1903

Modern Surgery - Chapter 37. Amputations

John Chalmers Da Costa
Jefferson Medical College

XXXVII. AMPUTATIONS.

An amputation is the cutting off of a limb or a portion of a limb. Removal of a limb or a portion of a limb at a joint is known as "disarticulation." Amputation may be necessary because of the existence of severe injury, of gangrene, of tumors, of intractable disease of bones or joints, of ulcers which will not heal, of traumatic aneurysm, etc. A re-amputation may be required because of the existence of a defect or disease in the stump.

Classification.—Amputations are classified as follows: (1) As to time of operation after the injury: a *primary* amputation is performed soon after the occurrence of the accident—as soon as the sufferer reacts from shock, and before he develops fever; a *secondary* amputation is performed some time after the accident, suppuration having supervened (Stokes); and an

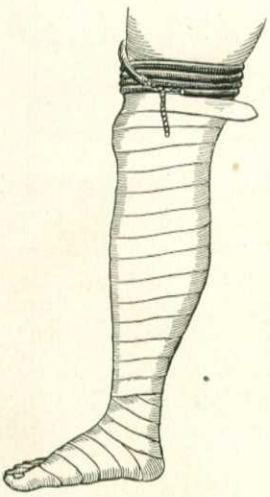

Fig. 599.—Esmarch's elastic bandage.

Fig. 600.—Application of tourniquet.

intermediate amputation is performed during the existence of fever, but before the development of suppuration. (2) As to the situation, where the bone is divided or according to which joint is cut through. (3) As to the form and situation of the flap.

In performing an amputation maintain rigid asepsis; completely remove the hopelessly damaged portion; sacrifice as little of the sound tissue as possible; prevent hemorrhage during the amputation, and carefully arrest it after the operation; have enough sound tissue in the flap to *cover* the bone, and enough skin to cover the muscles; and secure drainage at a dependent point.

Hemorrhage may be prevented by the elastic bandage of Esmarch (Fig. 599). Ordinarily we can apply this bandage from the periphery to well above the line of the prospective incision, encircle the limb with an elastic band (not the thin tube shown in the cut), and remove the bandage. The bandage and band, asepticized before using, are applied to the limb, which has been carefully sterilized. After the band has been applied the limb should

not freely or forcibly be moved, because of the danger of tearing muscles which are firmly fixed by the compressing band. When elastic compression is used in an operation the surgeon should be very careful to tie *every visible vessel.* The paralysis of the small vessels induced by pressure often prevents bleeding, and unless their mouths be found and the vessels be tied reactionary hemorrhage will occur. Reactionary hemorrhage is the great danger after the use of the Esmarch bandage, and paralysis or sloughing may also follow

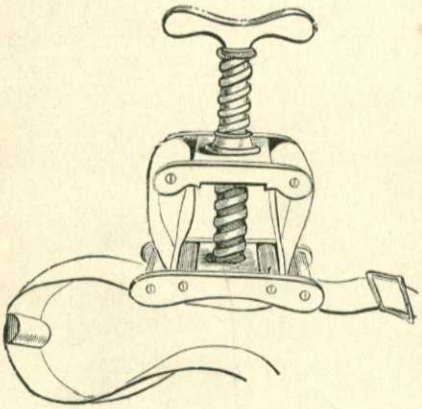

Fig. 601.—Petit's spiral tourniquet.

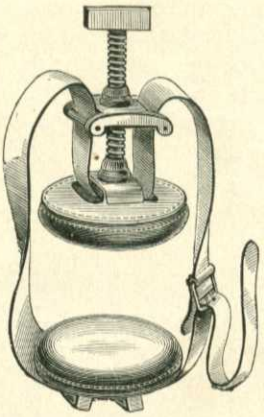

Fig. 602.—Charriére's tourniquet.

its employment. If there be an area of suppuration or of gangrene or an extra-osseous malignant growth, do not apply the bandage as directed above. One bandage can be applied from the periphery to near the lower border of the area of growth or infection, and another, from near the upper border of this area, up the limb. If the bandages are applied in this manner the contents of the diseased area (tumor-cells and fluid or septic products) are not squeezed into the circulation. In cases like the above many surgeons

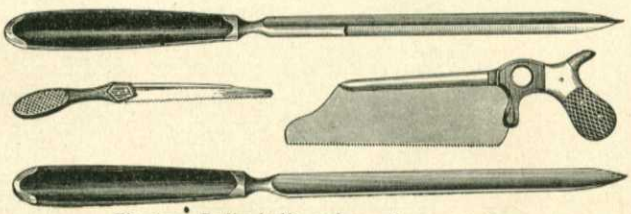

Fig. 603.—Catlin, knife, and saws for amputation.

hold the extremity in a vertical position for five minutes, lightly stroking it toward the body with the hand, and at once apply the constricting band. As a matter of fact, this plan satisfactorily empties the limb of blood, and it is not necessary in any case to force the blood out by elastic compression. Some surgeons prefer the tourniquet. Figs. 601 and 602 show two forms of tourniquet. To apply Petit's tourniquet, place the plates in contact, apply a small, firm compress over the artery and a broad thick compress over the outer surface of the limb, buckle the tapes around the limb so that the plate

is over the broad pad, and tighten the tourniquet by separating the plates with the screw (Fig. 600). When a tourniquet is applied to arrest bleeding during transportation, bandage the limb, sew the compress pad to a bandage, and place the plates of the instrument over the pad. Signorini's horseshoe tourniquet may be used upon the brachial artery. In hip-joint and shoulder-joint disarticulations Wyeth's pins are passed, and after the limb is emptied of blood the band is fastened above them. These pins prevent the bands from slipping.

The instruments and appliances required for amputation are Esmarch's apparatus or tourniquet, amputating knives, a bone-knife, scalpels, saws, a lion-jawed forceps, bone-cutting forceps, a periosteum-elevator, retractors of linen, dissecting, hemostatic, and toothed forceps, a tenaculum, an aneurysm-needle, a probe, scissors, needles, ligatures, sutures of silkworm-gut, dressings, bandages, and solutions. A retractor has two tails for the thigh and arm and three tails for the leg and forearm: it is made by taking a piece of muslin eight inches wide and twelve inches long and cutting tails on one side eight inches in length.

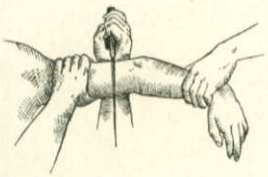

Fig. 604.—Amputation of arm by the circular method (Druitt).

Methods of Amputating.—Transverse Circular Method (Figs. 604 and 605).—This is the oldest method of amputating. The common circular incision is at a right angle to the axis of the limb. Kocher considers also as a circular incision an oblique cut around the limb if the line of the incision "continues in one direction" (Kocher's "Text-Book of Operative Surgery," translated by Harold J. Stiles). This method is called the *oblique circular amputation*. A *racket incision* is formed by adding a longitudinal cut to a transverse circular cut. If the edges are rounded, the *lanceolate incision* is formed. *Rectangular flaps* are formed when two longitudinal incisions are added to a transverse circular cut. If the corners of a rectangular flap are trimmed, *rounded flaps* are formed. The three last-mentioned plans are considered under the head of the Modified Circular Amputation (page 1026).

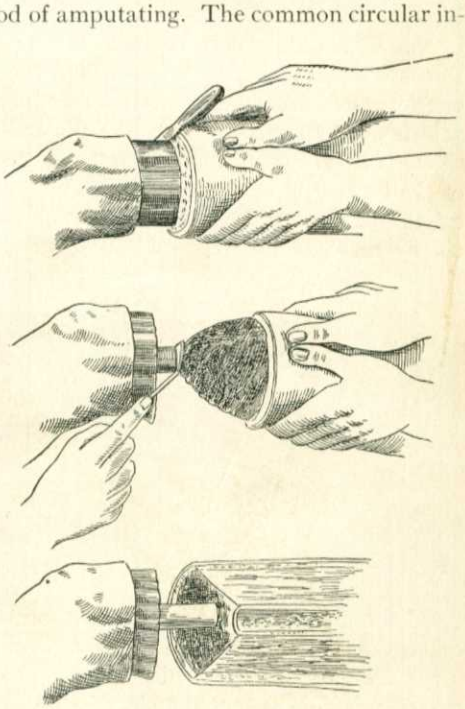

Fig. 605.—The steps of a transverse circular amputation (Kocher).

The surgeon should stand to the right of the limb and use a long amputating knife which cuts

from heel to point (Fig. 604). After an assistant has retracted the skin the operator divides the soft parts by a series of circular cuts. He does not cut at once to the bone, but divides the skin and subcutaneous tissues. At the retracted edge of the first cut the superficial muscles are divided, and after these muscles retract the deep muscles are divided. The periosteum is incised with a bone-knife and pushed up with an elevator, and after the application of the retractors the bone is then sawed, the saw starting from heel to point. A periosteal flap can be made to cover the end of the

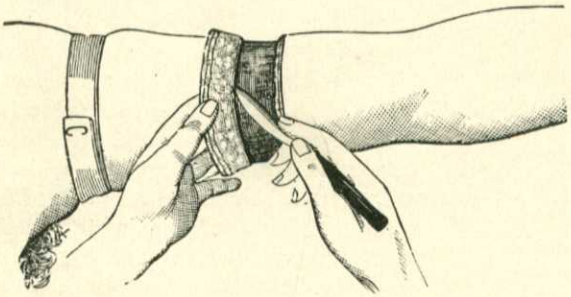

Fig. 606.—Circular amputation; dissecting up the skin-flap (Esmarch).

bone, but it is unnecessary. In this amputation is formed a cone whose apex is the bone and whose base is the skin-edge. Figure 605, from Kocher, shows the steps of the operation and the shape of the resulting stump. In one form of circular amputation (*amputation à la manchette*) the retracted skin is cut by a circular sweep of the knife, a cuff of skin and subcutaneous tissue is freed and turned up, and the muscles are cut circularly at the edge of the turned-up cut (Fig. 606). The pure circular amputation is performed on the arm and the thigh; the amputation *à la manchette* is performed chiefly through the wrist and the lower forearm.

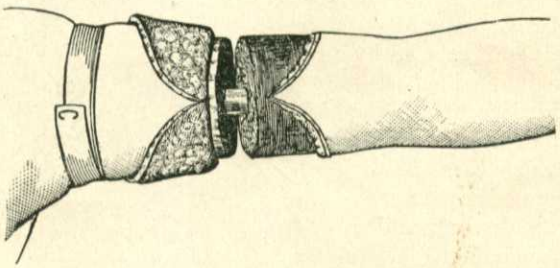

Fig. 607.—Modified circular amputation; skin-flaps and circular cut through muscles (Esmarch).

If there is more sound skin upon one side of the extremity than upon the other, the transverse circular incision sacrifices more of the limb than is necessary and the oblique circular is preferable. An objection to the transverse circular incision is that the cicatrix lies directly at the end of the stump and is liable to cause pain when subjected to pressure.

Modified Circular Method.—In this operation the circular skin-cut may be modified by making a vertical incision to join the first wound, the

muscles being cut by a circular sweep (racket incision) or by making two vertical skin-incisions (rectangular flaps). The lanceolate incision is made by rounding the edges of the flaps which result from a racket incision. Liston's modification consists in dissecting up two short semilunar integumentary flaps and in dividing the muscles circularly (Fig. 607). This is known as the "mixed method." The modified circular can be used upon the thigh, the leg, the arm, and the forearm.

Oblique Circular Method (Elliptical Method).—Mark the upper and lower ends of the incision as shown in Fig. 608. The lowest incision is at a right angle to the cutaneous surface; the highest incision is parallel to the cutaneous surface (Kocher). The skin and fascia are divided so that an oblique incision to the muscles surrounds the limb. The distal elliptical portion of skin is picked up and drawn toward the body and the muscles are divided to the bone, the knife being held transversely (Fig. 608). Kocher points out that this flap increases in thickness toward the bone. The rest of the muscles are divided on a level with and in the direction of the skin-edge. The periosteum is cut transversely and is treated as in the transverse circular operation. The flap of muscle and integument is brought over the wound. This method stands midway between the circular operation and the operation by a single flap, and is employed particularly in certain disarticulations.

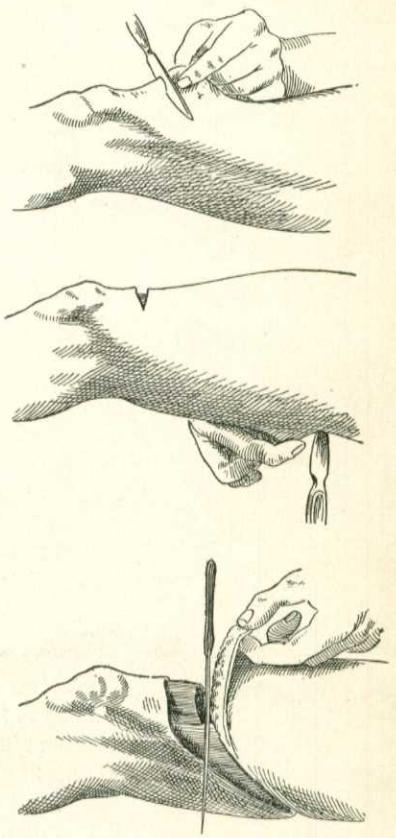

Fig. 608.—The early steps of an oblique circular amputation (Kocher).

Racket Method.—(If flaps are rounded, is known as the "oval" or "lanceolate" incision.) In an *oval* amputation the incision through the skin and subcutaneous tissue is an oval with a pointed end or a triangle; and the other parts down to the bone are cut from without inward. When a longitudinal incision down to the bone (Fig. 618, *a*, *b*) extends from the point of the oval, the operation is called the "racket" amputation. If the longitudinal cut joins a circular cut, the operation is known as a "T" amputation. The oval or racket operation is performed at the metacarpophalangeal, metatarsophalangeal, and shoulder-joints; the T operation may be performed at the hip-joint.

Flap Method.—A flap may be composed of *skin* only or of both *skin* and *muscle*, but the skin-flap must always be longer than the muscle-flap, so that the latter will be covered by it. A flap containing much muscle heals badly, but the best flap has a moderate amount of muscle (enough skin to

cover the muscle and enough muscle to cover the bone). Flaps may be *single* or *double*. Double flaps may be *lateral* or *antero-posterior*, *square* or U-*shaped*, *equal* or *unequal*, and they may be cut by *transfixion* (Fig. 609), by cutting from without inward, by dissection, or by cutting the skin from without inward and the muscles by transfixion.

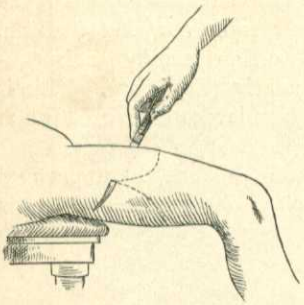

Fig. 609.—Amputation of the thigh by transfixion (Gross).

Completion of an Amputation.—When an amputation is completed, tie the main vessels, pull down the nerves and cut them high up, smooth the flaps, take off the constricting band, and after arresting hemorrhage apply sutures. In some cases the deep parts are stitched with a continuous catgut suture and the superficial parts are closed with silkworm-gut; in other cases the deep parts are not stitched at all, the skin alone being sutured with silkworm-gut. Drainage-tubes should be used except in amputations of the fingers and toes.

Special Amputations.

Fingers and Hand.—In amputating the thumb and index-finger save every possible scrap of tissue. In either of the fingers, if it be necessary to amputate above the middle of the middle phalanx, the attachment of the flexor tendons will be cut off and the finger will be liable to project directly backward, so that it is better with these fingers either to disarticulate at the metacarpal joints or to stitch the flexor tendons to the periosteum. The flexor tendons have fibrous sheaths extending from the proximal end of the distal phalanx to the metacarpophalangeal articulations, these sheaths being thin and collapsible opposite the joints, but being thick and rigid opposite the shafts of the bone. The fibrous sheath is known as the *theca*, and when it is cut in an amputation it should be closed, otherwise it may carry infection to the palm of the hand. The theca does not exist over the distal phalanx, and it is not distinctly visible over the joint between the distal and middle phalanges. To effect closure over the shaft of a bone, strip up the periosteum and pass catgut sutures vertically through the theca and the periosteum (Treves). In amputation of the fingers and the thumb an Esmarch bandage is unnecessary, though pressure may be made upon the arteries at the wrist. Only two or three ligatures are necessary. Close with a very few sutures, so as to favor drainage between the threads.

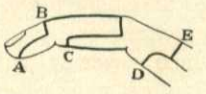

Fig. 610.—Amputation of the finger.

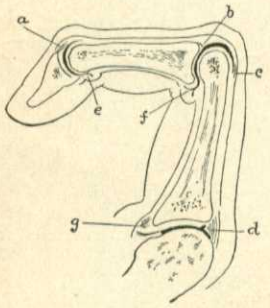

Fig. 611.—The line of the joints in the flexed position of the finger: *a*, Extensor longus digitorum; *b*, interossei and lumbricals; *c*, extensor longus digitorum and interossei; *g*, interossei and lumbricals; *f*, flexor sublimis; *e*, flexor profundus (Kocher).

The distal phalanx is best removed by a long palmar flap (Fig. 610, A).

The palmar flap (A) is marked out by cutting through the skin and subcutaneous tissue. The incisions are next carried to the bone, the flap is dissected from the bone, the finger is strongly flexed, a transverse incision (B) is carried across the dorsum on a level with the base of the third phalanx, the soft parts are pushed back, the joint is opened, the lateral ligaments are cut from within outward, the third phalanx is forcibly extended, and the remaining structures are cut from below upward. Fig. 611 shows the lines of the joints when the finger is flexed. The middle phalanx can be removed by the same method (C, Fig. 610). The proximal phalanx can be removed by a long palmar flap or by a long palmar and a short dorsal flap (D, E, Fig. 610).

Disarticulation at a metacarpophalangeal joint is best performed by the oval method. The incision upon the dorsum (A) is begun just above the head of the metacarpal bone, is carried down to beyond the base of the phalanx, and involves the skin only (Figs. 612 and 613). One

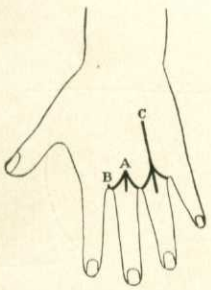

Fig. 612.—A, Disarticulation of a metacarpophalangeal joint; C, amputation of a finger with the metacarpal bone.

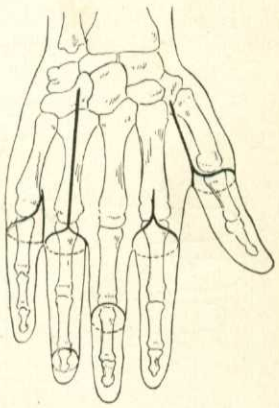

Fig. 613.—Disarticulation of the little finger and index finger. Disarticulation of the ring finger with its metacarpal bone. Disarticulation of the thumb with its metacarpal bone (Kocher).

incision sweeps around the finger at the level of the web, going only through the skin (B); the finger is extended and the palmar cut is carried to the bone; each lateral incision is carried to the bone while the finger is bent in the opposite direction, the flaps are dissected back to the joint, the finger is strongly extended, the joint is opened from the palmar side, and disarticulation is effected. Cutting off the head of the metacarpal bone improves the appearance of the stump but weakens the hand, hence in a workingman it must not be done unnecessarily. If it is necessary to remove a metacarpal bone, the incision (C) is made from the carpometacarpal joint.

Amputation of the thumb through its distal or proximal phalanx is performed identically as is an amputation of a finger. Amputation of the thumb, with a portion or the whole of its metacarpal bone, is performed by the oval or racket incision (Fig. 613).

Disarticulation at the wrist-joint can be done by the oblique circular method (Fig. 615) or by a double flap. In the double-flap amputation a dorsal flap is made by carrying a semilunar skin-incision between the styloid processes; the skin is lifted, the wrist is forcibly flexed, the joint is opened

by a transverse cut, and a long semilunar palmar flap which includes only the skin and fascia is made by dissection. Kocher prefers to amputate by an oblique incision. The lower end of this incision is about the middle of the palm and the upper end is in the line of the wrist-joint (Fig. 615). The hand is strongly flexed, the extensor tendons are divided, the posterior ligament of the joint is incised, and incisions below the styloid processes divide the lateral ligaments and certain tendons. The flexor tendons are separated from the bone and are divided so as to remain in the palmar flap.

Fig. 614.—Modified circular amputation of the forearm (Bryant).

Amputation through the forearm may be effected by the circular method (Fig. 615), the modified circular, or the flap operation. The modified circular is an excellent plan. A semilunar dorsal skin-flap and a semilunar skin-flap on the flexor surface are made. The flaps are raised, the muscles are

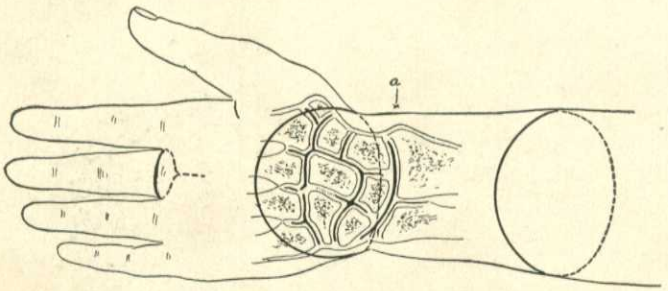

Fig. 615.—Disarticulation of the middle finger. Disarticulation at the wrist-joint. Amputation through the forearm by the oblique circular method (Kocher).

cut circularly (Fig. 614), the interosseous space is cleared with the knife, a three-tailed retractor is applied, the periosteum is pushed up, and the bones are sawn half an inch above the flap. In sawing the bones, start the saw upon the radius, draw it from heel to point, make a furrow on the radius and

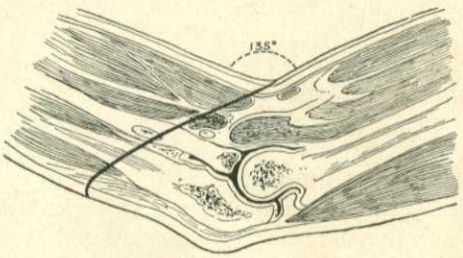

Fig. 616.—Disarticulation of the elbow-joint by the oblique circular method (Kocher).

ulna, and saw both bones at the same time. After sawing, cut away any irregular edge with bone-pliers. In the lower third Teale's amputation may

be done, the dorsal flap being the long one. In Teale's amputation rectangular flaps are made. The long flap is equal in width and length to one-half the circumference of the limb at the point where it is to be sawn. The short flap is equal in width to the long flap, but is only one-fourth its length. The two longitudinal cuts are at first taken only through the skin, but the two transverse cuts go at once to the bone. The flaps are dissected up from the interosseous membrane and the bone. In the middle or the upper third of a fleshy arm two semilunar skin-flaps can be cut from without inward, and the muscle can be cut by transfixion.

Disarticulation at the elbow-joint can be done by the elliptical method or by a long anterior and short posterior flap. In Kocher's oblique operation the incision begins anteriorly over the joint-line and ends posteriorly a hand's breadth below the summit of the olecranon (Fig. 616). A posterior flap which contains the integument, insertion of the triceps, the anconeus, and periosteum is dissected up until the posterior surface of the

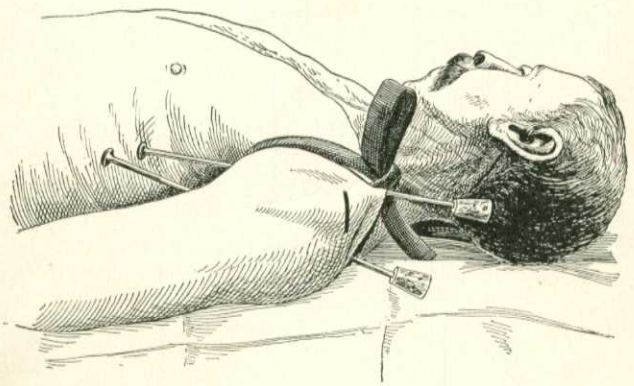

Fig. 617.—Use of Wyeth's pins in amputation at the shoulder-joint. The acromion is marked by a black line (Keen).

humerus is reached. The joint is opened anteriorly by a transverse incision and the radiohumeral articulation is opened from without inward (Kocher). In the double flap operation the forearm is partly flexed and a skin-cut marks out a long anterior flap, the knife being entered opposite the external condyle and being withdrawn one inch below the internal condyle. The muscles, which are bunched forward, are cut by transfixion. A posterior semilunar flap is made, which separates the attachments of the radius, the ulna is cleared, and the triceps is cut at its insertion (Bell). Gross advocated sawing through the olecranon and the inner trochlear surface.

Amputation of the arm is best performed by marking out with a knife two equal semilunar anteroposterior flaps, the first cut being carried through the skin alone, the muscles being then transfixed with a long knife. Teale's method is shown in Fig. 268. The circular or the modified circular amputation may be performed.

Disarticulation at the Shoulder-joint.—In this operation Wyeth's pins are passed to hold the Esmarch band in place. The anterior pin is entered at the middle of the lower margin of the anterior axillary fold, and emerges

one inch within the tip of the acromion. The posterior pin is entered at a corresponding point on the posterior axillary fold, and emerges more posteriorly than the first pin and an inch within the tip of the acromion. After the extremity has been drained of blood by the Esmarch bandage or by stroking and a vertical position the Esmarch band is applied above the pins (Fig. 617).

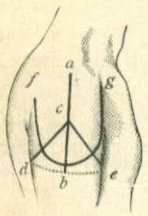

Fig. 618.—Amputation at the shoulder-joint: *a*, *b*, *c*, *d*, *e*, Larrey's operation; *f*, *g*, Dupuytren's operation.

Larrey's Operation.—In this method of shoulder-joint disarticulation the limb is held from the side and an incision is made down to the bone, the incision beginning just below and in front of the acromion and running vertically for four inches down the outer surface of the arm (Fig. 618, *a b*). From the center of this incision an oval incision (*c d*, *c e*) is carried around the arm, the inner aspect of the oval reaching as low as the lower end of the vertical cut. The oval incision at first involves only the skin and subcutaneous tissues. The anterior structures are divided close to the bone, and the posterior structures are next cut. To disarticulate, cut the capsule transversely upon the head of the bone; while the arm is rotated outward cut the subscapularis, and while the arm is rotated inward cut the supraspinatus and infraspinatus and the teres minor. Cut away any tissue holding the humerus to the body, hanging nerves, capsule-fragments, and tissue-shreds, and sew up the wound vertically. Bell advises an oval incision with a racket handle. Spence used an anterior racket incision.

Kocher's Operation.—Kocher makes an anterior lanceolate incision (Fig. 619). The incision begins over the clavicle just external to the coracoid process of the scapula, and is carried downward, dividing, as

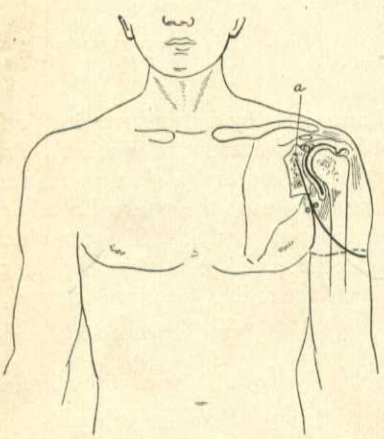

Fig. 619.—Disarticulation at the shoulder-joint by Kocher's method (Kocher).

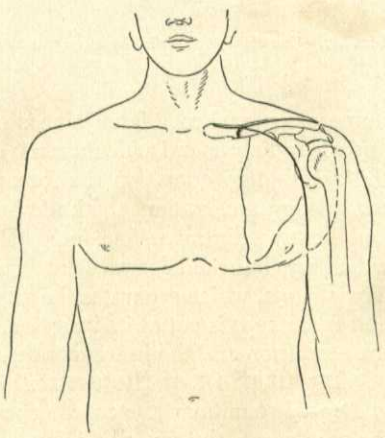

Fig. 620.—Removal of the entire upper extremity (Kocher).

it advances, the anterior fibers of the deltoid muscle. "Bleeding vessels and the cephalic vein are ligatured. In the upper part of the wound the acromial branches of the acromiothoracic artery are also ligatured. The knife

is carried down to the bone at the edge of the deltoid (only the upper fibers of which have been divided). The capsule is divided over the lesser tuberosity and the bicipital groove. The periosteum, the insertions of the subscapularis, pectoralis major, latissimus dorsi, and teres major are detached along with the capsule. The capsule, along with the insertions of the supraspinatus, infraspinatus, and teres minor muscles, is also detached from the upper part of the head and from the great tuberosity. The head of the humerus can now be protruded from the wound. In cutting down over the surgical neck it may be necessary to ligature the circumflex arteries; in any case the anterior must be tied. The racket incision is now completed by dividing the skin circularly at the level of the axillary folds. The vessels and nerves are then easily isolated, the former being ligatured and the latter divided" (Kocher's "Text-Book of Operative Surgery," translated by Harold J. Stiles). Kocher cautions us to avoid the circumflex nerve which supplies the deltoid, as the deltoid is the muscle of the stump.

Dupuytren's Operation.—In Dupuytren's shoulder-joint disarticulation a U-shaped flap is marked out by a skin-incision (Fig. 618, *f*, *g*). If the amputation is to be at the right shoulder, the arm is carried across the chest; the knife is entered at the root of the acromion, follows the margin of the deltoid, and is withdrawn at the coracoid process, the arm being gradually abducted and pulled off from the chest. If the left shoulder is to be amputated, the procedure is reversed (Treves). The knife next cuts through the deltoid and raises a flap composed of this muscle, the shoulder-joint is exposed, and disarticulation is effected as in Larrey's method. The knife is passed down back of the bone and a short internal flap is cut.

Lisfranc's amputation is by transfixion with the formation of an anterior and a posterior flap, and can be performed very rapidly, but only a most skilful surgeon should attempt it.

Amputation of the Entire Upper Extremity.—Berger's Amputation.—This operation is an amputation above the shoulder-joint. By it are removed the arm, the scapula, and a portion of or the entire clavicle. It is occasionally employed in cases of malignant disease and of severe injury. The operation is attended with profuse hemorrhage, and as a preliminary the subclavian vessels should be ligated. The incisions must be varied according to the necessities of the case. In this operation Berger divides the clavicle at the junction of its outer and middle thirds, and resects the middle third of the bone; ligates and divides the subclavian vessels; cuts the anterior flap; divides the brachial plexus; marks out the posterior flap; and completes the operation by dividing the structures which hold the shoulder-blade to the chest. It is in this last step that bleeding is profuse. Fig. 621 shows Berger's incision for the operation. Fig. 620 shows Kocher's incisions.

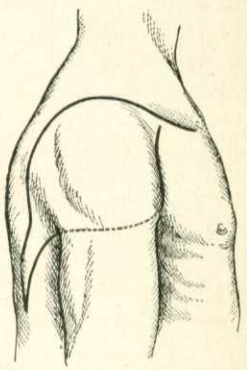

Fig. 621.—Removal of the whole upper extremity.

The usual procedure of tying the third part of the subclavian artery as a preliminary measure possesses certain disadvantages. The artery is very

deeply situated at this point, is in close relation with the pleura, and is covered to a considerable extent by the vein; and the phrenic nerve is very near. Le Conte maintains that one of two courses may be taken: The veins may be severed first, and afterward the artery may be exposed and tied. When this is done, the amount of blood remaining in the arm is lost. The procedure that he selects as the best, however, is to expose the axillary artery as high up as possible, and place a temporary ligature around it; then elevate the arm, empty it of blood, place a permanent ligature around the third part of the subclavian artery, and divide the artery in this portion of its course (Robert G. Le Conte, "Annals of Surgery," Oct., 1902).

Fig. 622.—Amputation of the toes with and without the metatarsal bones.

Amputation of the Toes and the Foot.—Only in the great toe is *partial* amputation performed, and it is effected by the formation of a long plantar flap, just as a long palmar flap is formed from the finger. Amputation at the metatarsophalangeal joints is performed by an oval or racket incision (Fig. 622, *c*). Amputation of a toe with removal of its metatarsal bone is shown in Fig. 622, *a b* and *d e*.

Disarticulation at the Tarsometatarsal Articulation.—Lisfranc's Operation (after Treves).—In order to amputate the right foot by this method begin an incision on the outer border of the foot, behind the tubercle of the fifth metatarsal bone; carry the incision forward one inch and sweep it across the foot half an inch below the tarsometatarsal articulations; bring the incision to the inner edge of the foot, half an inch in front of the articulation of the tarsus with the first metatarsal bone, and carry the cut straight along the inner margin of the foot until it reaches a point three-fourths of an inch above the articulation of the metatarsal bone of the great toe. A very short semilunar dorsal skin-flap is thus formed. Fig. 628 shows the flaps as cut by Kocher. After the skin-flap is dissected back for a quarter of an inch the tendons are divided, and the flap, which now contains all the soft parts, is dissected back to *above* the joint. A long plantar flap is cut, reaching from the origin of the first flap to the necks of the metatarsal bones. The skin-flap is dissected up until the hollow behind the heads of the metatarsal bones is reached, when, with the toes in extension, the tendons are cut across and a flap composed of all the soft parts is dissected up to above the tarsometatarsal joint. Figs. 623 and 628 show the line of Lisfranc at the tarsometatarsal articulation. The joint is opened from the outer side according to the following rule: in separating the fifth metatarsal direct the edge of the knife toward the distal end of the first metatarsal; in separating the fourth metatarsal direct the knife toward the middle of the first metatarsal; in separating the third metatarsal carry the knife almost directly across. The separation is facilitated by bending down the front of the foot, and at the same time the tendons of the peroneus brevis and tertius are divided. Open

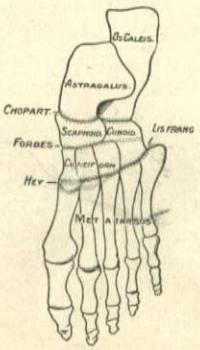

Fig. 623.—Lines in amputations of the foot (Gross).

the joint between the first metatarsal and the inner cuneiform bone, turning the knife toward the middle of the shaft of the fifth metatarsal, and at the same time divide the tibialis anticus muscle. Treves says that in disarticulation of the second metatarsal the knife is to be held as a trocar, it is to be thrust between the base of the first and second metatarsal bones until the point strikes bone (Fig. 624), and is then to be raised to a perpendicular and

Fig. 624.—Lisfranc's amputation—first step in disarticulating the second metatarsal bone (Guérin).

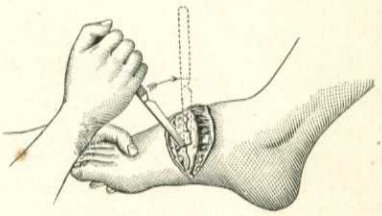

Fig. 625.—Lisfranc's amputation—second step in disarticulating the second metatarsal bone (Guérin).

the cut is to be made toward the external malleolus to sever the ligament of Lisfranc (Fig. 625). Divide any remaining ligaments, and also the tendon of the peroneus longus muscle. The skin-incisions in the *left* foot are begun on the inner side, and in disarticulating the tarsal joint of the great toe is first opened. Fig. 629 shows the parts after disarticulation at the line of Lisfranc.

Hey's Operation.—In Hey's method the incision is practically the same

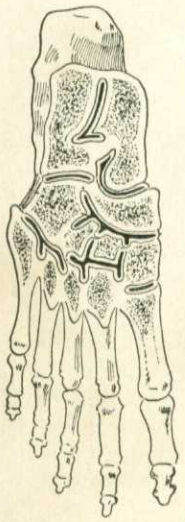

Fig. 626.—Anterior intertarsal disarticulation (Kocher).

Fig. 627.—Chopart's amputation.

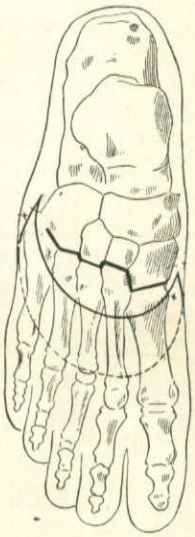

Fig. 628.—Lisfranc's amputation.

as that for Lisfranc's amputation. The four external metatarsal bones are disarticulated, but the first metatarsal is removed by sawing a portion of the

internal cuneiform bone. Guérin advised sawing all the bones across. Skey advised the division of the head of the second metatarsal. Fig. 623 shows the line of Hey.

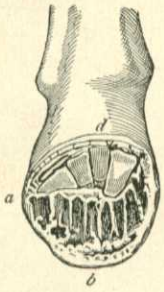

Fig. 629.—The parts after Lisfranc's amputation (Bernard and Huette).

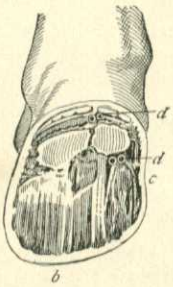

Fig. 630.—The parts after amputation by Chopart's method (Bernard and Huette).

Anterior Intertarsal Disarticulation.—The disarticulation is effected between the three cuneiform bones in front and the scaphoid behind, and the cuboid is sawn across. The incision of the soft parts is as for Lisfranc's amputation (Fig. 626).

Disarticulation through the Middle Tarsal Joint.—Chopart's Operation (Posterior Intertarsal Disarticulation).—Make a transverse incision through the skin of the instep, two inches below the ankle-joint; cut the tendons and muscles, expose the tarsus, and make on each side a small longitudinal incision reaching to below and in front of the corresponding malleolus. The flap thus formed is retracted. The plantar flap is made as in Lisfranc's amputation. The flaps as made by Kocher are shown in Fig. 627. Open the astragaloscaphoid joint, then the calcaneocuboid joint, and disarticulate. Fig. 623 and Fig. 627 show the line of Chopart. Fig. 630 shows the parts after Chopart's disarticulation. In *amputation through the tarsus*, Forbes, of Toledo, advises making flaps as in Chopart's amputation, disarticulating the scaphoid from the cuneiform bones, and sawing through the cuboid. Fig. 623 shows the line of Forbes.

Subastragaloid Disarticulation.—A circular incision is carried around the foot at the level of the middle tarsal joint and a racket incision is added to it running below and posterior to the tip of the external malleolus (Fig. 631). "The joint between the astragalus and scaphoid is opened upon the dorsum, without opening the calcaneocuboid joint. A narrow knife is then passed backward and slightly upward beneath the head of the astragalus so as to divide the strong interosseous ligament between it and the os calcis. The soft parts are then dissected off the os calcis, first from its upper surface, then from its outer and under surfaces, and lastly from its inner and posterior

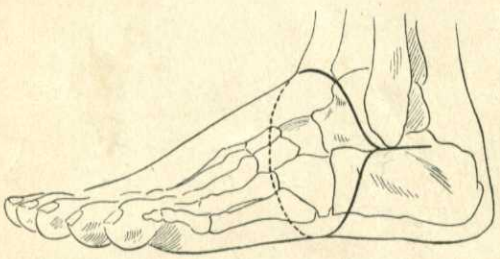

Fig. 631.—Subastragaloid disarticulation (Kocher).

surfaces. The greatest difficulty is met with at the inner side in clearing the projecting sustentaculum tali" (Kocher's "Text-Book of Operative Surgery," translated by Harold J. Stiles).

Disarticulation at the Ankle-joint.—Syme's Method.—The foot is held at a right angle to the leg, and a skin-incision is carried, from just below the external malleolus, straight across or a little backward across the sole to a corresponding point on the opposite side. Do not take this incision near to the inner malleolus, as to do so will endanger the posterior tibial artery. The incision is carried to the bone, the flap being pushed back and separated from the bone by means of a strong knife and the thumb-nail until the tuberosity of the os calcis has been reached. The foot is now extended and a transverse cut is made across the dorsum, joining the two ends of the first incision; the ankle-joint is opened, the lateral ligaments are cut, disarticulation is effected, and the foot is finally completely removed by severing the tendo Achillis. A thin piece of bone including both malleoli is sawn from the tibia and fibula. The flap is perforated posteriorly to secure drainage (Fig. 269).

Pirogoff's Method.—Flex the foot to a right angle with the leg. "Make an incision from the tip of the internal malleolus across the sole, a little in front of the long axis of the tibia, to a point in front of the apex of the external malleolus down upon the bone."* Dissect the flap backward from the calcaneum for a quarter of an inch, but do not dissect the flap from the posterior portion of the os calcis. Join the extremities of the first incision by another cut which reaches to the bone, and which is "half an inch in front of the lower extremity of the tibia" (Bryant); but saw off this bony projection obliquely and leave it adherent to the tissues. The saw is used after disarticulation of the ankle-joint; it is passed behind the astragalus, cutting downward and forward, sawing the os calcis obliquely, and leaving a considerable portion in place in the flap. The lower ends of the tibia and fibula are well exposed by raising the anterior flap slightly; the sawing is begun anteriorly just above the articular surface, and is completed half an inch above the articular surface posteriorly. The lines *a* and *b* (Fig. 632) show the sections made by the saw. The sawn surface of the os calcis is brought into contact with the sawn surfaces of the tibia and fibula, and the flaps are sutured.

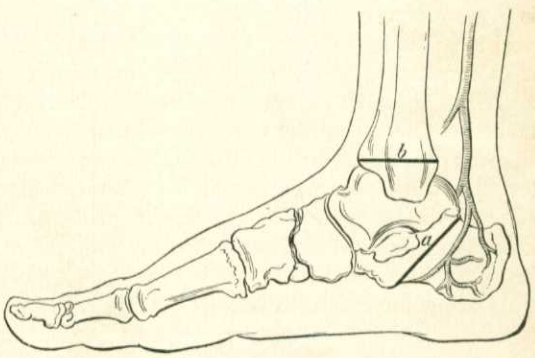

Fig. 632.—Lines of section of the os calcis and the bones of the leg in Pirogoff's amputation.

Amputations of the Leg.—The so-called "point of election" is at the

*"Operative Surgery," by Joseph D. Bryant.

upper part of the middle third of the leg. Seventy years ago Liston advised surgeons not to amputate in the lower third of the leg because of the scantiness of the soft parts, because the stump is apt to ulcerate, and because it is uncomfortable in an artificial leg. These views have been much modified. The amputation near the ankle is safer than the amputation near the knee, and artificial legs are now made which may be worn with comfort. In amputations of the leg by the *long anterior flap*, cut through the skin, dissect up the anterior muscles with the flap, and cut all the posterior tissues with a single transverse sweep. Amputation by the *rectangular flap*, Teale's method, is very useful (see page 1031). The long flap is anterior, and is in length and breadth equal to one-half the circumference of the limb. The short flap is one-fourth the length of the long flap. The flaps are dissected up, the bones are sawn, the long flap is turned upon itself, and its edges are sutured to the edges of the short flap.

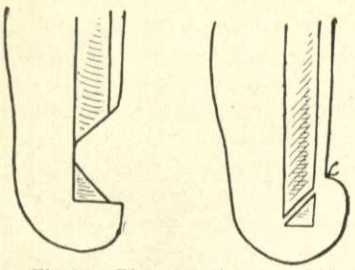

Fig. 633.—Diagrammatic representation of amputation of the leg after the method of Bier.

Bier suggests a plan (Fig. 633) to increase the supporting power of the stump after a leg-amputation. After the wound has healed, a wedge-shaped piece of bone is removed above the level of the stump. The lower extremity is turned forward and upward through an arc of 90 degrees, and unites in this position (Zuckerkandl's "Operative Surgery"). Thus the medullary cavity is closed and the skin which must bear pressure is healthy and free from cicatrices; and as the muscles are still attached to the bone, they do not undergo atrophy.

Sédillot's leg-amputation (Fig. 634) is by a long external flap. A longitudinal incision is made along the inner edge of the tibia, the tissues are drawn toward the fibula, a knife is introduced and passed to the outer edge of the tibia, just touching the fibula, and is brought out posteriorly, thus transfixing the calf-muscles and cutting an external flap. A convex incision is made on the inner side, the bones are cleared and are sawn one inch above the flaps, half an inch more being taken from the fibula than from the tibia, and the tibia being bevelled anteriorly.

Fig. 634.—Sédillot's amputation of the leg (Wyeth).

Modified Circular Amputation of the Leg.—Cut semilunar skin-flaps, lay them back, and cut circularly to the bone at the edge of the turned-up flap. Another method of modified circular amputation is by adding to the circular cut a vertical incision down the front of the leg. In sawing the bones of the leg the surgeon, who stands to the outer side of the right leg or to the inner side of the left leg, divides the fibula first, and at a higher level than the tibia, and bevels the anterior surface of the tibia. In sawing the left fibula the saw points to the floor; in sawing the right fibula it points to the ceiling.

Amputation of the Leg by a Long Posterior and a Short Anterior

Flap.—In this operation a posterior U-shaped flap is made equal in length and breadth to the diameter of the limb. The skin-incision is begun one inch below the point where the bone is to be sawn, and behind the inner edge of the tibia, and is carried to a point posterior to the peronei muscles. The gastrocnemius muscle is divided transversely at the level of the flap, the soft parts on either side in the line of the flap being cut to the bone. Through these vertical cuts the muscles are lifted from the bones and are divided through their lower part by cutting from within outward. The anterior flap is formed by making a semilunar skin-flap and by cutting the muscles across at its retracted edge (Fig. 635).

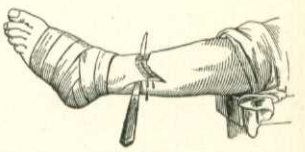

Fig. 635.—Amputation of the leg by a long posterior flap (Gross).

Amputation of the leg by lateral flaps is not a popular operation, as it offers too much encouragement to subsequent protrusion of the bone.

Amputation just below the Knee.—The seat of election is one inch below the tuberosities. No muscle is needed in the flap. Cut two flaps of skin, equal in size and semilunar in shape, these flaps beginning anteriorly two inches below the tuberosity of the tibia. One flap is antero-external and the other is postero-internal. The flaps are pulled up, the anterior muscles are cut as high up as possible, and the posterior muscles are cut through the middle of the portion exposed (Bell). The bone is sawn one inch below the tuberosity.

Disarticulation of the Knee.—In disarticulation by the long anterior flap, make a long anterior skin-flap, incise the ligament of the patella, turn up a flap containing the patella, open the joint, and complete the disarticulation by cutting from within outward and downward. The knee may be disarticulated by means of a long anterior and a short posterior flap. Kocher prefers the oblique incision (Fig. 636). This secures an anterior flap. The leg is so

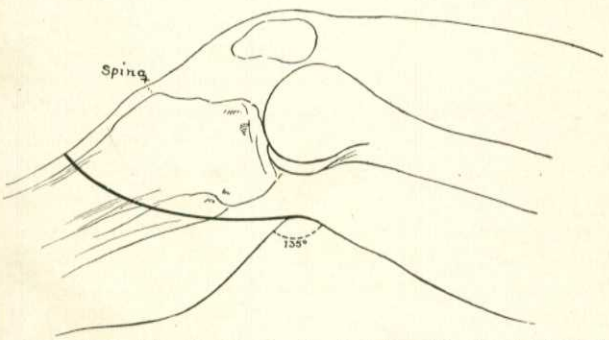

Fig. 636.—Kocher's obiique incision for disarticulation at the knee-joint (Kocher).

held that it makes an angle with the thigh of 135 degrees and "the incision falls in the continuation of the long axis of the thigh" (Kocher's "Textbook of Operative Surgery," translated by Harold J. Stiles). The posterior part of the incision is opposite the line of the joint and the anterior part of the incision ends four finger-breadths below the tibial tubercle.

Amputation through the Femoral Condyles.—*Syme's Method by a*

Long Posterior Flap.—Carry a skin-incision, with a very slight downward curve from one condyle to the other, across the middle of the patella. Cut down to the bone, retract the flap, and cut the quadriceps above the patella. Insert a long knife at one angle of the wound, pass it back of the femur, and make it emerge at the opposite angle, cutting a posterior flap eight inches long. Retract the posterior flap, clear for sawing, and section the condyles horizontally. Carden made a curved section of the condyles at their widest part. In children Buchanan showed that we can easily separate the lower

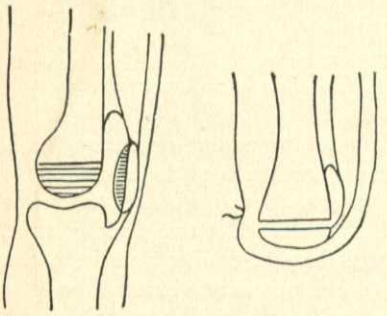

Fig. 637.—Diagrammatic representation of Gritti's operation.

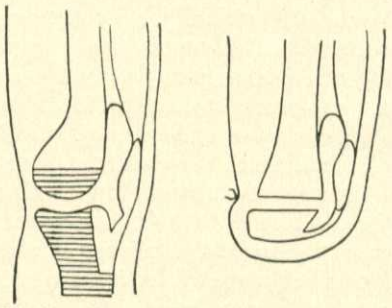

Fig. 638.—Diagrammatic representation of Sabanejeff's operation.

femoral epiphysis. In *Gritti's supracondyloid amputation* an oblique incision is made. The upper end of the incision is posterior and just above the condyles. Its lower end is anterior and two finger-breadths below the patella (Kocher). The ligament of the patella is cut, the flap is turned up, the femur is sawn at the base of the condyles, the articular face of the patella is sawn off, and the sawn patella is fastened to the sawn femur and the flaps are sutured (Fig. 637). Sabanejeff makes an anterior flap, opens the knee-joint from behind, saws the condyles at their broadest part, takes a bone-flap from the anterior portion of the tibia and fastens it to the femur (Fig. 638).

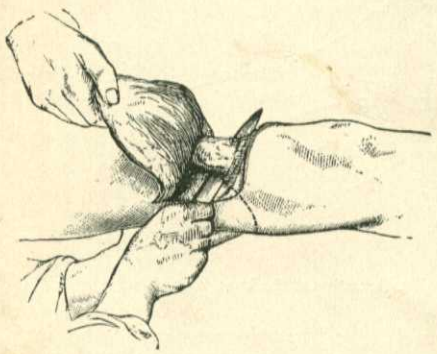

Fig. 639.—Amputation of the thigh (Bryant).

Amputation of the Thigh.—In high amputation in the *lower third* either a flap or a circular operation may be performed. In a double-flap operation a semilunar skin-incision should be made from without inward, and the muscles should be cut by transfixion (Fig. 639). In the lower third Teale's flap or the long anterior flap may be employed. The amputation by a long anterior flap consists in making a lengthy skin-flap, reflecting it, cutting the anterior structures to the bone, again entering the long knife at one angle of the incision, pushing it back of the femur, bringing it out at the outer angle, and cutting the structures behind the bone directly backward. Bell amputates by a long anterior semilunar

flap and a short posterior flap. In amputations in the *upper two-thirds* of the thigh the best plan is to mark out equal anterior and posterior semilunar skin-flaps, divide the skin with a scalpel, enter the long knife at one angle of the anterior flap, bring it out at the other angle, and cut the muscles by transfixion. Cut the posterior flap in the same manner. Some surgeons prefer a long anterior semilunar flap and a short posterior semilunar flap. The pure circular amputation is not adapted to the thigh.

Disarticulation at the Hip-joint.—Various methods have been employed to prevent or limit hemorrhage during this formidable operation. Abernethy uses digital compression of the external iliac artery or of the femoral artery, to prevent hemorrhage during amputation of the hip-joint. This is an extremely tiresome procedure; the finger is liable to slip; and, in any case, compression so situated fails to intercept the blood-current in a number of large vessels.

Various other methods have been employed. It was formerly the custom to compress the aorta by means of an abdominal compressor (Figs. 640, 641). A tourniquet is very likely to be displaced during the operation. The intention is to compress the artery against the spine, but in effecting this the circulation in a portion of the intestine may be impaired. In any case, as Senn says, the circulation is cut off from half the body, and the patient is exposed to grave danger from "sudden vascular engorgement of important internal organs" (Senn). Again, an abdominal compressor of this sort does not arrest venous bleeding. A number of years ago Davy suggested that a suitable cylindrical piece of wood, about 25 inches long, and shaped like a cone at the end, might be introduced into the rectum and used to compress the common iliac artery upon the pelvic brim. This appliance is known as *Davy's lever.* It is apt to slip, and may do serious damage to the rectum.

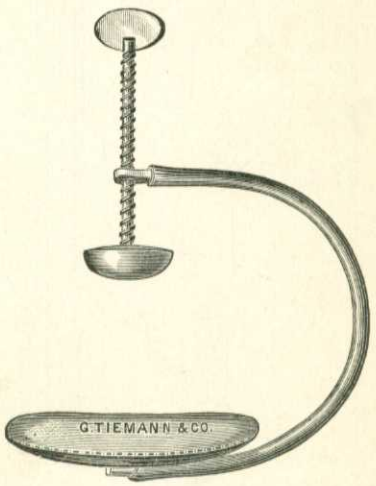

Fig. 640.—Pancoast's aorta tourniquet.

Some surgeons have practised preliminary ligation of the common femoral artery or of the external iliac artery, and others have tied the vessels while making the flaps. If any form of compression is used, that recommended by Macewen, of Glasgow, is the most successful and satisfactory (Fig. 642). The weight of the assistant's body is thrown upon the patient's aorta by the right fist, placed slightly to the left of the umbilicus. McBurney has suggested the prevention of bleeding by making a small abdominal incision and having an assistant make direct digital pressure upon the iliac artery. I employed McBurney's method in a recent case and found it most satisfactory. If the constricting band of Esmarch is applied by the ordinary method, it is certain to slip. It may remain in place if applied as a figure eight of the thigh and the pelvis, but even then it is uncertain.

The most satisfactory method in the great majority of cases is Wyeth's, in which the constrictor is held in place by the preliminary passage of two steel pins. Trendelenburg's method consisted in passing one pin and winding an elastic tube about it. Wyeth applied the principle and greatly improved the method. The outer pin is inserted an inch and a half below and a little internal to the anterior superior spine of the ilium, and is brought out just back of the great trochanter. The inner pin is entered one inch below the level of the crotch and internal to the saphenous opening, and it emerges an inch and a half in front of the tuberosity of the ischium. A sterile cork is pushed on the end of each pin, to save the surgeon from wounding himself upon the sharp points. After the limb has been emptied of blood by holding it in a vertical position for five minutes and stroking it from the periphery toward the body, the constricting band is fastened about the limb above the pins.

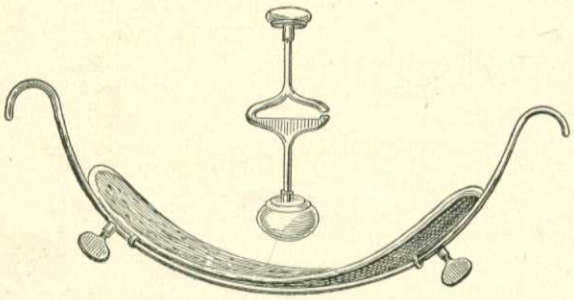

Fig. 641.—Von Esmarch's aorta tourniquet.

Fig. 642.—Macewen's method for compression of the abdominal aorta ("American Text-book of Surgery").

In the *bloodless method of Wyeth* (Figs. 643, 644), after the passage of the pins and the application of the band of the Esmarch apparatus, the amputation is proceeded with. The hip is brought well over the edge of the table, a circular incision is made down to the deep fascia six inches below the constricting band, and is joined by a longitudinal skin-cut reaching from the band to the level of the circular incision, and the cuff is reflected to the level of the lesser trochanter. The muscles are cut by a circular sweep at the level of the retracted cuff, the capsule of the hip-joint is opened freely, the cotyloid ligament is cut posteriorly, the thigh is bent upward, forward, and inward to dislocate the head of the bone, and, using the thigh as a handle, the round ligament is incised and the limb removed. After ligating the vessels and

introducing drainage-tubes the flaps are sewn together vertically. The old transfixion operation is practically extinct. A T-*amputation* may be employed. It consists of an external straight incision down to the bone, starting

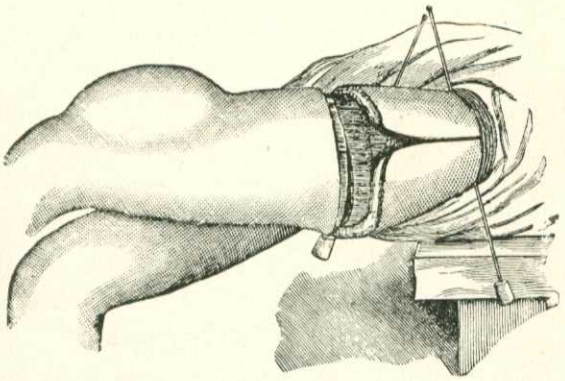

Fig. 643.—Amputation at the hip-joint—Wyeth's bloodless method.

over the great trochanter, down the outer side of the limb, and a circular incision through the skin five inches below the constricting band, the muscles being cut by a circular sweep at the level of the retracted skin. This method

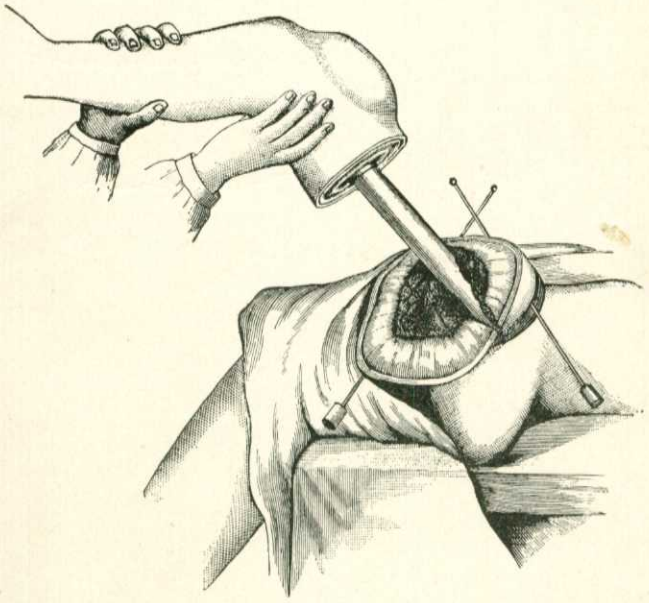

Fig. 644.—Wyeth's bloodless amputation at the hip-joint. Cuff of skin and subcutaneous fat turned back, muscles divided at level of small trochanter, bone partly stripped, and large vessels exposed for deligation.

affords easy access to the joint. The bloodless method of Wyeth, as applied to the hip-joint and shoulder-joint, is one of the notable modern advances in the art of surgery.

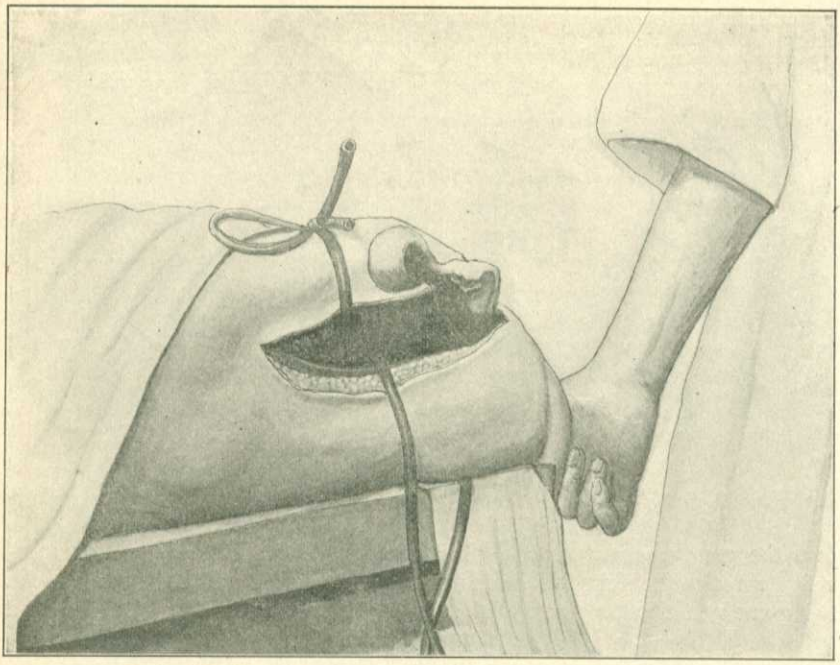

Fig. 645.—Senn's method of performing bloodless amputation at the hip-joint. Dislocation of head of femur and upper portion of shaft through straight external incision. Elastic constrictors in place, the anterior one tied (Senn).

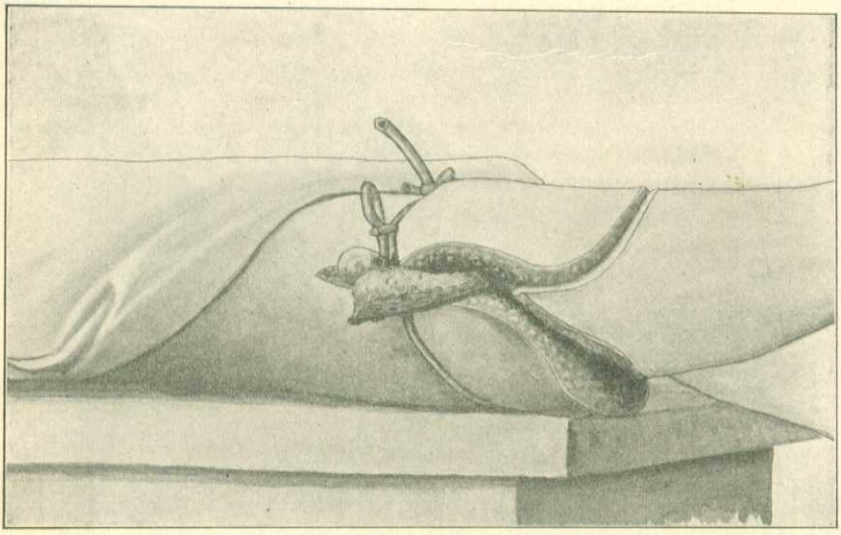

Fig. 646.—Elastic constriction completed by constricting the posterior segment of the thigh. Flaps formed including all the tissues down to the muscles (Senn).

Senn's Bloodless Method.—The elder Senn has devised a method for preventing hemorrhage during amputations of the hip-joint. He makes a straight incision, about eight inches in length, in the direction of the long axis of the femur and directly over the center of the great trochanter. This incision reaches about three inches above the upper margin of the great trochanter. The muscular insertions are divided close to the bone, and the thigh is flexed, strongly adducted, and rotated inward. The capsular ligament is divided at its upper and posterior aspect. While the thigh is brought into a position of slight flexion, the remaining portion of the capsular ligament is cut. Then the thigh is dislocated outward, and the ligamentum teres is cut. If this cannot be accomplished, the head of the bone is forcibly dislocated upon the dorsum of the ilium. After dislocating, the lesser trochanter and the upper part of the femoral shaft are cleared. The limb is now brought down in a straight line with the body, the thigh is slightly flexed, a long and stout pair of forceps is inserted into the wound behind the femur and on a level with the normal situation of the lesser trochanter, and the instrument is pushed downward and inward, two inches below the ramus of the ischium and just behind the adductor muscles. As soon as the point can be felt under the skin, an incision two inches in length is made upon it, and the instrument is forced through the opening. The tunnel in the tissues is enlarged by opening the forceps. A piece of rubber tubing three-quarters of an inch in diameter and four feet in length is caught about the middle with the forceps and is withdrawn. The rubber tube is cut in two at about the point at which the forceps have held it, and half of the tube is used to constrict the anterior segment of the thigh (Fig. 645) and the other half to constrict the remaining portion of the thigh (Fig. 646). Before the constricting bands are tied the limb is held vertically for a sufficient length of time to make it practically bloodless; the amputation is then completed (Senn's "Practical Surgery").

Other Methods.—John G. Sheldon ("Amer. Med.," April 19, 1902) has modified Senn's method as follows: He disarticulates the head of the femur and frees the upper part of the femur from its attachments. He then introduces a pair of long, stout artery-forceps behind the femur and clamps the femoral vessels. He forms the flap, removes the limb, and ligates the vessels. In this operation the surgeon can work rapidly and can make a flap of any size or shape, and is not hindered by a constriction apparatus; but this method does not cut off the bleeding from the obturator and the sciatic artery.

Larrey amputated by lateral flaps, and Liston by anteroposterior flaps. Forneaux Jordan's method consists in dividing the soft parts low down, tying the blood-vessels on the face of the stump, shelling out the femur from the soft parts, and disarticulating.