

of Syme's amputation, 20, or 24 per cent., submitted to reamputation; of 49 Pirogoff's operations, 8, or 16.3 per cent., were subjected to reamputation.

In cases of caries involving all the bones of the tarsus, preference should be given to the Syme operation, since disease is not unlikely to develop in the retained segment of the calcaneum. In traumatic cases, the greater ease with which it is made and the length of limb which follows it should incline the operator to choose the operation of Pirogoff. That necrosis often follows the latter operation is emphatically denied by its originator, who had never witnessed it in over sixty cases in which he had performed it.

**AMPUTATION OF THE LEG.**—An amputation may be performed in any part of the leg, according to the nature and seat of disease or injury. When the surgeon can select the seat of operation, the amputation should be made two or three inches above the malleoli, on account of the greater safety of the operation in this locality and the greater power to be exerted over an artificial limb. In all amputations of the leg, the fibula should be divided from half an inch to an inch above the saw line of the tibia, to prevent pressure against the outer wound margin. The operations which have hitherto been most frequently performed in amputations above the malleoli are the circular and that by lateral flaps. Unhappily, the anatomical construction of the part is such that after these operations the cicatrices are central and not infrequently adherent, and therefore unable to bear pressure. In this situation M. Guyon practises the elliptical method. According to Stimson, this operation promises well. "The incision is made in the form of an ellipse, whose lower end crosses the heel below the insertion of the tendo Achillis, and whose upper end is about an inch above the anterior articular edge of the tibia. Beginning at the lower end and dividing the tendo Achillis at its insertion, and hugging the bone all the way, the operator dissects up the flap posteriorly as high as the upper end of the ellipse. The anterior muscles are then divided by transfixion, the bones sawn through, and the posterior tibial nerve resected. In this operation the sheath of the tendo Achillis is not opened, and the tendon itself serves afterward as a covering for the ends of the bones."

In amputations in the lower third of the leg in fleshy subjects, a long anterior flap containing the interosseous muscles may sometimes be used with advantage (Bell).

The rectangular operation of Teale may likewise be practised in this region, the long anterior flap being

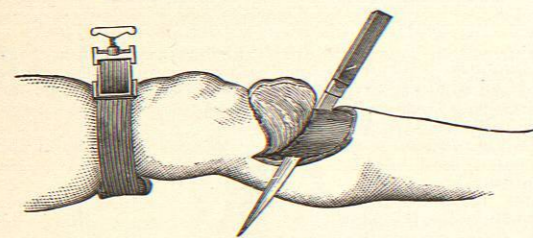


FIG. 178.

made from the soft part of its anterior aspect (Fig. 134, see above, Methods of Amputation). By this method the cicatrix, being placed posteriorly, is out of the way of pressure.

In the middle and upper thirds of the leg very many operators amputate by means of antero-posterior flaps after the following manner (for the left limb): The point of the knife being entered at the posterior edge of the tibia, an incision is carried downward along this for a distance of an inch and a half or two inches; then by a wide curve across the anterior surface of the leg it is continued to the posterior border of the fibula, up which it is carried until the level of its commencement on the

opposite side is reached. The broad flap thus outlined is rapidly dissected up, the interosseous muscles being carefully severed from the underlying membrane. The posterior flap is then made by transfixion and cutting from within outward, and should be about three inches long (Fig. 178, Erichsen). The flaps being held out of the way, the catling is to be used for completing the division of the interosseous soft parts, care being taken that the arteries be divided transversely and only once. After division of the bones with a saw, the sharp anterior edge of the tibia should be removed obliquely with the saw or bone-cutting forceps.

For the upper portions of the leg the long posterior rectangular flap amputation advised by Henry Lee gives an excellent result. The incisions, similar to those of the Teale operation, involve only the skin, the long flap being made from the posterior, the short one from the anterior surface of the limb. With the long posterior flap only the superficial muscles of the calf are reflected, the remaining soft parts being divided by a circular incision. A good covering is likewise obtained in this region by an external flap, made either by transfixion (Sédillot), or by cutting from without inward (Langenbeck). In the former operation the knife is entered a little external to the crest of the tibia, and while the soft parts are drawn to the outer side with the left hand, it is made to graze the surface of the fibula and to perforate the posterior surface of the limb as far to the inner side of the fibula as possible. By cutting downward, close to the bones, a broad rounded flap, three to four inches long, is formed. The extremities of this flap are then united by a slightly convex incision across the antero-internal aspect of the limb. The remaining soft parts being then divided by circular incision, the operation is completed in the ordinary way. In Langenbeck's operation, the internal incision is semicircular, and the external flap being cut from without presents a smoother surface and a more perfect outline. The arteries requiring ligation after amputation of the leg are the tibials, peroneal, and a varying number of muscular branches.

**Subperiosteal Amputation.**—When amputations of the leg are unsatisfactory, it is chiefly because of two things, namely, gangrene of the flaps, and the tendency of the stump to become conical, or, at any rate, to be unable to bear pressure. It is for this reason that Bruns devised his subperiosteal amputation, of which he reported seventeen cases in 1893. According to a recent report,\* this operation was performed in eighty-four cases without a death. In only three cases was there gangrene of the flaps, and in only two cases was a second amputation necessary. The operation is performed as follows: The skin being well retracted by an assistant, a circular incision involving all the soft parts is carried down to the bone. The two perpendicular incisions, from two to three inches in length, are then made, one along the inner border of the tibia, the other between the muscles over the fibula. Both incisions are carried to the bone through the periosteum. Through these incisions all the soft parts, including the periosteum, are raised from the bone. After the soft parts are well retracted the bones are divided in the usual way. After the amputation has been completed, there remain an anterior and a posterior flap of periosteum, muscles, and skin. The muscles are united separately by buried suture. When the amputation is done in the upper portion of the leg, the circular incision through the skin is made at a higher level than that through the muscles.

**Osteoplastic Amputations of the Leg.**—In 1892, Bier,† of Kiel, first described a method of securing a weight-bearing stump, which, in patients who are unable to purchase an artificial limb, secures for them a stump which will bear the body weight. The operation consists of the usual circular amputation. Thereupon follows, through an oval window cut into the soft parts, a cuneiform excision of part of the fibula. When the resection surfaces

\* Hahn: "Beiträge zur klinischen Chirurgie," vol. xxii., part ii.  
† Deutsche Zeitsch. f. Chir., vol. xxxiv., p. 436.

of the tibia are brought into apposition a kind of artificial foot projects anteriorly. The posterior surface of the tibia covered by the soft parts of the calf bear pressure. Bier has operated in many cases with uniformly good results. Some German surgeons think that this should be the normal procedure. A number of minor modifications of the original method have been made. When there is any possibility that the patient can secure an

practice is well shown by the statistics of Otis. Of 5,314 amputations in which the result was determined, 1,753 terminated fatally, the mortality being 32.9 per cent. From statistics obtained during the late War of the Rebellion, it appears that amputation of the leg is attended with least danger when performed in the middle third. The fatality of operations in the upper third was 27 per cent., in the middle third, 20.6 per cent., and in the lower third, 27.6 per cent. The mortality of amputations of the leg has been greatly reduced. Of 81 amputations of the leg 5, or 6.2 per cent., died. In the New York hospitals the mortality

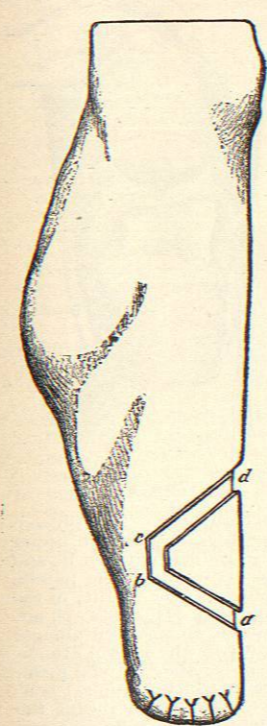


FIG. 179.

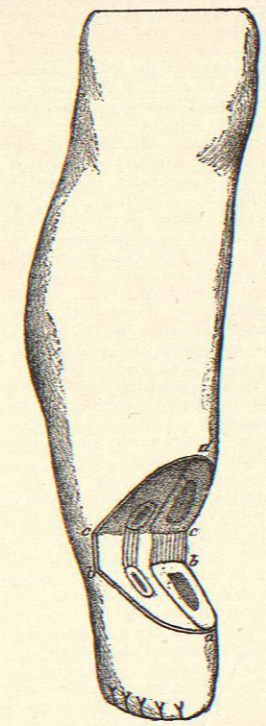


FIG. 180.



FIG. 181.

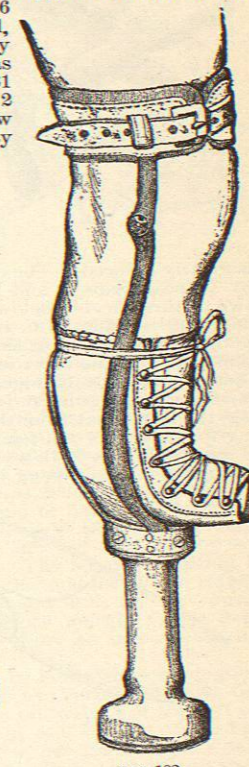


FIG. 182.

FIGS. 179 TO 182.—Osteoplastic Amputation, After the Method of Bier. (Langenbeck's Arch. f. Chir., vol. xlv.)

artificial limb, the operation has nothing to commend it. Figures 179 to 182 will illustrate the method of amputation and the result.

Since good results follow all the different methods of operation in the middle and upper portions of the leg, the surgeon should be guided in his choice solely by the desire to sacrifice as little of the limb as possible. An exception should probably be made in the upper portion of the upper third, where it is better to amputate at the knee than to save only the portion of the tibia above its tubercle.

The mortality following amputation of the leg, as has already been seen, is largely determined by the conditions necessitating it. According to Chadwick, the mortality of pathological amputations is 16 per cent.; that of amputations for trauma nearly 37 per cent. The general mortality of the operation at Guy's Hospital for a period of thirty years was 35 per cent.; that for traumatic amputations being 55 per cent., against 15 per cent. following those for disease. Volkmann, who employs a long anterior and short posterior flap, performed the operation in 54 cases with only 4 deaths (7 per cent.), of which there were 14 traumatic cases with only 2 deaths (14 per cent.). Of 46 amputations in the leg made by Bruns, 7 succumbed (16 per cent.). The fatality following amputations of the leg in military

is 12 per cent. In the Newcastle-on-Tyne Infirmary it is nearly 7 per cent.

**AMPUTATION AT THE KNEE.**—According to Sabatier, this operation was first performed by Fabricius Hildanus in 1581, in a case of gunshot injury. Although advocated by Guillemeau (1612) in preference to higher amputation, there is no record of a repetition of the operation until 1764, when it was successfully performed by Hoin, of Dijon, for traumatic gangrene. Brasdor and J. L. Petit advised the operation, the latter having twice witnessed it. In 1830, Velpeau attempted with success firmly to establish the operation by citing a number of successful cases. The operation was first performed in this country by Nathan Smith, of New Haven, in 1824, since which time it has gradually grown in popularity. Fergusson and Legouest for a long time questioned the advisability of the operation, preferring amputation in the lower portion of the thigh. The reasons which prevailed to give this operation recognition are the greater length of the stump and its ability to bear pressure, the smaller probability of pyemia, the medullary canal remaining unopened, and, most important of all, the smaller mortality which follows this operation, at least in civil practice, as compared with amputations of the thigh.

Amputation at the knee may be practised by either the

circular, the flap, or the oval method. In all methods of amputation it is best, if possible, to preserve the semilunar cartilages. Thereby the fascial attachments are maintained intact, and the tendency to retraction of the flaps

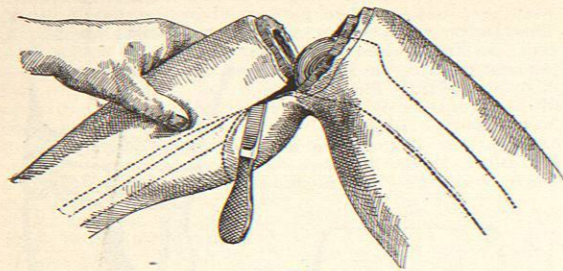


FIG. 183.

is greatly reduced. The circular operation recommended by Velpeau, Sanson, and Malgaigne, made by an incision two or three inches below the patella and the reflection of a cuff, is difficult of execution, and should be resorted to only when an insufficiency of tissue prevents the adoption of one of the other methods. The oval method has been practised by Baudens and Sédillot, the former preferring the integument from the anterior portion of the leg, the latter that from the posterior portion, as a covering for the end of the femur. The operation of Baudens is performed as follows: An oval incision is carried around the leg, crossing its anterior surface five finger-

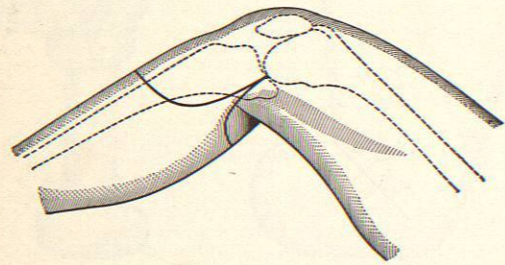


FIG. 184.

breadths below the end of the patella, and its posterior surface three finger-breadths higher than in front. The anterior and lateral portions of the oval are then reflected until the ligamentum patellæ is fairly exposed. This is then divided transversely, the capsule is fairly opened, and the lateral and crucial ligaments divided. In this, as in all amputations of the knee, the latter structures should be divided with the point of the knife, and from behind forward, to prevent injury of the popliteal vessels. When disarticulation has been effected, the soft parts on the posterior aspect of the limb are divided with one sweep of the knife. This operation is, doubtless, preferable to Sédillot's method, according to which the lower part of the oval is placed behind.

In amputating at the knee, a long flap may be taken from the anterior or posterior surface of the leg. The latter method, that of Hoin (Fig. 183), can be most readily executed, but is objectionable on account of the excess of muscular tissue in the flap, and the difficulty of establishing thorough drainage. Lateral flaps have been advised by Rossi and Stephen Smith. The operation which is generally performed, however, is that by one long anterior and one short posterior flap. It is readily performed, and leaves a wound that is easily drained, and a stump in which the cicatrix is protected from pressure.

*Operation.*—The leg being raised, a semilunar flap, three to four inches long, is outlined from the calf, the

incision beginning a little below the middle of the lateral border of the condyles. This flap is dissected up as far as its base. The leg being then flexed, an anterior flap, four to five inches long, is outlined on the anterior surface of the leg from the ends of the posterior incision (Fig. 184, Esmarch). The anterior flap is then raised from its attachments until the ligamentum patellæ is encountered and transversely divided. The capsule is then extensively incised laterally, and the anterior flap, including the patella, reflected (Fig. 185). Disarticulation and division of the soft parts on the posterior aspect of the limb are then effected in the manner already described. This operation is preferable to forming the posterior flap without the guidance of a cutaneous incision. The vessels requiring ligation are the popliteal artery and vein, which should be carefully separated and tied individually. A number of smaller arteries, sural and muscular, will also require ligation in the posterior portion of the wound.

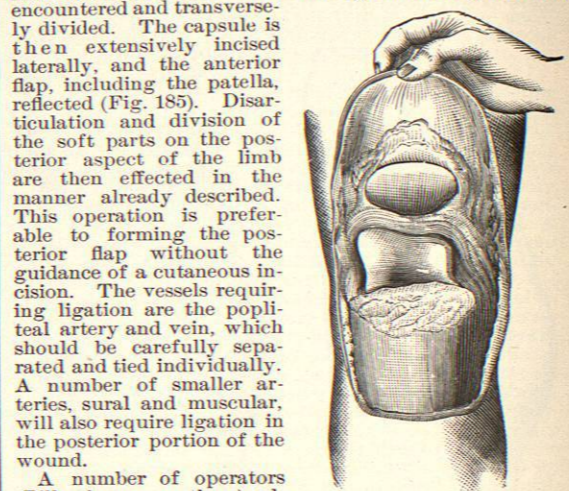


FIG. 185.

A number of operators (Billroth among them) advise the removal of the patella, lest inflammatory products accumulate in the pouch above it. This procedure is generally held to be superfluous, since the upper part of the wound can readily be drained without it, and the removal of the patella endangers the vitality of the long flap. It is always advisable, to insure drainage, to divide the lateral attachments of the synovial membrane to the femoral condyles, by which means the retention of inflammatory products in the pouch alluded to can be avoided.

In 1870 Stephen Smith\* described an amputation by "lateral hooded flap." It leaves an admirable stump, the cicatrix being placed behind and between the condyles. The writer gives it the preference over other amputations through or immediately above the knee.

Fig. 186 illustrates the incisions of this amputation and the method of forming the flaps. The incision begins an inch below the tuberosity of the tibia and passes over the outer side of the leg and is carried in a gentle curve to the middle of the posterior surface.

Here it ends opposite to the interarticular line. A similar but longer flap is outlined on the inner side. The flaps are then dissected up and are made to include everything down to the bone. While the flaps are being formed the limb must be maintained in extension. The disarticulation completes

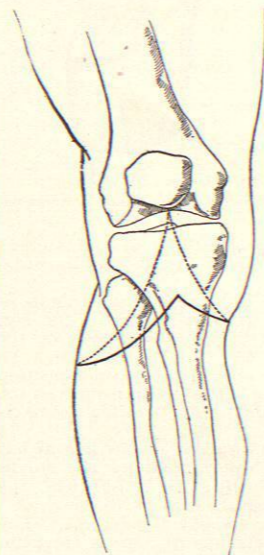


FIG. 186.

\* Amer. Journ. of the Med. Sciences, 1870, vol. lxxix., p. 33.

the operation, the semilunar cartilages being retained in the stump.

In the last forty years a number of modifications of the operations just described have been introduced. They all have the feature in common that a portion of, or the entire condyles of the femur are to be removed. In 1845 Syme advised amputation through the condyles, making a large posterior musculo-tegumentary flap. In 1846 Mr. Carden first performed the operation which has since borne his name, and has become deservedly popular. The operation consists in the formation of a long anterior flap, which, like a hood, falls easily over the divided end of the bone. The incision, similar to that made for amputation at the knee, extends no farther, down than the tubercle of the tibia. The anterior flap being reflected, the joint is opened above the patella, which is not included in the flap. After disarticulation has been effected, the soft parts of the posterior aspect of the limb are severed by a single stroke of the knife, and the saw is applied through the bases of the condyles. For the better coaptation of the cutaneous margins of the wound Lister has advised the formation of a short posterior tegumentary flap. Mr. Carden has recorded 30 operations, with only 5 deaths from this method. Of 26 Carden amputations made by Volkmann, 3 terminated fatally.

In 1857, Grritti, of Milan, devised an osteoplastic operation by which the articular surface of the patella is removed and placed in apposition with the divided ends of the femoral condyles. The operation was first practised by Sawostytzki in 1862. In this operation, long anterior and short posterior rectangular flaps are formed. Paikr and Linhart, after raising the anterior flap, amputate without first disarticulating. In 1870 Dr. William Stokes still further modified Grritti's operation by making an oval flap and dividing the femur at least half an inch above the antero-superior margin of the condyloid cartilage. Hence this amputation is generally known as the *supracondyloid* amputation, that of Carden being known as the *transcondyloid* operation. The relative merits of these various methods of amputation at the knee have been extensively investigated by American, English, and German writers. Edmund Andrews, of Chicago, shows that disarticulation at the knee and transcondyloid amputation present a like mortality (28 per cent.). Of Grritti's operation and Stokes' modification, Dr. R. F. Weir has collected 76 cases with 22 deaths. While time may show that the last-mentioned procedures may be of service in amputations for disease, sufficient evidence has been adduced by Zeiss, Beck, and Salzman, that, so far as military practice is concerned, the operation ought to be abandoned. From the more recent statistics quoted above for other amputations, the mortality of amputations at the knee in civil practice is 11 per cent., there being 7 deaths for 62 operations.

The mortality of amputations at the knee in civil practice appears from an examination of Table I. (see above). Of 187 amputations made for gunshot injury, in which the result was determined, 106 succumbed, the mortality being 56.6 per cent., and exceeding by 2.8 per cent. the fatality of amputations in the lower part of the femur.

*AMPUTATION OF THE THIGH.*—This operation may be called for in any part of the thigh. The central position of the femur, and its extensive muscular covering, sanction the application of any of the various methods of amputation in this part. The choice from among the different operations permits the surgeon at all times to save as much of the femur as possible. Until twenty years ago amputation of the thigh was generally performed by the transfixion method, by which an anterior and a posterior flap were formed. The rapidity and ease with which it could be performed were its chief commendations. The manner in which it is generally performed is the following: Grasping and raising the soft parts on the anterior aspect of the limb with his left hand, the operator introduces the knife at the side of the limb, at a point an inch or more below the level of the proposed section of the femur, and, carrying it across

the anterior surface of the femur, transfixes and cuts out a broad flap equal in length to half the diameter of the limb (Fig. 187, Fergusson). The flap thus formed being retracted, the knife is again introduced into the wound behind the femur, and a posterior flap formed by cutting from within outward and downward through the soft parts. The flap thus made should be quite as long as

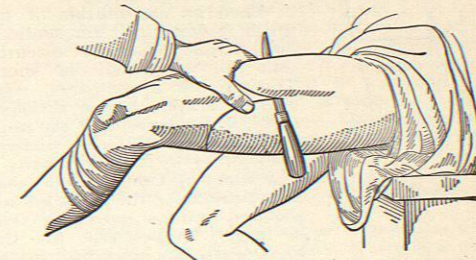


FIG. 187.

the anterior, since the greater retraction of the posterior muscles would otherwise reduce it to a size that would prevent the accurate coaptation of the cutaneous margins of the wound. In very fleshy subjects, all of the muscular tissue should not be included in the flaps thus made. When the flaps have been made they are retracted by an assistant, the bone is cleared of the still adherent soft parts by a circular sweep of the knife at the level where the saw is to be applied. In amputating by musculo-tegumentary flaps below the middle of the thigh, the anterior flap should be formed first; in amputations higher up it must be made last, in order that the femoral vessels may not be divided until the operation has been nearly completed. The vessels requiring ligation in amputations below the middle of the thigh are the femoral, anastomotic, and five or six muscular branches. To insure a smooth margin to the flaps, it is well first to outline them by an incision extending through the skin alone.

Amputation of the thigh by lateral musculo-tegumentary flaps, as recommended by Vermale, should not be resorted to, since, owing to the weight of the soft parts, the flaps are easily displaced, and the end of the bone is liable to protrude from the upper angle of the wound.

In the middle and upper portions of the thigh the very best results are unquestionably to be obtained by the modified circular method, the cutaneous flaps being made in front and behind, and the muscles divided by a circular incision. The admirable results which Volkmann and Bruns achieved from amputations of the thigh are largely attributable to their preference for this method. With a longer anterior and shorter posterior cutaneous flap, the wound obtains an excellent position for drainage (Fig. 188, Hueter), and the stump which is left is well suited for the application of an artificial limb. In the lower third of the thigh the operation may be made with only a single long anterior flap, which should extend as low as the upper margin of the patella, the integument on the posterior aspect of the limb being divided by a semicircular incision. The latter should be made at least half an inch below the margins of the anterior flap, to allow for the greater retraction of the

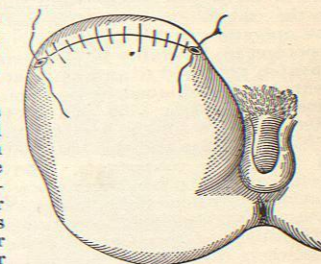


FIG. 188.