesthesia; an assistant supports and holds the forearm upon the triangular wooden block, which is used by the orthopedic surgeon; the forearm should rest upon this block a little distance above the lower end of the upper fragment. He then makes overextension and traction, followed by downward traction and flexion of the wrist and moulds into place the fragment or fragments. The completeness of the reduction is determined by a roentgen-ray examination.

Another method of treating Colles' fracture after the reduction of deformity consists in placing upon the dorsal surface of the forearm a padded stright splint, extending from the elbow to the tips of the fingers and a short straight splint upon the palmar surface of the arm, extending from the

Fig. 319.

Anterior and posterior splints applied.

elbow to the wrist (Fig. 319). These splints are held in position by a bandage, and the forearm carried in a sling with the hand inclined to the ulnar side (Fig. 320). The hand should be bandaged to the posterior splint for about seven days and then set free. The posterior splint should be left long for another week; at the end of this time it should be shortened so as to extend only to the wrist-joint, and the patient should be encouraged to use the fingers and make motions of the wrist. At the end of three weeks both splints should be removed and the patient should carry the forearm in a sling for a few weeks longer and be encouraged to use the hand.

The most important point in the treatment of this fracture is the complete reduction of the deformity at the first dressing, and if this has been satisfactorily done almost any splint may be used with a good result, and, indeed, some surgeons use no splint, applying only a compress over the seat of fracture, held in place by a strip of plaster, the arm being carried in a sling.

FIG. 320.

Dressing for Colles' fracture with long posterior and short anterior splint.

The after-treatment of these fractures consists in removing the splint and compresses after twenty-four or thirty-six hours and in sponging the surface of the skin with dilute alcohol, and the compresses and splints should then be reapplied in the same manner; the fracture should be dressed every second or third day for the first two weeks, and after this time it should be dressed at less frequent intervals. Union is usually quite firm at the end of four weeks, and the splint should be dispensed with at this time. A certain amount of stiffness of the wrist and fingers is apt to follow this fracture, which is usually soon overcome by passive motion and physiological use of the parts.

Epiphyseal Separation.—In children separation of the lower epiphysis of the radius is often met with, and its treatment is similar to that described above; a Bond splint with compresses or two straight splints with compresses being the most satisfactory dressing to employ in this injury, the dressings being retained for three weeks.

Chauffeur's Fracture.—The lower end of the radius is often fractured by a backward kick of a motor during the act of cranking. The resulting injury is often identical with the typical Colles' fracture. Extensive comminution of the lower end of the radius and marked displacement are not uncommon. The treatment is that outlined above for Colles' fracture.

Reversed Colles' Fracture.—This is a rare fracture of the lower end of the radius in which the lower fragment is displaced forward instead of backward, the deformity being the reverse of that seen in Colles' fracture.

Treatment.—This consists in the reduction of the deformity, the manipulation being the reverse of that employed in Colles' fracture, and the dressings are similar to those employed in the latter, with the exception that the position of the compresses is reversed.

Fractures of the Carpal Bones.—These fractures are often compound or open fractures, and are so frequently associated with extensive laceration of the arm and hand that operative measures have to be resorted to; but if such is not the case, they are dressed, when compound, with an antiseptic dressing, and the hand and forearm are supported upon a well-padded palmar splint held in place by a roller bandage; more or less impairment in the motion of the wrist is apt to follow these fractures. The dressings should be retained for three or four weeks, and after their removal passive motion should be employed to overcome as far as possible the joint stiffness resulting.

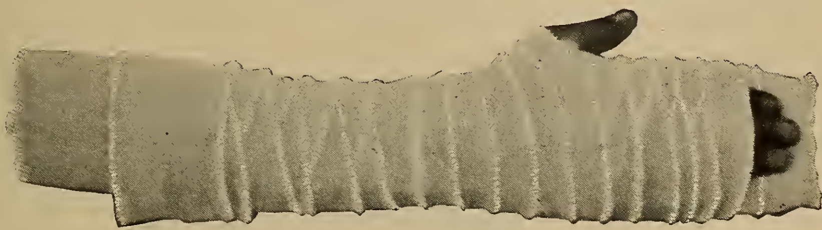
Fig. 321.

Agnew's splint for fracture of the metacarpal bones.

Fractures of the Metacarpal Bones.—These fractures are often met with as the result of direct or indirect force applied to the metacarpal bones.

Treatment.—This consists in first reducing the deformity, which is usually an angular one, the projection of the angle being toward the back of the hand; this is reduced by pressure with the fingers, and the hand and forearm should then be placed upon a palmar splint (Fig. 321) with a pad of oakum or cotton under the palm; a compress of lint is next placed over the seat of fracture, and the hand and forearm are bound to the splint by the turns of a roller bandage (Fig. 322). At the end of three weeks union at the seat of fracture is usually quite firm, and the splint should be dispensed with at this time.

Fig. 322.

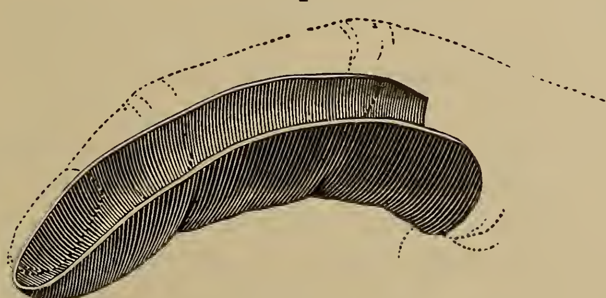


Dressing for fractures of the metacarpal bones.

Fractures of the Phalanges.—These may result from direct or indirect violence, and often present marked deformity.

Treatment.—This consists in reducing the displacement by extension and manipulation, and in placing the finger in a moulded gutta-percha or pasteboard splint (Fig. 323), and securing the splint in position by the turns of a roller bandage. When the proximal phalanx is fractured, a narrow padded

Fig. 323.



Gutta-percha splint for fracture of phalanx.

wooden splint extending from the end of the finger to the wrist should be applied upon the palmar surface of the finger and hand, and a short dorsal splint should also be used; if there is a tendency to lateral displacement, short lateral splints should also be employed, and the splints should be held in place by strips of plaster or by a roller bandage (Fig.

324). Splints made from a loop of wire may be fitted to the finger, padded, and secured in the same manner. A woman's hair pin, wrapped with adhesive plaster also makes a very satisfactory splint as it can be bent to fit the finger accurately.

Union in fractures of the phalanges is usually firm at the end of three weeks, and the splints can be dispensed with at that time.

Fig. 324.

Dressing for fracture of phalanx with anterior and posterior splints.

FRACTURES OF THE LOWER EXTREMITY.

Fractures of the Femur.—These may involve the *neck, great trochanter,* and *upper end of the shaft,* the *shaft,* or the *lower extremity* of the bone.

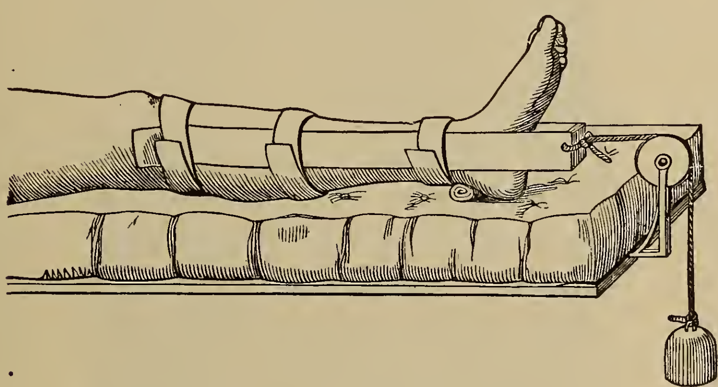
Fractures of the shaft of the femur are common in children, those of the upper extremity of the bone involving neck and intracapsular fractures are rare in children but common in adults, especially in adults over sixty years of age. Trivial accidents such as twisting the limb or slight falls upon the trochanter. frequently produce this variety of fracture. Inpaction of the fragments is not uncommon.

Fractures of the Upper Extremity of the Femur.—These may involve the head, neck, the great trochanter, and the upper portion of the shaft of the femur. Muscular spasm, localized pain and tenderness, eversion of the lower extremity, moderate shortening which may be progressive and relaxation of the fascia lata above the trochanter, as pointed out by Allis are suggestive of this lesion. Roentgen-ray examination should be made in all cases. As many of these fractures are impacted, especially those involving the region of the trochanter, the question of its treatment must be considered.

In the aged it is better not to relieve the impaction, but in children and vigorous adults under sixty years of age, better results may be obtained, by breaking up the impaction and dressing the limb in extreme abduction.

Treatment.—The patient should be placed in bed upon a firm mattress, and an extension apparatus made from adhesive plaster should be applied to the leg, extending as far as the knee-joint. The extension apparatus is constructed by taking a piece of adhesive plaster $2\frac{1}{2}$ inches in width and long enough to extend from the outer side of the knee or middle of the thigh to 4 inches below the sole of the foot, and from this point back to the inner side of the knee or

Fig. 325.



Adhesive plaster extension apparatus applied to limb.

middle of the thigh; in the center of this strip is placed a block of wood, $2\frac{1}{2}$ inches wide and 4 inches in length, with a perforation in its center; the block and the inner surface of the strip on each side are next faced with a similar strip of adhesive plaster to a point about 1 inch above each malleolus; a few straps are next wound around the wooden block to fix the previously applied straps; the strip of plaster is next warmed and applied to the sides of the leg and held in position by three or four strips of adhesive plaster carried around the leg at intervals; the strips may be applied to extend only to the knee (Fig. 325), and the plaster is made additionally secure by the application of a roller bandage applied to the foot and leg and carried up to the knee. Volkmann's sliding foot-piece may be employed to make the extension more effective.

Through the perforation in the block or stirrup is fastened a cord which passes over a pulley attached to the bed, and to this cord is attached the extending weight. The extension apparatus being applied, lateral support is given to the leg and thigh by sand bags applied on either side; the outer sand bag should extend from the foot to the axilla, and the inner one from the foot to the groin. A weight of 5 or 10 pounds is attached to the extending cord, and the lower feet of the bed should be raised on blocks a few inches high, to prevent the patient from slipping down in bed; a pad of oakum or cotton should also be placed under the tendo Achillis, to relieve the heel from pressure. This dressing is kept in place for from four to six weeks, and if union has occurred the patient is kept in bed for a few weeks longer and is then allowed to be about, using crutches. In the majority of cases of fracture of the neck of the femur fibrous union only takes place, and after employing the dressing before described for six weeks the patient is allowed to get up and go about on crutches. It often happens that the subjects in whom these fractures occur are old and feeble, and if it is found that restraint in bed with the dressings here described is not well borne, as these subjects are apt to develop hypostatic pneumonia and bedsores, under such circumstances they should be discarded and the patient allowed to sit up in bed with the limb resting on a pillow, or to get into a chair, the treatment of the local condition having to be disregarded, attention being given to the patient's constitutional condition.

Whitman has advocated the abduction treatment of fractures of the neck of the femur in the aged as well as the young. This treatment has been extensively used in recent years and the results show the soundness of his judgment. He abducts the limb under anesthesia and encases the entire lower extremity and pelvis in a plaster-of-Paris dressing, the bony prominences, pelvis and upper thigh being covered by a layer of felt before the plaster is applied. This dressing is remarkably well borne by old people and their care in bed is much simplified by the ease with which they may be moved. The head of the bed should be raised or they should be propped up to guard against hypostatic pneumonia. The position of the limb and the extent of the dressing is shown in Figure 326

In fractures in the upper portion of the femur where there is marked tilting forward of the upper fragment, Profes-

FIG. 326.

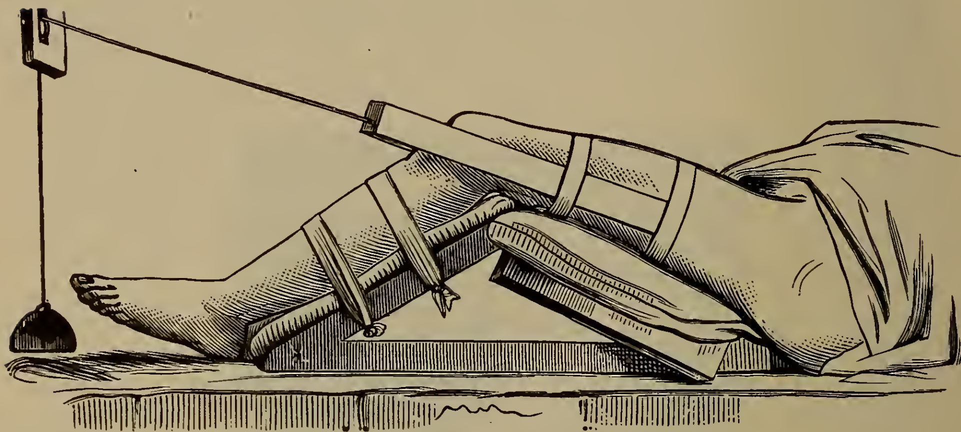
Abduction cast in fracture of neck of femur. (Ashhurst.)

sor Agnew employed extension made from the thigh and placed the limb upon a double inclined plane, maintaining this position during the treatment of the case (Fig. 327). With the same object in view, in place of the double inclined plane a double inclined fracture-box may be employed (Fig. 328), extension being made from the thigh by means of adhesive plaster strips applied above the knee, to which a weight is attached.

32

Fracture of the Shaft of the Femur.—This is a frequent fracture, and is usually accompanied by marked shortening and angular or rotatory displacement of the fragments. This fracture which is common in children and adults, but rare

Fig. 327.

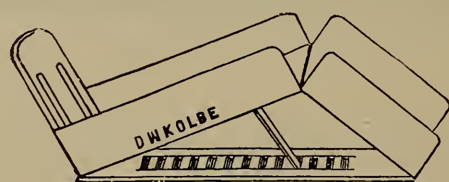


Dressing of fracture of the femur with extension upon an inclined plane.

in the aged, is evidenced by shortening often as much as 4 or 5 inches, anterior or lateral displacement, and rotation of the limb.

Treatment.—The patient should be placed upon a fracture-bed or an ordinary bed with a firm hair mattress; an extension apparatus of adhesive plaster is applied, and extension is

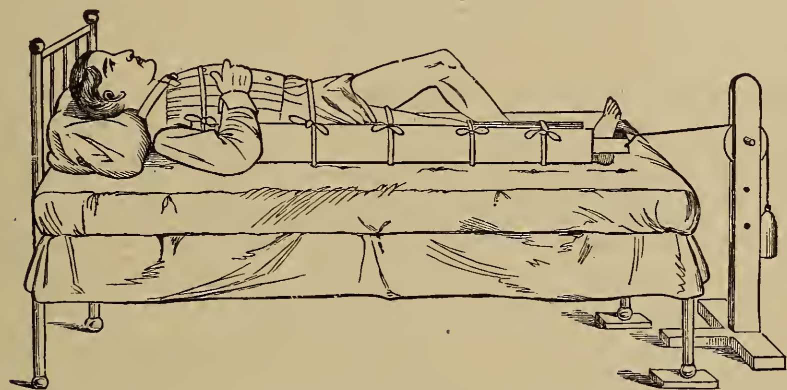
Fig. 328.



Double inclined fracture-box.

made by a weight attached to this, as previously described. The amount of weight attached to the extension apparatus should vary, in a muscular adult much more weight is required than in an adult with weak muscles or a child. Ten to 25 pounds are usually required. Lateral support is given to the limb by the application of two wooden splints—the outer or long one extending from the axilla to the foot, the inner or short one extending from the groin to the foot. The splints at their upper extremity should be about 6 inches in width and at their lower extremity about $3\frac{1}{2}$ inches. The splints are wrapped in a splint cloth, which extends from the foot to the groin, and after this has been placed under the limb the splints are fixed in their proper positions, the short one to the inner side, the long one to the outer side of the limb. Between the limb and the splints are interposed bran bags: the outer bag should be long enough to extend from the

Fig. 329.



Dressing for fracture of the shaft of the femur with lateral splints and bran bags.

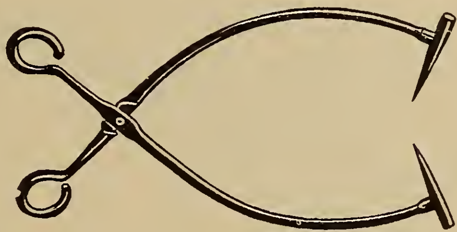
axilla to the foot, the inner one from the groin to the foot. The splints and bran bags are held in place by five or six strips of bandage passing under the limb and body and around the splints and bran bags at intervals. The heel is saved from pressure by placing a wad of oakum or cotton under the tendo Achillis, and after the splints have been brought into place the strips of bandage are firmly tied to secure them, and a weight of 10 to 25 pounds is attached to the extending cord. The foot of the bed is raised, to prevent the patient from slipping downward and to allow the weight of the body to act as a counter-extending force. After the application of the dressings the thigh should be slightly abducted. During the after-treatment of these fractures the surgeon should see that the splints and bran bags are kept firmly in place, and that the foot does not roll outward; this is accomplished by untying the strips and readjusting the bags, and then bringing up the splints and securing them in position by fastening the strips (Fig. 329). The extension apparatus usually does not require renewal during the course of treatment. The extension apparatus and splints are kept in place for four or six weeks, and at this time union at the seat of fracture is usually quite firm, so that they may be removed, and the fracture is then supported by moulded pasteboard splints or by the application of a plaster-of-Paris splint for several weeks longer, and at the end of eight to ten weeks it is safe to allow the patient to be up and around on crutches. The x-ray should be employed to verify satisfactory position of the fragments.

Suspension Traction Treatment of Fractures of the Long Bones near Joints.—This form of treatment of fractures of the long bones has been used during the last few years, and is at the present time extensively employed, and the results obtained are most satisfactory. The traction suspension treatment affords the best means of placing the distal fragment in proper alignment with the proximal fragment. It also provides for the care of the damaged soft parts, recognizing the fact that in many cases muscular, fascial and joint repairs are as important in restoring a good functioning limb as anatomical restitution of the bone.

This treatment requires special apparatus, experience in their use, with attention to detail, which requires a considerable expenditure of time, but those surgeons who have used it extensively consider that it is justified by the results. Traction may be applied by adhesive plaster attached to the skin, or by strips of canton flannel fastened to the skin by Sinclair's or Heussner's glue, or the Henniquen band around the flexed elbow in fractures of the humerus; and in fractures of the femur or bones of the leg, by means of the Ransohoff tongs (Fig. 330), or the Worcester modification of the same. This consists in making the points conical, to prevent too deep penetration. Suspension is obtained by the Thomas arm (Fig. 331) or thigh splint (Fig. 332), or Hodgen's splint and the Balkan frame.

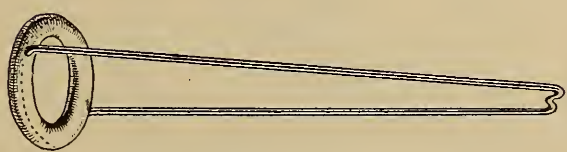
A preliminary roentgen ray is taken. In treating a fracture of the femur by this method the immediate application of sufficient weight to overcome shortening is most important.

Fig. 330.



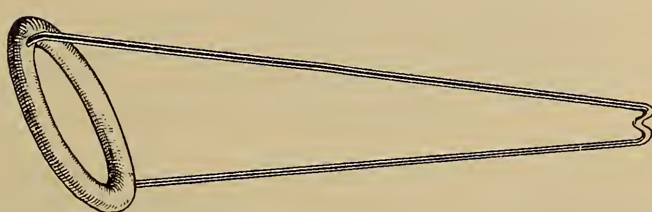
Ransohoff's tongs.

Fig. 331.



Thomas' arm splint.

Fig. 332.

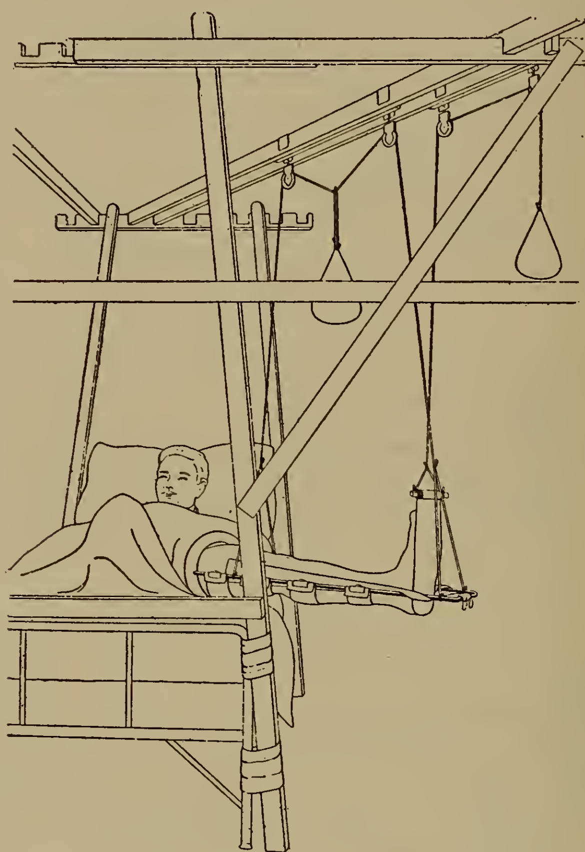


Thomas' traction leg splint.

In an adult male an initial weight of 25 pounds is often required; this can be diminished later if a subsequent roentgen ray shows that the shortage has disappeared or is diminishing. In fractures of the humerus from 8 to 10 pounds is usually sufficient.

Fractures of the bones of the leg are usually drawn into direct alignment without difficulty, but in certain fractures of the femur or humerus, to correct the deformity, traction must be made at different angles to the body (Fig. 333). Special additions to the Balkan frame permit traction at any angle with the trunk.

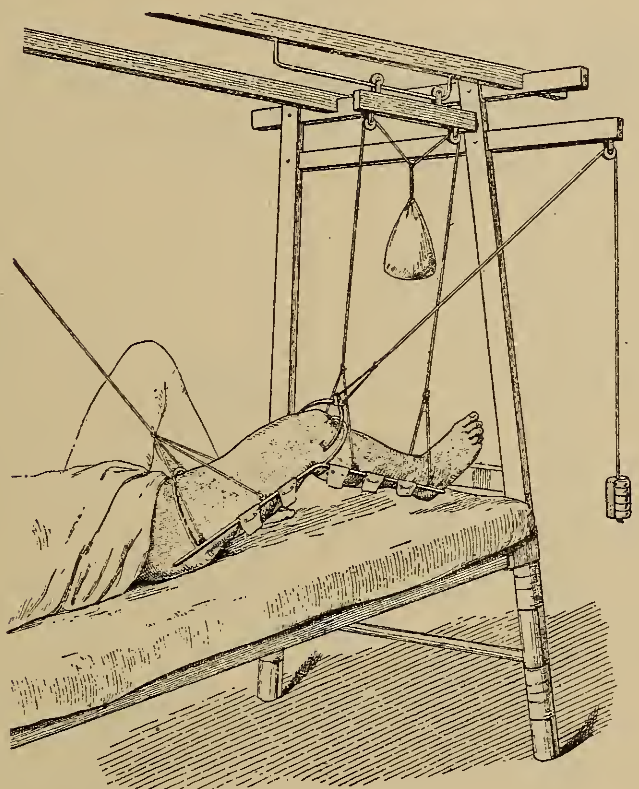
Fig. 333.



Thomas' splint suspension in abduction. (Splint Manual, U. S A.)

The extension apparatus may be made with Z. O. plaster, or by attaching strips of canton flannel to the skin by Sinclair's or Heussner's glue, which is painted upon the skin, and as it begins to dry the canton flannel strip is applied. Sinclair's glue is composed of glue, 50 parts; water, 50 parts; glycerin, 2 parts; calcium chloride, 1 part; and thymol, 1 part. Heussner's glue is made of resin, 50 parts; alcohol (90 per cent), 50 parts; Venice turpentine, 1 part and benzine, 1 part. In applying the tongs or caliper extension in fracture of the femur or bones of the leg, the tongs are usually applied to the condyles or to the malleoli (Fig. 334); the skin in the region is sterilized and painted with tincture of iodine, and a

Fig. 334.



Method of treating high fractures of the femur with the Hodgen's splint and traction by Ransohoff's tongs. Abduction is obtained by placing the pulley for the traction cord on an outrider, and outward rotation by tilting the splint. The suspension attachment for preventing foot-drop has not been drawn. (The more proximal of the distal suspension cords should have been attached to the splint at the proximal side of the knee.) (Blake.)

small amount of novocaine is injected into the tissues at the seat of application. A narrow knife is passed down the bone, and the points of the tongs are introduced and driven into the bone. A sterile gauze dressing is secured around the puncture points.

In fractures of the leg the tongs may be applied to the malleoli, or to the os calcis. The limb is next placed upon a Thomas or Hodgen's splint, and suspended from the Balkan frame. Extension is made by attaching a weight to the tongs, or other extension apparatus, by a system of pulleys

FIG. 335.

Fracture of the humerus in suspension and traction. (Ashhurst.)

attached to the Balkan frame and splint. The patient can change his position in bed without interfering with the extension or disturbing the fragments. In certain cases joint movements can also be accomplished. In fractures of the humerus and bones of the forearm, the suspension traction treatment may be employed with good results.

Many surgeons, in fracture of the shaft of the femur, prefer to use a *long external sand bag*, and a shorter *internal one* in place of the corresponding long and short splints and bran bags; if care is observed that the sand bags are kept accurately in contact with the limb and body, excellent results may be obtained by this form of dressing. After considerable experience with both methods of furnishing lateral support, in the dressing of fractures of the shaft of the femur, I am well satisfied that angular deformity is less likely to result where the splints and bran bags are employed.

Plaster-of-Paris Dressing.—In applying this as a primary dressing it is essential that the patient be anesthetized to reduce muscular spasm and extension, and manipulation should be made until the fragments are in accurate apposition; and a plaster-of-Paris bandage should be applied, including the foot, leg, thigh, and pelvis, extension being maintained under anesthesia until the bandage has become firm. In applying this dressing, the patient should be placed upon the pelvic supporter (see page 107).

Fracture of the Lower End of the Femur.—The fractures met with in this portion of the femur are supracondyloid fractures, those in which one condyle is separated from the other, or comminuted fractures, in which both condyles are separated; epiphyseal disjunctions of the lower end of the femur, met with in young subjects, may also be classed with fractures at this portion of the bone.

Treatment.—To reduce the deformity and approximate the fragments by extension and manipulation the use of an anesthetic is necessary. If there is shortening, the dressing should be similar to that employed in fractures of the shaft of the femur, consisting in the application of an extension apparatus and bran bags and splints or sand bags to give lateral support; if, however, there is no marked shortening, the dressing employed should be the same as that applied in fractures involving one or both condyles or epiphyseal separation. Where there is marked deformity the suspension traction treatment and tongs may be employed with good results.

The dressing employed in fracture of one or both condyles, or in epiphyseal disjunction of the lower end of the femur, consists in placing the limb in a fracture-box extending from the foot to the upper third of the thigh, the box being well padded with a soft pillow, or a well-padded posterior splint, or a moulded pasteboard or felt gutter may be employed; if either of these dressings is employed, the splint or gutter should be sufficiently long to extend from the lower part of the leg to the upper part of the thigh.

At the end of ten days or two weeks it is well to place the limb in a plaster-of-Paris dressing extending from the foot to the upper part of the thigh. This dressing should be retained for six to eight weeks; at the end of this time the dressing should be removed, and if union is sufficiently firm to allow the patient to go about on crutches, a fresh plaster-of-Paris splint should be applied, extending from the middle of the leg to the middle of the thigh, or lateral splints of pasteboard may be substituted for the plaster dressing. The plaster-of-Paris dressing may be applied as a primary dressing after the reduction of the fracture under anesthesia, if there is not much swelling of the parts.

A certain amount of permanent impairment of the joint-motion is apt to follow fractures involving one condyle or both condyles of the femur.

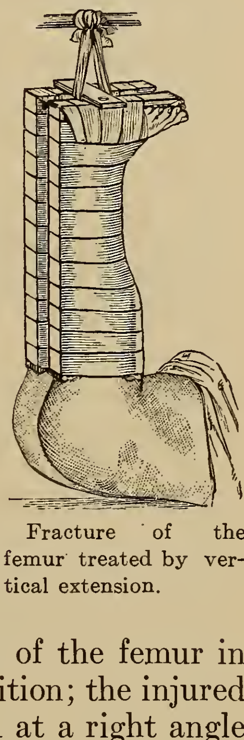
Fracture of the Shaft of the Femur in Children.—Treatment.—In infants the treatment by extension by a weight and pulley and lateral splints is often unsatisfactory on account of the difficulty in keeping the patient quiet upon his back, and from the soiling of the dressings by the feces and the urine. In children two years of age and over I have never found much trouble in employing extension and lateral support by splints and bran bags or sand bags, and in these cases I make additional fixation at the seat of fracture, and guard against displacement of the fragments by the child sitting up in bed when not watched, by carefully moulding external and internal pasteboard or felt splints to the thigh, and holding them in place by the turns of a bandage. I have employed this form of dressing even in children under two years of age with the most satisfactory results.

In cases of fracture of the femur in children from a few months to a year or eighteen months of age, in whom it is difficult to obtain quietude, or who have to be moved to give them nourishment if they are taking the breast, the dressing which I have found most satisfactory consists in first applying a roller bandage from the foot to the groin, and then moulding to the outer half of the foot, leg, thigh, and also to half of the pelvis, a pasteboard or felt splint which is well padded with cotton, and held in position by the turns of a bandage carried from the foot to the pelvis and finished with circular turns about the pelvis. The splint should be so moulded as to include a little more than one-half of the circumference of the thigh and leg. If this splint becomes soiled, it is easily replaced by a fresh one, and its removal and renewal are much easier than the plaster-of-Paris splint.

In young children fractures of the femur are often *incomplete* or *green-stick fractures;* and even when complete, the shortening is usually not marked, as the line of fracture is apt to be transverse, the periosteum often not being completely ruptured, which tends to hold the fragments in position.

In green-stick fractures the deformity should be reduced by manipulation, even if it is necessary to convert the incomplete fracture into a complete one to accomplish this object.

Fig. 336.



Fracture of the femur treated by vertical extension.

Mr. Bryant recommended that fractures of the femur in young children be treated in the *vertical* position; the injured limb, together with the sound one, is flexed at a right angle to the pelvis and fixed with a light splint, and attached to a cradle or bar above the bed (Fig. 336).

Plaster-of-Paris Dressing.—This is a very satisfactory dressing. The patient should be anesthetized, and after reduction of the fragments by extension and manipulation, the limb should first be enveloped from the foot, including the pelvis, with a flannel bandage, extension being made while the plaster-of-Paris bandage is being applied, and should be kept up until the bandage has become fixed. The plaster bandage should include the whole limb and the pelvis, so as to fix the hip-joint. To prevent the splint from absorbing the discharges and becoming offensive, the upper portion of it may be coated with shellac.

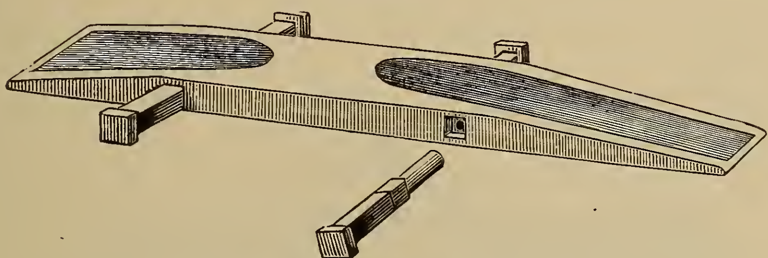
The time required for union in fractures of the femur in children is about four weeks, and the dressings may be removed at this time; but the child should not be allowed to use the limb for eight or ten weeks from the receipt of the injury, on account of the risk of consecutive shortening or angular deformity from bending of the bone at the seat of fracture.

Ambulatory Treatment of Fracturs of the Femur.—In this method of treatment in fractures of the femur the injured limb is strongly extended, and a flannel roller is applied to the leg, thigh and pelvis. A plaster-of-Paris bandage is then applied from the toes to the pelvis, and is made to include the pelvis by spica and circular turns. It should be well padded in the perineum, and the inner portion of the bandage should fit well in the region of the tuberosity of the ischium. The plaster dressing should be so applied that upon the patient standing upon the limb the weight is supported by the plaster cast resting upon the tuberosity of the ischium, and the expanded portion of the ilium. A Taylor hip-splint, reinforced by plaster bandages and the use of crutches, with a high shoe on the sound foot, may be used in the ambulatory treatment of fractures of the femur.

Fracture of the Patella.—These fractures result from direct violence and muscular action, in the latter the lateral fibrous extensions of the quadriceps are freely torn which causes wide separation of the fragments. The line of fracture is more or less transverse and the lower fragment is usually smaller. This fracture is rarely seen in children except when produced by direct violence.

Treatment.—As it is difficult to secure good apposition of the fragments by reason of the interposition of tissues between the fragments, the operative treatment gives the best results and is generally employed. In old persons and those suffering from visceral disease the conservative treatment which often is followed by a very useful limb, should be preferred. This consists, first, in the application of a roller bandage from the toes to the upper part of the leg; a well-padded posterior wooden splint long enough to extend from the middle of the leg to the middle of the thigh, or an Agnew splint, which is provided with pegs for the attachment of strips of adhesive plaster (Fig. 337), is next placed under the limb. A small compress of lint is next placed above the upper fragment, and a similar compress is placed below the lower fragment; a strip of adhesive plaster $1\frac{1}{2}$ inches in width and 24 inches in length has its middle portion applied over the compress, and its ends are then brought obliquely downward and fastened to the splint, or to the pegs if Agnew's splint

Fig. 337.



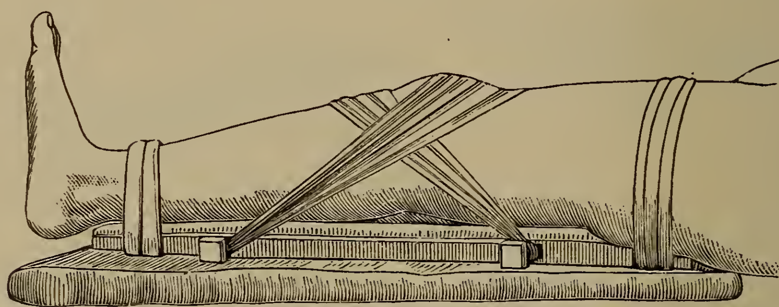
Agnew's splint for fracture of the patella.

be used; this may be reinforced by a second or third strip. The object of these strips is to bring the upper fragment down in contact with the lower fragment. A strip of plaster with the ends passing in the opposite direction is next placed over the lower compress, and the ends are fastened to the splint or pegs; this strip serves only to steady the lower fragment, as it cannot be drawn upward to meet the upper fragment by reason of the inextensibility of its ligamentous attachment (Fig. 338). If the Agnew splint is employed, the strips of plaster may be tightened by turning the pegs to which they are fastened without removing the splint.

The splint is next firmly fixed in contact with the limb by the turns of a roller bandage extending from the lower to the upper end of the splint. The limb should next be placed upon an inclined plane or in a long fracture-box, with its foot elevated to relax the quadriceps femoris muscle. This dressing should be removed and reapplied in a few days, as the dressings become loose as the swelling about the seat of injury subsides, and after this disappears the dressings require renewal at less frequent intervals; and usually at the end of three weeks the splint may be removed and a plaster-of-Paris bandage may be applied, extending from the middle of the leg to the middle of the thigh. At the end of six weeks the patient may be allowed to walk upon the limb, the knee-joint being fixed with a plaster-of-Paris or pasteboard splint.

It is well, after removal of the splints, for the patients to wear for some months a laced muslin knee-supporter, which gives some support to the knee-joint.

Fig. 338.



Agnew's splint applied.

A great variety of splints have been devised and used in the treatment of fractures of the patella, the main object of which is to fix the knee-joint and bring the fragments as nearly as possible in apposition.

The union in fractures of the patella is usually fibrous, although in rare cases bony union has occurred.

In cases of rupture of the fibrous union after fracture of the patella, which is not an uncommon accident, the treatment of the case should be the same as that for a recent fracture of the patella.

Operative Treatment.—This method, which consists in exposing the fragments by an incision and drilling and suturing them with catgut or silver-wire sutures, or in approximating the fragments by suturing the fibrous tissues with catgut, is the most satisfactory procedure and the one often employed at the present time, the strictest antiseptic precautions being taken to prevent infection of the wound. After the external wound has been closed without drainage, the limb is put up in a plaster-of-Paris dressing extending from the foot to the groin. Or the limb may be placed upon a straight splint extending from the middle of the leg to the upper third of the thigh, this may be used for ten days, and after the sutures have been removed a plaster-of-Paris dressing is applied for a few weeks.

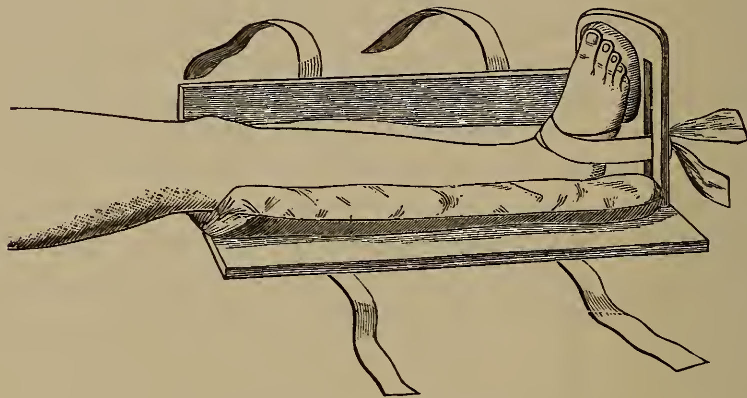
Rupture of the Quadriceps Extensor Tendon.—This usually results from muscular force, the tendon giving away instead of the patella, the tendon may tear just above the patella or its attachments to the bone may be separated. I have seen a patient who sustained a simultaneous rupture of both tendons. The symptoms are a depression above the patella, pain, inability to extend the leg or to stand or walk. The treatment in vigorous subjects is exposure of the ruptured tendon and suture; in aged or debilitated subjects this should be the same as that of fracture of the patella.

Fractures of the Tibia.—These may result from direct or indirect force, the line of fracture may be transverse, spiral of oblique. Those of the upper and lower portion may involve the knee-joint and ankle-joint. If the fibula is uninjured the deformity is not apt to be marked. The treatment is practically the same as that for fracture of both bones of the leg.

Fractures of the Tibia and Fibula.—In fractures of both bones of the leg the displacement is usually very marked. When only one bone is broken, the sound bone, acting as a splint, prevents much deformity, except in cases of fracture at the lower end of the fibula, when the foot inclines to the injured side.

Treatment.—The dressing of fractures of both bones of the leg, or of fracture of the tibia or the fibula alone, except in cases where the lower portion of the fibula is the seat of injury, is best accomplished by the use of a fracture-box. The displacement being overcome as far as possible by extension and manipulation, the leg is placed in a fracture-box, which is prepared for the reception of the limb by having the sides let down and having a soft pillow laid in it; the foot

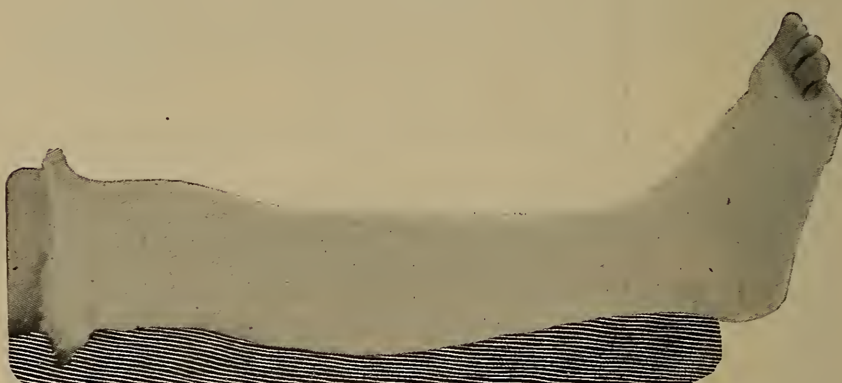
Fig. 339.



Application of the fracture-box.

is next secured to the footboard by a loop of bandage passed around the foot, the ends being tied after passing through the slots in the footboard; a pad of oakum or cotton is placed

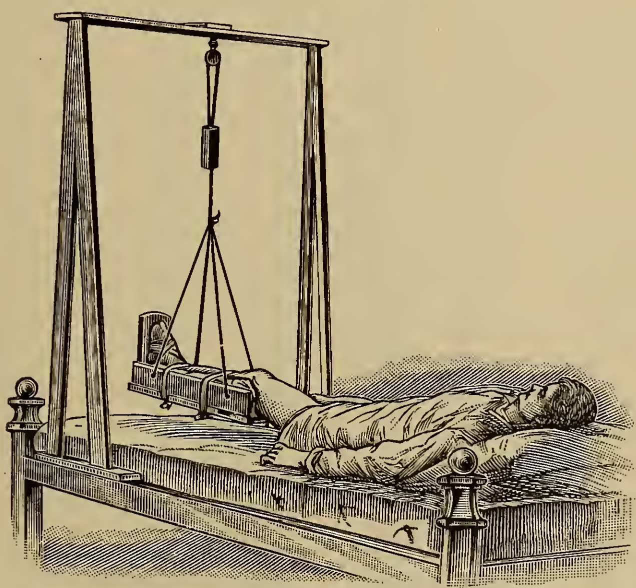
Fig. 340.



Plaster bandange applied to fracture of the leg.

under the tendo-Achillis, to relieve the heel from pressure, and a similar pad is placed between the sole of the foot and the footboard (Fig. 339). The sides of the box are then brought up and secured by two or three strips of bandage tied around the box. In using a fracture-box in the treatment of fractures of the bones of the leg the surgeon should see that the foot is kept well down to the footboard and is at a right angle with the leg, that there is no eversion of the knee, and that the pillow is full enough to make equable pressure upon the leg when the sides of the box are secured, and that the heel is not subjected to undue pressure, the use of a pad of oakum or cotton under the tendo Achillis being employed to prevent

Fig. 341.



Fracture-box suspended.

this complication. Where there is a tendency to tilting upward of the lower end of the upper fragment, the lower fragment can be brought in line with this by raising the foot by a mass of oakum or cotton placed under the tendo Achillis and heel, and so overcoming the deformity. In some cases division of the tendo-Achillis may be required before this deformity can be corrected.

The subsequent dressings of the case are conducted by letting down the sides of the box and correcting any displacement, if present, by adjusting the limbs and pads in their proper position, and again bringing up the sides of the box and securing them. At the end of two weeks the fracture box may be removed and a plaster-of-Paris dressing applied to the limb, which will allow the patient more freedom of movement in bed or permit of his sitting up without disturbing the fragments (Fig. 340).

Union in fracture of the bones of the leg is usually quite firm in six weeks, but for at least eight weeks the patient should not be allowed to put his weight upon the limb in walking.

If the patient is restless, and finds his position with the fracture-box resting upon the bed irksome, the fracture-box may be swung from a frame fastened over the bed (Fig. 341).

Plaster-of-Paris Dressing.—This dressing is extensively used in the treatment of fractures of the tibia or the tibia and fibula.

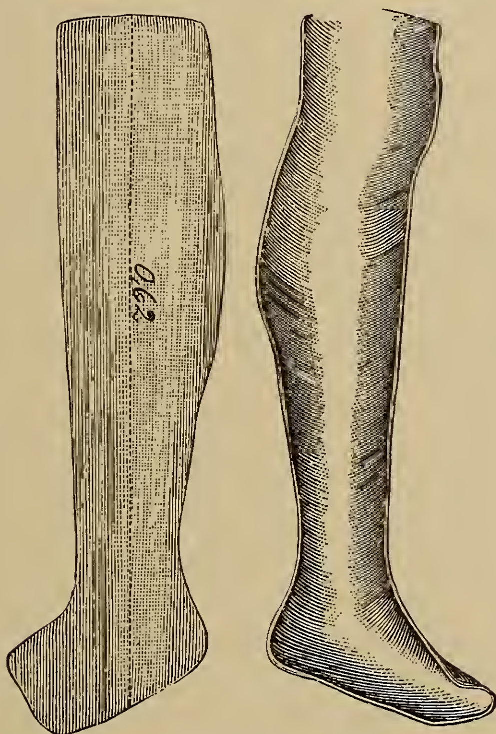
The deformity should first be corrected by extension and manipulation. To accomplish this an anesthetic is usually required, bony prominences are padded with layers of cotton, and a flannel bandage is applied to the limb from the toes to a point a little above the knee-joint. The plaster-of-Paris bandage is next to the limb from the toes to the thigh, and extension should be maintained until the bandage has set. The case should be under constant observation for a few days, so that the dressing can be removed if a dangerous amount of swelling takes place.

Moulded lateral splints of felt or pasteboard are also sometimes applied in the treatment of these cases (Fig. 342).

In patients suffering with *delirium tremens,* or in *maniacal* patients, the use of a fracture-box in the treatment of fractures of the bones of the leg is often not satisfactory, on account of the difficulty in restraining the movements of the patient and the consequent displacement of the fragments. In such cases it is well to apply a few strips of binders' board, well padded with cotton, to the limb, extending above and below the seat of the fracture, holding them in place by a few turns of a roller, and then to wrap the limb and foot in a soft pillow, and hold this in place by the turns of a roller bandage applied with moderate firmness. This dressing allows the patient to move the limb without serious disturbance of the fragments, and, after the patient recovers from his attack, the leg may be placed in the fracture-box or in a plaster-of-Paris dressing.

In fractures of the bones of the leg *in young children* the same difficulty is often experienced in keeping them quiet, and for this reason a fracture-box cannot be used with

Fig. 342.



Moulded binders' board splints for fracture of the leg.

satisfaction. In dressing these cases, two lateral splints of pasteboard, moulded to the foot and leg and well padded with cotton, may often be employed with the best results. The splints should not be wide enough to meet on the anterior or posterior surface of the leg or foot. The splints, after being carefully adjusted, are held in place by the turns of a roller bandage; and after these splints have been applied for two weeks, and all swelling has subsided at the seat of fracture, a plaster-of-Paris bandage may be substituted for them, which should be worn for four weeks; at the expiration of this time union is usually sufficiently firm to dispense with all dressings.

Plaster-of-Paris Dressing.—This may be used as a primary dressing, and is applied in the same manner as for similar fractures in adults.

Ambulatory Treatment of Fractures of the Bones of the Leg.—The application of a dressing for the ambulatory treatment of fractures of the bones of the leg is as follows: The fracture should be reduced and the skin of the leg washed with soap and water; a flannel bandage is applied from the toes to a point just above the knee. This bandage holds to the sole of the foot a number of layers of cotton wadding, which, when moderately compressed, makes a pad $\frac{3}{4}$ of an inch in thickness. A plaster-of-Paris bandage is applied to the foot and leg, and extends above the knee, and care should be taken to apply additional turns about the sole of the foot and ankle, to give it greater strength at these points. The turns of the bandage should also be firmly applied about the expanded head of the tibia.

In the ambulatory method of treatment, the patient, as soon as the bandage has become firm, is allowed to walk about, first with crutches or a cane, and finally bearing his weight upon the injured limb.

Fractures of the Fibula.—Fractures of the shaft of the fibula are rare, but very frequent in association with fractures of the tibia, and are quite common in the lower fifth of the bone. In isolated fracture of the upper part of the shaft of the fibula it is often difficult to secure apposition of the fragment, as they are buried in the muscles, and delayed union or non-union is not uncommon. The deformity is not marked, and they are usually dressed with a fracture-box applied as in the dressing of fractures of both bones of the leg, and at the end of two weeks a plaster-of-Paris dressing should be applied, and the patient allowed to get out of bed and move about on crutches. The *plaster-of-Paris dressing* may also be used as a primary dressing. The union in a fracture of the fibula is usually quite firm at the end of five weeks, at which time all dressings may be dispensed with.

Fracture of the Lower End of the Fibula (Pott's Fracture).—This fracture usually occurs in the lower fifth of the bone, and is often associated with laceration of the internal lateral ligament of the ankle-joint or a fracture or sprain-fracture of the internal malleolus, and is usually accompanied by marked eversion of the foot.

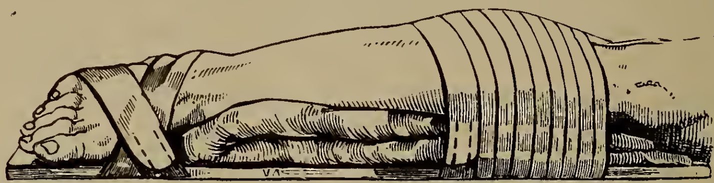
Treatment.—After reducing the displacement by extension and manipulation, the limb should be placed in a fracture-box provided with a soft pillow, the foot should be secured to the footboard, and a pad of oakum or cotton should be placed under the tendo-Achillis: before bringing up the sides of the box and securing them, two firm compresses of lint or oakum should be placed in contact with the leg and foot, one just above the inner malleolus, the other just below the outer malleolus. The sides of the box are next brought up and secured, and by the pressure of these compresses the foot is brought into an inverted position and the deformity is corrected.

The after-dressing of this fracture consists in letting down the sides of the box, and in inspecting the parts to see that the foot is kept in the proper position, and care should be taken that undue pressure is not made upon the skin by the compresses, which might result in ulceration; this may be avoided by sponging the skin with alcohol and changing the positions of the compresses slightly at each dressing. At the expiration of ten days the fracture-box and compresses may be removed and the limb put up in a plaster-of-Paris dressing, including the foot and leg, up to the knee. The patient may then be allowed to go about on crutches, and at the end of five weeks all dressings may be dispensed with.

This fracture may also be treated by the forcible correction of the deformity under ether and the immediate application of a plaster-of-Paris dressing.

Dupuytren's splint, which consists of a straight wooden splint long enough to extend from the condyles of the femur to the end of the toes, may also be employed; this splint is provided with padding, the thickest part of which, several inches in thickness, should rest upon the skin just above the inner malleolus when the splint is applied to the inner side of the leg. The splint is secured in position by the turns of a roller applied over the foot and at the upper part of the leg (Fig. 343). After using this dressing for a few days, if the displacement is satisfactorily corrected, the splint may be removed and the leg placed in a fracture-box or in a plaster-of-Paris dressing.

Fig. 343.



Dupuytren's splint applied.

Fractures of the Tarsal Bones.—The *calcaneum* and *astragalus* are the tarsal bones most frequently fractured.

Treatment.—The dressing of fractures of the *calcaneum,* after reducing the displacement, which is not usually marked unless the posterior portion of the bone is involved, by manipulation, consists in placing the leg and foot in a fracture-box, care being taken that the foot is kept at a right angle to the leg. When the fracture involves the posterior portion of the bones, and there is displacement by the action of the muscles inserted into the fragment, the leg should be flexed upon the thigh and the foot extended; this position may be maintained by applying a well padded curved splint to the anterior portion of the leg and foot and securing it in position by a bandage.

Fractures of the *astragalus,* after reducing any deformity which is present by extension and manipulation, are dressed by placing the foot and leg in a fracture-box, care being taken that the foot is kept at a right angle to the leg. This precaution is important, as anchylosis not infrequently occurs after this fracture, and if the foot is in the proper position it is much more useful to the patient.

As soon as the swelling, which is usually very marked after fracture of the calcaneum or astragalus, subsides, the foot and leg should be put up in a plaster-of-Paris bandage. The amount of tension and the inability to reduce the displacement in cases of fracture of the astragalus may be indications for excision of the fractured bone. The time required for union in fractures of the tarsal bones is from five to six weeks.

Fractures of the Metatarsal Bones.—These fractures are dressed by placing the foot upon a well-padded plantar splint, and using compresses to hold the fragments in place if there is much displacement, the splint and compresses being held in position by a bandage; or they may be treated by moulded binder's board or felt splints; the plaster-of-Paris dressing may also be used in these cases. The time required for union in fracture of the metatarsal bones is from three to four weeks.

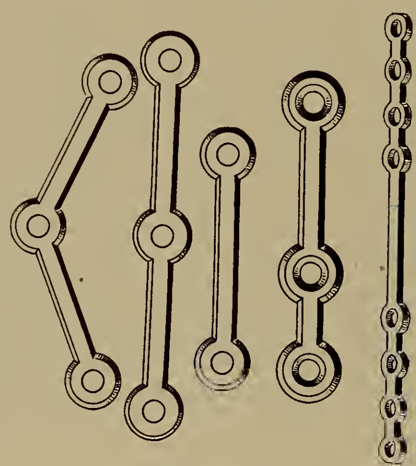
Fractures of the Phalanges of the Toes.—These fractures are often compound and attended with so much laceration of the soft parts that immediate amputation is required; when, however, the fractures are simple, or in compound fractures where amputation is not required, the dressing consists in applying a plantar splint of wood, wire or binders' board, extending beyond the toes and securing it in position by the turns of a roller bandage. When a single toe only is broken, a moulded splint of gutta-percha or binders' board may be applied, and a portion of the splint should extend some distance upon the sole of the foot, to fix the proximal joint, and also to give the toe a firm point of fixation; the moulded splint should be held in position by a narrow roller bandage or by strips of adhesive plaster. The time required for union in fractures of the phalanges of the toes is about three weeks.

COMPOUND OR OPEN FRACTURES.

In the dressing of compound or open fractures the same dressings and splints which are generally used in the treatment of simple or closed fractures may be employed; the wound in the soft parts requires a special dressing, and this should be so arranged as to secure free drainage and promote its prompt healing. In some cases of compound fracture the treatment of the injuries of the soft parts demands attention first, and in such cases the injury to the bones is for a time disregarded, care being taken that the fragments are kept quiet, so as to prevent further damage to the soft parts until the wound is in such a condition that the proper manipulation to reduce the displacement and fix the fragments by splints and suitable dressings may be undertaken without interfering with the repair of the wound.

Treatment.—In the dressing of compound or open fractures the skin surrounding the wound should first be carefully cleansed or painted with tincture of iodine, and the wound next be thoroughly irrigated with a 1 : 2000 bichloride solution, and any foreign bodies or loose fragments of bone removed; if there is hemorrhage, it should be controlled by securing the bleeding vessels with ligatures; free venous oozing may be controlled by gauze packing. The reduction

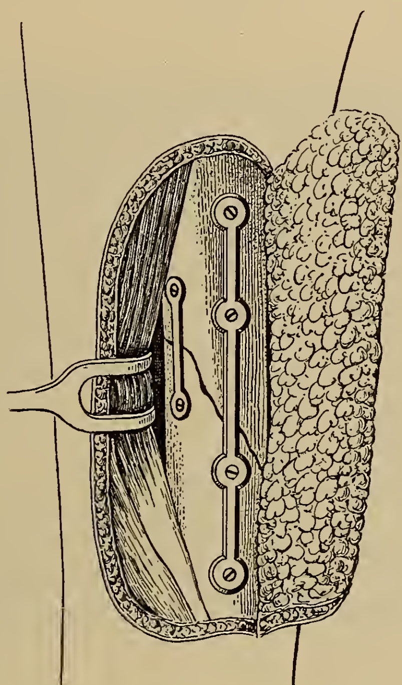
Fig. 344.



Lane's plates.

of the displacement should next be accomplished by making extension and by manipulation; if the fragments project from the wound before this can be satisfactorily accomplished, it may be necessary to enlarge the wound and to resect one or both ends of the fractured bones, and in some cases it may be necessary to drill the ends of the fragments and introduce a strong wire or catgut suture, or a metallic nail, screw, or silver plate, or Lane's plates (Figs. 344 and 345) to hold them in their proper positions. If metallic bodies are used to secure fixation of the fragments, where it is possible they should not be placed over a subcutaneous portion of the bone to prevent subsequent injury or irritation. In oblique fractures a single wire may be employed, introduced as shown in Fig. 346; in transverse fractures two wire sutures may be applied, as shown in Fig. 347. After reduction of the displacement the wound should again be thoroughly irrigated with an antiseptic or normal salt solution, and after making

Fig. 345.

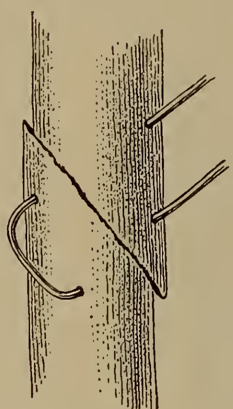


Lane's plates applied to oblique fracture of the tibia.

provision for drainage by the introduction of a drainage tube or tubes, counter openings being made to secure free drainage if necessary, sterilized or antiseptic gauze dressings should be applied. Débridement of the wound and Carrel-Dakin treatment may also be satisfactorily used in these cases.

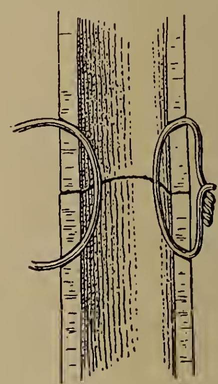
The wound, if a small one, need not be closed with sutures; but if extensive, a few catgut, silk, or silkworm-gut sutures may be applied to bring the edges of the wound into apposition, care being taken to avoid making undue tension; if the soft parts have been much lacerated or contused, it is better to introduce no sutures. If the limb is much swollen and the wound is a small one, free division of the *deep fascia* to relieve tension and secure drainage is often followed by good results. A final irrigation of the wound through the drainage tube is next made, and the wound is covered by a sterilized gauze dressing and a number of layers of sterilized cotton, the whole dressing being held in position by a gauze bandage applied with moderate firmness.

Fig. 346.



Oblique fracture fixed by single wire suture.

Fig. 347.



Transverse fracture fixed by two wire sutures.

The reduction of the fragments and the dressing of the wound having been accomplished as described, the splints appropriate for a similar fracture, if it were a simple or closed one, are next applied. If the surgeon has been able to render the wound aseptic, and has applied an antiseptic dressing, the compound fracture is often soon converted into a simple one by the prompt healing of the wound, and the patient may exhibit no more constitutional disturbance than he would have with a similar simple or closed fracture. The redressing of a compound fracture dressed in this way need not be made for a week or ten days, unless there is a rise in the patient's temperature or the dressings become soaked with discharges from the wound, or they become uncomfortable to the patient by reason of swelling of the soft parts in the region of the wound. When redressing of the fracture becomes necessary the dressings are removed, and the drainage tubes may also be removed if no longer needed; the wound being redressed with an antiseptic or aseptic dressing, the splints are reapplied and, after the wound is healed, the subsequent dressing of the fracture should be the same as that of a simple fracture. The time required for union in a compound fracture is usually much longer than in a corresponding simple fracture.

FIG. 348.

Fenestrated plaster dressing for compound fracture of the leg.

Plaster-of-Paris Dressing.—This may be used as a primary dressing in compound fractures; the displacement being reduced and the wound dressed with an antiseptic gauze dressing, a plaster-of-Paris bandage is applied to the parts so as to firmly fix the fragments; the joints on either side of the fracture should be fixed by the bandage, and the parts should be held in position until the plaster has set firmly. After the plaster has become firm a fenestrum should be made over the position of the wound, so that it may be inspected or dressed through this when necessary (Fig. 348).

The ends of a piece of stout wire, bent into a semicircle, may be incorporated in the turns of the plaster bandage above and below the position of the fenestrum, to give it additional strength after the removal of a portion of the bandage to make the fenestrum.

If the plaster-of-Paris dressing is applied as a primary dressing in compound fractures, the case should be carefully watched for a few days, and if much swelling occurs at the seat of fracture its removal and renewal are indicated; profuse discharge of serum may also soak the dressings and bandage, so that its renewal is necessitated. Some surgeons, therefore, prefer to defer the application of the plaster-of-Paris dressing in compound fractures for a few weeks until the swelling has diminished and the wound is nearly or quite healed; the wound being covered with an antiseptic dressing, the plaster bandage is applied, and a fenestrum is made over the position of the wound if required.

Binders' Board or Felt Splints.—These may also be employed in the dressing of compound fractures, being moulded to the parts after an antiseptic dressing has been applied to the wound, and held in position by the turns of a roller bandage.

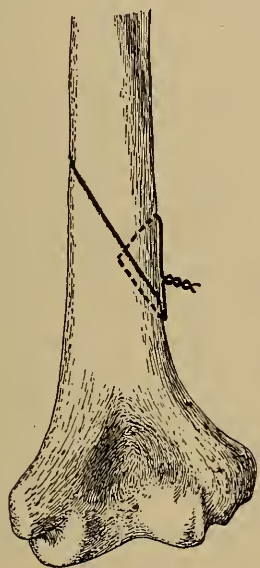
The principal advantage in the use of these splints is the ease with which they can be removed and reapplied if frequent dressings of the fracture are necessary for any reason. They may be used during the entire course of treatment; or, after a few weeks, when the swelling has diminished at the seat of fracture and the wound is well advanced toward repair, they may be discarded and a plaster-of-Paris dressing substituted. In compound fractures of the bones of the leg, after reducing the displacement and applying an antiseptic dressing to the wound, I usually apply moulded binders' board splints to either side of the leg, including the foot, and place the leg in a fracture-box for additional security. In a week or ten days I discard the binders' board splints and apply a plaster-of-Paris dressing.

UNUNITED FRACTURE.

This condition usually arises from local causes, such as imperfect coaptation of the fragments, the interposition of muscular tissue, fascia, a tendon, or nerve, or a portion of devitalized bone between the fragments. The ends of the bones may be rounded, or may be united by fibrous tissue, or there may be an attempt at the formation of a false joint, the end of one fragment being rounded off and the other cupped to receive it.

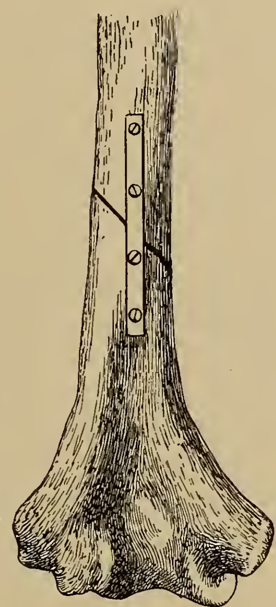
In cases of fracture in which union has not occurred at the usual time care should be taken to see that fixation of the fragments is as complete as possible, and in addition to the

Fig. 349.



Fragments in ununited fracture secured by silver wire.

Fig. 350.



Fragments in ununited fracture secured by silver splint.

retention of the fixation dressings a systematic use of Bier's hyperemic treatment should be instituted, as good results have often been obtained by its employment.

Treatment.—This consists in exposing the ends of the bones by incision, with full antiseptic precautions, and removing the ends of the bones to secure a healthy surface, and then fixing the bones securely together by drilling them and introducing one or more heavy silver-wire sutures (Fig. 349).

A dental engine equipped with a circular saw and drills will be found a most useful instrument in this work. In some cases the shape of the fragments is such that they can be sawed so as to form a mortise, and the bones can then be fixed by the introduction of one or more steel or silver screws. Another method of fixation is by a steel or silver splint (Fig. 350), a Lane's plate secured to the fragments by iron or silver screws. After the fixation of the bones has been accomplished, metal bands, and splints secured by screws, the wound should be closed and an antiseptic dressing applied; additional fixation is furnished by the application of a plaster-of-Paris dressing.

Bone Transplantation in Ununited Fracture.—This procedure has been practised in the treatment of ununited fractures. The ends of the bone are prepared as previously described, and a section of bone $1\frac{1}{2}$ to 2 inches in length and from $\frac{1}{2}$ to $\frac{1}{4}$ of an inch in width is removed from the anterior edge of the tibia, the periosteum being retained only if the graft is to be used to span a gap, not when it is to be used as an intermedullary peg. This fragment is introduced into the medullary cavity of the fragments to act as a dowel. It may be necessary to ream out cavities in the bone tissues to make spaces for the bone graft or dowel. A portion of the upper surface of a rib may be used as the graft. It is important that the bone graft be removed from the same individual. The bone graft furnishes some fixation, but if additional fixation is required, wire sutures or plates may be employed. The subsequent dressing is similar to that employed after other means of fixation of the fragments.

Albee's Method.—Albee has demonstrated that a properly prepared and applied bone graft will stimulate the autogenous production of bone. He has devised an electric motor which is equipped with circular saws, twin saws, drills, reamers and lathe to fashion dowels from pieces of bone.

The technic for ununited fractures is as follows: The ends of the bone are exposed by incision, the fibrous union is cut away and the ends of the bone are removed by a saw to obtain a healthy bone surface and the sclerosed tissue is removed from the medullary cavity. If there is over-riding of the fragments this is overcome by traction. If there is sufficient room to make a sliding bone insert, the twin saw is applied and a graft of sufficient length is cut from the cortex of the bone. The saw is next applied to the other fragment, a sufficient amount of bone is removed to receive the insert. Holes are next drilled through the cortex on each side of the grooves and after sliding the insert into its proper position it is secured by passing sutures of kangaroo tendon or chromicized catgut through the holes and securing them over the graft by tying.

If an isolated bone graft is to be used, the tibia of the patient is exposed and a graft of sufficient width and length is removed and secured in the groove prepared for it by sutures.

If an intermedullary graft is desired a dowel of sufficient length and thickness is made from a portion of bone taken from the tibia, and fitted into the previously prepared cavities in the fragment.

Deformed Union.—Union in fractures may occur with more or less deformity in spite of careful treatment. If the deformity does not cause loss of function, surgical interference for its correction is not absolutely necessary. If, however, impairment of function is marked, its correction should be undertaken. Deformity in fractures of from four to six weeks' standing may be corrected by manipulation under anesthesia. To accomplish this the bone is refractured. In cases of longer standing, it may be corrected by osteotomy in suitable cases, or by exposing the seat of fracture and cutting away the callus so as to expose the ends of the fragments. These should then be prepared and secured in the corrected position by wire sutures or plates, a fixation dressing of plaster of Paris being subsequently applied.

PART V.

DISLOCATIONS.

Dislocation.—This consists in displacement of the articular surfaces of the bones which enter into the formation of a joint. Dislocations may be *complete, partial, simple, compound,* and *complicated,* and they are also known as *habitual, recent,* and *old* dislocations.

Complete Dislocation.—This is a dislocation in which no portions of the articular surfaces of the bones remain in contact with each other.

Partial Dislocation.—This is a dislocation in which portions of the articular surfaces of the bones still remain in contact with each other.

Simple Dislocation.—This is a dislocation in which there exists displacement in the relation of the articular surfaces of the bones with little injury to the soft parts adjacent to the joint, and the displaced ends of the bones do not communicate with the air by a wound in the soft parts.

Compound Dislocation.—This is a dislocation in which there exists displacement of the articular surfaces of the bones which communicate with the air through a wound in the soft parts.

Complicated Dislocation.—This is a dislocation in which, in addition to the displacement of the articular surfaces of the bones, there exists a fracture, or a laceration of important bloodvessels, nerves, or muscles in connection with the dislocation.

Habitual Dislocation.—This consists in a dislocation which constantly recurs upon slight provocation, and is usually due to a relaxed condition of the ligaments of the joint.

Recent Dislocation.—This is a dislocation in which the displacement of the articulating surfaces of the bones has existed for such a period that time has not been afforded for inflammatory changes to take place in the articular surfaces of the bones or in the adjacent tissues which would seriously interfere with their reduction.

Old Dislocation.—This is a dislocation in which the displacement of the articulating surfaces of the bones has existed for some time; in this variety of dislocation the displaced bones often form firm adhesions to the surrounding tissues, and the articulating surfaces often undergo changes.

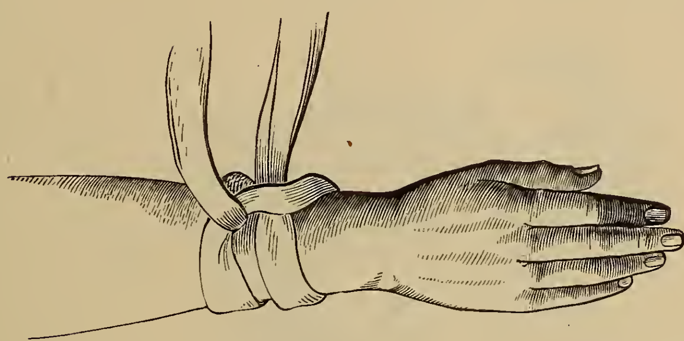
Treatment of Dislocations.—The first indication in the treatment of dislocations is to return the displaced articular surfaces of the bones to their normal position, and to retain them in this position by the use of suitable dressings. The return of the articular surfaces of the bones to their normal position, or *the reduction* of the dislocation, is accomplished by manipulation, extension, and counter-extension. The reduction of dislocations should be attempted as soon as possible after they have occurred.

The principal obstacles to the reduction of dislocations are muscular resistance and the anatomical peculiarities of the joints. The former is best overcome by the use of an *anesthetic* given to the point where complete muscular relaxation is produced. The resistance offered by the changed relations of the articular surfaces and the ligaments is to be overcome by the surgeon making such manipulations, founded upon his knowledge of the anatomy of the parts, as will make the ligaments, muscles, and bones assist in the reduction of the dislocation.

In recent dislocations, by the use of extension and manipulation, especially if an anesthetic be employed, the reduction is usually accomplished without the use of much force; but in old dislocations, where absolute muscular shortening has taken place, the use of extending bands is often required, and in securing these bands to the limb the clove-hitch knot is useful (Fig. 351).

The treatment of dislocations after reduction consists in in placing the joint at complete rest by the application of suitable splints and bandages, and in treating any inflammatory complications, if they arise, by the application of evaporating lotions, and in a week or two, after the injured ligaments have been repaired, passive motion should be resorted to for restoring the function of the joint.

FIG. 351.



Clove-hitch knot applied.

SPECIAL DISLOCATIONS.

Dislocations of the Vertebræ.—Dislocations of the *lumbar* and *dorsal vertebræ,* as simple dislocations, are extremely rare accidents; they are occasionally met with, but are more often associated with fractures of the vertebræ in these regions. Uncomplicated dislocations of the *cervical* vertebræ are more common. The *treatment* of dislocations of the vertebræ, whether complicated with fracture or not, consists in attempting reduction by making extension and counter-extension with manipulation, and by this means, in many cases, the luxations may be reduced. If, however, the efforts at reduction are unsuccessful, permanent extension should be applied by means of a weight extension apparatus from both legs and from the shoulders and head. The after-treatment consists in keeping the patient at rest upon his back in bed upon a firm mattress, and if the cervical vertebræ have been involved, the head and neck should be supported by short sand bags; and in case of the vertebræ below this point, the application of a plaster-of-Paris jacket may be used to give support and fixation to the part. The general management of the case as regards complications is similar to that in cases of fracture of the vertebræ.

Dislocations of the Coccyx.—These are reduced by manipulations with the finger in the rectum and external manipulation at the same time. The only after-treatment required is rest in bed for a few days and the administration of opium to keep the bowels quiet.

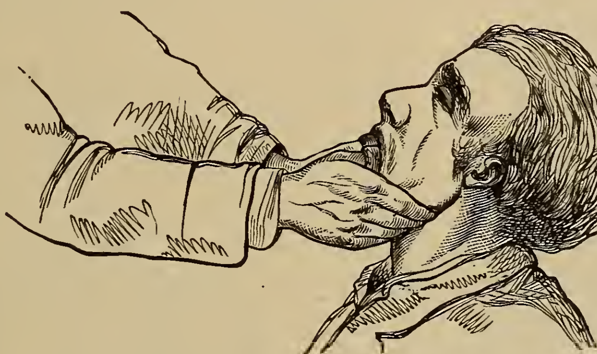
Fig. 352.

Bilateral dislocation of the lower jaw.

Dislocations of the Lower Jaw.—These dislocations may consist in the displacement of one or both condyles of the lower jaw from the glenoid fossæ, constituting the unilateral or bilateral dislocation of the jaw; the latter is the more common form of dislocation of the jaw met with, and the deformity resulting is shown in Fig. 352.

The *reduction* of a dislocation of the lower jaw is accomplished as follows: The surgeon placing his thumbs, well protected by strips of bandage or a towel, on the molar teeth or behind them, presses the angles of the jaw downward while he elevates the chin with his fingers, and by this manipulation the condyles of the jaw usually slip back into place with a snap (Fig. 353). After reduction of the dislocation the jaw should be fixed for a week or ten days by the application of a Barton's bandage or a four-tailed sling.

Fig. 353.



Method of reducing dislocation of the lower jaw.

Dislocation of the Hyoid Bone.—A few cases of dislocation of the hyoid bone have been recorded; the *treatment* consists in throwing back the head as far as possible, to place the muscles of the neck upon the stretch, depressing the lower jaw, and pressing the luxated bone into position.

Dislocations of the Ribs and Costal Cartilages.—The ribs may be dislocated at their vertebral articulations or at the junction with the costal cartilages, or the cartilages may be separated from the sternum. These injuries result from the application of great force, and are often fatal from associated injuries of the thoracic viscera. The *treatment* of these dislocations consists in reducing the displacement by manipulation and pressure, and then in fixing the chest to secure immobility of the ribs by strapping the affected side with strips of adhesive plaster, the same dressing being applied as in cases of fracture of the ribs, the dressing being retained for three or four weeks.

Dislocations of the Sternum.—Dislocation or diastasis of the sternum may occur at the junction of the manubrium and the gladiolus or at the junction of the ensiform cartilage and the gladiolus. The *reduction* is effected by extension of the chest by bending the dorsal spine over a firm cushion placed under the back and by pressure upon the projecting bone; when the displaced bone has been reduced, a compress should be placed over the seat of injury, and held in place by broad strips of adhesive plaster, or by a bandage to keep the parts at rest. The dressing should be retained for three or four weeks.

In the few examples of dislocation of the ensiform cartilage which have been reported, the displacement of the cartilage has in some cases given rise to persistent vomiting, which was relieved by reduction of the displacement; it is, however, almost impossible to keep the bone in place after reduction and excision of the displaced cartilage is indicated.

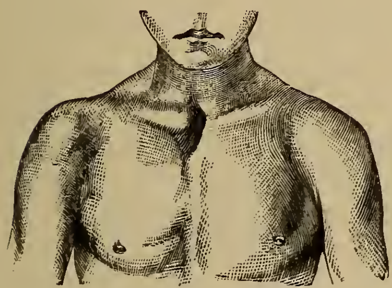
Dislocations of the Pelvis.—Dislocation or diastasis of the bones of the pelvis may occur at the pubic or sacro-iliac symphyses. They are generally serious injuries, as they are apt to be complicated by lesions of the pelvic viscera.

The *reduction* of these dislocations is effected by pressure and manipulation, and after reduction the parts should be supported by a compress held in place by a stout binder or by broad strips of adhesive plaster, the patient being kept quiet in bed and the pelvis being supported by means of sand bags. The dressings should be retained for from four to six weeks.

Dislocations of the Clavicle.—Dislocations of the clavicle may occur either at the sternal or acromial end; the latter injury some writers describe as a dislocation of the scapula, following the general rule that the distal bone is the one dislocated.

Dislocations of the Sternal End of the Clavicle.—These may occur in a forward, backward, or upward direction, and the displacement is generally well marked (Fig. 354). The *reduction* of this dislocation is effected by placing the knee against the spine, and drawing the shoulders outward and backward and pressing the displaced end of the clavicle into place. The reduction is generally easy, but it is often difficult to keep the end of the bone in its proper position. To accomplish this, a compress should be placed over the end of the bone, and this should be secured in place by broad strips of adhesive plaster; the shoulders should be brought well backward and secured by a posterior figure-of-eight bandage of the chest, and the arm of the injured side should be fastened to the side of the chest by spiral turns of a bandage. In some cases, in addition to the compress over the end of the bone, securing the arm of the injured side in the Velpeau position will be found all that is necessary to retain the bone in position.

Fig. 354.



Dislocation of sternal end of clavicle forward.

Fig. 355.

Dislocation of clavicle at acromial end.

Dislocation of the Acromial End of the Clavicle.—This may be upward, downward, or backward (Fig. 355). The *reduction* is effected by manipulation of the arm and scapula and by pressure over the displaced end of the clavicle. The displacement is usually reduced without much trouble, but it is often a matter of difficulty to keep the end of the bone in its proper place. The dressing consists in placing a compress over the acromial end of the clavicle and holding it in place by broad strips of adhesive plaster; the arm should at the same time be fixed in the Velpeau position.

Stimson's dressing consists in applying a long strip of adhesive plaster 3 inches wide, the center being placed over the flexed elbow and its end carried up in front of and behind the arm, crossing over the end of the clavicle and being secured on the front and back of the chest, respectively, while the bone is held in place by pressure upon the clavicle and the elbow. For additional security, the forearm may be supported in a sling and the arm bound to the side of the chest.

The dressings after reduction of dislocations of the clavicle should be kept in place for at least three weeks. Although in many cases a certain amount of deformity persists, the disability resulting from the injury is not often marked.

Persistent deformity with disability in either sternal or acromial dislocations of the clavicle may require fixation by suture.

Dislocations of the Scapula.—Dislocation of the acromion process of the scapula from the outer end of the clavicle, which has been described under dislocations of the acromial end of the clavicle, is classed by some writers as a scapular dislocation.

Dislocation of the Inferior Angle of the Scapula.—The displacement of the inferior angle of the scapula from under the latissimus dorsi muscle is due to relaxation of this muscle and of the serratus magnus, and is sometimes described as a dislocation of the inferior angle of the scapula. The *reduction* of this deformity consists in the employment of manipulation and pressure to overcome the displacement, and the use of a compress held in place by broad strips of adhesive plaster to secure the bone in its proper position.

Dislocations of the Shoulder.—The head of the humerus may be dislocated *downward, forward,* or *backward.*

Subglenoid Dislocation of the Head of the Humerus.—In this variety of dislocation the head of the bone rests in the axilla (Fig. 356).

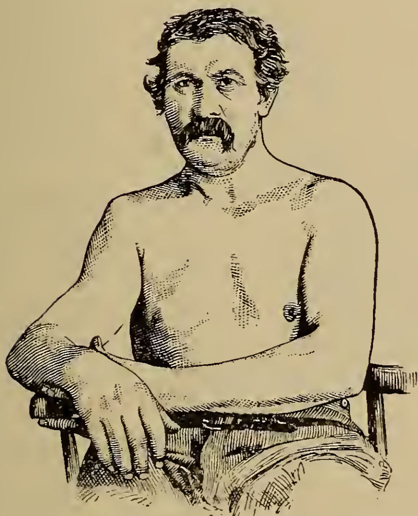
Subcoracoid Dislocation of the Head of the Humerus.—In this variety of dislocation the head of the humerus rests beneath the coracoid process of the scapula (Fig. 357).

Subclavicular Dislocation of the Head of the Humerus.—This may be considered an aggravated form of the latter variety of dislocation; the head of the humerus in this dislocation rests beneath the clavicle.

Subspinous Dislocation of the Head of the Humerus.—In this variety of dislocation the head of the humerus rests beneath the spine of the scapula (Fig. 358).

Reduction of dislocations of the humerus is effected by manipulation, by extension and counter-extension, and by a combination of these methods.

Fig. 356.

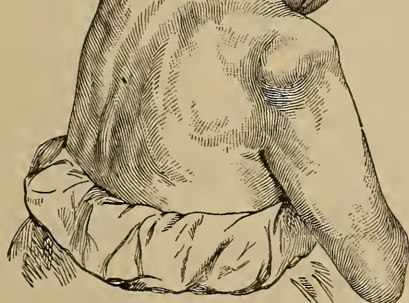


Subglenoid dislocation of the head of the humerus.

Fig. 357.

Subcoracoid dislocation of the head of the humerus.

Fig. 358.



Subspinous dislocation of the head of the humerus.

Manipulation in the reduction of *subglenoid dislocation* of the humerus is practised with the patient in the recumbent posture by first flexing the forearm upon the arm to relax the long head of the biceps muscle; the elbow is next seized and abducted so as to bring it to the side of the patient's head, thus relaxing the deltoid and supraspinatus muscles; the surgeon or an assistant next places his hand upon the head of the humerus in the axilla, and, as the arm is drawn outward to a right angle with the body by the other hand, he pushed the head of the bone into the glenoid cavity.

In the reduction of *subcoracoid* and *subclavicular* dislocations the manipulations are the same, except that the arm is to be rotated outward before being carried downward.

In the reduction of *subspinous* dislocations, after the arm has been abducted, it should be rotated inward and direct pressure made upon the head of the bone as the arm is abducted.

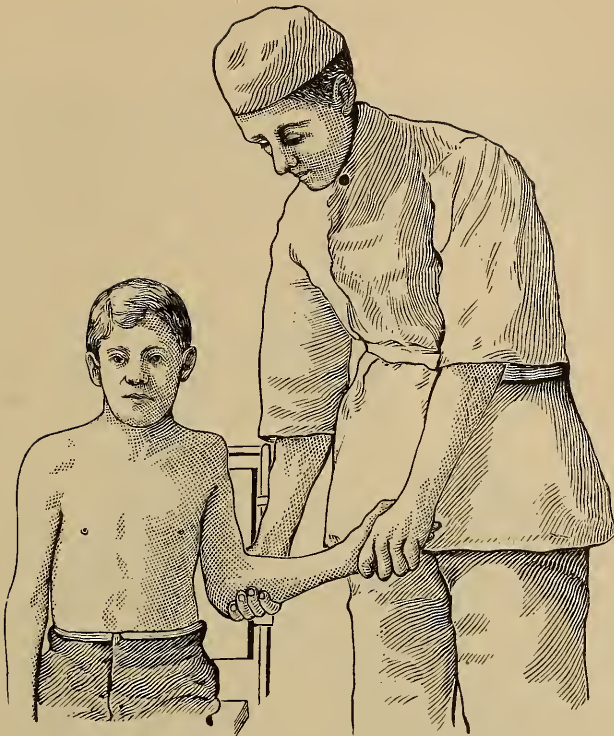
Reduction may also be effected by extension and counter-extension, as in Cooper's method, where extension is made from the arm downward and counter-extension is made by the heel in the axilla. This method is not to be recommended, on account of the damage which may occur to the axillary nerves and vessels.

Kocher's Method.—Place the patient in the sitting posture and flex the elbow to a right angle, at the same time pressing the arm against the chest; the flexed forearm is then turned as far as possible from the trunk by rotating the humerus outward until it occupies a position parallel with the transverse plane of the body (Fig. 359). While the external rotation is being maintained the elbow is slowly carried upward along the anterior border of the chest until it reaches a point opposite the ensiform cartilage (Fig. 360); the forearm is then quickly rotated inward until the hand touches the opposite shoulder and the elbow is lowered (Fig. 361).

Mothe's Method.—Reduction by this method may also be accomplished by extension made upward, the scapula being fixed by the foot or hand placed over the acromion process (Fig. 362).

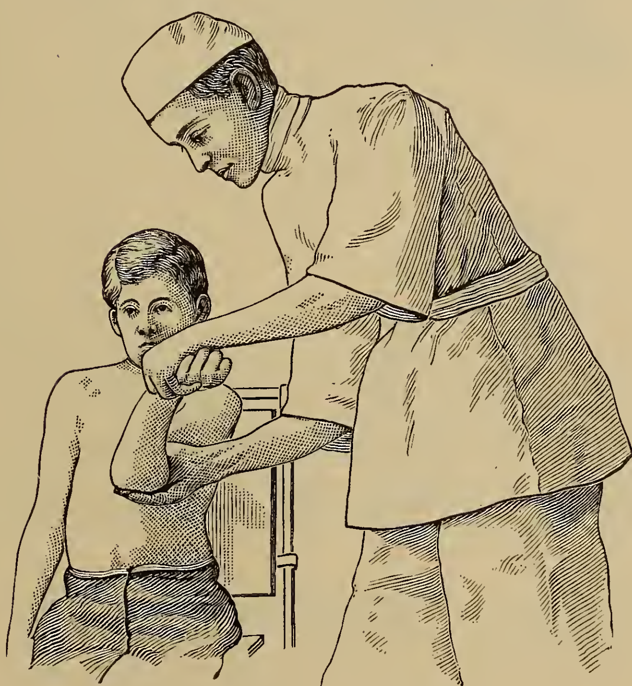
After reduction of dislocations of the head of the humerus

Fig. 359.



Kocher's method of reduction: first position.

Fig. 360.



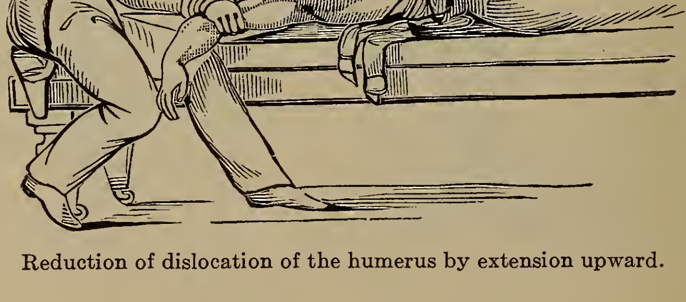
Kocher's method: second position.

the arm should be bound to the side of the body by the turns of a spiral bandage of the chest, or should be held against

Fig. 361.

Kocher's method: third position.

Fig. 362.



Reduction of dislocation of the humerus by extension upward.

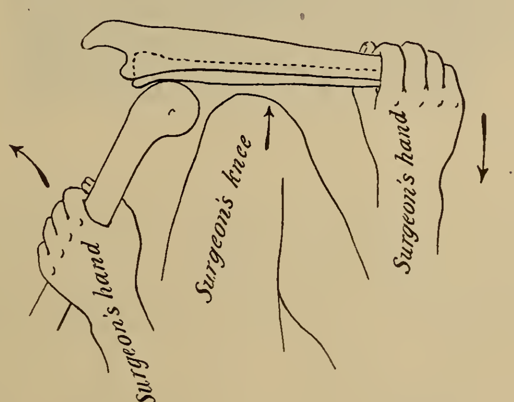
the side by the application of a Velpeau bandage; this dressing should be removed at intervals of a few days, and after ten days or two weeks all dressings should be dispensed with, passive motion should be employed, and the patient allowed to move the arm.

Fig. 363.

Dislocation of both bones of the forearm backward.

Dislocations of the Elbow.—Dislocations of the bones of the forearm at the elbow may be either *backward, forward,* or *lateral.* The backward dislocation is the most common form (Fig. 363).

Fig. 364.



Mechanism of reduction of posterior dislocation of elbow by aid of the knee. (Ashhurst.)

The *reduction* of **backward dislocations** is effected by making traction upon the forearm and at the same time making pressure upon the lower end of the humerus as the forearm is flexed upon the arm.

Or the reduction may be accomplished by bending the arm slowly and forcibly over the knee placed upon the inner surface of the elbows, so as to press upon the radius and ulna, separating them from the humerus and freeing the coronoid process from its abnormal position (Fig. 364).

Lateral dislocations of the bones of the forearm at the elbow may be external or internal and are usually due to direct force. External lateral dislocation is generally incomplete,

Fig. 365.

Internal lateral dislocation of ulna and radius. (Ashhurst.)

and complicated by fracture of the external condyle of the humerus, and extensive rupture of the internal lateral ligament. Internal lateral dislocation is not so apt to be associated with fracture. In both of these dislocations the bony processes are easily palpable and the deformity is extreme. These dislocations are reduced by making extension from the forearm, and at the same time making direct pressure on the displaced bones and counter-pressure on the lower end of the humerus.

Reduction is usually not difficult, but if associated with fracture of the condyle it is sometimes difficult to maintain.

Hyperflexion of the elbow is the best position in which to dress this injury.

Forward dislocations of the bones of the forearm at the elbow are reduced by making forced flexion at the elbow, together with extension and counter-extension, or by making forced extension of the forearm at the elbow, pressing the humerus backward, and suddenly flexing the forearm.

The dressing, after the reduction of dislocations at the elbow, consists in the application of a well-padded anterior right-angled or slightly obtuse-angled splint, to keep the forearm in a flexed position—the dressing being practically

Fig. 366.

Dressing after reduction of dislocation of the elbow.

the same as that for fractures of the lower end of the humerus, with an anterior angular splint (Fig. 366). This dressing should be retained for two or three weeks, being removed at intervals of several days; after the removal of the splint passive motion should be practised, to prevent stiffness of the elbow-joint.

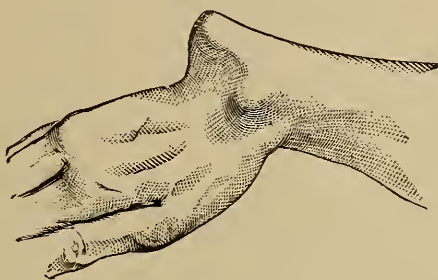
Dislocations of the Head of the Radius.—The head of the radius may be displaced *forward, outward*, or *backward*, the forward dislocation being the most frequent. In this dislocation the head of the radius slips out of the grasp of the orbicular ligament and is displaced forward by the action of the biceps muscle. This injury is often associated with a fracture of the upper end of the ulna. The *reduction* of these dislocations is effected by making extension from the forearm and counter-extension from the lower end of the humerus, and at the same time the head of the bone is pressed into its proper position. The dressing after reduction of the displacement consists in the application of a compress over the head of the bone, and the arm and forearm should be placed upon a well-padded anterior angular splint, which is secured by a roller bandage. The dressing is similar to that employed after reduction of dislocations of the bones of the forearm at the elbow. Difficulty is sometimes experienced in keeping the head of the bone in position after reduction, so that the use of a compress in addition to the use of the splint is often required. The arm should be kept upon the splint for three weeks, being redressed at intervals. *Subluxation of the head of the radius* also known as *pulled elbow* occurs only in children and results from vertical traction upon the forearm in lifting the child by one arm. The head of the radius is not completely dislocated but displaced slightly forward. Tenderness in front of the elbow and some loss of function are the principal symptoms of this injury. I have always been able to reduce this displacement by pressure over the head of the radius with the thumb with pronation and supination of the arm at the same time. The elbow should be kept at rest on an anterior angular splint for a week.

Dislocation of the Upper End of the Ulna.—The upper end of the ulna may be displaced backward, the olecranon projecting beyond the condyles of the humerus, while the head of the radius occupies its normal position.

The *reduction* of this displacement is effected in the same manner as that of both bones of the forearm backward, and the dressing after reduction is similar to that employed when both bones have been displaced.

Dislocations of the Wrist.—Dislocations of the carpus from the bones of the forearm are rare; may be *forward* (Fig. 367) or *backward* (Fig. 368). The *reduction* in either variety of displacement is effected by extension from the hand and by pressure. After reduction of the displacement, which does not tend to recur, the hand and the forearm should be placed upon a well-padded straight splint applied to the palmar surface of the hand and forearm. The splint should be retained for ten days or two weeks.

Fig. 367.



Dislocation of the carpus forward.

The lower end of the ulna may be dislocated from the radius *forward, backward,* or *inward.* The reduction of these displacements is effected by fixing the radius and pressing the ulna back into place. The dressing after reduction consists in placing the wrist-joint at rest by the application of well-padded anterior and posterior straight splints. The splints should be retained for three or four weeks, dressings being made at intervals of two or three days.

Fig. 368.

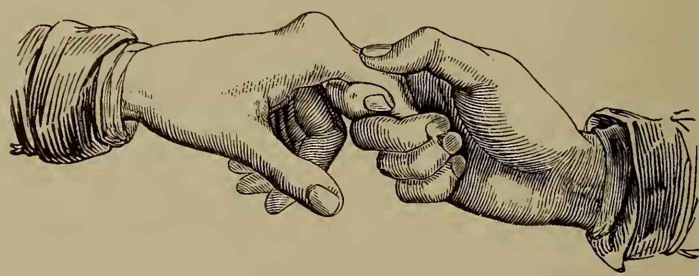
Dislocation of the carpus backward.

Dislocations of the Bones of the Carpus.—Displacement of the individual bones of the carpus occasionally takes place, the *semilunar* may be displaced forward and the os magnum and scaphoid backward, these being the bones most usually displaced, although other bones of the carpus are sometimes dislocated. *Reduction* which is not always possible is effected by means of extension and pressure, and the part should afterward be dressed with a palmar splint and compresses. If it is found impossible to reduce the displaced bone, it should be excised.

Dislocations of the Metacarpal Bones.—The metacarpal bones may be dislocated from the carpus; the bones most commonly displaced are those of the thumb and of the index and middle fingers; the latter are usually displaced backward, while the metacarpal bone of the thumb may go either backward or forward.

Reduction is effected by extension and pressure. The dressing after reduction consists in the application of a palmar splint to the hand and forearm and a compress over the

Fig. 369.



Backward dislocation of phalanx. Reduction by extension.

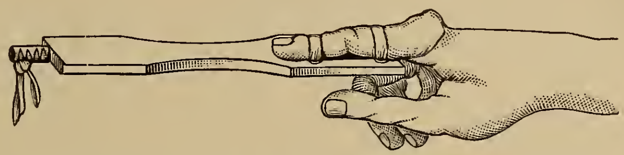
displaced bone. The dressings should be retained for two weeks.

Dislocations of the Fingers.—Dislocations of the phalanges of the fingers usually take place at the metacarpo-phalangeal junction, but sometimes occur at the interphalangeal joints. The *reduction* is usually easily effected by extension (Fig. 369), or by pushing the phalanx back until it stands perpendicularly upon the metacarpal bone, when by strong pressure upon its base from behind, forward, it is readily carried by flexion into its natural position.

Where difficulty is experienced in making extension in the reduction of these dislocations, the ingenious apparatus of the late Dr. Levis (Fig. 370), or the "Indian puzzle" apparatus (Fig. 371), may be employed with success.

Dislocations of the proximal phalanx of the thumb backward may result from a fall upon the thumb causing violent hyper-

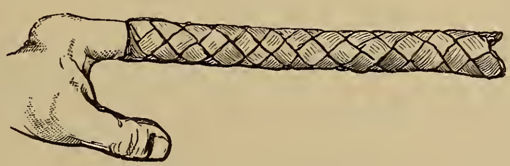
Fig. 370.



Levis' apparatus for dislocation of the phalanges applied.

extension. The deformity is quite characteristic (Fig. 372). The head of the metacarpal bone is buttonholed through the

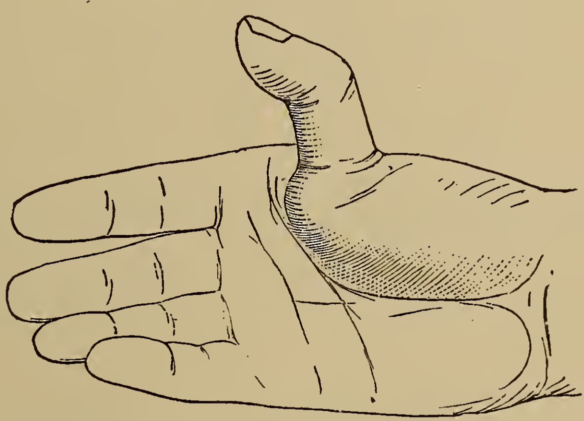
Fig. 371.



Extension by Indian puzzle.

anterior ligament, and the tendons of the short flexor muscles of the thumb and the lateral ligaments fit tightly about the

Fig. 372.



Dislocation of proximal phalanx of thumb backward.

neck of the metacarpal bone. The interposition of the external sesamoid bone is considered by some surgeons to be the cause of difficulty in the reduction of this displacement.

The *reduction* of this dislocation is often very difficult. It is effected by firmly pressing the metacarpal bone of the thumb strongly toward the palm of the hand, to relax the two portions of the short flexor muscle. The thumb is next extended upon the wrist until its tip points to the elbow. An assistant next places his finger behind the proximal phalanx to prevent its slipping backward, and by bringing the thumb down to the flexed position the bone slips into place. It sometimes happens that all efforts at reduction fail, and in such cases it may be necessary to divide one head of the short flexor muscle and the lateral ligament through a wound on the radial border of the flexor surface over the head of the metacarpal bone of the thumb before the displacement can be reduced.

The dressing of dislocations of the phalanges after reduction consists in the application of splints of wood, or moulded splints of binders' board, or gutta-percha, to fix the joint, which should be retained for ten days or two weeks.

Dislocations of the Hip.—The head of the femur is most frequently dislocated backward, downward, or upward, although it may assume other positions in exceptional cases.

This injury is a comparatively rare one, which generally results from indirect violence, the femur being forced beyond its normal range either in flexion and abduction, or in extension and abduction, the head of the femur by leverage is forced out of the acetabulum. The prominent symptoms of posterior dislocations are immobility, shortening with flexion abduction and internal rotation at the hip.

Posterior or Backward Dislocations of the Head of the Femur.—These are either backward and upward, when they are described as *iliac* or *dorsal,* the bone resting upon the dorsum of the ilium (Fig. 373); or the dislocation may be backward, the head of the bone resting upon the ischiatic notch; these are known as *ischiatic* dislocations, or dislocations of the femur, *dorsal below the tendon* (of the obturator internus), according to Bigelow (Fig. 374).

The *reduction* of the posterior dislocations of the femur can generally be effected by manipulation. The patient being anesthetized and placed upon his back, the surgeon grasps the leg at the ankle and knee, flexes the leg upon the thigh, and the thigh upon the pelvis in the position of adduction; he then abducts the limb and rotates it outward, bringing it in a broad sweep across the abdomen, and by bringing it down to its natural position the head of the bone will slip into the acetabulum (Fig. 375).

Fig. 373.

Backward and upward dislocation of femur.

Fig. 374.

Backward dislocation of femur.

Kocher, in posterior dislocations, recommends the following manipulations: (1) The surgeon grasps the ankle of the injured limb with one hand and the front of the knee with the other and rotates the thigh inward to relax the capsule and lift the head of the bone from the posterior surface of the pelvis; (2) the thigh is next flexed to 90 degrees, preserving the existing adduction and inward rotation; (3) traction is then made in the line of the femur, to make the capsule tense; (4) external rotation is then practised, which makes the posterior part of the capsule and Y-ligament tense, and returns the head of the bone to the acetabulum.

Direct Method.—The patient being under anesthesia is placed upon the floor upon a firm mattress, and the pelvis being firmly fixed by an assistant, the surgeon places his arm under the flexed knee. The thigh is flexed to a right angle on the pelvis, bringing the head of the femur toward the lower part of the acetabulum. The knee is next flexed to a right angle and the arm is passed under this and upward traction is

Fig. 375.

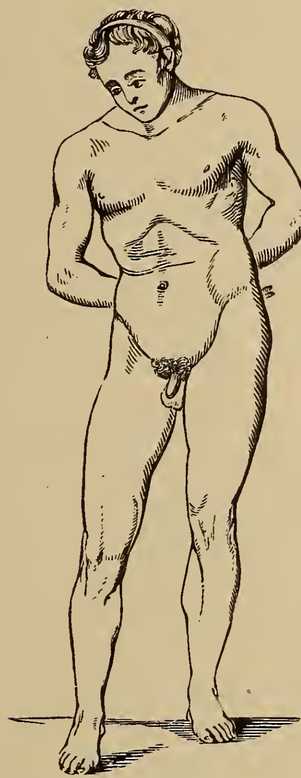
Reduction of backward dislocation of the femur.

made; at the same time slight adduction, or the thigh may be gently rotated in and out. Under this manipulation the head of the bone usually slips into the acetabulum. This method I have found most satisfactory in all posterior displacements.

Downward and Forward Dislocation of the Head of the Femur.—In this variety of dislocation the head of the bone rests upon the thyroid foramen; this form of displacement is sometimes spoken of as a *thyroid dislocation* (Fig. 376).

The marked symptoms of this displacement are immobility, flexion, abduction and eversion and apparent lengthening of the limb.

Fig. 376.



Downward and forward dislocation of femur.

Fig. 377.

Reduction of downward and forward dislocation of femur.

The *reduction* of downward and forward dislocations of the head of the femur is effected by flexing the leg and thigh and bringing the limb into a position of abduction; it is then adducted and rotated inward in a broad sweep across the abdomen and brought down to its natural position when the head of the bone slips into the acetabulum (Fig. 377).

In making these manipulations the head of the bone sometimes slips back upon the dorsum of the ilium, converting the downward dislocation into a posterior one; if this accident occurs the displacement should be reduced by making the manipulations appropriate for the reduction of the latter dislocation.

Kocher, in the reduction of these dislocations, recommends the following manipulations: (1) The leg should be flexed upon the thigh and the thigh carried up to a right angle with the pelvis, maintaining abduction and external rotation, to relax the Y-ligament; (2) traction should next be made in the line of the shaft of the femur, to render the posterior part of the capsule tense; (3) outward rotation is then made, which, twisting the tense posterior portion of the capsule and the outer branch of the Y-ligament, brings the head of the bone upward and backward into the acetabulum.

Forward and Upward Dislocation of the Head of the Femur.— In this variety of dislocation, which is very rare, the head of the bone rests upon the pubis; this form of displacement is also spoken of as a *pubic dislocation* (Fig. 378).

The *reduction* of forward and upward dislocations of the head of the femur is effected by much the same manipulation as is employed in the reduction of downward and forward dislocations, except that in the pubic dislocation the flexed limb should be carried across the sound thigh at a higher point. The thigh being flexed, the head of the bone is drawn down from the pubis; it is then semiabducted and rotated inward to disengage the bone completely. While rotating inward and drawing on the thigh the knee should be carried inward and downward to its place by the side of its fellow, and the head of the bone will usually slip into the acetabulum.

Kocher, in the reduction of forward and upward dislocations of the femur, recommends: (1) Traction should first be made in the axis of the limb to bring the head of the bone over the brim of the pelvis; (2) pressure should next be made with the hand upon the head of the femur to prevent its passing upward during flexion of the thigh; (3) the thigh should next be flexed to less than a right angle to relax the Y-ligament; (4) inward rotation is next made which directs the head of the bone into the acetabulum.

Anomalous Dislocations of the Head of the Femur.—These occasionally occur; the head of the bone may pass directly upward or downward between the sciatic notch and thyroid foramen, or downward and backward on the body of the ischium, or downward and backward into the lesser sciatic notch, or downward, inward and forward into the perineum. *Central dislocation* is occasionally seen in which the acetabulum is fractured and the head of the bone is driven into the pelvis. These anomalous displacements usually occur where there has been extensive laceration of the capsular ligament and Y-ligament.

Fig. 378.

Forward and upward dislocation of the femur.

The *treatment* of cases after reduction of dislocations of the head of the femur consists in keeping the patient at rest in bed upon his back; the limb should be kept at rest by sand bags applied to either side of the limb, or the knees should be tied together. If the joints are painful from the traumatism, extension should be applied for a few days which usually relieves the pain. The patient should be kept at rest for two weeks, and at the end of this time may be allowed to get out of bed and go about on crutches.

Dislocations of the Patella.—The patella may be dislocated *outward, inward* or *upward,* or it may be rotated upon its own axis. The *outward* dislocation is the displacement most usually seen (Fig. 379). A *downward* displacement associated with a rupture of the quadriceps extensor tendon also may occur.

Upward dislocation of the patella can only result from laceration of the ligamentum patellæ, and the treatment in such cases is similar to that for fracture of the patella.

Fig. 379.

Outward dislocation of the patella.

The *reduction* of dislocations of the patella is effected by extending the leg upon the thigh and flexing the thigh upon the pelvis, to relax the quadriceps femoris muscle, when the patella can usually be forced back into place by manipulation with the fingers; in some cases alternate flexion and extension of the leg will accomplish the same result.

The dressing after reduction of the displacement consists in the application of a posterior straight splint or a moulded binders' board or felt splint to keep the joint at rest; the splint should be worn for a week or ten days.

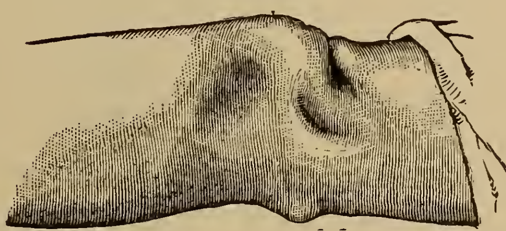
Dislocations of the Knee.—The head of the tibia may be dislocated *forward, backward* or *laterally;* the latter dislocations are always incomplete, forward dislocation being the variety of displacement most commonly met with (Fig. 380). Dislocations of the knee are comparatively rare injuries and may be very serious when complicated by injuries of the popliteal vessels or nerves.

The *reduction* of dislocations of the knee is effected by extension and counter-extension with forced flexion of the knee with pressure, aided by rocking movements. The treatment of cases of dislocation of the knee after reduction consists in fixing the knee-joint by the application of a straight posterior splint or a moulded splint of binders' board. As there is usually marked swelling following these injuries from violence to the joint structures, the application of evaporating lotions for a few days will be found useful. As soon as the swelling has subsided the limb should be put up in a plaster-of-Paris dressing, and this should be retained for four weeks.

Dislocation of the Semilunar Cartilages.—The displacement here consists in the slipping forward or backward and wedging of the semilunar cartilages between the femoral condyles and the tibia. The cartilage may be fractured and the anterior crucial ligament may also be ruptured.

Fig. 380.

Patella.



External condyle of femur.

Forward dislocation of the knee.

Reduction of the displaced cartilages can usually be effected by hyperflexion of the knee, followed by sudden full extension, or by alternately flexing and extending the joint. Excision of the displaced cartilages is sometimes required in cases in which they cannot be reduced by manipulation.

The dressing of these cases after reduction of the displaced cartilages consists in the application of a posterior straight splint or a plaster-of-Paris dressing to fix the knee-joint; the splint should be worn for three or four weeks, and if there is a tendency to redisplacement the patient should wear a brace, or a knee cap of leather or muslin to partially fix the joint, with compresses so arranged as to make pressure upon the edge of the joint.

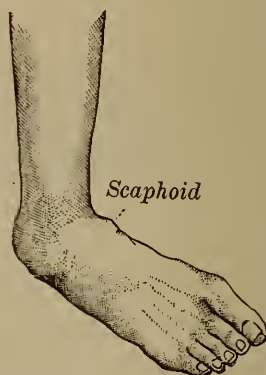
Dislocations of the Fibula.—Dislocations of the fibula may occur at either of its extremities, and the direction of the displacement may be *forward, backward* or *outward;* dislocation of the head or upper extremity of the fibula being the most common, although all are rare forms of displacement.

The *reduction* of dislocations of the head of the fibula is effected by flexing the leg upon the thigh and making direct pressure and extension. Dislocations of the lower extremity of the fibula are reduced by manipulation and pressure. The dressing of cases after reduction of dislocations of the fibula consists in the application of a compress and moulded binders' board splint; the dressing should be retained for three or four weeks.

Fig. 381.

Dislocation of foot backward.

Fig. 382.



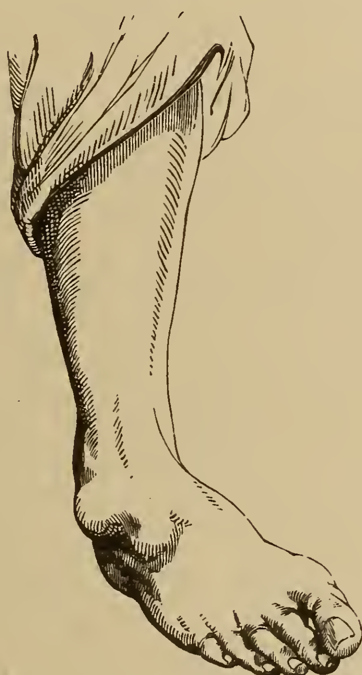
Dislocation of foot inward.

Dislocations of the Ankle.—Dislocations of the foot upon the bones of the leg result from separation of the articular surface of the astragalus from that of the tibia and fibula; the displacement may be *forward, backward* (Fig. 381) or *lateral* (Fig. 382), the latter variety being often associated with fractures of the malleoli.

The *reduction* of dislocations of the ankle is effected by traction, combined with flexion and rotation of the ankle-joint, the leg being first flexed upon the thigh to relax the tendo Achillis, and in some cases the subcutaneous division of this tendon is required before the reduction can be satisfactorily accomplished.

The dressing of dislocations of the ankle after reduction consists in the application of a fracture-box or of pasteboard splints to fix the ankle, care being taken to see that the foot is fixed at a right angle to the leg, and in the application of evaporating lotions for a few days; after the swelling has subsided a plaster-of-Paris dressing should be applied and retained for three or four weeks.

Fig. 383.



Dislocation of astragalus outward.

Dislocations of the Tarsal Bones.—The *astragalus* may be dislocated from the bones of the leg and from the other tarsal bones, being thrust *forward, backward, outward* (Fig. 383) or *inward*. The *reduction* of dislocations of the *astragalus outward* is effected by first flexing the leg upon the thigh and making extension from the foot and rotating it at the same time, direct pressure being made upon the displaced bone; in some cases subcutaneous section of the tendo Achillis has assisted materially in the reduction of the displaced bone. *Backward dislocation of the astragalus* is usually irreducible; the patient, however, in many cases recovers with a useful foot. In cases of irreducible dislocations of the astragalus excision of the astragalus may ultimately be required.

After the reduction of dislocations of the astragalus the foot and leg should be put at rest in a fracture-box, or by means of moulded splints of pasteboard or felt; evaporating lotions should also be employed over the region of the injury for a few days, and when the swelling has subsided a plaster-of-Paris dressing should be applied and retained for three or four weeks.

Dislocations of the calcaneum and scaphoid upon the *astragalus* or of the *calcaneum* upon the *astragalus* and *cuboid* or upon the *astragalus* alone, of the *scaphoid* and *cuboid* upon the *os calcis* and *astragalus* or of the *cuboid, scaphoid* or *cuneiform* bones are occasionally met with.

Their *reduction* is effected by traction and direct pressure, and after this has been accomplished the parts should be put at rest by the application of a splint and compresses.

Dislocations of the Metatarsal Bones and Phalanges of the Toes.—These dislocations usually result from crushing forces which destroy the vitality of the soft parts so completely that amputation is required. Their *reduction* in cases of simple or uncomplicated dislocations is effected by traction, manipulation and pressure. After reduction of the displacement the parts should be kept in position by the application of splints and bandages.

Old Dislocations.—The reduction of old dislocations is attended with more difficulty and danger than that of recent dislocations, due to the permanent contraction and structural changes which occur in the muscles and to the adhesions which form between the displaced bone and the parts with which it is in contact. Some dislocations became "old" much sooner than others. It may be wise not to attempt to reduce a dislocation of some months' standing unless pain and disability are marked. The *reduction* of old dislocations may usually be accomplished by the manipulations appropriate for recent dislocations of the same variety; but occasionally the use of more forcible extension is required, which is made by bands and pulleys. The first step in the reduction of old dislocations consists in thoroughly breaking up the adhesions which have been formed between the displaced bone and the surrounding tissues; this has, in some cases, resulted in the laceration of muscles, nerves and bloodvessels and in fracture of the displaced bones or neighboring bones, so that the manipulations should be made with the least force that will accomplish the object desired. After the reduction of old dislocations difficulty is sometimes experienced in maintaining the bone in its proper place, due to the changes which have occurred in the articular surfaces.

In such cases fixation of the bone in its normal position by a plaster-of-Paris dressing should be employed for some weeks, and after its removal passive motion should be practised. If the dislocation is found to be irreducible and the patient suffers from great pain and disability open operation is advisable. This consists in exposing the displaced bone and dividing the soft tissues which interfere with reduction or in making a complete or incomplete excision of the joint.

Compound Dislocations.—These are always grave injuries and amputations or excision may be required. With the modern methods of wound treatment, operative measures are not often required. The reduction is effected in the same manner as in simple dislocations of corresponding parts, the greatest care being taken to render the wound aseptic, and to keep it in this condition by the application of a full antiseptic dressing. After reducing the dislocation and dressing the wound some form of fixation splint should be applied to fix the joint until healing of the wound has occurred.

Complicated Dislocations.—In dislocations complicated by fracture near the seat of displacement the displaced bone should, if possible, be first reduced, and this in many cases is a matter of great difficulty, as the fracture prevents the surgeon from using leverage otherwise present, in the reduction, and he has often to depend entirely upon pressure and manipulation to overcome the displacement. After reduction of the dislocation the fracture should be reduced and dressed.

Dislocation complicated by rupture of the main artery of the limb may require, after reduction of the displacement, exposure and ligation of the vessel or amputation of the limb. Rupture of an important nerve trunk complicating a dislocation may call for subsequent exposure and suturing of the divided nerve.

Habitual, Pathological and Congenital Dislocations.—In the treatment of these varieties of dislocations after the reduction of the displacement by manipulation and pressure, much difficulty is often experienced in maintaining the reduction. To effect the latter object the use of splints and bandages is employed, and also the use of many ingenious forms of apparatus adapted to particular dislocations. Congenital dislocations of the hip are now successfully treated by the method of Lorenz. Operative treatment, such as excision of a portion of the capsule of the joint or ligaments, or operation upon the bone to increase the capacity of the joint may be practised.

Tenotomy or *myotomy* is often required to prevent recurrence of the deformity, and continuous extension is also of much value in the treatment of these displacements.

PART VI.

OPERATIONS.

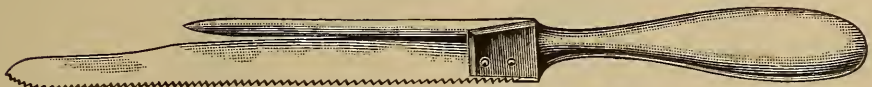
AMPUTATIONS OF THE FINGERS AND METACARPAL BONES.

The instruments required for amputation of the fingers toes and metacarpal or metatarsal bones are a scalpel (Fig.

Fig. 384.

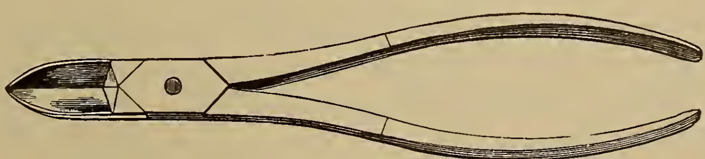
Scalpel.

Fig. 385.



Small amputating saw.

Fig. 386.



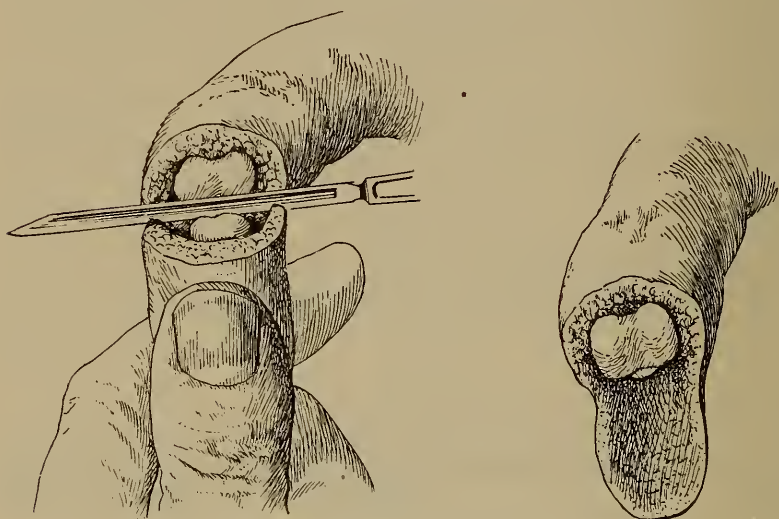
Bone forceps, or cutting pliers.

384), a metacarpal or small amputating saw (Fig. 385) and a pair of bone forceps or cutting pliers (Fig. 386).

In amputating the fingers or hand the surgeon should exercise the utmost conservatism. If a portion of the hand with one or more fingers or parts of fingers can be preserved the member is much more useful than any artificial appliance.

Amputations of the Fingers.—The fingers may be amputated in the continuity of the phalanges or in their contiguity, and, as a rule, as it is important to save as much as possible of the finger the former method is generally to be employed instead of disarticulation at a higher point. The incision should be so planned that the cicatrix does not occupy the palmar surface; the larger flap should, therefore, be taken

Fig. 387.

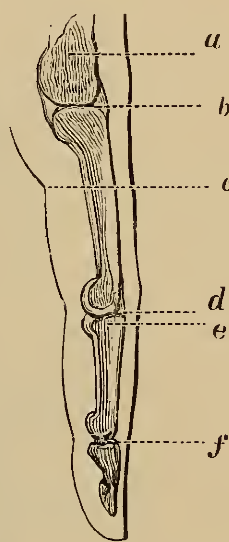


Amputation of a finger by the long palmar flap.

from the palmar aspect of the finger. In amputating the phalanges of the fingers in their *continuity* the circular method (Fig. 387) or a short dorsal flap and a long palmar flap may be employed. In *disarticulating* a phalanx it is best to enter the joint with a narrow knife from the dorsal side, and after having carried it through the joint, to cut a long palmar flap, keeping close to the bone (Fig. 387). In locating the position of the phalangeal joints it is well to remember that the prominence of the knuckle when the finger is flexed is formed entirely of the head of the proximal and not of the base of the distal phalanx (Fig. 388), and also that the folds on the palmar surface of the finger do not correspond exactly to the joints (Fig. 389).

Amputation of the Finger through the Metacarpo-phalangeal Articulation.—In this variety of amputation an incision is made from a point on the dorsal surface of the metacarpal bone $\frac{1}{4}$ inch above the articulation, which is carried through the interdigital web and back upon the palmar surface to a point $\frac{1}{4}$ inch above the flexor fold (Fig. 391). A similar incision beginning and ending at the same points is made upon the opposite side of the finger. The flaps are dissected back and the lateral ligaments, tendons and remainder of the capsule are divided (Fig. 390). The finger may also be amputated at the metacarpo-phalangeal joint by making an incision on one side and dissecting the flap back to the joint, then dividing the lateral ligament, opening the joint and carrying the knife across this, dividing the tendons and lateral ligament on the other side and cutting a flap from within outward.

Fig. 389.



Guides to articulations of the fingers. *a*, head of metacarpal bone; *b*, metacarpo-phalangeal articulation; *c*, relation of palmar fold to articulation; *d*, *e*, interphalangeal articulation; *f*, articulation of distal phalanx.

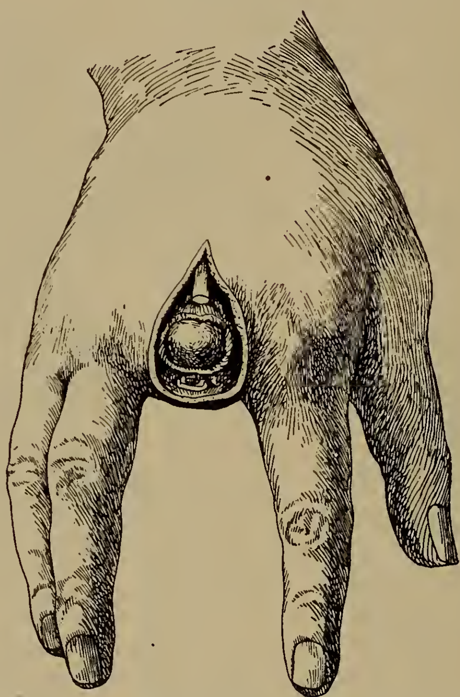
Fig. 388.

Phalanges flexed.

Removal of the head of the metacarpal bone if desired may be accomplished by the use of cutting pliers (Fig. 386); but, as a rule, this procedure is not to be recommended, for, although the deformity is lessened, the strength of the hand is diminished.

In amputating the *little* and *index* fingers a full lateral flap may be cut on the free side, and an incision is next carried across the palmar surface to the angle of the web, and thence back to the joint, which is opened and the disarticulation effected (Fig. 391). The digital arteries are usually the only vessels requiring the use of ligatures.

Fig. 390.

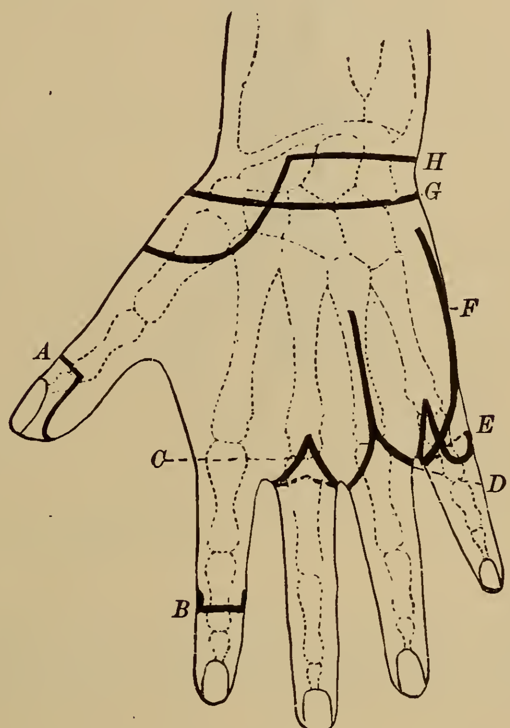


Racket-shaped incision for amputation of the finger at the metacarpo-phalangeal joint.

Amputations of the Metacarpal Bones.—In amputating the metacarpal bones it is advisable to leave the carpal ends of the bones to avoid opening the wrist-joint, except in the case of the first and fifth metacarpal bones, which do not communicate with the others and with the synovial sacs.

The incisions for the removal of the metacarpal bones are the same as for the removal of a finger at the metacarpo-phalangeal joint, the incision being prolonged backward as far as necessary over the dorsal surface of the bone (Fig. 391). After the metacarpal bone has been bared for a sufficient distance it is cut through with bone pliers or disarticulated, and the distal end is raised from its bed and carefully separated from the soft parts, care being taken to avoid injury of the structures of the palm of the hand.

Fig. 391.

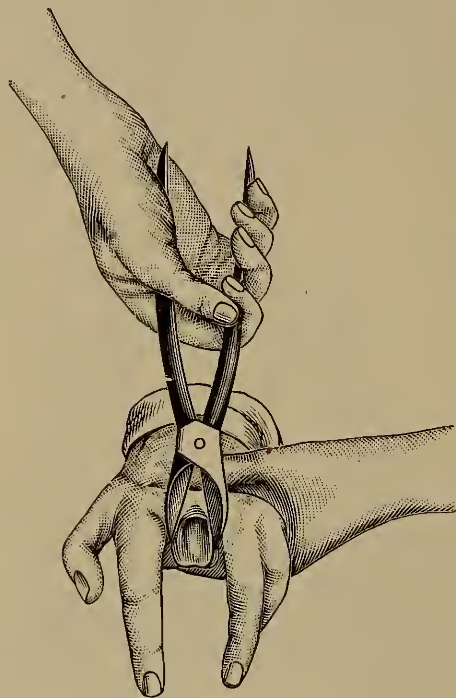


A, disarticulation of distal phalanx (palmar flap); *B*, amputation in continuity by a circular flap; *C*, metacarpo-phalangeal disarticulation; *D*, amputation of metacarpal bone in continuity; *E*, disarticulation of little finger; *F*, disarticulation of fifth metacarpal bone; *G*, amputation at the wrist, circular; *H*, amputation at the wrist, lateral.

In amputating the *fifth* metacarpal bone the incision should be made along the inner border of the hand and carried down to the bone between the skin and the abductor minimi digiti muscle (Fig. 393). The lower end of the incision passes over the knuckle to the web of the finger and backward under the palmar surface to join the first incision.

Amputation of the entire *thumb* with its metacarpal bone is effected by making an oval flap from the palmar surface; in

Fig. 392.



Removal of the head of a metacarpal bone.

the case of the left thumb the joint may be opened by an oblique incision on the dorsal surface of the hand, beginning a little in front of the joint and being carried down to the web

Fig. 393.

Incision for removal of the fifth metacarpal bone.

between the thumb and forefinger; the palmar flap is then made by thrusting the knife upward to its point of entrance and cutting downward and outward. In amputating the right thumb with its metacarpal bone it is better to make the palmar flap first by transfixion, the dorsal flap being made subsequently.

In amputations involving portions of the hand the superficial and deep arches are divided and numerous vessels require ligature.

Amputation of the hand at the carpo-metacarpal joint is occasionally performed, or between the rows of carpal bones; but is not, as a rule, to be recommended, as the carpal bones are apt subsequently to become diseased and require removal; it is, therefore, better to amputate at the radio-carpal joint.

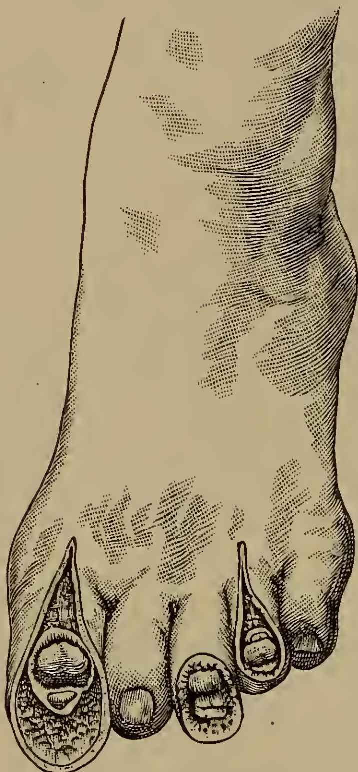
Dressing of Amputations of Fingers and Hand.—The bleeding vessel should be secured by ligatures. Before approximating the flaps in amputations of the fingers and metacarpal bones it is wise to introduce drainage—a few strands of catgut or silkworm gut or narrow strips of rubber dam. The great vascularity of these parts causes oozing of blood from many minute points which cannot be tied, and if the stump is tightly closed, blood clot is apt to accumulate under the flaps, causing pain and impairing their vitality. A sterilized gauze dressing is next applied and secured by a bandage. The application of a palmar splint to the hand and forearm keeps the part safe from injury and the rest of the parts favor prompt repair.

AMPUTATIONS OF TOES AND METATARSAL BONES.

Amputations of the Toes.—The phalanges of the toes may be removed in the same manner as those of the fingers. It is better to amputate at the metatarso-phalangeal articulations than to attempt to remove them at the joints in front of this articulation, except in the case of the great toe, as the preservation of a portion of a toe is rather a discomfort than an advantage, except in the instance mentioned. The heads of the metatarsal bones should be retained whenever possible, as they afford great support to the foot in walking. All incisions should be made so that the resulting cicatrix does not occupy the plantar surface, and it is well to remember that the web of the toes is considerably below the position of the metatarso-phalangeal joint.

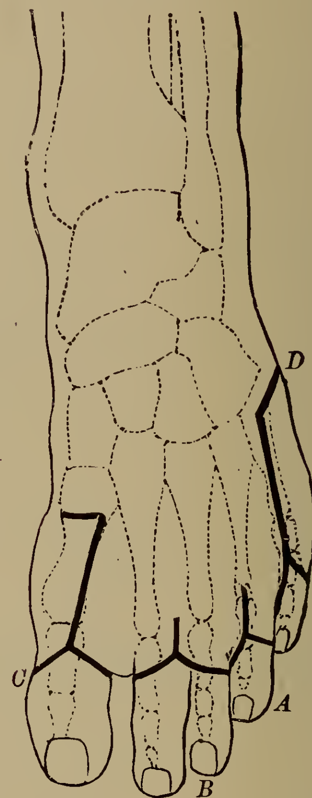
The toes are usually removed by an incision on the dorsal surface a little above the joint, which is carried down to the bone for about 1 inch and then diverges into the web, and is carried under the toe and back on the other side to the point of divergence (Figs. 394 and 395).

Fig. 394.



Amputation of the toes by the racket-shaped incision and flap method.

Fig. 395.

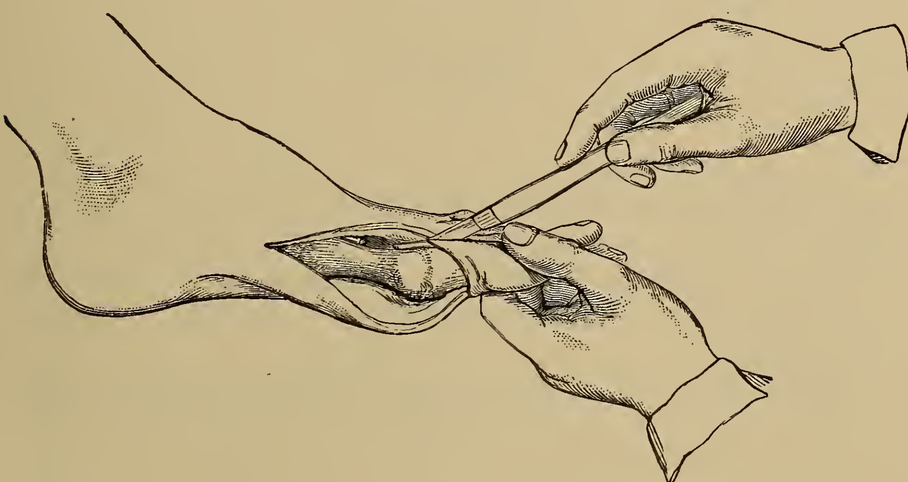


Incisions for amputation of toes and metatarsal bones.

Amputation of Two Adjoining Toes.—The dorsal incision should be made in the inter-metatarsal space just above the level of the joint (Fig. 395) and carried down to the beginning of the web; then over the toes to the beginning of the adjoining web; then under the plantar surface of both toes in the line of the digito-plantar fold, through the web and back to the point of divergence.

Amputation of the Great Toe.—This may be accomplished by means of the racket-shaped incision employed in amputation of the other toes (Fig. 394), or by means of a lateral flap. In the latter case the knife is made to enter the joint by cutting through the commissure and the operation is completed by carrying the knife through the joint and along the outer side of the bone, forming a flap of the required size. In this amputation a short dorsal flap and a long plantar flap may be employed or a large internal flap may be used.

Fig. 396.

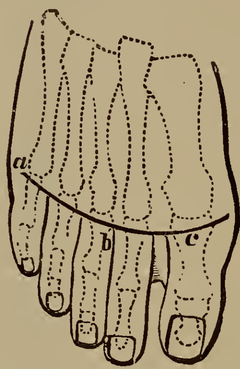


Amputation of the great toe and first metatarsal bone.

Amputation of the Great Toe with its Metatarsal Bone.—The incision begins upon the dorsal surface of the metatarsal bone, a little below the point at which the bone is to be divided, and is carried down below the metatarso-phalangeal joint, then diverges and passes under the toe and comes back again to the point of divergence (Fig. 395). The bone is exposed and cut through with cutting forceps, and is then lifted up and dissected loose from the tissues (Fig. 396).

Amputation of All the Toes.—To amputate all the toes make a dorsal incision from the head of the fifth to the head of the first metatarsal bone; the incision should be a curved one passing just in front of the joints (Fig. 397). Dissect up the flap and open the joints, dividing the lateral ligaments and pass the knife behind the phalanges and cut a flap from the plantar surface.

FIG. 397.



Incision for amputation of all the toes.

Amputations of the Metatarsal Bones.—It is better in these amputations to leave the tarsal head of the metatarsal bone in place and divide the bone, or, in other words, to do an amputation in continuity to prevent opening up the tarsal articulations.

Amputation of the Little Toe and the Fifth Metatarsal Bone.—The incision for the removal of the little toe and the fifth metatarsal bone is made over the bone a little below the metatarso-tarsal articulation, and is carried down and curved around the toe (Fig. 395, *D*), and after the bone is exposed by dissecting back the flaps it is divided, or the joint is opened and it is dissected out.

Amputation through All the Metatarsal Bones.—In performing this amputation an incision is made across the dorsum of the foot, and a short dorsal flap is dissected up; the metatarsal bones are next divided with a saw and a long plantar flap is cut from within outward by entering the knife behind the ends of the bones. After amputation of one or more of the toes or portions of the metatarsal bones, after controlling the bleeding by ligatures, drainage, as in care of the fingers, should be introduced and the flaps approximated by sutures.

A gauze dressing is next applied and held in place by a bandage.

Warts or Verruca.—A wart consists in a localized hyperplasia of the epidermis. It may be smooth, firm and rounded in outline or present an irregular, granulated or cauliflower surface. The favorite sites for warts are the skin of the back of fingers and hands, face, scalp and neck. They usually appear to grow spontaneously; in some cases a suspicion of contagion exists. They are most common in children and young adults. They show little tendency to enlarge and occasionally disappear spontaneously.

Treatment.—This consists in touching the surface with nitric, acetic or chromic acid or the application of solid CO_2; in a few days the wart shrivels and falls off. They may be snipped off with scissors and the base touched with the solid stick of nitrate of silver. Electrolysis may also be used for their removal.

Venereal warts have no necessary connection with venereal disease, although they frequently occur in connection with this disease where the parts become irritated by filthy discharges. They are frequently observed upon the moist skin around the anus, vulva or inner surface of the prepuce. They may be successfully treated, if the surfaces from which they grow are kept dry, by washing them with peroxide of hydrogen, drying with cotton and dusting them with a powdered talcum and oxide of zinc, equal parts, or one of calomel, ʒj; bismuth, ʒij; oxide of zinc, ʒj. Where very extensive, excision and cauterization of their bases may be required.

Papilloma.—This is an epithelial tumor growing from the skin or mucous membrane. It consists of a fibrous stroma which contains bloodvessels and lymphatics and is covered by epithelium. It is frequently observed upon the mucous surface of the lips, cheeks and tongue. Those of the skin are usually firm, while those upon the mucous surfaces are soft. The treatment consists in excision of the growth and cauterization of its base with cautery or acid. Desiccation with the high frequency current is now much used for this purpose.

Callosity.—This is an hypertrophied condition of the epidermis in the palms of hands and soles of the feet, and is occasionally seen in the skin of other parts of the body, and results from long-continued pressure or friction.

Clavus or Corns.—This is a painful circumscribed thickening of the epidermis, which may develop in the center of a callosity or upon the exposed surface of the toes. There is a pyramidal-shaped outgrowth of epithelial cells, which separates the papilla of the skin and causes pain by pressure on the sensitive nerve endings. A soft corn originates from the moist surfaces of the lateral aspects of the skin of the toes. When of long duration a bursa may develop under a hard corn, giving rise to a bunion which is most commonly observed over the metatarso-phalangeal articulation of the great toe.

Treatment.—This consists in removing the cause of pressure by the wearing of proper shoes, the use of an ointment of salicylic acid (5 to 10 per cent) or wearing over the corn a salicylated plaster (20 per cent) and protecting the part from pressure by a shield. After using this ointment or plaster the softened corn may be lifted off. Bunion is best treated by excision of the enlarged bursa.

Sebaceous Cysts or Wen.—This occurs from the excretory duct of a sebaceous gland becoming occluded by foreign matter or inflammation. They occur with the greatest frequency upon the scalp, face, neck and back, and are often multiple. They are rarely seen below the level of the umbilicus. Sebaceous cysts are occasionally observed on the skin of the scrotum. The skin is adherent to the cyst at the orifice of the duct and it contains a malodorous wax-like material. They frequently become infected and suppurate, and discharge pus mixed with sebaceous material.

Treatment.—The opening of the duct can be recognized by a dark spot. After sterilizing the surrounding skin or scalp, this is circumscribed by an incision, and the cyst can be dissected out, care being taken not to rupture the sac, but remove the whole of the sac, for if even only a small portion is left a new cyst develops. One or two sutures of catgut may be introduced to approximate the skin or scalp and a gauze pad and bandage are applied. A dressing of gauze strips held in place by benzoin and collodion may also be used.

Inflamed cysts are difficult to remove. In such cases it is better to open the cyst, curette out its contents, cauterize the inner surface with carbolic acid and allow the wound to heal; and if the cyst wall is not destroyed later remove the sac when it is not inflamed and after it again has begun to become distended.

The late Prof. Ashhurst, in removal of sebaceous cyst of the scalp, passed a narrow bistoury through the base of the cyst and cut directly outward; then with two pairs of forceps, one grasping the skin, the other the edge of the sac, by traction enucleated the sac and its contents. I have frequently employed this method, dealing with cysts of the scalp, and in spite of the chances of infection, it rarely seems to occur, and repair occurs promptly. This method is not satisfactory for the removal of inflamed sebaceous cysts.

Paracentesis Thoracis.—This may be done with an ordinary trocar and cannula, but it is better to employ an aspirator. For purposes of diagnosis a hypodermic syringe with a long needle may be used. The instrument and the skin over the area in which the tapping is to be made are sterilized with tincture of iodine, and the patient is placed in a semi-recumbent posture. The site of the exploration is located by the physical signs elicited by percussion and auscultation and usually is an intercostal space between the sixth and eighth rib in the midaxillary line. A puncture is made through the skin over the upper edge of the rib. This position is selected to prevent injury of the intercostal vessels and the skin is drawn upward and the aspirating trocar is passed through the puncture into the chest near the upper edge of the rib, the trocar is removed and the stopcock is turned, which allows the fluid to enter the vacuum bottle. After the fluid has been removed the aspirating cannula is removed and the small wound is sealed with pledget of gauze and collodion.

Paracentesis Abdominalis.—This operation may be required for the withdrawal of extravasated serum. It may be done with trocar and cannula, or with an aspirator. The latter is better as it prevents the admission of air. The patient should be in the sitting posture and the bladder should be empty.

The point usually selected is in the median line, from 2 to 3 inches below the umbilicus. This is the thinnest part of the abdominal wall and is free from large vessels. The surgeon should satisfy himself that bladder is empty before introducing the trocar.

The skin and instrument being sterilized, a puncture is made through the skin with a sharp-pointed knife, and the aspirating trocar is made to enter this puncture and gently pushed through the abdominal wall. The surgeon should watch to note the depth to which the trocar is passed. The trocar is next removed and the stop-cock turned, which allows the fluid to escape in the vacuum bottle. If the fluid fails to escape, either the instrument has not been introduced sufficiently far enough or the omentum may have occluded the cannula; by further introduction or changing the position of the cannula the difficulty may be removed and the fluid escapes.

Sometimes, on account of the condition of the patient, it is not advisable to remove all of the fluid at one sitting. Some surgeons apply a many-tailed bandage to the abdomen with the tails secured on the back. This is gradually tightened and secured with pins as the abdomen becomes emptied of fluid.

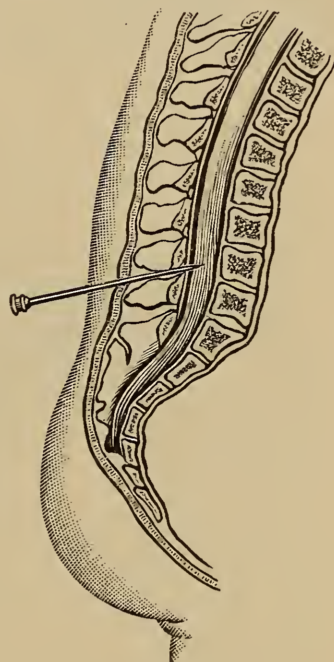
When the fluid has been removed the cannula is removed and the puncture sealed with a pledget of gauze and collodion. If serum continues to escape from the puncture, as often occurs, a sterilized gauze pad should be secured over the wound. This leakage usually stops within a few hours.

A firm, many-tailed bandage should next be applied and is a comfortable dressing for the patient.

Paracentesis Pericardii.—This operation may be required to remove serum or purulent fluid from the pericardium. The aspirating trocar is introduced through the skin in the fifth left intercostal space 2 inches to the left border of the sternum, external to the internal mammary artery. A moderate-sized aspirating needle should be used, as it is advisable to have the fluid escape slowly. The needle is removed and the wound sealed with gauze and collodion. The pericardium may also be reached by a puncture in the fourth or fifth interspace, near the border of the sternum, which avoids the pleura and internal mammary artery.

Paracentesis Vesicæ.—In cases of impassible stricture, as a temporary procedure, a distended bladder is sometimes emptied by aspiration. There is always risk of infection of the tissues in the line of puncture by the urine; so this procedure is to be avoided if possible. A trocar and cannula or an aspirating trocar is introduced through the tissues in the middle line just above the pubes; the urine is withdrawn, and, after removing the cannula, the puncture is sealed with a pledget of gauze and collodion.

Fig. 398.



Lumbar puncture showing position of needle.

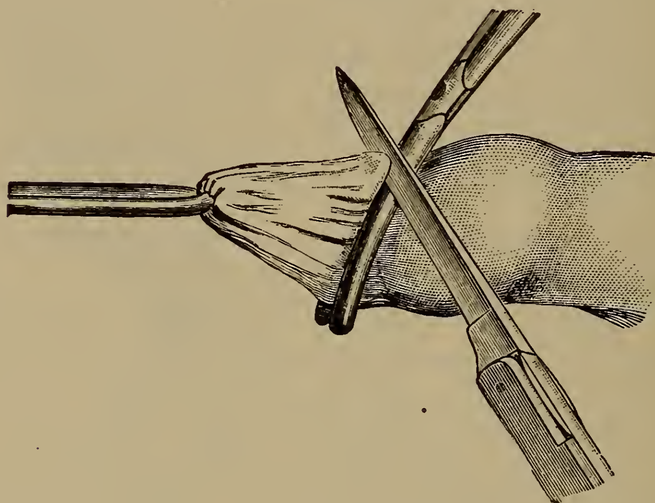
Lumbar Puncture. — This procedure is frequently employed for diagnostic and therapeutic purposes. The skin of the lumbar region is sterilized with tincture of iodine and may be anesthetized by injecting a few drops of a 2 or 4 per cent novocaine solution. The patient is next made to bend forward and the tip of the spinous process of the fourth lumbar vertebræ is located by the left index finger. The needle attached to an empty syringe is made to penetrate the skin ½ inch to the right and just below the tip of this process and is pushed forward, inward (toward the median line) and slightly upward into the intraspinous space between the fourth and fifth lumbar vertebræ (Fig. 398). The entrance of the needle into the subarachnoid space is shown by the sense of lessened resistance. The distance penetrated is from 2½ to 3 inches. If the needle is in the subarachnoid space upon drawing out the piston of the syringe, clear cerebrospinal fluid will appear in the syringe.

It is permissible and may be easier to introduce the needle in the median line; also a higher level than the fourth lumbar interspace may be used.

After removing a sufficient quantity of fluid the needle is withdrawn and the small wound is sealed with gauze and collodion.

Spinal puncture is the preliminary step in the injection of drugs to produce spinal anesthesia, the introduction of tetanus antitoxin and the removal of cerebrospinal fluid to relieve pressure in cases of fracture of the base of the skull, and in cases of cerebrospinal meningitis, anterior poliomyelitis and hydrocephalus. For diagnostic purposes in certain cases examination of the spinal fluid is of great value.

Fig. 399.



Circumcision.

Circumcision.—Circumcision is performed by drawing the prepuce forward and then clamping it with the handles of a pair of scissors or a pair of clamp forceps placed obliquely just in front of the glans (Fig. 399). The prepuce is next divided with a straight bistoury, and the forceps removed, when the skin and mucous membrane retract. The mucous membrane, if adherent, is dissected loose from the glans; if redundant it is trimmed with scissors to make it correspond to the line of skin incision; the cut edge of the mucous membrane is next fastened to the cut edge of the skin by a few sutures of silk or fine catgut. Catgut is the best suture material to use in children, as the sutures are absorbable and do not require removal which is often a troublesome procedure in this class of patients.

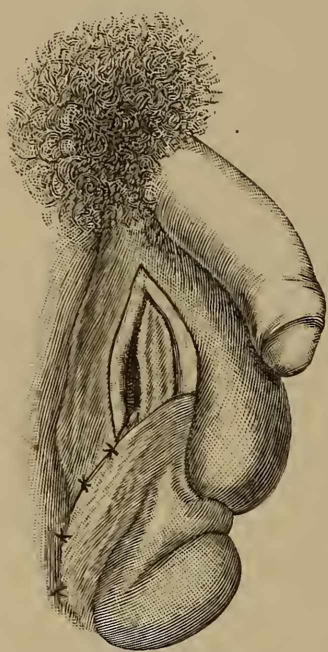
Varicocele.—In operating for varicocele, after sterilizing the skin of the scrotum or of the groin, the veins of the spermatic cord may be exposed by an incision $1\frac{1}{2}$ or 2 inches in length at the upper part of the scrotum, over the cord, or the cord may be exposed by an incision in the groin as it emerges from the inguinal canal, as recommended by Binnie. The veins being exposed, the larger portion of them are isolated, and two ligatures are passed around the mass of veins about 1 or $1\frac{1}{2}$ inches apart and firmly tied, care being taken that the vas deferens is not included with the veins. The portion of the veins between the ligatures is excised and the divided ends of the veins brought in contact by tying together the ends of the ligatures upon the proximal and distal ends of the veins; the wound is then closed with sutures.

Treatment of Hydrocele.—**The Palliative Treatment.**—It is well to examine the tumor for translucency with transmitted light to discover if there is any abnormal position of the testicle. Old hydroceles with thickened sacs and those in which hemorrhage has occurred are opaque. The skin of the scrotum should be sterilized and the tumor rendered tense by grasping it with the hand; a sterile trocar is then introduced through the anterior wall of the scrotum into the cyst, care being taken to avoid wounding any large superficial vein, being directed upward and backward to avoid wounding the testicle. After the fluid has escaped the cannula is removed and the puncture sealed with a sterile piece of gauze or cotton and collodion.

Injection Treatment.—This consists in emptying the cyst by means of a trocar and injecting from 1 to 2 drams of tincture of iodine. Another method consists in first introducing the needle of a hypodermic syringe, charged with 10 to 12 drops of pure carbolic acid, into the upper part of the sac—this is held by an assistant. The sac is next emptied by introducing a trocar at a lower portion of the cyst. After removing the fluid the carbolic acid is injected into the cyst and evenly distributed by rubbing the walls together. The instruments are removed and the punctures sealed with gauze and collodion. Pain and swelling follow each of these operations, but usually subside in forty-eight hours. The injection treatment was formerly frequently employed, but in recent years has been superseded by the operative methods of eversion or excision of the sac.

Eversion of Sac.—An incision is made exposing the sac for several inches, it is then incised and emptied and the testicle is brought out through the wound. The gubernaculum testis is next ligated and divided, then fold the two sides of the divided sac behind the testicle and fix them by a few sutures, one of which should intersect the superficial tissue of the cord (Fig. 400). The testicle is then replaced in the scrotum and the wound closed with sutures without drainage.

Fig. 400.



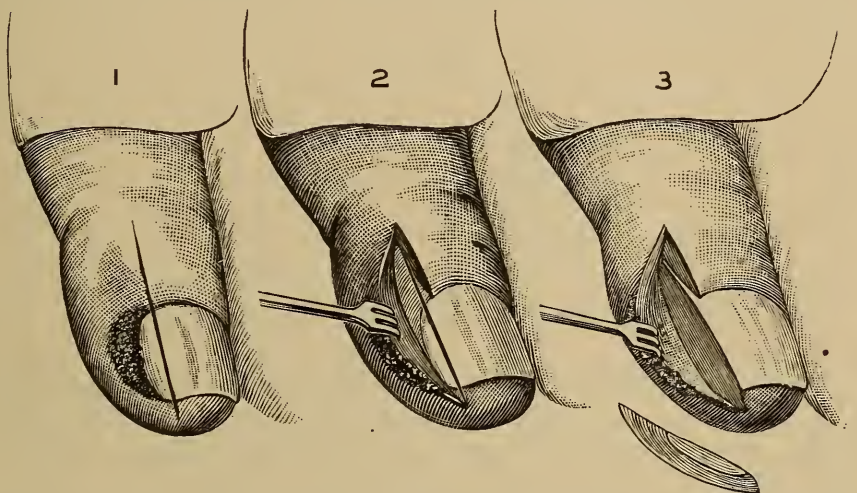
Operation for hydrocele by eversion method.

Excision of the Sac.—This consists in making an incision 2 or 3 inches in length over the anterior surface of the scrotal tumor, and dividing the tissues until the sac is exposed. This is next incised and the parietal layer is dissected out as far as possible and the testicular portion of the tunica vaginalis lightly scarified to destroy its secretory surface; a strip of rubber tissue or a gauze pack is introduced and allowed to remain for forty-eight hours and is then removed. The wound usually heals in from ten days to two weeks. Recurrence after the injection or eversion treatment is not infrequent, but seldom occurs after excision of the sac.

Ingrown Toenail.—In this condition the edge of the nail usually of the great toe, by pressure upon the flesh beneath it, causes ulceration or suppuration. The condition is painful and causes marked disability. It may be treated by carefully introducing a little wisp of cotton under the edge of the nail raising it away from the ulcer, and applying to the cotton a few drops of collodion and tincture of benzoin, which saturates the cotton and becomes dry forming a scab on which the edge of the nail rests. This dressing should be repeated at intervals of a few days and will often result in complete relief of the condition.

In aggravated cases operative treatment is often required. The essential point is to remove both the edge of the nail and that portion of the matrix from which it grows. The

Fig. 401.



Operation for ingrown toenail. 1, line of incision; 2, skin flaps reflected; 3, section of nail and matrix removed.

following operation will be found satisfactory: Sterilize the toe as completely as possible and tie a rubber band around its base; inject a few drops of a eucaine or novocaine solution along the edge of the nail and beneath it as far back as the second phalanx. Make an incision through the nail and overlying skin and matrix about $\frac{1}{4}$ inch from the edge of the nail (Fig. 401, 1). The overlying skin is next dissected free from the edge of the nail and its matrix (Fig. 401, 2).

The portion of the nail marked out by the first incision is then dissected out with its matrix, care being taken that all of the matrix corresponding to the nail is removed (Fig.

401, 3). The wound is irrigated with a 1:2000 bichloride solution and closed by wrapping a gauze dressing around the toe and securing it by a bandage firmly applied. The rubber bandage is next removed. The wet dressing should be renewed daily for a few days, and after this time a dry dressing may be employed.

Paronychia.—This is an infection of the base of the finger-nails, commonly known as *run-around.* The infection usually results in a small subepithelial abscess involving the tissues on one side of the nail, which, if not promptly opened, spreads along the base of the nail to the other side. If not relieved by incision the nail becomes separated at its base and is cast off.

Fig. 402.

Lines of incision in paronychia. (Kanavel.)

Treatment.—This consists in making a longitudinal incision on one or both sides of the outer edge of the nail as far back as the sulcus. In cases of some standing it is well to push back the eponychium, and with the point of a scissors inserted under the detached edge of the nail cut off as much of the root of the nail as has become separated from the matrix.

Felon or Whitlow.—This may consist: (1) The **subcuticular** felon, which consists of a collection of pus under the epidermis, in which, after incision and evacuation of the pus and the removal of the dead skin, pain is relieved and a prompt recovery takes place.

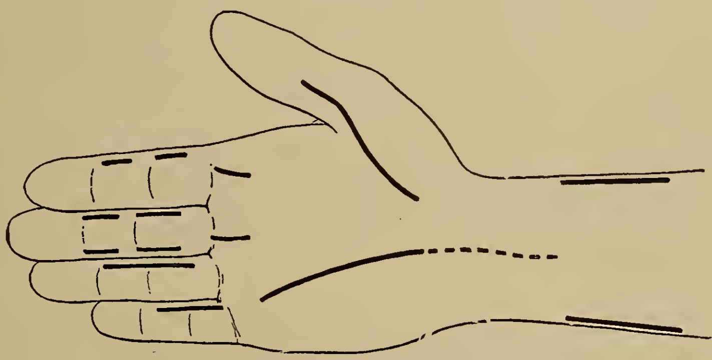
2. The **subcutaneous** form, which consists in a cellulitis of the pulp of the finger or thumb over the last phalanx, resulting from infection through a puncture or abrasion. The inflammatory condition results in severe throbbing pain and swelling of the parts. Unless the condition is relieved by

incision the bone may become involved or the process may extend to the tendon sheath.

The *treatment* consists in early and free incision and the subsequent use of hot antiseptic dressings. The incision should be made as soon as the edema restricted to the first phalanx has developed to the point of producing hardness of the tissues. It should not be made in the center of the finger, but at the side to avoid a scar over the site of the tactile portion of the finger.

3. **Suppurative Thecitis.**—This may follow the variety just described or may arise from infection of the tendon sheath from wounds. Pain, swelling and disability of the fingers

Fig. 403.



Lines of incision to open various tendon sheaths. (Kanavel.)

are prominent symptoms. If the condition is not arrested by treatment suppuration may extend along the tendon sheaths to the palm of the hand and give rise to palmar abscess. Sloughing of the tendon is apt to occur and may result in a useless finger. This condition is more likely to occur when either the little finger or thumb is involved, because their tendon sheaths communicate with the common palmar sac.

Treatment.—The patient should be anesthetized and a careful dissection should be made through the inflamed tissues parallel to the sheath of the tendon to evacuate the purulent matter. The lines of incision employed to open the various tendon sheaths is shown in Fig. 403. If pus is found external to the sheath this should not be opened, but if the sheath is found distended it should be opened at one or more points to secure free drainage. The tendon sheaths or thecal sacs in connection, if infected, should, after being opened, be irrigated with an antiseptic solution or with saline solution. Hot antiseptic dressings should be applied, and the hand should be put at rest upon a splint. Bier's hyperemic treatment may be used with advantage in these cases.

Palmar Abscess.—This consists in a collection of pus beneath the palmar fascia and may develop from an infection arising in the tendon sheaths of the fingers or from wounds, contusions or abrasions of the palm of the hand. As the pus accumulates under the palmar fascia, marked swelling and edema of the back of the hand may occur. Severe pain, throbbing in character, and swelling of the hand are prominent symptoms. If the condition is not relieved promptly by operation sloughing of the tendons may occur.

A thecal abscess of the index, ring or middle finger is usually arrested in the palm, and if ruptured, pus escapes giving rise to a palmar abscess. In suppurative thecitis of the little finger or thumb the pus may follow the tendon sheaths into the forearm.

Treatment.—The patient should be anesthetized and a careful incision should be made into the tissues of the palm, the line of incision should correspond to the middle of the metacarpal bones and should be distal to a line crossing the palm at the level of the web of the thumb to avoid the superficial palmar arch. When the palmar fascia has been opened the pus usually escapes freely. If there is much swelling of the back of the hand incisions may be required at this point. Strips of rubber dam, or rubber drainage tubes, should be introduced into the incisions, a moist antiseptic gauze dressing applied and the hand should be placed upon a palmar splint.

Tracheotomy.—This operation consists in dividing the tissues over the trachea in the median line of the neck, and after the trachea has been exposed it is opened by dividing two or three of the tracheal rings.

The instruments required are two small scalpels, one short grooved director, a tenaculum, two aneurysm needles (which may be used as retractors), hemostatic forceps, two pairs of dissecting forceps, a pair of scissors, a pair of tracheal forceps, a tracheal dilator, tracheotomy tubes, tapes, ligatures, gauze sponges, a flexible catheter and feathers. The *director* should be short; the ordinary grooved director is too long to use with satisfaction in operating upon the short necks of children (Fig. 404).

Hemostatic forceps are also useful in controlling hemorrhage during the operation in case of the division of vessels which bleed freely, when the operator from the urgency of the case does not think it justifiable to ligate them at the time of their division. They may also be employed under similar circumstances to clamp the isthmus of the thyroid gland on either side of the trachea when it becomes necessary to divide it to expose the trachea.

Fig. 404.

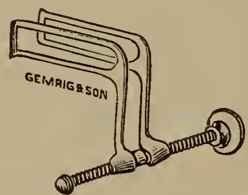
Author's tracheotomy director.

Tracheal dilators of various kinds are employed, but the most satisfactory tracheal dilator which I have employed is that of Golding-Bird (Fig. 405), which is a self-retaining instrument; the blades are slipped through the tracheal incision and are then expanded by turning the screw to which they are attached. Trousseau's tracheal dilator, the blades of which are introduced through the incision in the trachea and are expanded by bringing together the handles, is also a satisfactory instrument (Fig. 406). Tracheal dilators may be improvised from bent hair-pins or pieces of wire, which will often serve a useful purpose where ordinary dilators cannot be obtained.

It is also well to have at hand a number of pliable feathers, to be used in clearing the trachea or larynx of mucus or membrane after it has been opened; by their use this object may be accomplished with little risk of injury to the mucous membrane.

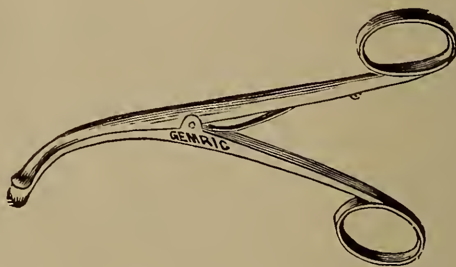
Tracheal forceps, which are constructed with a double spring and curved blades, are also useful in removing membrane or foreign bodies from the larynx above the wound or from the trachea below the tracheal incision (Fig. 407).

Fig. 405.



Golding-Bird's tracheal dilator.

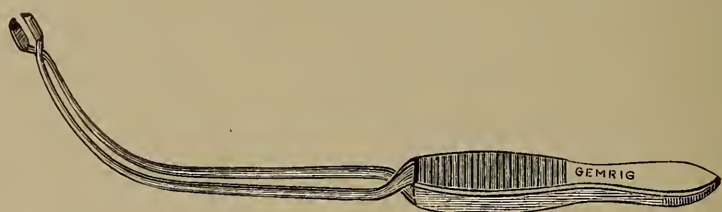
Fig. 406.



Trousseau's tracheal dilator.

Tracheotomy tubes of various shapes are made of silver, aluminum, hard and soft rubber, but the tube which I consider the most satisfactory for general use is a silver quarter-circle tube with a movable collar (Fig. 408), and provided with a fenestrated guide (Fig. 409). A satisfactory tracheotomy tube is one which inflicts the least possible injury upon

Fig. 407.

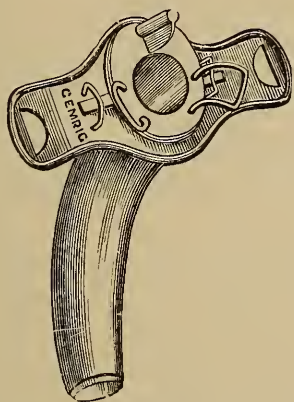


Tracheal forceps.

the mucous membrane of the trachea, and to insure this object the part of the tube within the trachea should lie exactly in its axis, and its free extremity should be capable of as little movement as possible. The tracheotomy tube is held in position, after being introduced, by means of tapes attached to the shield of the tube and tied around the neck.

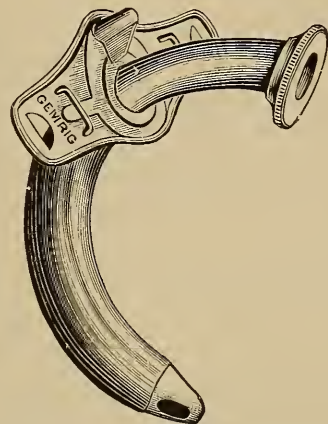
Position of Patient for Tracheotomy.—The best position in which to place the patient for this operation is one which brings the neck into the greatest prominence, and this may

Fig. 408.



Silver tracheotomy tube.

Fig. 409.



Silver tracheotomy tube with fenestrated guide.

best be obtained by laying the patient upon his back upon a firm table and placing under the shoulders a round cushion;

Fig. 410.

Position of patient for tracheotomy.

or an empty wine bottle or a roller-pin wrapped in towels, will answer the same purpose (Fig. 410); or the head may be held over the edge of the table. If an anesthetic is not used the arms should be held by an assistant. An anesthetic is contraindicated in dyspnea.

Operation of Tracheotomy.—The trachea may be opened above the isthmus of the thyroid gland or below it, and these operations constitute respectively the *high* and the *low* operation.

The high operation is generally selected because at this point the trachea is more superficial and is more easily exposed, whereas in the low operation the trachea is more difficult to expose by reason of its relatively greater depth, the large size and number of veins, and its proximity to the large arterial trunks.

High Operation.—The patient being placed in position, the operator stands at the head of the patient; this position I prefer, as it is easier from this point to keep the incisions exactly in the median line of the neck. The operator next makes himself familiar with the landmarks of the neck; locating the position of the *cricoid cartilage,* he makes an incision through the skin in the median line of the neck from $1\frac{1}{2}$ to 2 inches in length, the position of the cricoid cartilage being the middle point. There is no disadvantage in making a longer incision if a freer exposure of the parts is required. Having divided the skin, the operator will often see a large vein lying in the superficial fascia—the *superficial anterior jugular;* this should be displaced and the fascia divided upon a director.

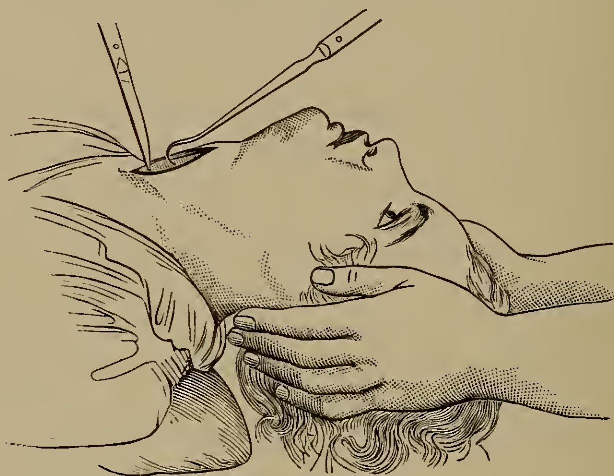
The surgeon should keep his incisions strictly in the median line of the neck, for this is the line of safety; and he should be careful, as the wound increases in depth, not to make the incisions too short, so that the wound becomes funnel-shaped. When the deep fascia is exposed it should be picked up and divided upon a director; any large veins in the line of the wound should be carefully displaced, or, if this is impossible, they should be ligated on each side and then divided between the ligatures.

The operator next looks for the intermuscular space between the *sternohyoid* and the *sternothyroid muscles,* which may generally be found without difficulty; the muscles are now separated in this line, with the handle of the knife or with a director, and the *isthmus of the thyroid gland* exposed. The muscles should now be held aside by retractors placed on either side. He should carefully explore the wound with the finger to locate exactly the position of the trachea, and to ascertain, if possible, the presence of anomalous arteries.

The isthmus of the thyroid gland having been exposed, which generally occupies a position over the first three tracheal rings, the gland will be found surrounded by a plexus of veins, which should be displaced with the director; or, if this is impossible they should be ligated on each side and divided between the ligatures. The thyroid isthmus is next displaced upward or downward, according as the surgeon desires to open the trachea below or above this body. This is often done without difficulty, especially its upward displacement; but when there is difficulty in displacing it downward, a procedure recommended by Bose may be employed, which consists in making a transverse incision across the cricoid cartilage to divide the layer of fascia by which the isthmus is bound down; the director is then passed into this incision and the isthmus is depressed without difficulty.

Having displaced the isthmus of the thyroid gland downward, the trachea, yellowish-white in appearance, covered by the tracheal fascia, will be exposed; this fascia should next be thoroughly broken up with a director or the handle of the knife, so as to bare the trachea, and in doing this the operator may feel it crepitate under the finger from the suction of air drawn in with inspiration. The trachea is next fixed with a tenaculum, introduced into it a little to one side of the median line; an incision is made into it with a narrow knife from below upward, from $\frac{1}{2}$ to $\frac{3}{4}$ inch in length (Fig. 411), care being taken to see that this incision is in the median line, for if the trachea be opened by a lateral incision the wound does not heal so promptly and the tracheotomy tube does not fit well, and its lower extremity may cause injury to the mucous membrane of the trachea. If the wound be a deep one, after fixing the trachea with the tenaculum the operator may lift it slightly from its bed, thereby bringing it more prominently into view and making it more superficial in the wound, thus facilitating its opening. As soon as the incision is made into the trachea, air mixed with blood and mucus escape from the incision. A tracheal dilator should next be introduced and the trachea cleared of membrane, if it is present in the region of the wound, with a feather or with forceps. The tracheotomy tube is next introduced, and is secured in position by tapes tied around the neck. If respiration has ceased artificial respiration should be resorted to. If possible the first tracheal ring should not be divided in order to avoid subsequent stricture.

Fig. 411.



Opening of the trachea.

Laryngotomy.—In this operation an opening is made into the air passages through the *cricothyroid membrane*. It is a simple operation, and one which is practically free from risk, and can, therefore, be performed much more rapidly and safely in urgent cases than tracheotomy.

The patient being placed in the recumbent posture, with the shoulders slightly elevated and the head thrown back to make the neck as prominent as possible, the surgeon feels for the prominence of the *thyroid cartilage*, and steadying the larynx between the finger and thumb of the left hand, he makes an incision in the median line over the center of the thyroid cartilage and extending downward for 1 or $1\frac{1}{2}$ inches. The skin and superficial fascia being divided, the fascia between the *sternohyoid muscles* and the areolar tissue is exposed and divided, and the *cricothyroid membrane* is exposed. The knife is then passed transversely through the membrane into the larynx, care being taken that both that membrane and the mucous membrane which covers its inner surface are divided at the same time. As soon as the knife enters the cavity of the larynx blood and mucus will be forcibly expelled.

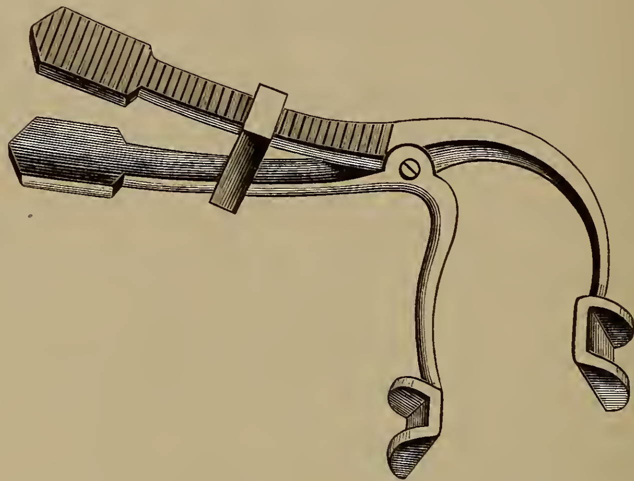
The wound should be carefully enlarged and a tube introduced, which differs from the ordinary tracheotomy tube in being slightly flattened; this is secured in position by tapes tied around the neck as in the case of the ordinary tracheal tube. The only bleeding which is likely to occur is from the *cricothyroid artery* or *veins,* and if these cannot be avoided, and are divided in the operation they should be temporarily secured by hemostatic forceps or ligated; if the case is not extremely urgent all bleeding should be arrested before the cricothyroid membrane is incised.

Laryngo-tracheotomy.—This operation consists in making an incision into the air passages by dividing one or two of the upper rings of the trachea, the cricotracheal membrane, the cricoid cartilage and the cricothyroid membrane. This operation is employed in cases where, from the age of the patient, the cricothyroid space is too small to admit of a sufficient opening, or in those in which, for any reason, the surgeon does not deem it advisable to attempt to open the trachea lower down. The incision in the skin and superficial fascia of the neck is made in the same manner as in the operation of laryngotomy, but is carried a little further downward. It may be necessary to displace the isthmus of the thyroid gland downward to expose the upper portion of the trachea, and when the trachea is exposed the incision should be made through this and the cricoid cartilage from below upward. A tracheotomy tube is introduced through the wound and secured by tapes tied around the neck.

Intubation of the Larynx.—This procedure at the present time, is widely employed as a substitute for tracheotomy in the treatment of dyspnea due to inflammatory affections of the larynx or trachea, or stenosis of the larynx; it consists in the introduction of a metallic or hard-rubber tube into the larynx, which is allowed to remain in place for a few days.

This operation has been introduced to the profession by the late Dr. O'Dwyer, of New York, who devised a set of ingenious instruments for the purpose of laryngeal intubation.

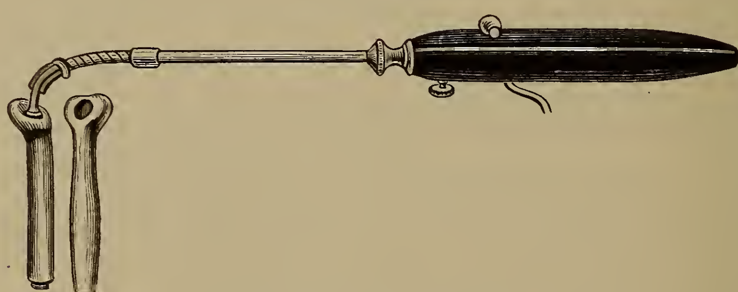
Fig. 412.



Mouth gag.

The instruments required are a mouth gag (Fig. 412), with which the jaws are separated and held open; an instrument for the introduction of the tube, which is fastened to the obturator, which fills the cavity of the tube (Fig. 413) and an

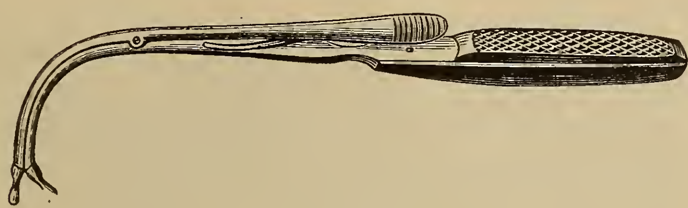
Fig. 413.



Intubation tube and introducer.

instrument for extracting the tube after it has been placed in the larynx (Fig. 414). The tubes are of metal or hard rubber, and have a collar which rests upon the false cords, and bulge slightly toward their middle and again taper toward their lower extremity; at the collar of the tube there is a perforation through which a strand of silk is passed which is made into a loop; this is used to enable the operator to remove the tube if on its introduction it is found to have passed into the esophagus instead of the larynx, and is also

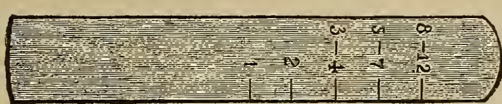
Fig. 414.



Intubation-tube extractor.

useful in removing the tube if it becomes occluded with membrane while in the larynx. The intubation set now in common use is provided with a scale of seven tubes, ranging in size from such as are suited for a child of one year or less up to the age of twelve or fourteen years (Fig. 415). Special tubes are required for intubation in adults.

Fig. 415.



Scale of intubation tubes.

Operation of Intubation of the Larynx.—In performing the operation of intubation, the child is placed upon the lap of the nurse or assistant, wrapped in a blanket, and the arms secured by the nurse holding the elbows so as not to interfere with the respiratory movements. The patient's head is next held by an assistant. The position of the head, neck and body should be as if the child were hung from the top of the head, and this position should be maintained during the insertion of the tube. An intubation tube can be introduced without difficulty with the patient in a recumbent posture.

This position should be utilized when it is not desirable to place him in the sitting posture. The mouth gag is next inserted upon the left side and the blades dilated so as to open the jaws widely, and as the gag is self-retaining, this position is easily maintained. The jaws being thus held open, the operator, sitting on a chair facing the patient (Fig. 416),

Fig. 416.

Intubation of the larynx.

next introduces the index finger of the left hand, protected by a strip of adhesive plaster or a metal shield, into the mouth and passes it over the tongue until he feels the epiglottis. The introducing instrument, to which the tube is attached, is held in the right hand and introduced into the mouth after observing that the silken loop is free; it is swept over the tongue and passed down until it touches the epiglottis; this is hooked up by the index finger of the left hand and the tube passed into the larynx; the index finger of the left hand is then transferred to the edge of the tube, and by pressing upon the trigger of the instrument with the thumb of the right hand the obturator is detached and the instrument is withdrawn, and before removing the finger it is well to place it upon the head of the tube and to sink it well into the larynx. As soon as the obturator is removed there is usually a violent expiratory effort, which is accompanied by a gush of mucus, mucopurulent matter, or membrane from the tube, and after this escapes the breathing is usually satisfactorily established. If the operator has passed the tube into the esophagus and has detached it from the introducing instrument, no improvement in the respiration takes place; it should then be withdrawn by the silk loop attached to the tube, and another attempt made to introduce it into the larynx.

The mistake which inexperienced operators make in attempting to introduce the tube is in not hugging the posterior surface of the tongue closely, thereby passing the tube over the epiglottis into the esophagus.

The silken loop may be brought out at one side of the mouth and adjusted around the ear or fastened to the side of the face by strips of adhesive plaster for a few hours, so that by drawing upon it the nurse or attendant can withdraw the tube instantly if it should become obstructed with membrane; or, if it is coughed up, by this means it may be withdrawn from the esophagus if it has not been expelled from the mouth. Some operators keep the loop attached to the tube during the time it is retained in the larynx. I prefer to remove it after the tube is securely placed in the larynx, and to withdraw the tube by means of the extracting instrument when required.

Extubation or the removal of the tube is, as a rule, more difficult than its introduction. This is done with the patient either in the sitting position or prone; the jaws are held open by the mouth gag and the operator passes his finger into the mouth and locates the epiglottis and head of the tube; the extracting instrument is next introduced and the closed blades are passed into the opening in the tube and the blades expanded and the instrument withdrawn with the tube attached. If there is difficulty in grasping the tube it may be loosened and pushed upward by pressure and manipulation on the neck over the upper part of the trachea and larynx, and when it protrudes from the larynx it may be

Fig. 417.

Feeding a case of intubation of the larynx.

grasped with forceps and removed. The tube should be removed at the end of the second or third day, and if the child can breathe comfortably for an hour or two it need not be reintroduced; if, however, the dyspnea returns, it should be reintroduced and allowed to remain one or two days longer; several attempts may have to be made before the tube can be permanently removed; it is usually dispensed with from the third to the eighth day.

The most serious complication which is apt to occur during the introduction of the intubation tube is the detachment and pushing of a mass of membrane in front of the tube into the trachea; if the mass is too large to be expelled through the tube the breathing is suddenly arrested. The tube should be removed at once, and if the mass of membrane does not escape with the expiratory efforts of the patient the trachea should be rapidly opened as the only means of reëstablishing the respiratory function. So much do I dread this accident, which has occurred in a few cases, that I never introduce the intubation tube without having at hand the necessary instruments to do a tracheotomy if it should be suddenly required, and, if possible, obtain the consent of the parents or friends to perform tracheotomy if it should be indicated.

Feeding after Intubation.—One of the greatest difficulties after intubation of the larynx is the satisfactory feeding of the patient; liquids, as a rule, are not swallowed well, a portion escaping into the tube, causing coughing and difficulty in breathing. The diet I usually prefer is semisolid, such as cornstarch, soft-boiled eggs and mush; and if these are not well swallowed it may be necessary to resort to nutritious enemata or the use of a stomach tube to introduce food. Some patients swallow liquids and semisolids quite well if the head is placed a little lower than the body during the act of deglutition (Fig. 417).

PART VII.

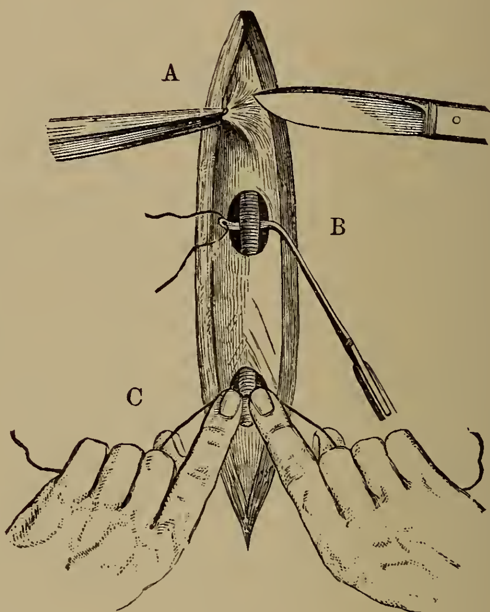
LIGATION OF ARTERIES.

In the application of a ligature to an artery in its continuity the surgeon should make his incision in the line which corresponds to the general course of the vessel, and he should be thoroughly familiar with the anatomy and with the surgical landmarks of the part. A portion of the artery, when possible, should be selected for the application of the ligature half an inch or an inch from any large collateral branch. The position of the incision being selected, the surgeon steadies the skin with two fingers and makes an incision of the required length through it with a scalpel; the superficial fascia is next picked up on a director, any large superficial veins which come into view being displaced, and divided to an equal length with the incision in the skin; the deep fascia being exposed, it should be nicked and divided upon a director; the intermuscular space, or the edge of the muscle or muscles which are the guide to the vessel, should next be sought for, and small arteries coming from the main vessel through these spaces will often serve as valuable guides to the position of the artery. The surgeon next separates the tissues with the director or handle of the knife until the sheath of the vessel is exposed; this is recognized by its communicated pulsation and by the absence of the smooth, shining surface and pinkish-white color which the surface of the artery presents. The sheath of the artery should be picked up with forceps and nicked with the point of the knife applied flatwise (Fig. 419, *A*); the incision into the sheath should be very limited, only sufficiently large to allow the aneurysm needle to pass through it around the vessel; extensive dissections or separations of the sheath from the artery should be avoided, as the nutrition of the artery at the point of ligature may thus be impaired, and sloughing and secondary hemorrhage may result. A distinct sheath is found only about the main arterial trunks, which is replaced in the smaller artery by a layer of loose cellular tissue. The wall of the artery being exposed, an aneurysm

Fig. 418.

Aneurysm needle.

Fig. 419.



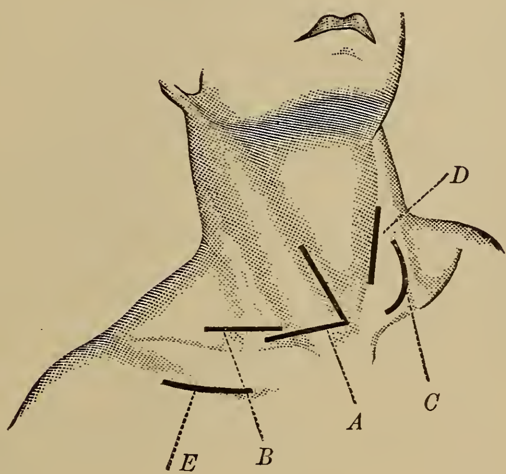
A, opening sheath; *B*, passing ligature around the vessel; *C*, tying the artery.

needle (Fig. 418) is passed around the vessel, threaded with a catgut ligature, and withdrawn (Fig. 419, *B*); the needle may be threaded before being passed, in which case the ligature is grasped with forceps and drawn through while the needle is withdrawn. The best material for ligatures is silk or carefully prepared chromicized catgut. The needle should be passed away from important structures, such as accompanying veins and nerves.

Before the ligature is tied the surgeon should satisfy himself that the ligature when tied will control the circulation in the artery below its point of application, by placing the tip of his finger upon the vessel and drawing upon the ends of the ligature, so as to occlude the vessel at the point of application. Being satisfied as to this point, the ligature is tied with a reef knot, or a surgeon's knot and reef knot combined, and the ends of the ligature are cut short in the wound (Fig. 419, *C*).

Some authorities recommended the application of two ligatures a short distance apart in the ligation of vessels in their continuity, and a division of the vessel between them, so that both ends may retract into the cellular sheath.

FIG. 420.



Lines of incision for—*A*, innominate artery; *B*, right subclavian artery; *C*, left subclavian artery; *D*, vertebral or inferior thyroid artery; *E*, axillary artery below clavicle.

Ligation of Special Arteries.—Ligation of the Innominate Artery.—The innominate artery lies immediately behind the sternoclavicular articulation, and is in relation in front with the innominate veins and pneumogastric nerve, on the inner side with the trachea, on the outer side and behind with the pleura.

The *incision* is a V-shaped incision, each branch of which is $2\frac{1}{2}$ or 3 inches in length, one of which lies over the anterior edge of the sternocleidomastoid muscle and the other parallel to and a little above the clavicle (Fig. 420, *A*). The incisions are carried down to the superficial fascia and a flap is dissected up. If the anterior jugular vein is met with it should be displaced. The sternal and clavicular attachments of the sternocleidomastoid are next divided upon a director $\frac{1}{2}$ inch above the bone. The sternothyroid and sternohyoid muscles and the middle cervical fascia are then exposed, covered by the thyroid veins. The outer fibers of the sternohyoid and sternothyroid muscles are next divided, the thyroid vein being held aside, when upon tearing through the fascia with a director the common carotid artery is exposed and traced down to the innominate artery; the innominate veins are pressed against the sternum with the finger, and the artery is separated from its sheath about $\frac{1}{2}$ inch below its bifurcation, and the aneurysm needle is passed around the vessel from the outer side, so as to avoid the vein, pneumogastric nerve and pleura.

Ligation of the Subclavian Artery.—This artery may be tied at three points; in its *first* portion, between the trachea and scaleni muscles; in its *second* portion, behind the scaleni muscles; and in its *third* portion, external to the scaleni muscles.

The left subclavian artery in its first portion is larger and more vertical in its direction than the right subclavian, and is situated more posteriorly. From the difficulty in exposing this portion, and from the possibility of injuring the thoracic duct, the ligation of this artery in its first portion has been seldom attempted.

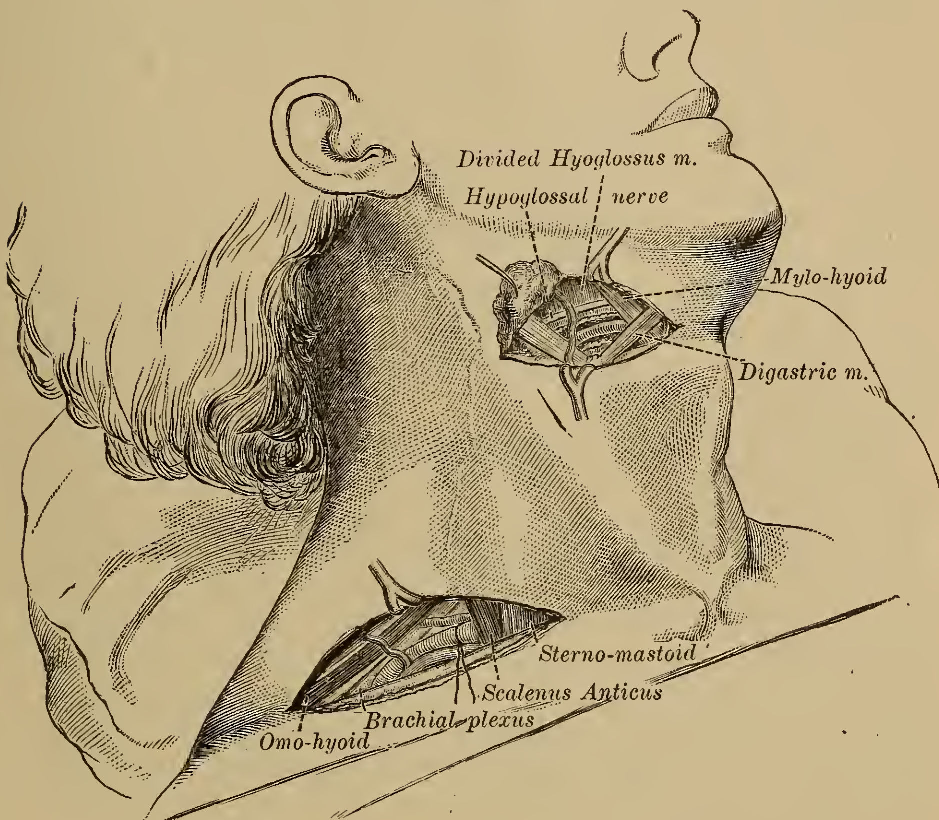
The *incision* for the *first portion* of the subclavian artery is the same as that for the innominate (Fig. 420, *A*), and the ligature is passed from the outer side, the pneumogastric and phrenic nerves being pressed inward toward the carotid artery.

The right and left subclavian arteries are also seldom tied in their second portions—that is, behind the scaleni muscles—but are frequently tied in their third portions—that is, external to the scaleni muscles.

The *incision* for the *second portion* of the subclavian artery begins an inch external to the sternoclavicular articulation,

$\frac{1}{2}$ inch above and parallel to the clavicle, and is 3 or 4 inches in length (Fig. 420, *B* or *C*). The steps of the operation are the same as for ligation of the third portion, and when the scalenus anticus muscle has been exposed it is divided upon a director; the phrenic nerve, which lies upon its anterior aspect, is to be avoided.

Fig. 421.



Ligation of subclavian and lingual arteries.

The *incision* for the *third portion* of the subclavian artery is the same as for the second portion (Fig. 420, *B* or *C*). The skin and platysma being divided, the external jugular vein is exposed and drawn to one side or divided between two ligatures; the superficial fascia is next divided upon a director; the posterior belly of the omohyoid muscle is next found and drawn upward and outward; the outer border of the scalenus anticus is next felt for and followed down to the tubercle of the first rib—the artery lies against this, between it and the lowest bundle of the brachial plexus. The artery is next denuded with the director, and the needle is passed from below, care being taken not to include the lowest bundle of the brachial plexus in the ligature (Fig. 421).

Ligation of the Vertebral Artery.—The *incision* for the ligation of the vertebral artery is 3 or 3½ inches in length, parallel with the anterior edge of the sternocleidomastoid muscle, ending 1 inch above the clavicle (Fig. 420, *D*). The anterior edge of the sternocleidomastoid being exposed, the middle cervical fascia is divided and the carotid artery and jugular vein are exposed and drawn inward. The gap between the longus colli muscle and the scalenus anticus muscle is next felt for about 1 inch below the carotid tubercle; the fascia covering it is next torn through and the muscles are separated and the vertebral vein comes into view. When this vein is held aside the vertebral artery is exposed and the ligature is then passed around it.

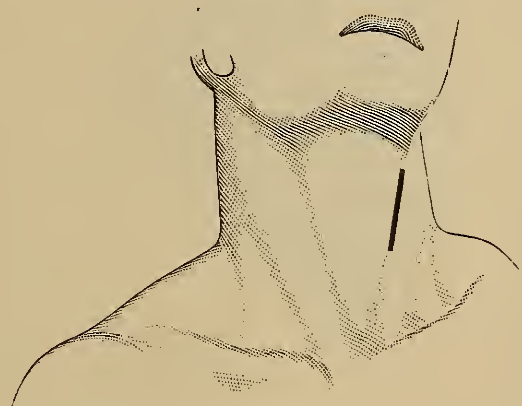
Ligation of the Inferior Thyroid Artery.—The *incision* for the inferior thyroid artery is the same as that for the vertebral artery (Fig. 420, *D*). The anterior edge of the sternocleidomastoid muscle being exposed, it is drawn outward, the middle cervical fascia is next divided, and the carotid artery and internal jugular vein are drawn outward with a retractor. The head being flexed slightly, the surgeon feels for the carotid tubercle, and then separates the cellular tissue with a director, and the artery should be found below the carotid tubercle. The needle should be passed between the artery and vein.

Ligation of the Internal Mammary Artery.—The *incision*, a vertical one, 2½ inches in length, commences at the lower border of the clavicle, parallel with and three lines external to the margin of the sternum. Divide the skin and superficial fascia and expose the fibers of the great pectoral muscle, the external intercostal aponeurosis, and the muscular fibers of the internal intercostal muscle. Raise the fasciculi of the latter muscle upon a director and divide them, and the vessel will be exposed. The internal mammary artery is not often tied below the fourth intercostal space.

Ligation of the Common Carotid Artery.—The point of election for the ligation of the common carotid artery is just above the omohyoid muscle, about $\frac{3}{4}$ inch below the bifurcation of the vessel, which takes place at a point on a line with the upper border of the thyroid cartilage.

The *incision* for the common carotid artery is 3 inches in length along the anterior border of the sternocleidomastoid muscle, the center of which corresponds with the cricothyroid space (Fig. 422).

Fig. 422.

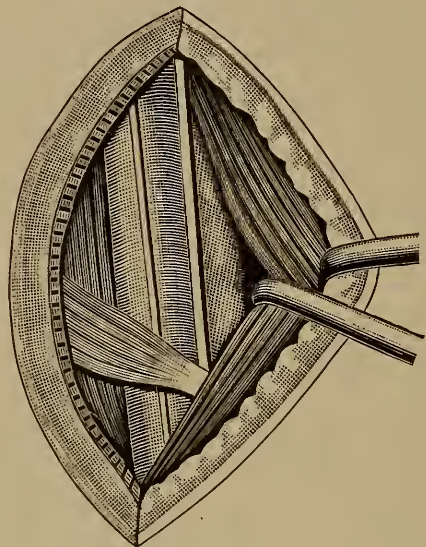


Line of incision for common carotid artery at point of election.

Divide the skin, platysma, cellular tissue and aponeurosis, avoiding the superficial veins and expose the anterior edge of the sternocleidomastoid; seek for the interspace between this muscle and the sternohyoid and sternothyroid muscles, draw the latter muscles inward, and the artery will be exposed with the jugular vein external to it; the descendens noni nerve lying upon its sheath should be displaced outward. The sheath is next picked up and opened and the artery is separated from it with a director; the artery lies internally, the internal jugular vein externally and somewhat more superficial, and the pneumogastric nerve lies between the two, and is more deeply placed. The sympathetic nerve is posterior to the vessel external to the sheath. The needle is passed from without inward, care being taken to avoid injury of the vein and nerve (Fig. 423).

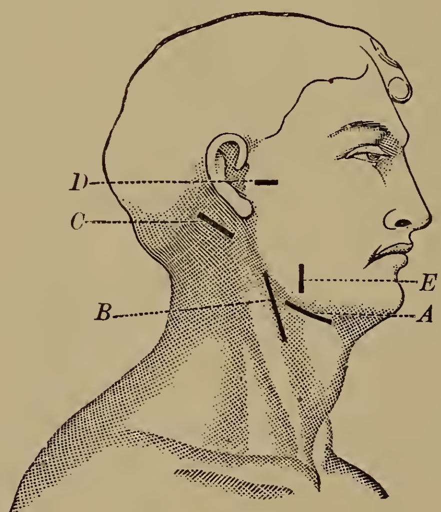
Ligation of the External Carotid Artery.—The *incision* for the ligation of the external carotid artery is over the inner edge of the sternocleidomastoid muscle from the angle of the jaw

Fig. 423.



Relations of the left common carotid artery above the omohyoid muscle.

Fig. 424.



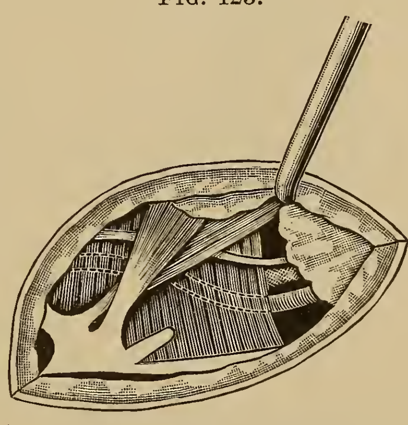
Lines of incision for—*A*, lingual artery; *B*, external and internal carotid arteries; *C*, occipital artery; *D*, temporal artery; *E*, facial artery.

to a point corresponding to the middle of the thyroid cartilage (Fig. 424, *B*). The skin, platysma and cellular tissue being divided, the external jugular vein is drawn aside when encountered; the deep fascia being opened, the facial and lingual veins will be exposed, which should be drawn to one side; the artery is next exposed, covered by the hypoglossal nerve and the stylohyoid and digastric muscles. The vessel should next be isolated from the internal carotid artery and internal jugular veins, both of which lie along its outer side. The needle should be passed from without inward.

Ligation of the Internal Carotid Artery.—The *incision* is the same as for the external carotid artery (Fig. 424, *B*); the vessel is external to the external carotid artery, and in passing the needle the point should be directed away from the internal jugular vein—that is, from without inward.

Ligation of the Superior Thyroid Artery.—The *incision* is about 3 inches in length along the anterior border of the sternocleidomastoid muscle, starting a little lower down than that for the external carotid artery. The skin, superficial fascia, platysma and deep fascia being divided, the cellular tissue in the sulcus between the upper portion of the larynx and the great vessels of the neck should be broken up with the director and the vessel exposed. The needle should be passed around the vessel from above downward.

Fig. 425.



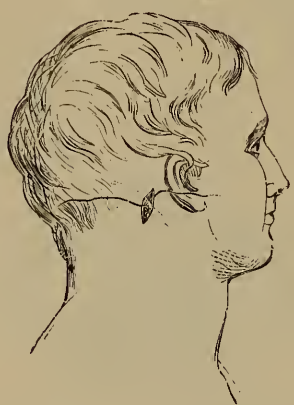
Relations of the lingual artery.

Ligation of the Lingual Artery.—The *incision* is a curved one 2 inches long, its concavity directed upward from the anterior edge of the sternocleidomastoid muscle, $\frac{1}{2}$ inch above the great horn of the hyoid bone, to a point 1 inch within the median line of the neck (Fig. 424, *A*). Divide the skin and platysma, displacing the superficial veins, and open the deep fascia, when the submaxillary gland will be exposed; this is displaced upward with the handle of the knife, when the tendon of the digastric muscle attached to the hyoid bone, and the hypoglossal nerve will be exposed; next divide the fibers of the hyoglossus muscle midway between the hypoglossal nerve and the hyoid bone, and the lingual artery will be exposed (Fig. 425). The needle should be passed around the vessel from above downward in order to avoid the nerve.

Ligation of the Facial Artery.—The facial artery passes over the inferior maxilla just in front of the anterior edge of the masseter muscle, and is accompanied by the facial vein, which lies nearer to the muscle.

The *incision* is either a horizontal one along the lower border of the maxilla or a vertical 1 inch in length (Fig. 424, *E*). The skin, subcutaneous tissue and fascia being divided, the artery is exposed; the needle should be passed around the vessel away from the vein.

Fig. 426.



Ligation of the occipital artery.

Fig. 427.

Ligation of the temporal artery.

Ligation of the Occipital Artery.—The *incision* is 2 inches in length, starting from a point $\frac{1}{2}$ inch below and in front of the apex of the mastoid process, and carried obliquely backward, parallel to the border of this process (Fig. 424, *C*). Divide the skin and fascia and expose the insertion of the sternocleidomastoid muscle, which is also divided, and the aponeurosis of the splenius is exposed; this is also opened and the digastric groove is felt for, and when the belly of the digastric muscle is exposed the artery is brought into view by separating the cellular tissue in the anterior angle of the wound with a director (Fig. 426).

Ligation of the Temporal Artery.—The *incision* is transverse one, 1 inch in length, starting from the tragus of the ear forward over the zygomatic arch (Fig. 424, *D*), or a vertical one of the same length a little in front of the tragus of the ear.

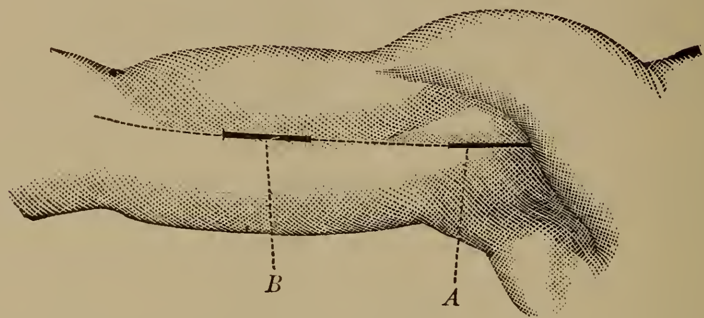
Divide the skin and expose the subcutaneous cellular tissue, which in this region is very dense and fibrous. This tissue should be broken up with a director, and the artery should be found in it about $\frac{1}{4}$ inch in front of the ear (Fig. 427). The temporal vein accompanies the artery and lies nearer to the ear, and in some cases the auriculotemporal nerve is in close relation to the artery. The needle should be passed from behind forward.

Ligation of the Axillary Artery.—The axillary artery extends from the middle of the clavicle to the insertion of the teres major into the humerus; the axillary vein lies upon the inner side and in front of the artery. The axillary artery is tied either in its *upper* portion, just below the clavicle, or at its *lower* portion in the axilla.

Axillary Artery below the Clavicle.—The *incision* is 4 inches in length from the summit of the coracoid process inward a short distance below the clavicle (Fig. 420, *E*), or an incision 3 inches in length, commencing at a point $\frac{1}{2}$ inch from the sternoclavicular articulation and carried obliquely downward toward the axilla.

The skin and subcutaneous tissue having been divided, the deep fascia is exposed and opened, and the axillary artery may be reached by following the intermuscular space between the sternal and clavicular fibers of the pectoralis major which leads upward toward the clavicle and to the pectoralis minor; or the fibers of the pectoralis major being exposed, are cut through and the costocoracoid membrane is next torn through with a director, care being taken to avoid injury of the cephalic vein at the outer portion of the wound; the pectoralis minor is now seen, and after separating the cellular tissue with a director the axillary vein is seen crossing from the upper edge of the muscle to the clavicle; the vein almost completely covers the artery, which is exposed by drawing the vein inward. The needle is passed around the artery from within outward.

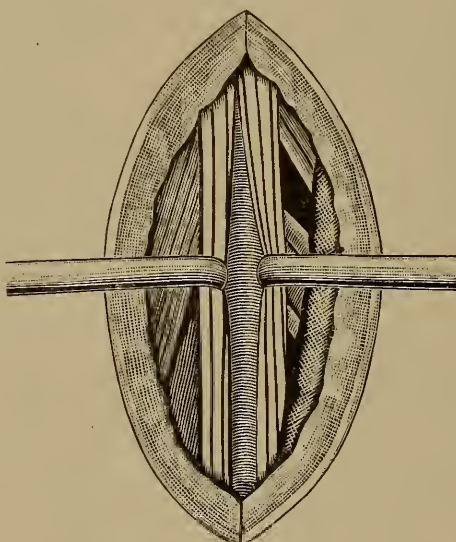
Fig. 428.



A, incision for axillary artery in axilla; *B*, incision for brachial artery.

Axillary Artery in the Axilla.—The *incision* is 2 inches long, started at the upper part of the axilla and carried down

Fig. 429.



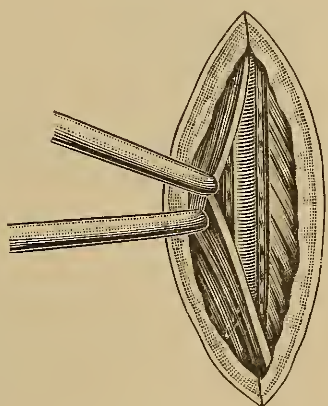
Relations of right axillary artery in axilla.

the arm at the edge of the coracobrachialis muscle (Fig. 428, *A*). The skin only is divided in the first incision. The deep fascia is then picked up and divided upon a director.

As soon as the fibers of the inner border of the coracobrachialis muscle are exposed and held aside by a retractor, the operator will see the median nerve, the musculocutaneous nerve, and the axillary artery. To the inner side of the artery are the axillary vein, ulnar and internal cutaneous nerves (Fig. 429). The needle should be passed around the artery from the vein toward the coracobrachialis muscle.

Ligation of the Brachial Artery.—The *incision* is 3 inches long at the middle of the arm, on a line corresponding to the inner edge of the biceps muscle (Fig. 428, *B*). The skin and cellular tissue having been divided, care being taken not to

Fig. 430.

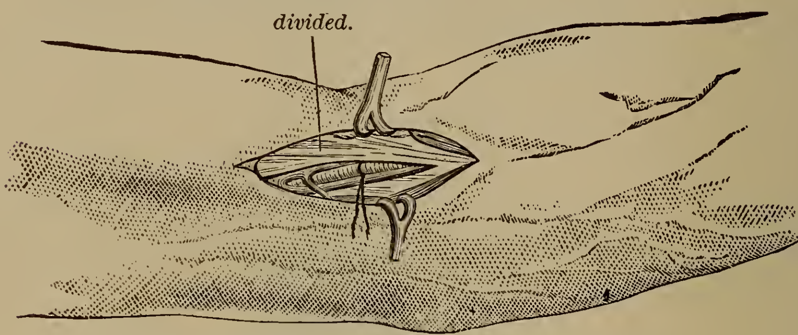


Relations of right brachial artery at middle of arm.

injure the basilic vein, which should be displaced posteriorly, the deep fascia is next cut through and the fibers of the biceps muscle are exposed (Fig. 430); this muscle should be drawn forward and the sheath of the vessels enclosing the artery, veins and median nerve exposed; the sheath having been opened, the median nerve is pressed aside and the artery is separated from its veins, and the needle is passed from the side of the nerve around the vessel. In ligating the brachial artery the occasional high division of the vessel must be borne in mind.

Brachial Artery at Bend of the Elbow.—The *incision* is 2 inches in length, along the inner border of the tendon of the biceps muscle. Divide the skin, superficial fascia and the bicipital aponeurosis, under which the artery will be exposed, resting upon the brachialis anticus muscle (Fig. 431). The median nerve is to the inner side and some distance from the artery. The needle should be passed around the vessel, after isolating the veins, from within outward.

FIG. 431.



Ligation of the brachial artery at the bend of the elbow.

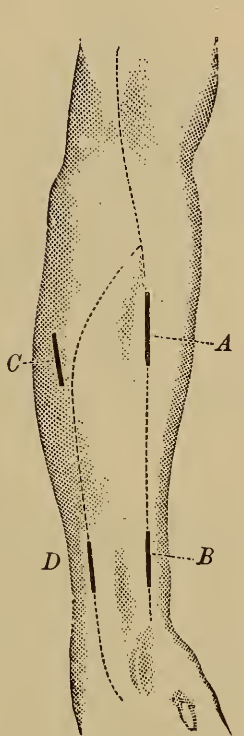
Ligation of the Radial Artery.—The radial artery extends in a straight line from a point ½ inch below the center of the fold of the elbow to the inner side of the styloid process of the radius.

The radial artery may be tied at its upper, middle or lower third, or at the root of the thumb.

Radial Artery in the Upper Third of the Forearm.—The *incision* for the radial artery at its upper third is 2½ inches in length on a line drawn from the middle of the bend of the elbow to the ulnar side of the styloid process of the radius; the incision should begin 1½ inches below the bend of the elbow (Fig. 432, *A*). Divide the skin and superficial fascia, avoiding the superficial veins. When the deep fascia is exposed, find the edge of the supinator longus muscle and divide the aponeurosis along its ulnar side, and expose the fibers of the pronator radii teres muscle. The vessel lies in the interspace between these muscles surrounded by adipose tissue, and upon being exposed the veins should be isolated and the needle passed from without inward. The radial nerve lies so far external to the artery that it is not often exposed in the operation (Fig. 433).

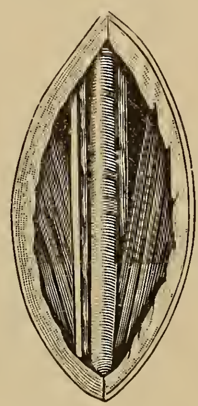
Radial Artery in the Middle Third of the Forearm.—The *incision* is 2 inches in length, following the same line as that

Fig. 432.



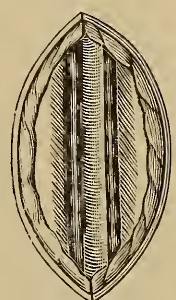
Line of incision for—*A*, radial artery in upper third; *B*, radial artery in lower third; *C*, ulnar artery in upper third; *D*, ulnar artery in lower third.

Fig. 433.



Relations of right radial artery in the upper third of the forearm.

Fig. 434.



Relations of right radial artery above the wrist.

for the upper third of the artery. After dividing the skin, superficial and deep fascia, the artery is found in the interspace between the flexor carpi radialis on the inner side and the supinator longus on the outer side; the radial nerve at this part of the arm is in close relation with the vessel to the radial side, and the needle should be passed around the artery from without inward.

Radial Artery in the Lower Third of the Forearm.—The *incision* is 2 inches in length, following the same line (Fig. 432, *B*), ending 1 inch above the wrist. The skin, superficial and deep fascia being divided, the artery will be found between the tendon of the flexor carpi radialis on the inner side and the tendon of the supinator longus on the outer side (Fig. 434). The veins being separated, the needle may be passed in either direction.

Radial Artery at the Root of the Thumb.—The radial artery may also be tied at the root of the thumb. The *incision* is 1 inch in length between the tendons of the extensor ossis metacarpi pollicis and extensor primi internodii pollicis on the outer side, and the tendon of the extensor secundi internodii pollicis on the inner side. The skin and superficial fascia being divided and the radial vein being displaced, the deep fascia is opened and the artery is exposed at the bottom of the wound; the needle may be passed in either direction.

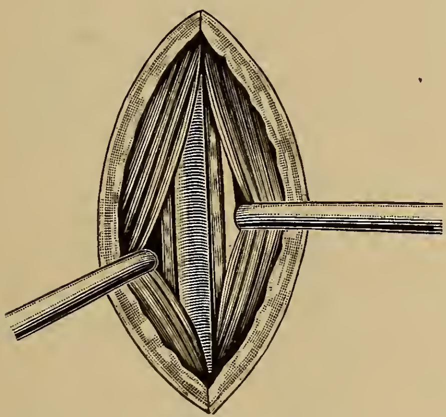
Ligation of the Ulnar Artery.—The ulnar artery is tied at the junction of the upper and middle thirds of the forearm and at the lower third.

Ulnar Artery at the Junction of the Upper and Middle Thirds of the Forearm.—The *incision* is 3 inches in length, starting 4 inches below the internal condyle of the humerus on a line passing from the internal condyle of the humerus to the outer border of the pisiform bone (Fig. 432, *C*). Divide the skin and superficial fascia, and when the deep fascia has been exposed and the interspace between the flexor carpi ulnaris and the flexor sublimis digitorum appears, enter this interspace and raise the flexor sublimis digitorum and work transversely across the arm. The artery will be found resting upon the deep flexor, with the ulnar nerve to the ulnar side. The needle should be passed from the nerve around the artery (Fig. 435).

Ulnar Artery in the Lower Third of the Forearm.—The *incision* is 2 inches in length, a little to the radial side of the tendon of the flexor carpi ulnaris, which is attached to the pisiform bone, ending 1 inch above the wrist (Fig. 432, *D*).

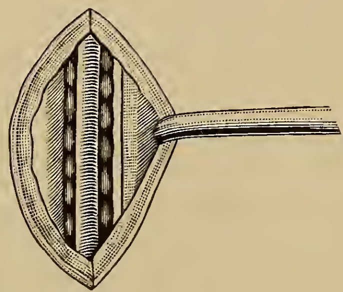
Divide the skin and superficial fascia and open the deep fascia; the artery will be exposed with its accompanying veins, between the tendons of the flexor carpi ulnaris and flexor sublimis digitorum, the ulnar nerve being to the ulnar side of the vessel. The needle should be passed from within outward to avoid the nerve (Fig. 436).

Fig. 435.



Relations of the right ulnar artery of upper third of the forearm.

Fig. 436.



Relations of the right ulnar artery above the wrist.

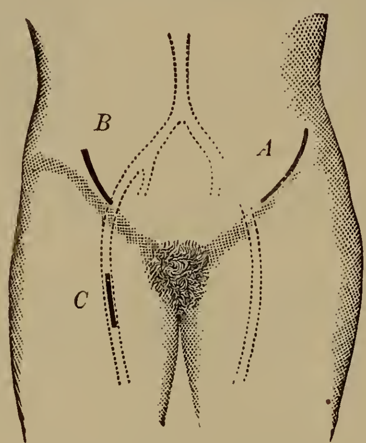
Ligation of the Interosseous Artery.—The *incision* is similar to that employed in the ligation of the ulnar artery in its upper third.

Ligation of the Abdominal Aorta.—The *incision* is in the linea alba from a point 3 inches above the umbilicus to a point 3 inches below it. The superficial structures being divided, the peritoneum is opened upon a director, and the intestines are pressed aside and the aorta is exposed, covered by peritoneum, with the filaments of the sympathetic nerve resting upon it and the vena cava to the right side. Tear through the peritoneum and pass the needle from right to left around the vessel. After tying the ligature the ends should be cut short and the external wound should be closed as in the ordinary laparotomy wound.

The vessel may also be exposed by an incision along the anterior border of the quadratus lumborum muscle, from the last rib to the crest of the ilium. The skin, lumbar muscles and fascia transversalis being divided, the wound is held open with blunt hooks, so that the retroperitoneal space is exposed and the aorta brought into view. The vessel being separated from the vena cava and nerves, the needle is passed around it and the ligature applied.

Ligation of the Common Iliac Artery.—The aorta divides into the two common iliac arteries on the left side of the fourth lumbar vertebra, and these arteries are usually about 2 inches in length, and bifurcate opposite the sacroiliac synchondrosis to form the internal and external iliac arteries; the length of the common iliac artery, however, may vary considerably, being 3 or 4 inches in some cases.

Fig. 437.



Lines of incision for—*A*, common iliac artery; *B*, external iliac artery; *C*, femoral artery in Scarpa's triangle.

The *incision* for ligation of the common iliac artery is 4 to 6 inches in length, beginning ½ inch above the middle of Poupart's ligament, and is carried outward, curving upward after passing the anterior-superior spine of the ilium (Fig. 437, *A*).

Divide the skin, superficial fascia and aponeurosis of the external oblique muscle, and then divide the fibers of the internal oblique and transversalis muscles upon a director and expose the transversalis fascia. This is opened at the lower part of the wound, and the finger is introduced and the peritoneum pressed back; the opening in the transversalis fascia is next enlarged, and the peritoneum is carefully drawn inward and upward with the fingers toward the inner edge of the wound. The operator next feels for the external iliac artery, and passes the finger along this until the common iliac artery is reached. The loose cellular tissue in which it is imbedded is next separated, and the needle is passed from within outward, to avoid the common iliac vein (Fig. 438), which on the left side lies on the inner side of the artery, and on the right side lies behind the artery. The ureter generally remains attached to the peritoneum; if not, it is seen crossing the bifurcation of the common iliac with the genitocrural nerve; care should be taken to avoid injury of these structures

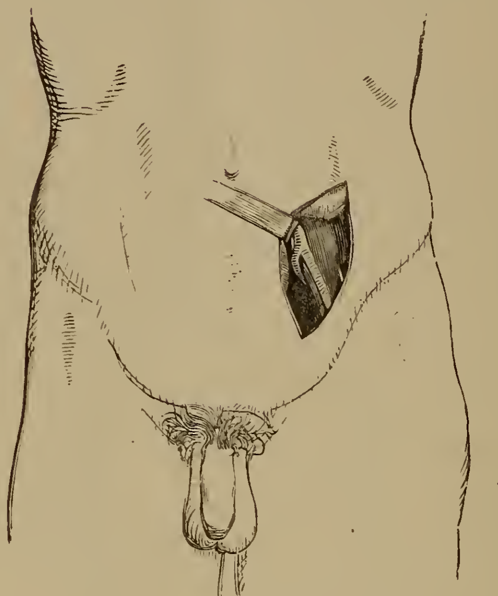
Transperitoneal Method.—The common iliac artery may also be exposed and tied by an incision made over the artery through the abdominal wall opening the peritoneal cavity; the vessel being tied, the ends of the ligature are cut short, and the external wound is closed in the same manner as that resulting from exposure of the abdominal aorta by incision through the peritoneum.

Ligation of the Internal Iliac Artery.—The *incision* is in the same line as for the common iliac artery, but it need not be quite so long (Fig. 437, *A*). The peritoneum being exposed, it is pushed upward and inward, and the internal iliac artery is exposed. The vessel is carefully isolated from the vein, which lies behind and on the inner side, and the needle is passed from within outward.

The *transperitoneal* method may also be employed in exposing and ligating this vessel.

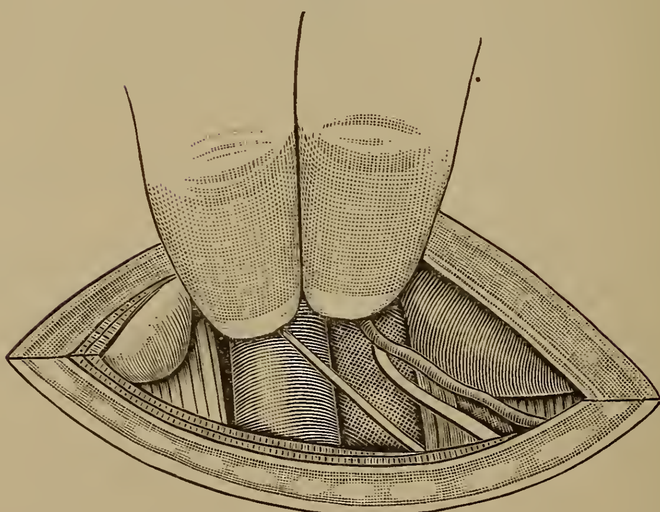
Ligation of the External Iliac Artery.—The *incision* is 3 or 4 inches in length, ½ inch above the middle of Poupart's ligament, made at first parallel to it and then curved upward (Fig. 437, *B*). The tissues of the abdominal wall being divided and the peritoneum exposed, it is pushed upward and inward in the same manner as for exposure of the common iliac artery. The artery lies at the inner border of the psoas muscle, the vein on its inner side and the anterior crural nerve covered by the iliac fascia on the outer side; the genitocrural nerve passes obliquely across the artery (Fig. 439). The needle should be passed from within outward.

Fig. 438.



Ligation of the common iliac artery.

Fig. 439.

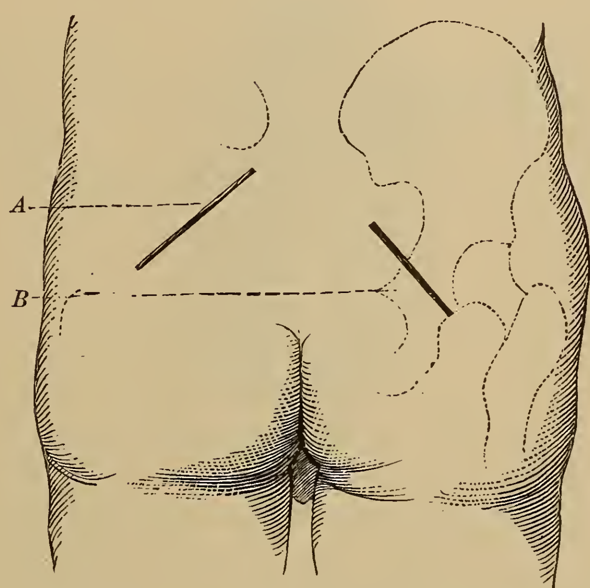


Relations of the right external iliac artery.

The *transperitoneal* method may also be employed in ligating this vessel.

Ligation of the Gluteal Artery.—The *incision* is 3 or 4 inches in length, from the posterior-superior spinous process of the ilium to a point midway between the tuber ischii and the great trochanter (Fig. 440, *A*). After division of the skin and fascia the fibers of the gluteus maximus muscle are separated and held apart, the deep fascia is divided and the artery should then be sought for above the pyriformis muscle at the upper border of the great sacrosciatic notch. It is accompanied by large veins, injury to which should be avoided in exposing the artery and passing the needle.

FIG. 440.



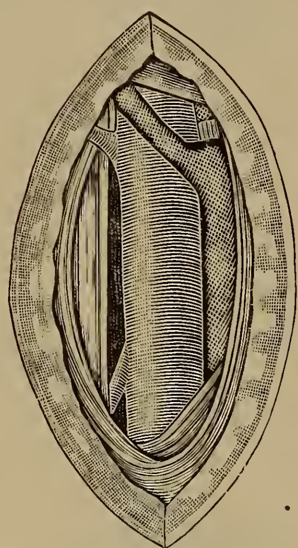
Lines for—*A*, gluteal artery; *B*, sciatic and internal pudic arteries.

Ligation of the Sciatic and Internal Pudic Arteries.—The *incision* is 3 or 4 inches in length, a little lower than that employed for exposure of the gluteal artery (Fig. 440, *B*). Divide the skin, superficial fascia and fibers of the gluteus maximus muscle and deep fascia, and search for the vessels as they leave the great sciatic notch at the lower edge of the pyriformis muscle. The internal pudic artery enters the pelvis through the lesser sciatic notch, lying on the inner side of the sciatic artery during its passage over the spine of the ischium. The vessels are isolated and the needle is passed so as to avoid injury of the veins.

Ligation of the Femoral Artery.—The femoral artery may be ligated just below Poupart's ligament, at the apex of Scarpa's triangle, at the middle of the thigh or in Hunter's canal.

Femoral Artery below Poupart's Ligament.—The *incision* begins midway between the anterior-superior spinous process of the ilium and the symphysis pubis, $\frac{1}{4}$ inch above Poupart's

Fig. 441.

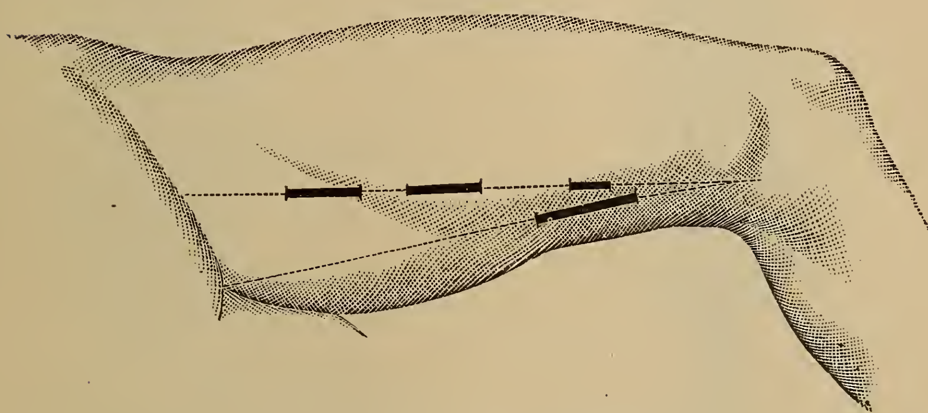


Relations of the right femoral artery below Poupart's ligament.

ligament, and extends 2 inches downward. Divide the skin and superficial fascia and the deep fascia so as to expose the sheath of the vessels; open this $\frac{1}{2}$ inch below Poupart's ligament and isolate the femoral artery from the femoral vein which lies to the inner side; the anterior crural nerve lies to the outer side. Pass the needle from within outward (Fig. 441).

Femoral Artery at the Apex of Scarpa's Triangle.—The *incision* is 3 inches long, the center of which should be a little above the point where the sartorius muscle crosses a line drawn from the middle of Poupart's ligament to the inner condyle of the femur (Fig. 442). Divide the skin, superficial and deep fascia, avoiding the internal saphenous vein, and expose the edge of the sartorius muscle, which may be recognized by the direction of its fibers. This muscle is drawn outward and the sheath of the vessels is exposed and opened; the vein lies on the inner side and somewhat behind the artery, and the long saphenous nerve is on the outer side (Fig. 443). Pass the needle from within outward.

Fig. 442.

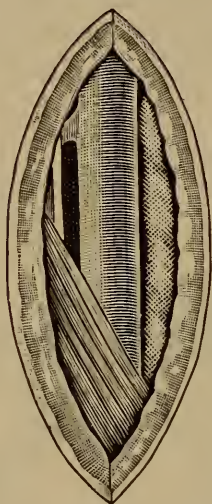


Lines of incision for the femoral artery.

Femoral Artery in the Middle of the Thigh.—The *incision* is in the line above mentioned, its center being a little above the middle of the thigh. Divide the skin, superficial and deep fascia, and expose the sartorius muscle, which is drawn outward after the leg has been flexed; the sheath of thei vessels is exposed and opened; the long saphenous nerve lees upon the artery and the femoral vein lies behind the art ry; the saphenous vein lies more superficially and internal to the vessel. Pass the needle from within outward (Fig. 444).

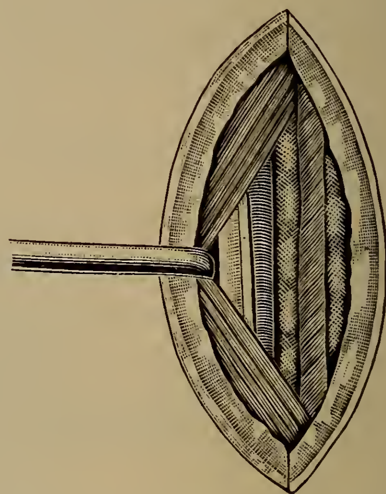
Femoral Artery in Hunter's Canal.—The *incision* is 3 inches in length along the tendon of the adductor magnus, the center of which is at the junction of the lower and middle thirds of the thigh (Fig. 442). Divide the skin, superficial and deep fascia, care being taken not to injure the internal saphenous vein, which should be displaced, and expose the sartorius muscle, which should be displaced downward, and expose the aponeurosis which forms the anterior wall of the vascular canal; this should be opened upon a director, and the artery uncovered and separated from the vein which lies upon the outer side. The needle is passed from within outward.

Fig. 443.



Relations of the right femoral artery at the apex of Scarpa's triangle.

Fig. 444.



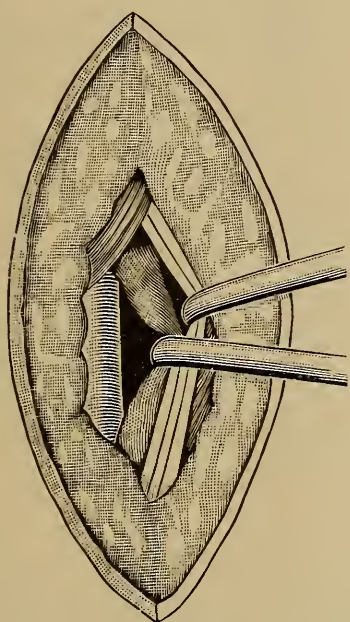
Relations of the right femoral artery in the middle of the thigh.

Ligation of the Popliteal Artery.—The *incision* is 3 or 4 inches in length, along the external border of the semimembranosus muscle. Divide the skin and superficial fascia, taking care not to injure the saphenous veins, and open the deep fascia. The edges of the wound being held apart, the adipose tissue is broken up with a director, and the internal popliteal nerve will first be exposed, and the vein next—both external to the artery (Fig. 445). The artery is isolated and the needle passed from without inward.

Ligation of the Anterior Tibial Artery.—The anterior tibial artery may be tied in the upper, middle and lower thirds of the leg; the general direction of the artery corresponds with a line drawn from the middle of the space between the head of the fibula and the tubercle of the tibia to the middle of the anterior intermalleolar space.

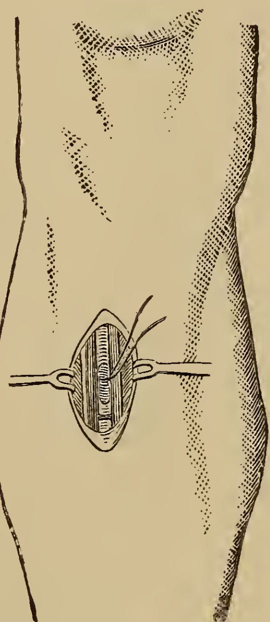
Anterior Tibial Artery in the Upper Third of the Leg.—The *incision* is $2\frac{1}{2}$ to 3 inches in length $1\frac{1}{4}$ inches external to the spine of the tibia. Divide the skin and superficial fascia, and when the deep fascia is exposed open it on a line corresponding to the intermuscular space between the tibialis anticus and the extensor longus digitorum muscles. Separate the muscles and work down in this interspace until the artery is found with a vein on either side of it, and the anterior tibial nerve externally (Fig. 446). The needle should be passed from without inward after isolating the veins.

Fig. 445.



Relations of the right popliteal artery.

Fig. 446.



Ligation of the anterior tibial artery at its upper third.

Anterior Tibial Artery at its Middle Third.—The *incision* is 3 inches in length in the same line as that for the upper portion of the vessel. After dividing the skin, superficial and deep fascia, the interspace between the tibialis anticus and the extensor longus digitorum muscles is opened, when a third muscle comes into view, the extensor proprius pollicis. The artery lies between the extensor proprius pollicis and the tibialis anticus muscles; and the anterior tibial nerve is to the outer side. The veins should be isolated and the needle passed from without inward.

Anterior Tibial Artery in its Lower Third.—The *incision* is 2 inches in length, beginning 3 inches above the ankle-joint on the line of the artery. Divide the skin, superficial and deep fascia, and seek for the tendon of the extensor proprius pollicis muscle, the second tendon from the tibia. The artery is found in the interspace between this tendon and the tendon of the extensor longus digitorum muscle, the nerve being to the outer side. The veins are isolated from the artery and the needle is passed from without inward.

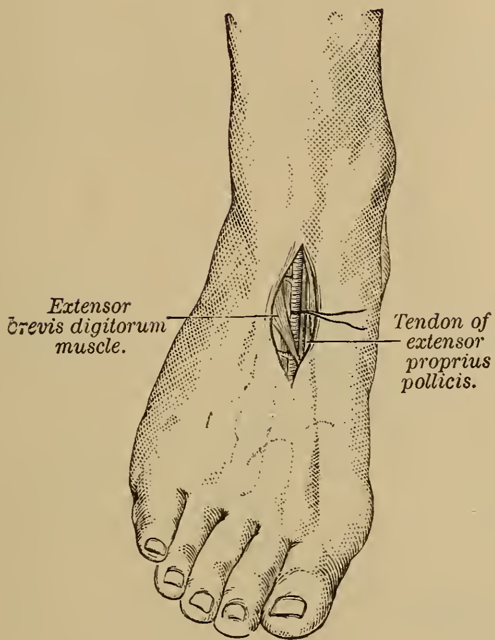
Ligation of the Dorsalis Pedis Artery.—The *incision* is 1 inch in length on a line drawn from the middle of the anterior intermalleolar space to a point midway between the extremities of the first two metatarsal bones or along the outer border of the tendon of the extensor proprius pollicis. Divide the skin, superficial and deep fascia, and the artery will be found lying next to the inner tendon of the short extensor muscle of the toes (Fig. 447). The nerve is to the outer side. After separating the veins the needle is passed from without inward.

Ligation of the Posterior Tibial Artery.—The course of the posterior tibial artery is indicated by a line drawn from the middle of the popliteal space to a point midway between the tendo Achillis and the internal malleolus of the tibia.

The posterior tibial artery may be ligated in its upper, middle and lower thirds.

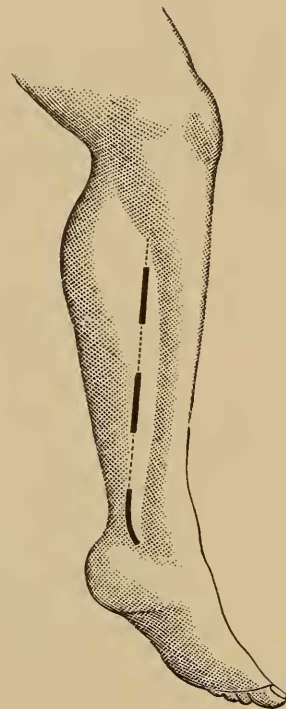
Posterior Tibial Artery at its Upper Third.—The *incision* is 3½ inches in length, ½ inch from the inner edge of the tibia, beginning 2 inches from the upper edge of the bone (Fig. 448). Divide the skin and superficial fascia, avoiding large superficial veins; next open the deep fascia and detach the origin of the soleus muscle from the tibia, and on raising it the under surface will present a white, shining sheath of tendinous material, beneath which will be seen a layer of fascia covering the tibialis posticus muscle. If search is made toward the middle of the leg the artery will be found covered by the intermuscular fascia, the nerve being to the outer side. The needle is passed from without inward after the veins have been separated from the artery (Fig. 449).

Fig. 447.



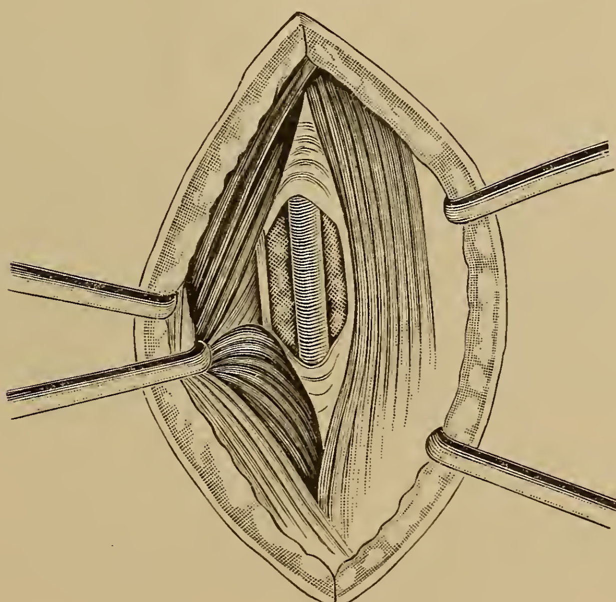
Ligation of the dorsalis pedis artery.

Fig. 448.



Lines of incision for the posterior tibial artery.

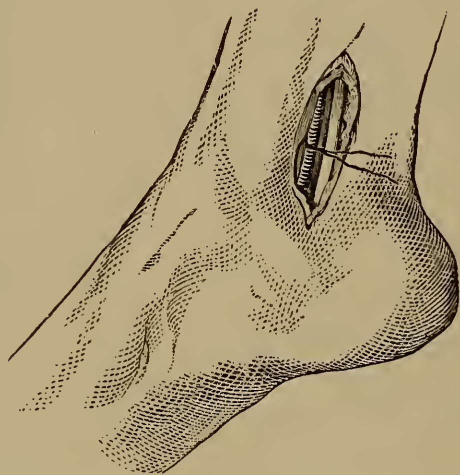
Fig. 449.



Relations of the right posterior tibial artery in its upper third.

Posterior Tibial Artery at its Middle Third.—The *incision* is $2\frac{1}{2}$ inches in length, parallel with the inner edge of the tibia and $\frac{1}{2}$ inch from its border. Divide the skin, superficial and deep fascia, and the inner edge of the soleus will be exposed; press this outward, when the artery with its veins will be exposed also the posterior tibial nerve to the outer side. Pass the needle from without inward after separating the veins.

Fig. 450.



Ligation of the posterior tibial artery behind the inner malleolus.

Posterior Tibial Artery behind the Inner Malleolus.—The *incision* is a curved one 2 inches in length, midway between the tendo-Achillis and the internal malleolus (Fig. 448). Divide the skin and superficial fascia, then lift the deep fascia upon a director and open it freely, when the artery will be exposed, with the tendons of the tibialis posticus and flexor longus digitorum muscles on the inner side and the posterior tibial nerve and the tendon of the flexor longus pollicis muscle on the outer side (Fig. 450). After separating the veins from the artery the needle should be passed from without inward.

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