

Pitha's, "Handbook" vol. ii., Heft ii., 2 Abth., p. 19), in which an entire arm was caught in a cogwheel and stripped of its integument, the muscles of the arm and forearm being laid bare as in a careful dissection. Although amputation at the shoulder was successfully resorted to and the acromion removed, the integument was insufficient for the closure of the wound.

(c) The simultaneous injury of the main artery and vein of an extremity has usually been considered an indication for amputation, since it almost invariably results in its mortification if conservatism is practised. This has applied particularly to wounds of the femoral artery and vein. The advisability of an operation in all such cases must, however, be seriously questioned, since instances are multiplying in which with neoplasms, several inches of the main vessels of the limb have been removed without resulting in its death. When the vein alone is slightly injured, it is far preferable to trust to a properly applied lateral ligature, or if it is completely divided, an attempt to save the limb should be made by ligation of the accompanying artery. Quite recently a case has been recorded by Pilcher in which an incised wound of both femoral artery and vein was successfully treated by double ligation of both vessels. On the other hand, amputation may be required for the relief of traumatic aneurisms or those of spontaneous origin which have become diffused. Particularly may ablation of the thigh be preferable to other plans of treatment of aneurism of the popliteal and of the deep arteries of the leg in persons of advanced years. In cases of subclavian aneurism exarticulation at the shoulder has likewise been successfully performed as a modified distal ligation. Finally, secondary hemorrhage after injuries from whatever cause, when other measures have failed, can be relieved alone by the sacrifice of the limb. Since, after ligation in continuity of an artery, the secondary hemorrhage most frequently comes from the distal end of the vessel, it is apparent why amputation is often successfully practised.

(d) Compound fractures and dislocations are the conditions which most frequently call for amputation in all communities where manufacturing interests are largely developed and where railroads furnish employment to large numbers. Not very long ago, the presence of a compound comminuted fracture was deemed sufficient cause for an amputation, even if unattended by extensive laceration of the soft parts. In no field of surgery have greater triumphs been recorded than in the conservative treatment of these compound fractures. There can be no question but that to-day all surgeons of twenty years' experience save limbs which in their earlier experiences they would have doomed. For these results we are in the main indebted to the principles of antiseptic treatment, which, although first promulgated in 1865 in Glasgow by Mr. Lister, were first extensively practised on the Continent, especially in Germany, by Bardeleben, Volkmann, and Nussbaum.

It is immaterial for our purpose which of the numerous antiseptic agents be preferred, or whether the open method of wound treatment with thorough drainage be employed. Such remarkable results have been achieved in the conservative treatment of compound fractures that ordinary cases may be said to present no indications for amputation. Nearly a year ago a lad of eighteen had his left arm caught in the belt of a wheel in a machine-shop. When brought to the Good Samaritan Hospital, in Cincinnati, an hour after the accident, there was detected a double fracture of the humerus, one of which was compound, a simple dislocation backward of the elbow, a compound fracture in the middle third of the radius with two inches of fragment protruding, and a compound dislocation of the ulna at the wrist. An amputation was strenuously advised, but, fortunately, it was rejected by the parents. The boy, after confinement for nine months, recovered after two inches of the radius and six inches of the ulna had been removed. The hand and forearm are almost useless, but this condition is infinitely preferable to that of being obliged to wear an artificial limb, no matter how perfect it may be.

In his service at the Cincinnati Hospital the writer recently saw a negro with a cog-wheel crush of the ulnar half of the wrist and metacarpal bones, and of the upper third of the humerus, and pulpifying of the overlying deltoid. The removal of the upper third of the humerus, including its head, and of the crushed bones of the carpus and hand, and the establishment of ample facilities for drainage, left the man with good use of forearm and three fingers. Particularly in injuries of the upper extremity is conservatism commendable.

Statistics of the advantages of conservatism in the treatment of these accidents are rapidly accumulating. Thus, Volkmann was enabled to report 75 compound fractures of the larger long bones without a single death, although in 8 cases he was compelled to resort to secondary amputation. Sir Joseph Lister, with rigid adherence to the antiseptic method, lost 2 out of 97 cases. In the treatise of Billroth and Luecke is a most exhaustive compilation of 254 cases which were treated by the Listerian method. Of 224 of these cases which were treated conservatively only 14 died. But it remained for our own countryman, Dr. Fred. S. Dennis, to record the most brilliant and, indeed, unique successes ever obtained in this field. Of 144 cases of compound fracture treated in Bellevue Hospital, New York City, not one died from septic infection, and 100 cases were treated without a death from any cause. Extensive splintering of bone and laceration of soft parts can, therefore, no longer be considered an excuse for the sacrifice of the limb. If amputations still form a considerable percentage of the operations performed in large hospitals, it is because of the more extensive employment of heavy machinery, and the great extent of railway travel. Most of the primary amputations thus practised are indicated by the conditions above detailed (sub a).

(e) Closely allied to compound fractures in their relation to amputations are compound dislocations. Since the more general appreciation of the value of primary excision of joints, amputations for these injuries are now less frequently resorted to than formerly. Indeed, all formal operations for compound dislocations should be greatly restricted. Cooper and Nélaton already leaned toward conservatism. The latter advised reduction of the dislocation, closure of the external wound, and antiphlogistic measures. What has been accomplished in this way in recent years, and particularly by immobilization, could be demonstrated by a stately array of cases of compound dislocations of large joints in which the limb was saved, and often with perfect motion. Compound dislocations of shoulder, wrist, hand, and elbow, unless the damage of the soft parts is such as *per se* to call for amputation, should always be treated without operation, or by excisions. A compound dislocation of the elbow, with laceration of the brachial artery, was successfully treated without operation by McCarthy, and Davis reports another such dislocation of the knee, in which all the functions of the joint were retained.

On the other hand, amputations for compound dislocations of the foot and ankle are more frequently indicated, since excision and conservative measures often leave the parts useless, if not positively a burden, and the dangers of primary amputations are at least no greater than those which attend milder methods of treatment of these cases.

(f) *Gunshot Wounds.*—These are of sufficient frequency in civil practice often to call for amputation. Here, on account of suitable accommodations and facilities for proper treatment, conservative means may be adopted, whereas in the field a part must be sacrificed for the benefit of the whole. Revolver wounds of the large vascular and nerve trunks, with shattering of the bones, may necessitate amputation. Shotgun wounds, from the greater laceration inflicted, particularly in the neighborhood of the larger joints, may require the sacrifice of a limb. Nevertheless, with our better methods of wound treatment, the surgeon should even here lean toward conservatism. The writer has recently saved a lower and

an upper extremity by a typical resection of the knee and shoulder in cases of gunshot wounds sustained at close range.

Before the introduction of small-calibre projectiles Connor enunciated the conditions calling for amputation as follows: 1. When there has been great destruction of soft and hard parts, as in a crush by large shot, or when the limb has been almost completely or altogether carried away. 2. When the fracture is associated with laceration of the main vessels or nerves of the part. 3. When acute, infective osteomyelitis has been developed. In the chronic form of this disease, when the entire length of the bone has become affected, it may or may not be necessary to amputate, according to the general condition of the patient and the particular bone that is diseased. 4. When there is severe secondary hemorrhage from an eroded vessel, or from a ruptured traumatic aneurism. 5. When gangrene has supervened.

The small calibre of the modern rifle ball has so modified wounds sustained in action that amputations are but rarely demanded. Furthermore, the thorough curetting of the medullary canal in acute osteomyelitis when it has developed, tends still further to limit the scope for amputation. Secondary hemorrhage from an eroded vessel or the rupture of a traumatic aneurism should, in the light of our better methods of the treatment of wounds of vessels, not be considered an indication for amputation until search for the wound and ligation have been tried without success.

(g) *Mortification.*—The presence of mortification, as a sequel of trauma or of the application of the extremes of heat and cold, offers an unmistakable indication for the ablation of a part as soon as the evidences of the limitation of the gangrene are made manifest. Nor is it always advisable to wait for this in the case of traumatic gangrene, which often extends with such rapidity that a few hours will rob the sufferer of his only chance. The mortification which follows the ligation of an artery, or upon an embolism, is a condition calling for operative interference. In senile and diabetic gangrene amputation is often demanded. Amputation should be performed far from the gangrenous area. In the first-named form of gangrene, as of the foot or part of it, the amputation must be made at or, better, above the knee. In both forms of gangrene amputation, to be successful, must be performed before secondary and general infection has taken place from about the gangrenous field.

(h) *Tetanus.*—Amputation may be said to be one of the most successful measures for the relief of traumatic tetanus (when thorough curetting of the wound has failed to relieve). According to the latest experiences an equal proportion of good results follows this method and nerve section. The latter should be given the preference in every case; and then, in the event of failure, amputation should be resorted to as a *dernier ressort*.

**NON-TRAUMATIC AFFECTIONS.**—(a) *Inflammation.*—Severe and extensive inflammations of the skin, subcutaneous cellular layer, and intermuscular layer, as they are frequently encountered in phlegmonous erysipelas from injuries which in themselves are most trivial, and which from septic infection or protracted suppuration would lead to death, are conditions that may necessitate an amputation. While with free incisions, the permanent water dressing, and irrigation, many limbs thus affected may be saved, amputation must always be resorted to in a certain small proportion of especially aggravated cases. The presence of septicemia and pyæmia should not be deemed a contraindication, unless the want of vitality of the patient will preclude the possibility of surviving the shock resulting therefrom. Billroth, Volkmann, Fayrer, Weinlächner, Luecke, and numerous other surgeons cite cases in which amputation was successfully practised after a varying number of rigors had placed the presence of the gravest constitutional infection beyond doubt. By removing the primary seat of the septic changes, the general manifestations of pyæmia may frequently be caused to disappear.

(b) *Inflammatory conditions of the bones and joints*

which cannot be relieved by less radical measures often make an amputation imperative. Acute spontaneous osteomyelitis, when unrelieved by trephining, and when affecting only a single bone, must be considered a condition requiring this radical interference. Necrosis which involves the entire thickness of the shaft of the bone, as for example a part of the humerus, or the femur, and especially when repeated necrotomies have proved to be unavailing, occasionally requires the sacrifice of a limb. In extensive caries of the articular ends of the long bones, or of the carpus and tarsus, when from the depraved condition of the patient excision is unfeasible, amputation is compulsory. The improved methods of dealing with suppurative and destructive affections of joints by immobilization, and, if need be, by resection, have happily reduced the number of cases calling for amputation from these causes to a minimum.

(c) *Extensive circumferential ulcerations of the leg,* which sap the strength of the patient through hemorrhage or profuse suppuration, or which unfit him for the vocations of life, not unfrequently render amputation advisable. This also applies to cases of true and spurious elephantiasis, in which milder measures have proven of no avail.

(d) *Tumors of benign and malignant character,* when from their size they destroy the usefulness of a limb or endanger life, are well-recognized indications for amputation. The neoplasms most frequently demanding the latter are carcinomatous degenerations of chronic ulcers or epitheliomata developing around a sequestrum, or an osteosarcoma of the articular ends of the long bones. Under all these conditions amputation offers a better chance for permanent recovery than does excision.

The rule which applies to the management of neoplasms generally, that an operation must be refrained from unless all of the diseased tissue can be removed, is particularly to be remembered before an amputation is determined upon for the relief of a tumor of an extremity. The bearing of amputation upon certain traumatic affections of the blood-vessels and upon special spontaneous aneurisms has already been referred to. Congenital telangiectases likewise exact amputation when rapidity of growth endangers life or when other plans of treatment have been unsuccessful.

**DEFORMITIES.**—(a) *Supernumerary fingers and toes* are proper cases for removal, and the operation may be safely practised six months after birth. This early removal assures a better form of hand or foot and a diminutive scar. Cases of club-foot which have been altogether neglected or badly managed, and which, from extensive ulceration or inflamed burse, entail great suffering upon the patient, not infrequently can be relieved by amputation only. But in early life no case of talipes is of sufficient severity to warrant the removal of the foot.

(b) *Cicatricial contractions of the joints,* associated with great wasting of the muscles, from extensive burns; great deformity and uselessness of a limb from neglected dislocation (foot or ankle), may call for an amputation. For these and similar cases, amputations of expediency may occasionally be required, but the surgeon should carefully weigh all factors in the case before subjecting his patient to the risks of an operation for the relief of a condition which in itself is only a burden and not a source of danger. To this category belong limbs useless below the knee from infantile paralysis. Such legs are often burdensome from one cause or another (sensation of cold, proneness to superficial ulceration, etc.) and, since they are useless, it is probably better to amputate them and substitute an artificial limb.

**TIME FOR AMPUTATION.**—When, in consequence of an injury, an amputation is indicated, the proper time for performing it must be considered. While the patient is still suffering from shock, collapse, or even exhaustion from excessive hemorrhage, it would be sealing his fate to resort to an operation. At least moderate reaction must invariably be awaited, irrespective of its early or late appearance. When reaction has once been established, with the aid of restoratives (among which



the intravenous injection of normal salt solution ranks first), the most appropriate period for an amputation will have arrived, since, for a period varying from twelve to seventy-two hours, the injured part remains in apparently the same condition that it was in immediately after the accident. After this interval, there may be expected to supervene those local and systemic manifestations in the injured part which belong to severe inflammatory changes. All amputations practised prior to the advent of these changes are designated *primary amputations*. Since the time when these changes supervene varies from one to three or four days, according to a multitude of circumstances, foremost of which is the character of the wound and the extent to which it can be maintained aseptic, no absolute limit can be fixed to the time when an amputation should no longer be classed among the primary amputations. With very few exceptions, surgeons of the present day recognize the necessity of immediate amputation in every instance in which conservatism cannot be practised. The diversity of opinion which has prevailed on this subject has been great. Among the advocates of primary amputation may be enumerated Du Chesne, Wiseman, Pott, Percy, J. Bell, Larrey, and Guthrie; among its opponents, Faure, Hunter, and, within the last quarter of a century, J. Neudörffer, Paul, and Gross. The extensive experiences of Guthrie and Larrey have finally convinced surgeons of the advantages of early, as compared with late, amputations. Of 291 primary amputations, 107 recovered, 24 died, and 160 remained under observation. Of 551 secondary operations, 170 recovered, 265 died, while 116 remained under treatment (Guthrie). The accumulated experiences of the Crimean and Franco-Prussian wars, and the vast statistics of our Civil War, indorse the prevailing practice of resorting to early amputations. In the statistics of Otis, there were in 3,259 primary amputations of the arm, 602 deaths, 18.4 per cent. mortality; in 902 intermediary amputations of the arm, 302 deaths, 33.4 per cent. mortality; in 411 secondary amputations of the arm, 114 deaths, 27.7 per cent. mortality; in 1,914 primary amputations of the lower third of the thigh, 927 deaths, 48.7 per cent. mortality; in 676 intermediary amputations of the lower third of the thigh, 459 deaths, 67.9 per cent. mortality; in 207 secondary amputations of the lower third of the thigh, 100 deaths, 48.3 per cent. mortality. The obvious reasons for the better results which follow early operations are that they are made at a time when the constitution has not yet been exhausted by protracted suppuration and high temperatures, and that they leave wounds which can be kept free from septic infection.

The second date at which an amputation might be forced upon the surgeon is that during which the severest local and general signs of inflammation present themselves. The damaged limb has become red, edematous, and painful. From the wound there issues a sanious, malodorous fluid, and a more or less extensive sloughing of the tissues adjacent to the wound ensues. Associated with these local conditions are an acceleration of the pulse, elevation of the temperature, often to a dangerous degree; headache, dry tongue, scanty urine, and muttering delirium. Unless the patient succumbs to the paralyzing influences of excessive temperatures, his condition becomes gradually ameliorated in from five to fifteen days. As the discharge of scanty serum is followed by a free secretion of pus, the gangrenous parts are exfoliated, and the swelling largely subsides; the fever and acceleration of pulse are reduced; the tongue regains its normal moisture and color, and a comparative degree of comfort is enjoyed. Amputations practised during this stormy period of the clinical history of an accident have, after the designations of Boucher and Alcock, been called *intermediary*. Since they are made at a time when the damaged part and the system at large are in the very worst condition for operations, it is not remarkable that such amputations offer the worst prospects for recovery. Although the mortality following such amputations must, therefore, be very much greater than that following

primary or late amputations, cases will arise in which the very gravity of the local and general phenomena, such as recurrent hemorrhage, impending gangrene, or septicæmia, will necessitate the speedy removal of the limb, as the last hope of deliverance.

With the subsidence of the grave constitutional symptoms and the advent of profuse suppuration begins that period when, if amputations are performed, they are termed *secondary*. It has already been seen that the prospects for recovery after amputations in this period are less promising than after those of an earlier period. An equally strong objection to waiting for this period is that more of a limb must generally be sacrificed than by an early operation. Thus Guthrie observes that "When an amputation is delayed from any cause to the secondary period, a joint is most frequently lost: for instance, if a leg be shattered four inches below the knee, it can frequently be taken off on the field of battle and the joint saved. Three or four weeks after, the joint will in all probability be so much concerned in the disease that the operation must be performed in the thigh; the same in regard to the forearm and hand, and the upper part of the arm with the shoulder." Notwithstanding the drawbacks attending secondary amputations, certain circumstances frequently make them imperative. Continued fever, impending exhaustion from excessive and protracted suppuration, and evident uselessness of the limb, even if saved, may force the knife into the hand of the surgeon, after much valuable time has been lost through an error of judgment on his part, or a procrastination on the part of friends.

**PREPARATIONS.**—Before beginning an amputation it is essential to make such preparations for it as are required for every major operation. If possible, the amputation should be made in the early part of the day, in order that if there be much hemorrhage subsequent to the operation

its source may be looked for without artificial illumination. It can be most satisfactorily performed on any operating table, or, in the absence of this, on two kitchen tables placed end to end. The instruments necessary for major amputations are: 1. An Esmarch elastic bandage and strap for the production of anemia of the part to be removed. 2. A suitable tourniquet. 3. Amputating knives of various lengths and widths, with at least one double-edged blade (Fig. 118) (cutting). 4. One large and one metacarpal amputating saw. 5. From six to twelve hæmostatic forceps. 6. A bone-cutting forceps, and a lion-jawed forceps. 7. Ligature and sewing materials, drainage tubes, needles, and an abundance of hot water.

The preparations which are to be made for the after-treatment, although they are necessarily a preliminary to the operation itself, will vary according to the plan to be adopted, and will be considered at some length hereafter.

While a finger or toe can be removed by a surgeon with only such aid as a layman can give, at least three assistants are required for every larger amputation. The duties of these should be first clearly defined by the operator, lest valuable time be lost during the

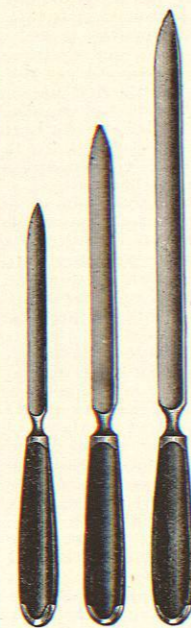


FIG. 118.

operation. The undivided attention of one must be given to inducing and maintaining anaesthesia. The second is to support the part to be removed, after which he can be entrusted with the ligation of the vessels. The duty of the third should be confined to

controlling the circulation of the limb above the seat of operation, and eventually to retract the flaps. Where there is a fourth assistant, it should be his duty to hand the instruments to the operator as he may require them. This assistant is dispensable, since, when the instruments are placed on a table near the operator, the latter can help himself quite as expeditiously as when assisted to them. These details arranged, the patient is anesthetized and brought into such a position that the limb to be removed is everywhere accessible. The part to be removed must now be carefully wrapped in towels, the entire limb thoroughly cleansed with soap and brush, and the hair removed from the part where the incision is to be made. The surgeon is then ready to take the final and most important preliminary measure for the amputation, that by which he intends to control the circulation of the limb and reduce the loss of blood to a minimum.

There are various methods by which the circulation may be more or less controlled during an amputation, and they are of sufficient importance to justify a detailed consideration. To prevent hemorrhage the surgeon can choose between tourniquets, digital compression, and

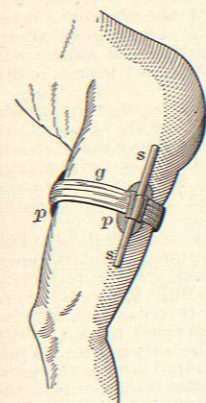


FIG. 119.—Moret's Tourniquet.

the Esmarch elastic bandage, or combine the latter with one of the other two. From the time of Morel the ingenuity of surgeons has been taxed to devise an instrument which will safely compress the main artery of a limb above the point where an amputation is to be practised. Of the many instruments introduced, only a few have been able to gain general recognition. The oldest of these is the Spanish windlass or garrôt of Morel, which consists of nothing more than a wide band (*g*) of an unyielding material (muslin or linen), firmly drawn around the limb and tied. Over the main artery and at a point diametrically opposite, there are inserted underneath it compresses of linen, a piece either of thick leather or of paste board (*p*). At a point opposite the artery a firm rod (*s, s*) is introduced underneath the encircling band and is then turned in such a manner as to shorten the latter, and thus the compression of the main artery is effected (Fig. 119). Owing to the simplicity of its construction, the garrôt of Morel stands without a peer in cases of emergency in civil as well as military practice. It has, however, one very objectionable feature, which renders its use a matter of necessity rather than of choice. Notwithstanding the use of the pads of linen or leather already referred to, veins, arteries, and soft parts are compressed to an almost uniform degree; hence extensive venous hemorrhage and insufficient retraction of the muscles follow. A great improvement on the windlass is the tourniquet of Petit, which was in general use until the Esmarch strap was introduced. It consists of two metal plates, the distance between which can be regulated by a screw, and which are connected by a strong linen band supplied with a buckle, by which the limb is encircled (Fig. 120). To apply it properly, the limb should be surrounded by a few turns of a roller, while the body of the bandage (*p*) is placed over the artery (*a*). Over this bandage the lower metallic plate is then placed, and the band and buckle are fastened, when, by turning the screw, compression of the main vessel can be regulated at pleasure. The objection has been raised to the tourniquet of Petit that it compresses not only the artery, but also its accompanying vein, and thus induces venous stasis, and enhances the dangers of thrombosis. While this is doubtless true, it is an insurmountable

defect common to all tourniquets, and based more on theoretical than on clinical data. When properly applied the tourniquet of Petit is not apt to slip or yield, and its safety is such that in case of emergency the management of the screw might be entrusted even to a layman. In order to limit the compression to the main vessel alone, complete or incomplete metallic rings have been devised which, while they surround the limb more or less completely, make compression at only two points, *i. e.*, over the artery and at a point diametrically opposite. The best known tourniquets constructed on this principle are the horseshoe tourniquet of Signorini and Dupuytren, the arterial compressor of the late Professor Gross, and the abdominal tourniquet of Pancoast and Lister (Fig. 121). While with these the compression can be limited to the

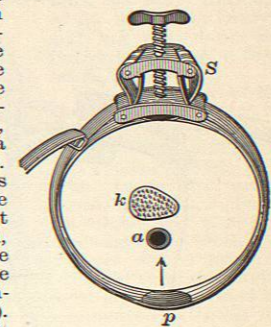


FIG. 120.—Petit's Tourniquet.

main vessels of the limb, and the circumferential constriction of the latter is thus avoided, they are more liable to slip than the tourniquet of Petit, and are far less reliable than digital compression. For certain amputations, however (of the hip and shoulder), the instrument of Petit is inapplicable; it is then that one or other of the horseshoe tourniquets or digital compression will be found indispensable.

**Digital compression**, when made by trustworthy hands, is admirably suited to control temporarily the circulation. If compression of the artery alone is anatomically possible, it can be best accomplished by the finger. To be practicable, the vessel must be contiguous to a bone against which it can be pressed, as the femoral upon the os innominatum, the brachial upon the humerus, the subclavian against the first rib, or the abdominal aorta against the vertebrae. Since only a few minutes are required for the amputation of a limb, and the ligation of the larger arteries, the endurance of the assistant entrusted with the duty is not severely taxed. In digital compression, associated with the use of the elastic bandage, we have a combination with which the circulation of a limb can be completely controlled, and by which certain parts, the compression of which would be useless or even harmful, are protected. Notwithstanding the advantages of this method, the surgeon should never resort to it unless he can absolutely rely upon the ability and skill of his assistant. (For amputations at the hip or shoulder direct compression of the common iliac through a laparotomy wound, or of the subclavian through an incision above the clavicle is justifiable. With unreliable assistance temporary ligation of these vessels would be an absolute safeguard against excessive bleeding.)

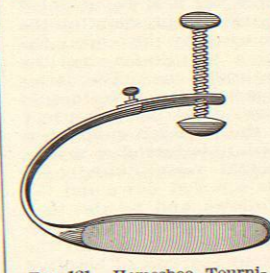


FIG. 121.—Horseshoe Tourniquet.

**Elastic Compression.**—Notwithstanding the precautions against hemorrhage after amputations, these were invariably associated with very great loss of blood until twenty years ago. The blood thus lost was venous in character, and came from the veins of the amputated member. Through the practices of Grandesso Silvestri, an Italian surgeon, and particularly of Esmarch, of Kiel, the blood contained in the part to be removed is saved, and that this is not an inconsiderable quantity has been demonstrated by experiment. The apparatus of Esmarch consists of an elastic bandage and an elastic tube or flat



band with chain or clasp attachments. Commencing at the fingers or toes, the bandage is applied by spiral turns until the limb is covered to a line at least four inches above the point where the bone is to be divided. Above the last turn of the bandage, the elastic band or tube is rather firmly and repeatedly wound around the limb,

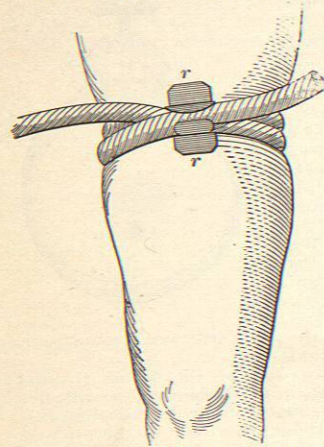


FIG. 122.—Esmarch's Apparatus. (Bandage not shown in cut.)

and secured by clasp or hook and chain (Fig. 122). When the bandage is then removed, a condition of ischæmia is observed in the limb, which will permit its amputation without a more than appreciable loss of blood during the operation proper. In recent years the elastic bandage has been abandoned because of the danger of disseminating the infective or malignant process for which the amputation is to be done. By elevating the limb for five minutes before applying the strap, complete ischæmia can always be induced. When the elastic strap is removed, the integument of the stump rapidly assumes a bright-red color, and in the wound there appears free, persistent, and often embarrassing, capillary oozing. It is generally accepted now that the source of this hemorrhage is from the dilated capillaries, the walls of which have been paralyzed in consequence of the pressure exerted by the strap on the vasomotor nerves. When in from twenty to thirty minutes the vessel walls regain their tonicity, the hemorrhage ceases. To check this capillary oozing, a number of remedies have been suggested. That of Riedinger, to apply the faradic current, while very serviceable, is not always practicable. Esmarch relies upon closure of the wound and elevation of the stump before the strap is entirely removed. Hot water (150° to 180° F.), applied with sponges, often acts admirably in these cases. Since compression of the vasomotor nerves, caused by the bandage, is the cause of this parenchymatous hemorrhage, this can best be obviated by completely substituting digital compression for the elastic strap, or, if the latter be used, by preventing the ingress of blood by the use of a tourniquet until the vessels have regained their natural tone. The latter plan, as practised by Ashhurst, is "to place a tourniquet in position, but not screwed down over the main artery of the limb, and then to apply the Esmarch tube a few inches above the point at which it is intended to amputate. As soon as the principal vessels have been secured, the tourniquet plate is screwed down and the tube removed. No bleeding follows, and by the time that the remaining arteries requiring ligatures have been tied, the vessels will have regained their tone, and the tourniquet can be removed without any risk of bleeding following." In amputations near the trunk, the elastic strap or tube should not be used in the ordinary manner (see Special Amputations). In an amputation of the shoulder, and in another of the hip, I have seen it loosen or slip over the stump immediately after the disarticulation was effected, and in both instances the hemorrhage was most alarming. In amputation at the shoulder, when, by the use of the bandage, the blood in the extremity has been returned to the economy, it is better to rely upon compression of the main artery against the first rib with the finger or a padded key. In amputations of the hip, the main artery can be compressed against the pubic bone, or even the circulation in the aorta can be

controlled by one of the many compressors already referred to.

**METHODS OF AMPUTATION.**—Every amputation consists of three steps: (1) Division of the soft parts; (2) division of the bone, or disarticulation; (3) ligation of the vessels and closure of the wound.

According to the method adopted for the division of the soft parts, amputations are classified as circular or flap operations, and in the choice of the method the surgeon must be guided by the condition of the soft parts about the bone, the ease with which the joint can be opened in a disarticulation, the probable position of the cicatrix and form of the stump, and, above all, the desire to save as much of the limb as possible. Of the circular and flap operations, all methods of amputation may be said to be but modifications. By the circular method it is attempted to give to the stump the form of an inverted cone or funnel, the apex of which is occupied by the divided end of the bone, the base or margin of which is represented by the cutaneous margin of the wound. In the flap operation the soft parts are so divided as to make one or more flaps, the bases of which are on a level with the divided bone, and the free margins of which are so adapted to each other as completely to cover the bone and admit of the ready closure of the wound. Whatever plan of operation is adopted, the surgeon should stand in such a position that he grasps the stump with his left hand, and that the amputated part therefore falls toward his right side.

**Circular Method.**—All modifications of the circular method call for a similar incision through the skin and subcutaneous cellular layer, this incision being made around the entire circumference of the limb and at a right angle to its axis. According to the depth to which the incision is carried, the method is subdivided into that by single incision and that by double incision.

Single incision: This, as already remarked (see History), is the oldest method of amputation, and is generally known as the Celsian operation. After retraction of the soft parts, a long amputating knife is swept around the limb, and all of the soft parts are divided down to the bone. This is then divided on a slightly higher level by the retraction of the soft parts. While this operation yields the smallest wound, and is the most rapid in its execution, its manifest disadvantage is in the insufficient covering which it affords for the bone. It is admissible only in greatly emaciated subjects. Brünninghausen, in the beginning of the century, reintro-

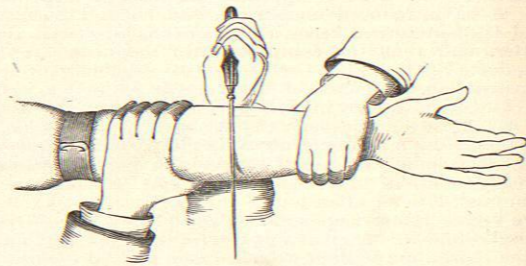


FIG. 123.

duced this method, but, after the amputation of the limb was completed, made a second section of the bone several inches above the point at which it was first divided.

Double incision: This operation, of which those of Petit, Cheselden, B. Bell, Desault, and Alanson are but unimportant modifications, has received its name from the fact that the skin, underlying fascia, and muscles are divided upon different levels, and, therefore, by at least two circular incisions. It is made as follows: The surgeon, firmly holding the limb with the left hand, carries his right hand, in which he firmly holds a large amputating knife, underneath and around the limb until

the heel of the cutting edge is over the uppermost part of the line of the proposed incision. Giving the knife this position forces the operator into a more or less stooping posture, from which he raises himself as the incision is completed. This is commenced with the heel of the knife, which, by a single sweep, is carried around the entire circumference of the limb, severing the skin and adipose layer down to the deep fascia (Fig. 123). Two incisions, the ends of which meet, will answer as well as the division by a single sweep of the knife. As soon as the integument is divided the wound gapes. The upper margin is raised by the thumb and finger of

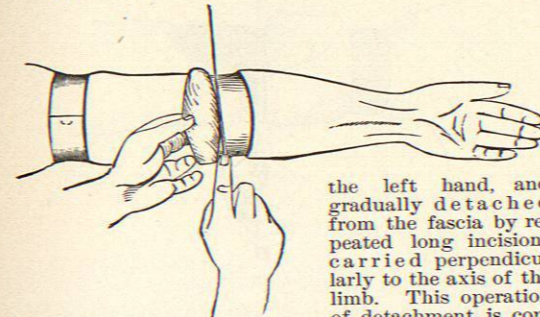


FIG. 124.

the left hand, and gradually detached from the fascia by repeated long incisions carried perpendicularly to the axis of the limb. This operation of detachment is continued until the skin and adipose layer can be reflected like a cuff, the length of which should be equal to half the diameter of the limb (Fig. 124). Where the latter rapidly increases in circumference, or there is a thick subcutaneous layer, or this has been infiltrated, the reflection of a cuff is often impracticable. Then two longitudinal incisions, diametrically opposite each other, will materially facilitate this part of the operation, al-

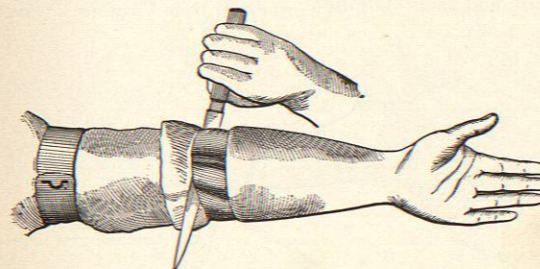


FIG. 125.

though by this means the amputation is in a manner converted into a flap operation. The integument having been reflected to the required extent, the muscles are next divided close to the line of reflection by one steady circular sweep of the knife, which should cut through everything down to the bone (Fig. 125).

Where there is but one bone to be divided, the surgeon is now prepared to use the saw. Where there are two bones, the interosseous tissues remain to be divided. Whereas this can be accomplished with an ordinary amputating knife, it is safer to use a double-edged instrument (catling) for this purpose. By using it in the manner indicated in Fig. 126, there is no danger of cutting the blood-vessels twice, and thus one danger of troublesome hemorrhage is avoided. To protect the soft parts from injury by the saw, they must be well retracted by the hands of an assistant, or by the use of a band of muslin (retractor) divided into two or three slips, according to the absence or presence of an interosseous space (Fig. 127).

When it is deemed advisable to save sufficient peri-

osteum to cover the divided end of the bone, this can now be readily effected with the back of the knife or the handle of the scalpel. The utility of this procedure must certainly be questioned, since in a number of instances it has interfered with the ready drainage of the medullary cavity, and has thus been the indirect cause of a fatal issue.

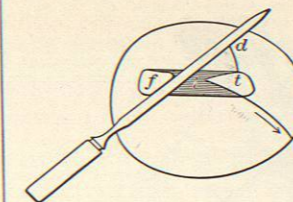


FIG. 126.

The movements of the saw can be greatly facilitated by guiding them with the nail of the left thumb (Fig. 128). The to-and-fro movements of the saw should be slow, lest the heat developed by its too rapid use endanger the vitality of the bone. Where there are two bones of the same diameter (forearm), they should be divided simultaneously. In the leg, the tibia is to be almost entirely divided before the section of the fibula is commenced. Unless this precaution is adopted, splintering of the bone is not easily avoided. For the same reason, the assistant in charge of the part to be amputated should hold it horizontally, allowing it neither to drag by its weight nor to be raised in a manner to interfere with the movements of the saw. Should splintering of the bone nevertheless occur, the splinters and sharp margin of the latter must be removed with the cutting bone forceps.

**Oval Method.**—Holding an intermediate position between the circular and flap operations is the oval method, which, although practised by the older Langenbeck and others, was first generalized by Scoutetten (1827). The essential feature of this amputation in the continuity of the limb is, that the incision, instead of being made perpendicular to its long axis, is carried at an angle of forty-five degrees, and in such a way that the soft parts in front of the bone are divided upon a higher level than those on its posterior aspect. At the same time the upper portion of the wound is converted into an acute angle, whereas its lower portion is given an oval outline. The upper extremity of the wound is placed at the point where the bone is to be divided. The operation is commenced by two incisions, in the form of an inverted V, the lower ends of which are united by a transverse cut on the posterior surface of the limb (Blasius). Here, as in the circular amputa-

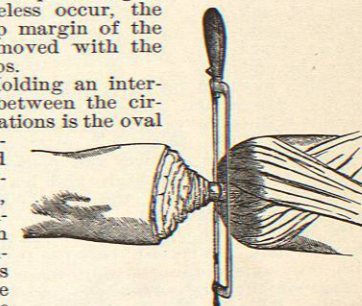


FIG. 127.

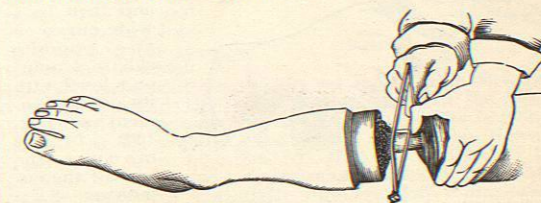


FIG. 128.

tion, by a single incision all the soft parts are divided at once on each side of the bone, and then those on its posterior aspect. This operation has been generally discarded for amputations in the continuity, although for