A manual of military surgery, [Confederate States Army], 1863

1863

# A manual of military surgery - Chapter IV: Amputations in general

# CHAPTER IV.

## AMPUTATIONS IN GENERAL.

An amputation is the complete removal of all the structures of a part, or of the whole of a limb. This may be effected either at a joint, or at any intermediate point. In the first case the knife suffices for the separation, and the amputation is said to be *in the contiguity.* In the last, or an amputation *in the continuity*, a perfect section demands the use of the saw or bone pliers. Whatever the seat of the operation, due care must be taken to preserve enough of the soft structures to cover, without tension, the cut or articular end of the bone.

In the standard methods of amputation, the integument is divided by circular, elliptical or hemi-elliptical incisions; or by a combination of the first and last forms.

In the first method, the soft structures are necessarily incised in succession from without inwards, or from the surface towards the centre. This plan may be pursued in the execution of the other methods; but they may also be wholly or partially completed by cutting out after transfixing the limb on the opposite sides of the bone at points *not quite* co-incident. The whole operation being effected on this plan, or by combining this with the cut from within outwards.

These standard methods have received names from the shape of the resulting wound. Hence the terms circular, flap and oval amputations. See figures 1, 2, 3, 6, plate I.

ARRANGEMENTS.—As in all operations, the necessary instruments, dressings, &c., should be placed in order, and within easy reach of the surgeon. The patient should occupy the required position. In all cases, that giving the operator entire command of the seat of amputation. The skin must be shaved for several inches above and below the line of incision. The assistants should take place as directed by the surgeon, and should, as far as possible, retain their relative posi-

tions to the end of the operation. Two points must be care-
fully attended to before the slightest wound is inflicted. If
an anæsthetic is used at all, see that the patient is *fully* under
its influence. Be sure the chief artery of the limb is com-
manded either by hand, or by the tourniquet. When the
tourniquet can be applied, *prefer* it to all other means of con-
trolling the local circulation, no matter what the surgeons
theoretical views with regard to the advantages of other
kinds of pressure. Be certain that the instrument is so ap-
plied that no struggles of the patient will impair its power.
The direction is sometimes given to place the tourniquet as
*far* as possible from the seat of operation. This is not a rule
for general guidance. The precept would be better enunciated
thus: Adjust the instrument so that it may compress the
artery against a bony surface, and let it be as *near* the line of
incision as may be compatible with a proper retraction of the
soft parts, and perfect freedom of action on the part of the
surgeon. When the command of a single large trunk will
not entirely arrest the circulation through the parts to be
sacrificed, be careful not to tighten the instrument until the
moment before the incisions are begun. When the condition
of the patient demands the greatest economy of blood, ele-
vate the limb, and bandage tightly from its distal end to the
point where the artery is to be compressed. In screwing up
the tourniquet let the movement be as rapid as possible.

The directions here given are somewhat precise and de-
tailed, because the success of an amputation, both as regards
the life of the patient and the quality of the stump, will more
often be secured by the strict observance of these simple sug-
gestions, than by the mode of amputation selected, or the
dexterous manipulation of the operator. One ounce more, or
less, of vital fluid, retained in the vessels, will often go far to
decide the issue. These preliminaries settled, the surgeon
may proceed at once to amputate in accordance with the me-
thod previously selected.

THE CIRCULAR METHOD (Figures 1, 2, plate I).—What-
ever the seat and mode of operation, if the patient is to be
anæsthetized, he should occupy the recumbent posture, and
should lie at length upon a table of such dimensions as will
exact the least possible restraint in the movements of the
operator.

The part to be removed, in the case of the larger amputa-

tions, should project beyond the edge of the table, and should be supported and controlled by an assistant. In the circular method the surgeon always stands on the right of the diseased limb in such manner, that his left hand may rest upon and command the part to be saved. An assistant, grasping the whole circumference of the integument a short distance above the seat of operation, steadily and evenly stretches the skin, by pulling in the direction of the body. If it has been found advisable to adjust the tourniquet near the line of incision, the retraction of the integument may be made previous to its application. The operator stooping, and encircling the limb with his right arm, holds the long amputating knife like a sword, so that its point presents downwards and towards himself—the heel of the instrument resting on the upper part of the skin to be divided. Here the incision begins, and is continued with a gently sawing motion, drawing the blade from heel to point, completely around the limb, to the spot where the cut commenced. At first the hand is prone and extended, subsequently supine, and lastly, prone and strongly flexed. During the progress of this procedure the surgeon rises, and at its termination has resumed the erect posture. The first incision should divide the skin and superficial down to the deep fascia. Many prefer to make two *semi*-circular cuts, whose extremities coincide. This proceeding is more easily managed, and is equally efficient, although it does not tickle the fancy of critics. In either case the integument should be cut at right angles to its general surface.

The question whether this and subsequent incisions shall be made transverse or oblique, with reference to its long axis, is decided by the comparative length of the muscular fibres on the different aspects of the limb. When these are nearly equal, the cut should be transversely, when unequal, obliquely circular. In other words, the divided skin and muscles should be longer on the side of greatest retraction, which will always correspond to the longest muscular fibres. In amputations of the thigh, for instance, at its middle or lower third, a transversely circular division of the soft parts will give an oblique or pointed stump. Here the long fibres of the sartorius, gracilis and great adductor retract more than those of the quadriceps, and carry the skin with them.

The next step in the circular method will depend somewhat on the point of amputation. In the thigh and arm,

where there is but one bone, and where the tissues are healthy, and slide easily on one another, two more circular incisions are made, in accordance with the directions already given. The one divides the more superficial layer of muscles; the other reaches to the bone. Each is made in a line with the margin of the superjacent structures, when strongly retracted by an assistant. The edge of the knife in these last incisions is somewhat inclined towards the proximal end of the limb. So, that as a result of the whole proceeding, there is a hollow conoidal wound, at whose apex the bone is divided by the saw. (Figure 2, plate I.)

Where there are two bones, or the soft structures, as in many secondary amputations, are too adherent to admit an even and thorough retraction, it is found better, before severing the muscles, to dissect and turn up the skin like a coat cuff. (Figure 1, plate ) In such cases endeavor as far as possible to hollow out the muscular layers by the proper use of the knife. If they should prove very unretractile, dissect the deep layer back from its periosteal attachments for an inch or more before the bone is sawed. When two bones are involved in the amputation, the section of the soft tissues between them forms a distinct step in the operation, and care should be taken not to introduce the knife with the edge upwards. The interosseous soft parts should be incised close to the seat of proposed bone section. When the conformation of the limb does not admit the ready reversion of the skin cuff, as just above the ankle, wrist or knee, in muscular subjects, it may be necessary to make a longitudinal cut, equal in length to the skin to be turned up, and meeting the margin of this at some point in its circumference—usually over a bone. The distance of the skin incision from the point at which it is intended to saw, the hard textures must be decided by reference to the dimensions of the limb. One-fifth the circumference of the latter will give the required length.

FLAPS, (Figures 37, 38, 39.)—In amputating by this method, the operator stands on the side most convenient to himself. Either side presents its advantages. If his position brings his left hand in relation with the proximal end of the limb, he can more readily grasp and elevate the structures, out of which the flap is to be fashioned, and can conveniently make with his thumb and fingers the points of entrance and exit for the trans-fixing knife. On the other hand, if his position

is reversed, he is better able to control and steady the parts to be removed during the latter stages of the operation; and he may thus, it is thought, prevent the binding of the saw or the splintering of the bone.

Flaps may be single or double; may be cut from within outwards, or by the reverse method; and they may be cut from either or both opposed aspects of the part to be amputated.

In making double flaps by transfixion, the operator grasps the soft parts with his left hand, his fingers and thumb being so placed on the opposite sides of the limb as to correspond usually to the extremities of its transverse axis. These points, with the intervening structures, are so elevated as to permit the ready passage of the blade on the side of the bone from which the flap is to be cut. A long bladed, sharp pointed knife is then thrust transversely, or obliquely (having due regard for the precepts already given concerning the unequal retractility of the muscles) through the part, an inch or two below the point elected for the bone section. The knife should graze the bone, and is made to cut its way gently downwards and outwards, so as to fashion a flap, whose length, without stretching, shall equal one-half the diameter of the proposed stump. In some cases it is found advisable to graze the bone in a downward line until sufficient length of the flap is obtained, and then to cut abruptly outwards. The withdrawn knife is again entered one or two inches below the original point of transfixion, and traverses the limb on the opposite side of the bone. A second, similar and opposed flap is thus made. The flaps are turned up, and, as in the circular method, the tissues are strongly retracted. An encircling sweep of the blade divides the remaining muscular substance and the periosteum close to the separated angle of the retracted flaps. The bone is sawed at the same point. When the flaps, owing to parcity of skin, are likely to be at all deficient, it will be well to dissect back the deep muscles from their periosteal connections (as already advised in cases of circular amputation) before using the saw.

It is evident that any proportion between the flaps may be obtained, according to the will of the operator or the exigencies of the case. It being always remembered, that in order to secure a good stump, one flap must be increased in length just in the same ratio that the other is reduced. These altered relations may be carried to the extreme, resulting in a single

flap on one side and a transverse cut on the other; giving a combination, so to speak, of the two principal methods just described.

In very muscular subjects better results may be sometimes obtained by cutting the flaps from the surface towards the centre. In such, too, one or other of the following plans may be adopted: Semi-elliptical skin flaps may be dissected and turned up, while the muscles are divided close to their base by a circular sweep down to the bone; or the skin flaps, made as before, may be simply retracted, and the muscular structures incised by transfixing and cutting outwards from their retracted margin; or the redundant tissue may be pared, as an after step in the ordinary flap operation.

Mr. Teale, of Leeds, has proposed a modified flap operation, (figures 4 and 5, plate I.) which presents the advantage (if it be an advantage) of withdrawing the line of cicatrix from the face of the stump, and for which he claims an extended success. Two flaps are cut from opposite aspects of the limb. Each is to possess a rectangular outline. They are to be of unequal length. The long one is to be a square, whose sides shall measure half the circumference of the part to be incised. The short flap is to be one-fourth of the length of its fellow. Their outline is to be traced with ink previous to the operation, as in figure 4. He directs the longitudinal cuts to be made first, and only through the skin. The transverse incisions are cut at once to the bone. Each flap is completed by dissecting upwards close to the periosteum; care is taken to select the long flap from that side of the limb not containing the larger nerve trunks and blood vessels. The bone is sawn transversely at the base of the flaps. The long one is doubled on itself, so as to appose its free end to that of the short one. These and the other margins of the resulting wound are held in apposition by sutures alone. No other dressing is used. The stump is elevated on a cushion, covered with a wire cage, and cleansed by sponging from time to time. The appearance of the lines of incision, when brought in contact in the manner described, will be understood by reference to figure 5, plate I. Theoretically, at least, we would be inclined to reject Mr. Teale's procedure, especially in field amputation. It produces a larger wounded surface and a more extended cicatrix than any of the usual methods.

OVAL METHOD, (figure 5, plate I )—This name is given

to an amputation in which the line of incision presents two limbs parting from the same point, to give the figure of an inverted V on one-half the limb, which, being rendered continuous, circumscribes the remaining half with a semi-circular outline. The apex of the Λ is made to correspond to the seat of the desired bone section or disarticulations, and should, if possible, lie opposite to the great nerves and arterial trunks. The division of the soft parts is made at once to the bone, cutting from the surface; or, still better, the skin may be first divided, making a second step of the separation of the deeper tissues. In disarticulations at some of the larger joints, and in some amputations in the continuity, it is found easier and every way better to connect the limbs of the V by transfixing at their terminus, and cutting from without inwards.

AMPUTATIONS IN THE CONTIGUITY.—The nature of these operations has already been mentioned. They are also called disarticulations. While their performance requires fewer instruments than those just described, it involves the observance of the same general rules as to preparations, arrangements and character of incisions. Due regard must be had to the conformation of the joint, the seat of operation, and every care must be taken to secure a sufficient covering of soft tissue. An accurate anatomical acquaintance with the parts concerned is an essential prerequisite to the dexterous accomplishment of the proposed task.

The recognition of the articular line is to be derived from its constant and invariable relation to bony prominences, skin creases and tendinous attachments, visible through the integument, which, at the joints, fits more closely upon the hard structures than in the continuity of the limb, and permits us, in the healthy state, to ascertain without difficulty the line of junction between any two segments of the skeleton. When swelling masks these guides, it is possible, ankylosis being absent, to gain the desired information by moving the parts to be amputated upon that to be preserved, while the latter is rendered fixed and immovable. The line separating the points of motion and quiescence, ascertained by firm pressure during the manipulation mentioned, will, of course, give the seat of articulation. When this and other expedients fail, we have, with rare exceptions, an opportunity for comparison with the opposite limb. An accurate measurement of the distance from parts plainly seen on both sides of the median plane will give

the desired knowledge. The exact position of the joint ascertained, the configuration of the articular surfaces, the attachment, shape and extent of the ligamentous and tendinous bonds of union must be present to the mind in effecting a speedy and skillful separation of the injured and healthy segment.

The covering for the bony stump is obtained by the practice of such incisions of the soft structures as are used in amputations in the continuity, due allowance being made for the retractility of the soft tissues, which, in the muscles, is always in exact ratio to the length of the fibres connecting the parts to be separated. As specific rules will be furnished on this point in the description of the individual disarticulations, it is not deemed necessary to anticipate them in a consideration of the general principles to be observed.

From what precedes we have learned that all amputations may be performed by one of two principal methods, or by their combination. These are the circular method and the method of double flaps. The single flap mode and *"methode ovalaire"* may be justly regarded an association of steps derived from the two first. The former, giving a semi-circular cut on one aspect of the limb; the latter, presenting at one end two distinct flaps; at the other, a continuous line of incision.

Formerly, much time was spent in contrasting the relative value of the flap and circular operations. Now, a recital of all the arguments on both sides is almost useless. The majority of leading surgeons seem to have quieted themselves with the conviction, that, *"cæteris paribus,"* the circular operation is *par excellence* the operation to be selected whenever the circumstances of the case will permit. This statement, perhaps, carries greater weight in military than in civil practice. Still it will not be amiss if the surgeon will consent to forget the business of the advocate and look somewhat into both sides of the question. He will do well, until he attains the requisite facility, to practice each of the operations named whenever a suitable opportunity presents, because what may be true as a general rule admits of undoubted exceptions. Thus, in amputation at the hip, the double or single flap operation will be found preferable. In the removal of the fingers and toes, and the extreme metacarpal and metatarsal bones, the oval method should be selected. Let him bear in mind, in all amputations, that he sacrifices a part to save life, and that, in doing this,

it is desirable to save as much limb as possible. A circular operation makes a smaller wound and cuts the arteries transversely. For the first reason, it shocks less and gives a less extensive suppurating surface—makes a more compact stump, and, therefore, bears the jars of transportation better. For the second reason, the small arteries will either contract permanently, or will be certain to show themselves at once and permit ligation, and will thus guard against subsequent hemorrhage. The single, or even the double flap, method may permit us to save more limb. Both may be performed with great rapidity, and both, under favorable circumstances, provide a thicker cushion for the bony stump. The first is a questionable advantage if chloroform be used—the last is not a certain result. But, as before indicated, it is not desirable to be too obstinate in our prejudices in favor of either method, since, in full practice, we will certainly encounter conditions where we shall only be able to do full justice to the patient when capable of adapting one's self to the special exigencies of the case. In other words, the surgeon should be prepared to undertake any variety of amputation.

All amputations involve at least four steps: I. The incision of the soft parts. II. The bone section, or disarticulation. III. The ligation of the vessels. IV. The dressing of the resultant wound. *The division of the soft structures* is governed by the principles already given.

*The bone section* is effected by the saw, in the case of the larger bones—by the bone pliers, in the case of the smaller bones. Previous to the use of the saw, the periosteum should be cleanly incised by a circular knife cut. The circumference of the bone section should coincide with this periosteal groove. If there is but one bone, the saw may be applied horizontally, and should first be drawn from heel to point with a firm, steady pressure, the blade being meanwhile guided and supported by the thumb-nail. This begins a cut, in which the instrument may be worked backwards and forwards rapidly, with a light, sweeping movement. During progress, it is well to change its direction from horizontal to oblique, and, by the termination of this step, it is best to work the saw vertically. Where two bones are to be cut, the saw is applied to both simultaneously, but the section of the more slender, or most movable, is first to be completed. In the leg, the fibula—in the forearm, the radius—is first to be divided.

*The disarticulation* presents differences dependant on the
seat of the amputation. It includes the division of all the
immediate bonds of union constituting the articulation, but
especially the section of the ligaments, which bear constant
relation to the nature of the joint and the character of its
movements. This division can only be performed with ce-
lerity when we know where, how and what we ought to cut.

*Ligation of the Vessels.*—As a general rule, the arteries
alone require ligature. When bleeding from a vein is obsti-
nately persistent, despite the elevation of the part, a ligature
may be applied. It is well to avoid the use of this resource.
All arteries seen to bleed had better be secured with ligatures,
which should always be smooth, round, and as small as may
be consistent with sufficient strength, provided the arterial
coats are healthy. Usually one end of the ligature is cut off
close to the knob. This is really unnecessary trouble. The
sharp, cut extremity is a source of as much, if not more, irri-
tation than the smooth, continuous thread.

*The Dressings.*—Hemorrhage having entirely ceased, and
the raw surface being thoroughly cleansed by the free use of
cold water and the sponge, the lips of the wound are to be
adjusted and held in apposition by ligatures, adhesive strips
or bandages, or by a combination of two or more of these means
as the case may require. In the circular operation, any direc-
tion may be given to the line of union. That is, it may be
made transverse, vertical or oblique, in either sense. When
free suppuration is to be anticipated, it is found better to facili-
tate the draining off of the discharges by favoring their gravi-
tation to one angle of the wound. The line of union is there-
fore generally made oblique. In the flap or oval operations
no choice is permitted. We are per force controlled by the
line of incision. In any case the ligatures are arranged in
groups, to be drawn out at the nearest angle of the wound.
The interrupted suture is most in use; the distance between
individual stitches being governed by our views as to the
probability of immediate union, and the consequent necessity
of close apposition. Metallic sutures are preferable. Strong,
even, well waxed silk thread will answer very well. Flax or
cotton may be substituted when neither of the former can be
obtained. If not contraindicated, keep up the administration
of the anæsthetic during the introduction of the sutures. The
patient will thereby be saved much undoubted and unneces-

sary suffering. The application of adhesive strips will depend partly on the degree of support needed to prevent dragging on the sutures, and partly on the size of the wound. In *small* wounds, where the arteries have ceased to bleed *without* ligature, adhesive strips, *accurately* closing the line of incision, constitute an essential first dressing. Sutures may here be entirely omitted, and immediate union is sought by the perfect apposition of the edges of the incised integument, and the careful exclusion of air. This refers to amputation through *healthy* tissues. In the larger amputations a certain amount of suppuration is almost inevitable under the most favorable circumstances, and must be anticipated. If from no other surface, it will be certain to occur along the track of the ligature groups. Provision must be made to permit the free exit of this pus by leaving the corresponding points uncovered by anything except an absorbent material. In these cases where the patient is to be subjected, at once, to the jars of transportation, interrupted adhesive stripping or a supporting bandage is demanded. *Wet* dressing is unnecessary in amputations through normal textures. And it is well to remember that we should endeavor to secure the immediate union of as much of the line of incision as possible, and that this end can only be attained by a perfect opposition of the corresponding integumental edges.

## Amputation of the Upper Extremities.

Observation would seem to teach that the hazard of an amputation is *cæteris paribus* in direct relation with the dimensions of the resulting wound, and the length of the part removed. Differently expressed, the larger the wound and the nearer it is to the proximal end of the limb, the greater the risk to life. The inference is that we should always endeavor to save as much of the diseased or injured segment as possible. This rule of general acceptance is especially applicable to the upper extremity, and especially to its terminal segments. In nothing, perhaps, are surgeons so much in accord as with reference to the duty of preserving, within certain limits, the smallest fragments of the fingers. Hence, short as are the phalanges, it is customary, whenever possible, to cut in the continuity as well as to disarticulate. In either case, it is well to note a brief outline of the structure of the parts concerned.

The skeleton of each finger is a jointed column (figures 7, 8, plate I.; figures 9, 10, 11, plate II.) composed of three long segments surmounting the heads of the metacarpal bones, and joined end to end. Each is shorter than the other, proceding from the upper to the terminal phalanx. The extremities of each segment are broader than the intermediate portion, which is convex in both directions on its dorsal, concave in both on its palmar aspect, and tapers slightly from above downwards. There are three joints in each finger; one between the basal phalanx and the metacarpal bone, the other two, resulting from the apposition of phalanges. The metacarpal joint is condyloid. The articular surfaces are more or less elliptical. The metacarpal is convex in both senses and prolonged towards the palm, so that its long diameter is antero posterior and opposed to the short diameter of the corresponding end of the phalanx, whose articular extremity is concave. (Figure 11, plate II.) The phalangeal articulations are both of the ginglymus variety. These are formed by the distal end of the second and middle phalanges, each bearing a surface fashioned like the segments of a pulley, and the proximal extremities of the second and terminal phalanges, conversely figured. That is, bearing a central antero-posterior ridge, flanked on either side by a glenoid depression. (Figure 10, plate II.) In each case the long diameter of the joint is transverse. In each case, too, this diameter of the upper end of the more distant phalanx exceeds somwhat in dimensions the opposed extremity of the bone it joins. The bonds of union between all these segments are two strong lateral ligaments, attached to non-articular depressions, flanking the extremities of the contiguous bones; while the flexor and extensor tendons cross and are closely applied to the palmar and dorsal aspects of the joints. The sublimis attaching itself to the palmar margins of the second, and the profundus to the bases of the terminal phalanges; the common extensor getting connection with similar points of the dorsum. The principal blood vessels and nerves, two for each finger, skirt the junction between the lateral and palmar surfaces. The integument clothing the parts is thin and loose, laterally and behind; thick and regularly marked in front. Where we find with tolerable constancy three a principal and distinct transverse creases or lines bearing a nearly invariable relation to the joints just described. (Figure 8, plate I.; figure 9, plate II.) The middle line *corresponds*

to the joint between the metacarpal and second phalanges. The line nearest the matacarpal bone is twelve or thirteen lines *below* the articulation of that bone with the basal phalanx ; while the terminal skin crease is about one line and a half *above* the distal phalangeal joint ; (*f*, figure 42.)

AMPUTATION OF THE FINGERS—*between the joints*—may be performed by the circular, double or single flap methods. In the circular operation the skin and areolar tissue are divided by the first cut, and retracted to a sufficient distance, when a second sweep incises the theca tendons and periosteum. Bone pliers or a fine saw will cut the phalanx. (Figure 12, plate II.) Double flaps may be dorsal and palmar or lateral. Each is semi-elliptical, with its convexity downwards. In the first case, the palmar cut may be made by transfixing and grazing the phalanx. The other flaps can only be fashioned by incising from without inwards. One may be so increased in dimensions as to furnish alone a sufficient skin covering for the stump, the other being altogether omitted and replaced by a transverse division of the tissues. When this single flap is palmar, it gives the best possible result, throwing the line of cicatrix in the dorsal aspect of the finger. But little art is needed in the performance of these amputations. The great point is to make such calculation for retraction as will bring the bases of the flaps to coincide with the point where it is desired to cut the bone. Otherwise, we shall have to sacrifice an unnecessary amount of phalanx, just what we wish to save.

DISARTICULATIONS OF THE PHALANGES.—In these, as in all amputations in the continuity, the first step is to recognize the articular line. A due regard to the general precepts and anatomical outline of the parts, already given, will conduct to the desired end. Here, as in the operations between the joints, the two principal methods, with their obvious modifications, may be practised. Such accuracy of eye and judgment, as may be required to make allowance for retraction of the soft parts, will be especially needed. Remember that it is easy to pare redundant integument, while one cannot shorten the bone and at the same time preserve its articular end. The position of the joint certainly ascertained, the circular division of the skin at the proper level presents no peculiarities ; the lateral ligaments are divided, and the joint may be entered from either aspect, cutting first either the dorsal or palmar tendon ; finishing the separation by the

division of its opponent. Flaps may be fashioned, as for amputations, in the continuity. The palmar flap, when required, by transfixing one or two lines below the articular junction, and cutting downwards and outwards. Where a single palmar flap is proposed, it may be made, as suggested, previous to, or after, disarticulation  In the first method, (figure 14, plate II.) the hand is to be held supine. The flap is commenced by transfixion. When finished, it is turned up and retracted. The lateral ligaments, flexor and extensor tendons, and dorsal integument are incised by an almost continuous movement from within; traction being made by the surgeon upon the part to be removed, to render tense the fibrous bonds of union and facilitate disarticulation, while retraction of the skin secures its sufficient preservation. If it is proposed to disarticulate before carving the palmar flap, the skin must be first incised transversely a line below the joint, (figure 13, plate II.) the ends of this cut coinciding with the level of the palmar aspect of the articulation; the hand meanwhile being prone and the part to be removed somewhat flexed. The joint is traversed as before, but from behind forwards. The same tractions are exercised, and disjunction being effected, the knife is passed in front of the phalanx, which, at this moment, is to be extended, to begin the palmar flap, completed in the usual way.

AN ENTIRE FINGER may be removed at the metacarpal joint by either of the standard methods.

*The circular* is the least desirable in practice. In this, the line of incision of the soft tissues is made to correspond with the upper transverse palmar skin crease *c*, Figure 8, Plate I. Subsequent dissection and disarticulation complete the operation.

*Double flaps* should be lateral. In this and in the oval method, first recognize the articulation. When there is little or no swelling, the ligaments and tendons will so yield to strong traction as to permit a slight separation of the bones. The atmospheric pressure on the soft tissues, will force them into the joint, whose line is then indicated by a slight depression, visible at the sides and behind. Where the condition of the parts will not admit this procedure, the distance of the joint from the transverse palmar crease, (rarely wholly effaced) about one inch may be measured. The other fingers being held aside by an assistant, the parts to be ampu-

tated prone and somewhat bent, is fixed by the left hand of the operator. The incision begins over, or a little above, the back of the articulation, and is carried obliquely downward to the web between the fingers. This cut is prolonged to a corresponding point on the palm. The soft parts on the opposed side are divided in the same manner. This cut, like the first, beginning and terminating at the point already mentioned ; so that both incisions coincide at their extremities. Disarticulation is then effected by a division of the lateral ligaments and the tendons. In Lisfrancs' operation, the joint is entered and the bones are separated after the completion of one flap; the second being formed by cutting from within outwards. The dotted lines diverging from *a*, fiigure 15, plate II. show the line of incision on the dorsal aspect of the part; *c*, *b*, figure 16, plate III, show the flaps where fashion and where disjunction has been completed. While making this palmar cut, the finger is to be extended, and the hand so elevated as to permit the eye to guide the knife.

*In the oval method*, the diverging dorsal incisions, instead of converging to a point on the palm opposite to where they began, are made to coincide and become continuous with the palmar transverse skin crease. The knife, on reaching the web, follows the direction of the skin-line, while the finger is extended, and reaching its opposite extremity mounts again on the dorsum, retracing its steps to the point whence it started ; the finger, meanwhile, resumes the semi-flexed position. The dorsal view, before disarticulation, is traced in figure 15, plate II. by the lines *a*, *c*, *b*, *a*. The appearance when the amputation is finished, is seen in figure 16, plate III. *a'*, *b'*, *c'*, *d'*.

The expanded head of the metacarpal bone is quite a prominent object after this operation. With a view to the production of a more agreeable and convenient looking hand, many surgeons of eminence counsel the removal of this head, thus converting what was intended as a disarticulation into an amputation in the continuity ; performing, in fact, a double operation to accomplish a single object. All must admit that the extent of and the risks of the operation are thereby augmented. In the case of the middle and ring fingers, where appearance is most to be served, this last step involves greater difficulty and more violence to the soft structures, than in the case of the index and little fingers. The writer would always

prefer to leave the metacarpal head of the fore-finger undisturbed. Its opposition to the thumb is too valuable to throw away for appearance sake. In the other fingers, a certain amount of atrophy will at last occur; so that it is, all things considered, a matter of some doubt whether it is good surgery to do more than mere disarticulation, where it can be avoided. If the taste of the surgeon, the wishes of the patient, or the nature of the injury or disease necessitate a further sacrifice of bone, it may be effected by prolonging *ab initio* the dorsal incisions to a point above the site of the desired section. The bone is cleared by close dissecting along its sides and palmar surface, and bone pliers are used for its division.

AMPUTATION OF FOUR FINGERS at the junction, between the phalanges and the metacarpal bones, may be done in *Lisfranc's method*, figure 17, plate III. The hand to be operated on is held prone. The fingers, slightly flexed, are grasped by the operator, while he steadies the part and abducts the thumb. An incision through the skin, whose curve is parallel with the articular line, is made on the dorsum, half an inch below the joints. The assistant meanwhile retracts the integument. The exposed extensor tendons are cut in succession on a level with the metacarpal heads. The lateral ligaments and flexor tendons are then divided; the knife, (figure 17, plate III.) passed in front of the disjoined phalanges, cuts out a palmar flap, ending at the margin of the web  A slight modification of this operation will answer for two or more contiguous fingers.

THE PHALANGES OF THE THUMB may be removed by methods and rules similar to those given for the fingers.

SINGLE METACARPAL BONES can be amputated *in their continuity*, at any point, by extending upwards the dorsal portion of the incisions practised in the disarticulation of the proximal phalanges. Care must be taken to cut close to the periosteal surface in dissecting the soft textures, that the larger palmar nerves and blood vessels may escape injury. Bone pliers must be used for the middle and ring fingers.  A saw may be applied to the little and fore fingers, subsequent to the adjustment of a retractor. These last should be cut obliquely downwards from the corresponding margin of the hand, *a*, figure 18, plate III. The metacarpal bone of the thumb, however, is to be divided at right angles to its long axis.

THE FOUR METACARPAL BONES of the fingers may simultaneously be amputated *in continuity* by the single or double flap methods. The flaps are dorsal and palmar, or only palmar. The last may be made by transfixion, although its margin can be more neatly fashioned by cutting from without inwards. After the bones are cleared, a five-tailed retractor protects the soft parts during the application of the saw, (figure 19, plate V.)

AMPUTATIONS AT THE CARPO-METACARPAL JOINTS.— The upper extremities of the five metacarpal bones form an irregular articular line with the second row of the carpus, whose general direction gives a curve with the convexity downwards. The metacarpal bones of the fingers are also connected with one another. Leaving the thumb out of consideration, these joints are all of the arthrodial variety and permit but slight movement of the several pieces entering into their composition. The immediate bonds of union are short fasciculated filaments, attaching the dorsal and palmar aspects of the bones, with dense interosseous fibres crossing between the opposed surfaces, (figures 20, plate III., 28, plate IV.) give a general idea of the mutual relations of the several pieces. The carpo-metacarpal joint of the thumb is distinct and independent. It is an articulation by mutual reception, in which the trapezium and metacarpal bone offer surfaces alternately convex and concave in opposite directions, with the short diameters of each opposed to the long diameter of the other. The ligamentous connection is a loose fibrous capsule, permitting all varieties of motion except rotation. Here the synovial membrane is also distinct, while in the other carpo-metacarpal and inter-metacarpal joints it is a mere dependence of the common synovial membrane of the whole carpus. The extremities of the general articular line (*h*, *f*, figure 28, plate IV.) can usually be recognized with facility, unless swelling marks the configuration of the parts. Forced adduction and opposition of the thumb produces a dorsal prominence of its carpal end. The corresponding extremity of the fifth metacarpal bone projects sufficiently in any position, beyond the ulnar margin of the unciform, to be manifest to the touch in ordinary conditions. Besides, when the hand is between abduction and adduction, each of the points referred to is about one and a quarter inches below the styloid processes of the radius and ulna. Remembering the direction of the curve, formed by the joints between

the two, no great error can arise in ascertaining their position. Removal of the metacarpal bone of the thumb is always a separate operation. The other pieces of the series may be taken away separately or together.

THE FIRST METACARPAL BONE may be conveniently amputated by either the flap or the oval methods.

*Flap Operation.*—An assistant commands the fingers and supports the hand. The operator abducts the thumb to be sacrificed. All the structures connecting the thumb and forefinger are divided by an incision, carried from the centre of the connecting web to the base of the metacarpal bone. Care should be taken to graze the bone as the blade approaches its upper end. Otherwise, the radial artery, as it traverses the first interosseous space, will be wounded. The edge of the knife, arrested by the trapezium, is directed towards and opens the joint. Disarticulation is effected by light touches of its point. The blade, passed around the upper end of the bone, is then made to cut downwards and outwards, so as to detach an antero-external flap large enough to cover in the surface laid bare by the first incision. Figure 21, plate III. shows the position of the hand and knife just before the disarticulation is begun. The dotted line indicates the shape of the outer flap. To obtain the desired extent of covering, the bistoury is carried beyond the junction of the phalanx and metacarpal bone before cutting out.

*The oval method* of Malgaigne, as modified from Scoutetten. An incision starts six lines above the joint on its dorsal aspect. An inch below, it divides into two slightly diverging branches, whose greatest separation corresponds to the width of the thumb at its phalangeal end of the metacarpal bone. Here, each cut approaches the palmar surface, across which the two coincide at the level of the web. This incision may be practised by a continuous movement of the knife down one side, across the palm and up the other, to the point where it meets itself. Clearing the bone by close dissection and disarticulation form the last steps of the operation. *a, b* and *c*, figure 22, plate IV. show the line of dorsal incision. In figure 23, plate IV. disarticulation is being effected; *a*, shows where the cut divides.

*Liston's method* is more elegant than either of those just described, and agrees with the last in avoiding a palmar cicatrix. It is thus given by Erichsen, "The point of a long

narrow-bladed bistoury should be introduced well on the palmar aspect of the carpo-metacarpal articulation, carried over this, which it opens, and the dorsum of the hand as far as the web    The point of the knife should then be pushed downwards through the ball of the thumb, transfixing this and issuing where the incision commenced.  It is next made to cut outwards, keeping next to the metacarpal bone, which is readily twisted out, the remaining attachments being separated by a few touches of the knife.'  In order to avoid an awkward crossing of the hands, on the part of the operator, who is not ambidextrous, in amputating the right thumb, the steps of the operation are reversed.  The ball is first transfixed to make the palmar cut; next, we have the dorsal incision and disarticulation.

THE SECOND METACARPAL BONE is usually removed by the oval method.  A glance at figure 20, plate III. will show how this bone joins three pieces of the carpus, and, on the ulnar side, with the third metacarpal.  The direction and extent of the several articulations, when viewed from behind, are seen in the plate.  A point, one and a quarter to one and a half inches below the styloid process of radius, marks the level of the joint with the trapezium.  The dorsal incisions practised in this operation are shown in figure 20, plate III. *a*, *b* and *c*.  These begin just above the joint, descending to the margin of the interdigital web within and to a corresponding point without, become continuous by following the palmar skin crease.  The sides of the bone are cleared by close dissection; the dorsal, external, interosseous and palmar bonds of union are severed in succession; and lastly, the wound being opened by an assistant, who commands the thumb and fingers, the knife is laid flat side in front of the osseous segment, whose remaining connections are then divided by cutting downwards.  The last step of the operation is given in figure 25, plate III. where *a* marks the point of the bistoury and *b* the radial edge of the metacarpal bone.  Some surgeons prefer, in this operation, to practise a longitudinal cut over the radial margin of the bone, which divides near its head into two diverging branches.  One of these crosses the dorsum in an oblique curve to the interdigital web ; the other, the palm, to the same point.

THE THIRD AND FOURTH METACARPAL BONES may be disarticulated by incisions and dissections similar to those just

described. The difference in the number and direction of their carpal joints may be learned by consulting figure 20, plate III.

THE FIFTH METACARPAL BONE may be removed either by the oval or single flap operations. The joint is most easily found by tracing downwards the ulnar margin of the bone upwards. A prominence, surmounted by a distinct depression, is encountered. The point of junction between the two corresponds to the joint. Here, or a little above, in the *oval method*, the incision is begun, and is carried nearly as far down as the head of the bone, where it divides into two branches. One crosses the dorsum of the proximal phalanx and descends on its radial side in an oblique curve, to terminate at the margin of the interdigital web, while the other is carried as far as the ulnar end of the palmar skin crease, whose direction it then follows, and so meets the first. The separation of the soft tissues and the division of the ligaments are steps easily accomplished. The joint is entered from within and behind, the edge of the knife being directed obliquely downwards and outwards. In figures 26 and 27, plate IV. are respectively traced the line of incision and the resulting cicatrix.

*The flap operation* is performed thus: The hand being prone, the structures of the hypothenar eminence are grasped by the fingers and thumb of the operator, who lifts them beyond the ulnar margin of the bone; close to this, and on a level with the carpal joint, the knife is thrust in somewhat obliquely from back to palm; and the flap fashioned by cutting downward, hugging the bone all the way, should end opposite the margin of the interdigital web. This is turned back. The skin is dissected and sufficiently retracted to completely clear the upper end of the interosseous space, when the knife is again entered, its point passing out at the same spot as before. Grazing the radial margin of the metacarpal bone, all the interdigital textures are divided. Disarticulation is accomplished as in the former case. The flap will be found adapted to cover the exposed surface.

*The metacarpal bones of the four fingers* may be simultaneously separated from their carpal connections by Maingault's method. The operation is thus described in Bernard and Huette (figures 29 and 30, plate V.):

1st. The hand being held in a position of forced supina-

tion, recognize at its outer border the articulation of the first metacarpal bone with the trapezium, and at its internal side the articulation of the unciform with the fifth metacarpal. 2d. Introduce a small straight knife between the bones and the soft parts, carrying it a little below the projections formed by the unciform and the trapezium, so as to bring out its point below the thumb.   3d. Carry the blade of the knife along the anterior surfaces of the metacarpal bones, and cut out a large flap of an elliptical outline.   4th. Then turn the hand in the prone position, and make a semicircular incision across its back, two-thirds of an inch below the line of the articulation, and carrying the knife through the tissues, connecting the thumb with the index finger, join the first incision. Whilst an assistant is drawing the integuments upwards, the surgeon, holding the metacarpus in his left hand, proceeds with the disarticulation from the front of the hand, commencing with the metacarpal bone of the index or little finger, according as he is operating upon the right or left hand.

AMPUTATION AT THE WRIST-JOINT.—The radio-carpal articulation is a condyloid joint.   The articular surface at the lower end of the radius, taken together with the triangular-fibro cartilage, connecting this with the ulna, gives a shallow elliptical concavity whose long diameter is transverse.   This is opposed and accurately adapted to the convexity presented by the contiguous upper faces of the scaphoid, lunar and cuneiform bones of the carpus.   The joint is flanked within and without by the styloid processes of the ulna and radius, from whose extremities proceed strong lateral ligaments.   Anterior and posterior fibrous bands cover the front and back of the joint and complete its ligamentous connections.   The articulation is still farther strengthened on these aspects by the flexor and extensor tendons of the hand and fingers, confined by their respective annular ligaments.   The radial and ulnar arteries, their accompanying and the median nerve cross the junction between the hand and fore-arm.   The skin behind is loose, thin, and covered with more or less hair, that in front thicker and less moveable.   Figure 28, plate IV. presents an outline of the skeleton of these parts; *c* and *d* marking the extremities of the joint in question.   The recognition of this joint is usually attained without difficulty by tracing downward the outline of the radius and ulna, until the position of the styloid processes is distinguished.   Malgaigne states that

10

the joint is two and a half lines below their level.  When the hand is strongly flexed, the transverse ridge on the front of the radius may be felt on the outside of the radial flexor tendon.  The articular line is just below this.  Strong flexion of the hand will also produce a rounded prominence at the back of the wrist.  The summit of this projection is just below the joint.  There are usually three transverse skin-creases in front of the wrist.  According to Velpeau, the middle one overlies the articulation.

The circular and flap methods are both in use for the removal of the hand.

*Flaps* may be single or double.  The former may be cut from either dorsum or palm.  The single flap operation of Denonvillier's is performed as follows:  The hand being prone and the skin strongly retracted towards the elbow by an assistant, the thumb and index finger of the surgeon are placed as guides on the styloid processes.  A curved dorsal incision, with the concavity downwards, is made through the skin and areolar tissue, parallel with and two lines below the joint.  Farther retraction of the skin and flexion of the hand expose the subcutaneous structures.  Another cut similar, in direction to the first, divides the fascia tendons and posterior ligaments.  The lateral ligaments are incised, and the knife, passed into the articulation and in front of the carpus, fashions an anterior flap two inches or more in length.  Care should be taken to avoid the pisiform bone by the direction given to the edge of the knife.  The tendons, if too long, should be clipped before adjusting the parts for suture.  Avoidance of the pisiform is easier in theory than in practice.  It may be safely stated that a neater result can be obtained by cutting on both sides from without inwards, whether in making one or two flaps  In figure 32, plate V. the palmar line of incision is traced.  Figure 33, plate V. shows the position of the parts at the moment disarticulation is effected.

*Circular Method.*—One assistant supports the hand; another holds the fore-arm midway between pronation and supination, and retracts the integument.  A circular cut is made through the skin at the base of the thenar and hypothenar eminences.  The skin is dissected back and turned up high enough to expose the joint.  A second incision at this point incises the fascia and tendons.  The joint is opened from behind, and all its connections severed.  The lips of the wound

are brought together transversely. In these operations the brachial artery must be compressed. The radial and ulnar always, and the interrosseous sometimes require ligature. Figure 31, plate V. shows the knife applied to make the second incision. Some surgeons prefer to remove the styloid processes. They may be cut with bone pliers.

AMPUTATION OF THE FORE-ARM, says Legouest, may be performed at any height. The rule is to save as much as possible, although Larrey only favored operations above the lower third, as avoiding the danger of inflammation of the tendinous sheaths. Any of the standard methods may be adopted, but the circular is preferable in the opinion of most surgeons in the lower half. Baudens recommends the flap operation in muscular subjects, because of the difficulty of reflecting the skin. One or more lateral incisions, however, as already explained, in no wise injurious to the result, will obviate this objection. The French statistics show these to be the most successful of the larger amputations. In all cases the circulation in the brachial artery should be well commanded. And, on account of the free anastomosis of its branches, the tourniquet is found the best means of compression.

*Circular Method.*—The fore-arm is placed midway between pronation and supination, and held by an assistant, who retracts the skin. A second assistant supports the hand. The surgeon, armed with a double-edged, sharp-pointed knife, makes a circular cut through the skin and areolar tissue down to the deep fascia, two or three fingers' breadth below the point at which it is desired to saw the bone. The integument is detached from the fascia and turned up. A second circular cut is made to sever the muscles with a sawing motion, close to the margin of the reflected integument. The interosseous structures are cleanly divided on the same level, by transfixing the space obliquely on opposite sides of the limb; and the periosteum is incised as high as the retraction of the muscles, assisted by a three-tailed retractor, passed between the bones, will permit. The saw is applied to both bones at once, completes *first* the section of the radius. The radial, ulnar and interosseous arteries are tied, and the lips of the wound so applied as to give a transverse cicatrix. In figure 34, plate V. the knife is seen as applied for the second incision.

*The double flap operation* is thus described by Mr. Joseph

Lister: "In front, when the muscles are in large amount, transfixion may be adopted. Behind, the presence of the two bones prevents this, except near the wrist, where it may be effected, provided the soft parts have their natural laxity, by pinching up the skin and passing the knife as close to the radius and ulna as possible. When, after the integument has fallen back to its usual position, the extremities of the wound will be placed so far forwards, that the knife can be introduced through them in forming the anterior flap." "The surgeon standing on the (patient's) left side of the limb, [a matter of taste,] and holding it with the dorsal surface towards him, enters the knife a little to the palmar side of the bone that is further from him, and cuts through the skin and fat, so as to shape a rounded dorsal flap, terminating a little to the palmar side of the nearer bone, where he at once pushes in the point of the knife, so that it may pass in front of the bones, and emerge at the place where the operation was commenced, and cuts out a fleshy palmar flap downwards and outwards. He then dissects up the dorsal flap; and the soft parts being drawn back by an assistant, clears both bones thoroughly about three-quarters of an inch higher up, and applies the saw. If the median or ulnar nerve is exposed in the palmar flap, it should be shortened with the scissors to prevent the occurrence of painful symptoms as the stump heals."

DISARTICULATION AT THE ELBOW-JOINT.—This operation can be performed expeditiously only by those who are familiar with the configuration of the articular surfaces and the position of the ligamentous and tendinous connections. The joint is a ginglymus, into whose formation the humerus and both bones of the fore-arm enter. Figures 36, 37, plate VI. $a, c, d$. The lower end of the humerus presents within, an articular trochlea, surmounted in front and behind, by the coronoid and olecranon cavities, for the reception of the ulnar processes of the same name, whose larger sigmoid depression is adapted to the trochlea; without, a rounded head, which corresponds to a cup-like depression at the upper end of the radius. A groove separates the two. The antero-posterior curves of these surfaces are all segments of circles, varying in diameter. Marked non-articular prominences, easily distinguished through the skin, flank the parts just described. These projections, distinguished as the internal and external condyles

of the humerus, give attachment to the upper extremities of
the strong lateral ligaments of the joint, whose lower ends are
respectively connected with the inner margins of the coronoid
and olecranon processes, and with the annular ligament. The
latter is a fibrous band, thrown around the head of the radius
to bind it to the lesser sigmoid cavity.    Anterior and posterior
ligaments also fasten the bones of the fore-arm to the humerus.
The brachialis muscle is applied to the front of the joint,
which is crossed by the tendon of the biceps and in part by
the muscles, taking origin at the inner condyle.    The brachial
artery and median nerve descend on the same side, the radial
nerve trunk lying without.    The posterior aspect is in part
covered by the anconeus and the extensor muscles of the
fingers coming from the outer condyle.    The ulnar nerve
trunk crosses within the olecranon, which process forms a
prominent sub-aponeurotic projection, rising half an inch
above the interarticular line during extension of the fore-arm,
and giving attachment to the triceps muscle, is to be distin-
guished through the integument, no matter how great the
swelling.    The recognition of the articular interline is gener-
ally derived from reference to the condyles.    Its outer end is
three and its inner six lines below the corresponding projec-
tion.    As the condyles form the extremities of a horizontal
line, the general transverse direction of the joint is oblique
from without and above, downwards and inwards.    Figure 36,
plate VI. gives a front view of the elbow joint, in which $a$
marks the humerus, $c$ the radius, $d$ the ulna, $b$ the radial tu-
berosity of the humerus, $f$ the trochlea, $e$ the articular in-
terline.

*Circular Operation.*—The articulation recognized, the bra-
chial artery commanded and the fore-arm held extended and su-
pine, a circular cut through the integument fat and superficial,
down to the deep fascia, is made about three fingers' breadth
below the joint.    (Legouest recommends that this incision
shall descend lower behind than in front.)    This is dissected
up and reflected on a level with the articulation.    The mus-
cles in front are divided; the lateral and anterior ligaments
incised; the joint entered from before; disarticulation is
effected, and the operation completed by severing the attach-
ments of the triceps.    The brachial is the only large arterial
trunk cut.

*Flap Operation.*—A good single flap may be obtained from

the fleshy mass before the joint. In doing this, the fore-arm
is supine, and at first slightly flexed. The part is transfixed
on the palmar side of the bones by a sharp pointed straight
blade, making its entrance and exit half an inch below the
external, and an inch below the internal condyles, cutting
downwards and forwards, a curved flap at least three inches
long is obtained—this is turned up. The fore-arm being now
extended and the integument drawn towards the shoulder, a
transverse cut behind the limb connects the points of trans-
fixion. Disarticulation is performed, as in the circular opera-
tion. The radial and ulnar arteries will demand ligation.

*The double flap operation* of Guerin may, under some cir-
cumstances, be found advantageous. This surgeon transfixes
the fore-arm obliquely, entering the knife in front of the ra-
dius, carries it across the neck of that bone on the outside,
making exit beyond its posterior surface, cutting a fleshy flap
from the antero-external portion of the limb. The other is
obtained from the opposite aspect, and is shaped by incising
from the skin towards the bone. It is stated that a good
stump may thus be made.

AMPUTATION OF THE ARM.—Here, as elsewhere, we at-
tempt to save as much as possible, although Larrey favors
separation at the shoulder-joint in preference to amputation
near the tuberosities. Even French statistics, however, show
the former operation to be more fatal, and Guthrie is so im-
pressed by his experience as to counsel section below the joint
whenever possible.

The English and Eastern surgeons select the method by
flaps. The circular operation is the choice of the French.
In this it is directed that the cut shall descend to a lower
level behind than in front, when the amputation is high up.
The front and back of the humerus are well covered by soft
parts, which encroach on the inner margin, along its lower
half, leaving the outer edge nearer to the integument. At
the upper third, most of the muscles, except the deltoid, are
inserted more or less at right angles to the long axis of the
bone, and tend to separate from it as soon as cut. A single
large artery traverses the whole length of this segment of the
limb. The arm is well adapted to the *circular operation*—
whose performance here presents no peculiarities, except that
in a healthy state of the tissues, it is unnecessary to reflect
the skin like a cuff. Slight dissection permits it to be retracted.

The more superficial muscular fibres are incised close to its margin; farther retraction permits a higher division of the deep muscular substance, giving the desired hollow cone. The bone is sawed at its apex.

*The flap operation* may be double or single. Flaps of equal, or unequal dimensions, are cut from the front and back of the limb by transfixing on opposite sides of the humerus. The patient being in the recumbent posture, the arm is extended at right angles to the body. The surgeon grasps and lifts, with his left hand, the soft parts, which are pierced with the catlin an inch, at least, below where the bone is to be sawed. Cutting downwards obliquely until the desired length is obtained, from two to three inches, the knife is turned suddenly outwards to finish the rounded end of the first flap. This is not reflected at once. The same process is repeated on the opposite side. To avoid an encounter between the bone and the knife-point, and to secure a more even margin to the second flap, it is found best to transfix somewhat below the original points in beginning its formation. The flaps are now turned up and well retracted by an assistant. A circular sweep of the knife divides all the textures between their bases down to and through the periosteum. The bone-section finishes the amputation. Great expedition is attained by transfixing to make a single large flap on one side, whilst the remaining tissues are incised circularly.

*The oval method* is recommended by Guthrie in amputating just below the tuberosities. While the subclavian artery is controlled and the limb extended, an incision is begun two fingers' breadth below the acromion process; it descends obliquely in the front of the arm just beyond the attachment of the pectoralis major, crosses on the inner side of the limb, and meets the end of, or is continued to make, another cut behind similar to, and starting from, or terminating at, the same point where the operation begun. The skin is retracted, the muscles divided, the bone cleared to the desired height, and the saw applied. The nerves should be shortened with the scissors before closing the wound.

The rectangular method of Mr. Teale has been practised with good result. In figure 44, plate VII. Teale's rectangular incisions are traced. For a description of the operation, see "general considerations."

In figure 42, plate VI. the appearance of double flaps is in-

dicated. Figure 44 shows transfixion and the line of section for an anterior flap.

AMPUTATION AT THE SHOULDER-JOINT.—According to Legouest, the mortality is 12 per cent. greater in this operation than in amputations of the arm in continuity. Yet the results are most satisfactory, for his compatriot Larrey saved ninety out of a hundred cases.

The shoulder joint is an enarthrodial articulation, in which the large spheroidal head of the humerus is applied to the shallow glenoid cavity of the scapula. A loose fibrous capsule, strengthened in front by the expansion of the coraco-humeral ligament, connects the circumference of the cavity with the anatomical neck of the os brachii. The tendons of the four rotator muscles are also blended with this capsule in proceeding to attach themselves to the humeral tuberosities. The upper tendons of the biceps, coraco-brachialis, and triceps, surround the articulation. The long head of the former lies within the capsule. These parts being all capped externally behind and in front by the thick fleshy mass of the deltoid, are overhung and roofed in by the outer end of the clavicle and the prominent acromion process of the scapula. The latter, easily seen and felt, form excellent guides to the position of the joint. Within the acromion, with which it is connected by a ligament, and from which it is separated by a short space, is found the coracoid process, whose tip can be felt just below the collar bone. The axillary vessels and nerves cross the joint on its inner side. Figure 45, plate VII. is intended to show the skeleton of the parts described.

Of the various methods proposed for amputation at the junction of the humerus and scapula, Lisfranc's and Larrey's yet hold the first place in the esteem of surgeons. The one is a double flap, the other an oval operation. Malgaigne, Jacob and Bourgery, Bernard and Huette, Guthrie, with others who have followed, differ, among themselves, as to the steps advised by Lisfranc, and are by no means so clear in their account of his operation as might be wished. It is the most expeditious, and may be easily performed, circumstances favoring, in accordance with the following directions:

*Lisfranc's Method.*—The arm is raised from the side, so as to relax the deltoid, a long straight knife is entered below the clavicle, between the coracoid and acromion processes, and is passed around the joint, above and behind, so as to emerge

close in front of the posterior axillary fold. If the left limb is the subject of operation, the direction of the transfixing knife is reversed. A large postero-external flap is rapidly cut. This is elevated and held up. The arm being now depressed and carried inwards and forwards, disarticulation is effected by incising the tendons about the joint and the capsular ligament. The head of the bone is next withdrawn from its socket, that the knife may pass around it and descend along the inner surface of its shaft. During this last step, the humerus is again elevated, while the hand of an assistant follows the blade, to grasp the structures between it and the axilla and compress the artery before its division and the completion of the short antero-internal flap.

This operation is rarely available in civil and, perhaps never, primarily, in military practice. Its satisfactory performance demands the continuity and leverage of the humerus.

"On the other hand," says Mr. Joseph Lister, (Art. Amputation, Holmes' System of Surgery,) "Larrey's mode of operating by lateral flaps of equal size, proved almost always applicable in his cases of gun-shot wound, while it was as secure against hemorrhage as that of Lisfranc. Thrusting the point of a knife, of moderate length, down to the bone immediately below the acromion process, Larrey first made a longitudinal incision, about two inches in length, from the extremity of which he cut in a curved line at each side of the limb to the fold of the axilla; then dissected up the flaps so as to expose the articulation completely, a finger of an assistant being placed on the divided circumflex artery; and having severed the connexion of the head of the humerus, passed the knife around it, and kept the instrument close to the inner side of the bone, till, turning the edge towards the surface, he last of all divided the tissues intervening between the axillary folds, containing the artery, previously commanded by the hand of an assistant following the knife."

Dupuytren transfixed at the base of the deltoid, horizontally, beneath the acromion process, and cut a single long external flap. Guerin makes a flap from the same parts by cutting from without inwards. The circular operation may occasionally be practised with good result; but circumstances often arise for which no specific rules can be given. The surgeon, governed by his judgment, must turn to the best advantage the soft parts that are available for covering in the

10*

necessary wound ; and, even when these are deficient, he may hopefully trust to the granulating process, as shown in some of Larrey's cases, which terminated satisfactorily, despite extensive loss of tissue and the removal of parts of the scapula.

Figure 46, plate VII. shows the primary line of incision, and figure 47, the terminal step in Larrey's operation.

In figure 48, the mode of disarticulation, and figure 49, the line of incision for the external flap of Guerin.

Figures 50, 51, plate VIII. indicate the first and last steps in Lisfranc's operation.  C and a, figure 51, correspond to the points of transfixion ; b is the outline of the flap.

## Amputations of the Lower Extremity.

The general rule, with regard to saving as much as possible, is, within certain limits, as applicable to the foot as to the hand.  The observance is carried so far by some surgeons, that the distal and middle phalanges of the lower limb are cut in their continuity; although, except in the case of the great toe, it was at one time thought useless even to disarticulate beyond the tarsal joint.

The conservative inclination of the operators of the present day is good.  It is well to recollect that the loss of several toes impairs the facility of locomotion, and that the value of the parts increases from the fifth to the great toe.  The last-named is the most important of the series.  The head of its metatarsal bone, contrary to the precepts of Dupuytren, should always be preserved.  It forms one abutment of the plantar arch.  When the amputation of three or four of the larger toes is imperative, Legouest (*Chirurgie d'Armée*) recommends the removal of the whole range, as affording a more convenient organ.

In all amputations of the inferior extremity, unless otherwise stated, the patient is supposed to be placed in the dorsally recumbent posture.  In operations in front of the ankle-joint, the parts to be sacrificed do not necessarily project beyond the margin of the operating table.  When the separation of the foot or its segments is in question, the circulation may be controlled by pressure on the popliteal artery.  Some of the British surgeons, however, prefer so to adjust the tourniquet as to act especially on the two tibial vessels.

The foot is constructed on the same type as the hand, with such modifications as adapt it more particularly to the functions of progression and support. Solidity and great increase of dimensions distinguish the tarsus. The several pieces of the metatarsus are arranged on the same transverse plane and are connected at both extremities; while the terminal segment appears, so to speak, atrophied, when compared with the corresponding part in the upper limb. The phalanges and metatarsal bones are the same in number and in the general configuration of their shafts and articular ends. The arrangement of the ligaments, tendons and other soft parts is so similar as to render farther consideration unnecessary, unless to remark that the *metatarsal* heads are farther from the interdigital web than are the *metacarpal*.

Figure 52, plate VIII. shows the skeleton of the foot and ankle: *a*, *b*, the bones of the leg; *c*, the astragalus; *d*, the os calcis; *e*, the scaphoid bone; *f*, the cuboid; *g*, *h*, *i*, the three cuneiform. The numbers indicate the several pieces of the metatarsus, and *k*, *k*, &c., the phalanges.

THE AMPUTATION OF THE PHALANGES, whether in the continuity or in the contiguity, beyond the metatarsal articulations of the first row, may be conducted on the principles applicable to like operations on the fingers.

DISARTICULATION OF A SINGLE TOE.—In this operation, the oval and flap methods are in use.

*Oval Method.*—This is similar to the one practised on the fingers. While the toe is commanded by the thumb and fingers of the left hand and slightly flexed, an incision, begun on the dorsum behind the metatarsal joint, is carried obliquely forwards to one side and descends to the web, or to its level. It then follows the transverse depression of the skin, and rising on the opposite side, joins itself a short distance in front of the articulation. The successive division of the tendons and ligaments sets free the bone to be removed.

*Double lateral flaps* are objectionable on account of the consequent plantar cicatrix. Figures 53, 54, plate VIII. sufficiently indicate the nature of the procedure requisite to their formation. A *dorsal and plantar flap* may be obtained, in the case of the great and little toes, by traversing the dorsal and plantar surfaces, each with a curved incision, convex forwards, starting from the interdigital web and meeting its fellow on the opposite side, just behind the metatarsal joint. A

somewhat similar result is obtained by dividing, with a circular cut, the soft structure clothing the proximal phalanx on a line with the web—which section is met by a straight, antero-posterior incision along the margin of the foot, near its dorsum—sufficiently prolonged to permit disarticulation, after the consequent flaps are detached and reflected. The last operation presents the advantage of ensuring an abundant covering for the expanded head of the first metatarsal bone.

Figure 53, plate VIII. shows the formation of lateral flaps in disarticulation of the great toe. The dotted line traces the proper length of the outer flaps. In figure 54, the last stage of a similar operation on the little toe is represented.

DISJUNCTION OF ALL THE TOES demands for its performance the same steps as the disarticulation of the four fingers. The unequal length of the metatarsal bones gives a curved direction to the general articular interline, whose concavity looks backwards. The ends of this line are usually recognized with facility. An incision, parallel with the joints and two lines in front of them, descends at its extremities as low as the plantar surface of the phalanges. This divides skin, fasciæ and tendons. The knife passed beneath the bones, after disarticulation, shapes a plantar flap, whose margin reaches almost to the web. If the tissue of the sole is deficient, a dorsal flap is furnished by advancing the line of the first incision, while its ends are prolonged horizontally to the site of the extreme joints. The plantar flap may be also fashioned by cutting from without, as practised by Guerin. The *circular method* has been applied in this region. Figure 55, plate IX. traces the dorsal cut. In figure 56, the sole of the foot is presented, while the margin of the plantar flap is being shaped.

AMPUTATION OF THE METATARSUS IN THE CONTINUITY. —Transfix horizontally the plantar structures, in front of the line on which it is intended to saw the bones, cutting forwards until the desired extent of tissue is detached, turn the edge of the knife down and finish the flaps. The dorsal division is made from the skin towards the bone. Incise the interosseous soft parts, clear the bones, apply a six-tailed retractor and use the saw. Figure 57, plate IX. shows the application of the saw and retractor.

SINGLE METATARSAL BONES may be cut in their continuity with bone-pliers, the chain, or metacarpal saw, after the prolongation backwards of the dorsal or marginal incisions

practised for the removal of the toes at their roots, and the dissection required to clear the bones.

DISARTICULATION OF THE METATARSAL BONES.—Fracture generally demands the section of these bones in front of their carpal extremities. After frost-bite, it is regarded better surgery to disarticulate. They may be separated isolatedly or collectively.

At their bases the metatarsal bones resemble the metacarpal They are tied together by dorsal, plantar and interosseous ligaments, and form an irregular line of junction with the anterior pieces of the tarsus, whose general articular curve is interrupted by the forward projection of the two extreme cuneiform bones. There results therefrom a deep recess for the reception of the second metatarsal bone. The inner cuneiform advancing thrice as far as the outer, proportionately overlaps the second metatarsal segment, with which it is connected by a strong, interosseous ligament. The external cuneiform also sends interosseous fibres to the second, as well as to the third metatarsal bone. Dorsal, plantar and lateral ligaments cover in the whole circumference of this compound joint. The individual articular surfaces are so nearly plain as to require no special description; and the general arrangement of the enveloping soft textures so closely assimilates to that of the analogous segment of the hand, as to do away with the practical necessity of a more detailed notice.

The extremities of the articular interline are thus recognized. Trace backwards with the finger the fibular margin of the fifth metatarsal bone—a very considerable prominence will be encountered belonging to the tarsal end of that bone, which projects a little behind the outer limit of the joint. A similar manœuvre on the opposite side of the foot reveals two slight projections close together. The depression between them marks the inner end of the articulation. As the prominences last mentioned are not always well developed, and as tumefaction will mask their existence, it is well to bear in mind that the desired point will be found nearly five-eighths of an inch in front of a transverse line reaching from the tuberosity of the fifth metatarsal bone, which process can nearly always be felt; and is also one inch in advance of the plantar process of the scaphoides. The movements which the first metatarsal piece can be caused to execute, will afford further assistance in the search for the joint.

THE FIRST METATARSAL BONE.—The carpal articular surface of this bone is a slight concavity, with the long diameter vertical, adapted to the convexity of the corresponding cuneiform. A line drawn through the joint across the foot will strike the shaft of the fifth metatarsal at its middle. *The oval*, or, more correctly, the battledore incision (*incision en raquette*) may be practised for its entire removal, as seen at figure 58, plate IX. After the ligaments are divided, and the disarticulation is complete, section of the strong tendon of the peroneus longus will be required to set free the bone.

It is desirable to avoid the dorsalis-pedis artery, where it descends in the first interosseus space to communicate with the plantar arch. Dissection close to the bone, while clearing it, will usually prevent this accident.

In Lisfranc's method a single internal flap is made by transfixing from back to sole, to cover the section of the interosseus structures accomplished by the same manœuvre.

No operation on the foot can be commended, which (as this does) gives a plantar cicatrix. It is only properly admissible when the character of the injury to the sole precludes the adoption of other methods.

THE DISARTICULATION OF THE FIFTH METATARSAL BONE is executed on the same principles as that of the first. The joint is found by reference to the prominent extremity of the bone to be excised, easily felt through the integument. The articular surfaces are flat. A line drawn through the joint across the foot will strike the proximal end of the first phalanx of the great toe. In this operation the tendons of the two shorter peroneal muscles are cut. The lines of incision for the *oval method* are given at *a b*, *a c*, figure 59, plate IX.

THE SECOND, THIRD AND FOURTH METATARSAL BONES are removed, by preference, in accordance with the directions for the *oval method* of disjoining the same bones of the metacarpus. *A, b, c*, figure 60, plate IX, mark the dorsal cuts.

The oval operation is said to be applicable to the simultaneous disarticulation of the two outer metatarsal bones. The loop of the cut, embracing the roots of both toes, is shown at figure 61, plate IX. But Beclard has proposed an ingenious means for the concurrent disjunction of the first and second of these bones, which may be applied with equally good result to the removal of the fourth and fifth. Two incisions are begun on the dorsum of the foot, on a line with the joints

to be opened, separated by a distance nearly equal to the combined width of the carpal ends of the bones to be removed. Each of these cuts proceeds obliquely forward, so that the two cross about midway between the tarso-metatarsal joints and the roots of the toes—the one descending to the interdigital web, the other to a corresponding point on the outside of the little, or the inside of the great toe, (in accordance with the bones to be excised.) The two join in front on the plantar aspect, by following the web and skin creases. The triangular dorsal flap, embraced by the posterior half of these incisions, is detached to and turned back. This step exposes freely the articulations. They are entered, disjunction is accomplished, and the bones isolated. The flap is now laid down, and the lips of the wound beyond brought into apposition. The two cuts form a St. Andrew's cross on the back of the foot, and the consequent cicatrix is like a Y, with an oblique lower limb.

THE DISARTICULATION OF THE WHOLE METATARSUS.— *Lisfranc's Method.*—This is an operation performed without much difficulty, if the operator retains a distinct remembrance of the character of the articular interline of the tarso-metatarsal joint. See page 229. The surgeon grasps the sole of the foot in front, and applies the fore-finger and thumb as guides over the extremities of the joint, whose position is discovered by the means already indicated. A curved cut, convexity forwards, dividing all the soft tissues, is made across the dorsum, half an inch in advance of the articulation. Care should be taken that it starts and terminates just below the level of the bones. Disjunction is best begun on the outside, and is carried as far as the second metatarsal bone. The first metatarsal bone is next separated, leaving the second still in place. The point of the amputating knife is thrust obliquely downwards and backwards between the inner cuneiform and the bone in question; keeping the point fixed, the handle is pushed back until the instrument is perpendicular to the foot. This proceedure divides the strong, interosseus ligament on the inside, and is repeated at the outside. Disarticulation is now easily effected. All the bones being dislocated, the knife is passed below their bases and the front of the foot is raised to its natural level ; when a plantar flap is fashioned by cutting forwards almost to the web on the inside, and to a less advanced point without. Some of the British surgeons direct transfixion

across the sole, immediately after the dislocation of the first
and fifth metatarsal bones.' The disarticulation of the fourth,
third and second, forming a subsequent stage of the operation.

Lisfranc's method of dividing the interosseous ligaments is
an unnecessarily violent process, and is not unapt, even in
skillful hands, to separate the cuneiform bones. A stout
scalpel is well adapted to their section. It is only requisite
to push the blade steadily back to the desired depth.

Mr. Hay, of Leeds, saws off the rather unsightly projec-
tion of the inner cuneiform. 'Mr. Skey avoids the disarticu-
lation of the second metatarsal, and cuts it with bone pliers
on a level with the cuneiform surfaces. Either of the pro-
ceedings just indicated affords a more regular bone stump,
obviates the difficulty experienced in ossification of the liga-
ments, and prevents the formation of a pus pocket. Guerin
traces a plantar flap accurately through the skin by an inci-
sion reaching to the sesamoid bones of the great toe on the
inside, and on the outside to the junction of the middle and
anterior thirds of the fifth metatarsal bone. It is finished by
transfixing and cutting forward to divide the subcutaneous
structures. Figure 62, plate X, indicates the position and
direction of the dorsal cut; figure 63, the division of the in-
terosseous ligaments, according to Lisfranc. In figure 64 the
knife is shaping the anterior margin of the plantar flap. Fig-
ure 65 gives Guerin's method of tracing this flap.

TARSAL DISARTICULATIONS.—Two principal operations
are performed on the tarsus; one called the *medio-tarsal* am-
putation, the other the sub-astragalian operation. After the
first, the os calcis and astragalus, both retain their position.
After the second, the astragalus alone remains.

The tarsus consists of seven pieces, differing in dimensions,
and unlike in conformation, arranged in two groups placed
one behind the other. The posterior group embraces the two
largest bones, the astralagus and the os calcis; the former
resting upon and articulating with the latter. In the anterior
group are five bones—the scaphoid, the cuboid and the three
cuneiform. The first two lie side by side, and form, with the
bones of the posterior group, the medio-tarsal joint, the gene-
ral direction of whose interline is transverse. 'Viewed more
closely, however, and from above, this line, like the clavicle,
presents a double curve. Its inner half traces the junction
between the elliptical convex head of the astragalus, opposed

to the less extensive concavity of the scaphoides, while its outer half bounds the reciprocal surfaces of the os calcis and cuboides. The last-named surfaces are sinuous. The os calcis encroaches on the dorsum of the cuboid internally, and the cuboid on the plantar aspect of the os calcis externally.

The cuboides is bound to the calcaneum by four ligament: s two are plantar; one, dorsal; the fourth, internal, interosseous and very strong. The os calcis is also attached to the sca-phoides by two fibrous bands; one above, the other below. The last is a dense ligament. It stretches from the inner and front part of the os calcis to the contiguous margin of the scaphoid bone. Its upper surface, serving to complete the concavity intended for the reception of the astragalian head, is lined by a synovial membrane. A single broad, but feeble band connects the dorsum of the scaphoid with the astragalus.

The medio-tarsal joint is recognized by reference to the plantar projections of the scaphoid and cuboid bones. These occupy the opposite margins of the foot, and, when swelling is absent, can generally be distinguished by the touch. The ends of the inter-articular line are found immediately in the rear of these prominences.

The *inner* extremity of the articulation is also placed one inch *in front* of the corresponding malleolus; the *external*, half an inch *behind* the tuberosity of the fifth metatarsal bone. Forced extension of the anterior tarsal bones will render mani-fest the head of the astragalus. The consequent prominence will mark the middle of the joint.

THE MEDIO-TARSAL AMPUTATION.—*Chopart's Method.* —Chopart practised a transverse dorsal incision, two inches in front of the malleoli, descending along the margins of the foot. The resultant flap was elevated and the articulation opened. Two lateral cuts, starting from the ends of the first, and meeting on the plantar region far enough forwards to secure a sufficient covering for the exposed cartilages, cir-cumscribed the remaining soft parts. Subsequent sections of the deeper structures set the bones free. (Vidal, *op cit.*)

*Modern Process.*—As in disarticulation of the metatarsus, the operator's left hand grasps the sole of the foot, resting the thumb and index finger on the respective tuberosities of the scaphoid and cuboid bones. Behind these points, a curved dorsal cut, dividing the soft structures half an inch in advance of the joint, is made to begin and end. The articulation may

be attacked at either side, but is more easily entered at its inner aspect, care being taken to apply the knife two lines behind the process of the scaphoides, and to direct the edge of the instrument obliquely forwards and outwards. The division of the dorsal and interosseous ligaments, combined with downward pressure on the bones to be removed, will cause the joint to open widely. The blade, passed in, divides at a single cut the plantar bands, slips beneath the bones and shapes an inferior flap, almost as long as in the tarso-metatarsal operation.

A too great advance of the dorsal cut on the inner side, sometimes leads to the separation of the cuneiform bones. The scaphoides, thus left in position, should not be retained. Its preservation, by sparing the tendon of the tibialis posticus, would involve an increased tendency to permanent elevation of the heel.

*Sedillot's Method.*—The site of the articulation is determined as before. A transverse incision is carried from the outside of the calcaneo-cuboid joint, to the same side of the anterior-tibial tendon, over the back of the foot. From the termination of this, a curved cut passes obliquely forwards and downwards, to within two fingers' breadth of the distal end of the fifth metatarsal bone, descends on the inner margin and crosses the sole of the foot, to reach the point at which the operation was begun. The flap embraced in the line of incision is dissected up to the joint and the operation completed by the separation of the bones.

THE SUB-ASTRAGALEAN AMPUTATION.—The two bones of the first row of the tarsus are placed one above the other. The astragalus rests upon and articulates with the front part of the os calcis. The articular surfaces of the latter bone, two in number, are separated by an oblique groove, directed backwards and inwards. Of the two facettes presented to be astragalus, the posterior is broad and convex; the anterior, narrow and concave. Conversely fashioned facettes, of similar outline, are found on the under surface of the astragalus, also parted by a groove.

When the two bones are *in situ*, the opposed grooves form a canal, filled, in the recent state, by dense interosseous fibres, constituting a strong bond of union between them. A special external ligament belongs to this joint and a posterior is also described. The lateral ligament of the ankle crosses and pro-

tects the inside of the articulation. The tendons of the toes and foot surround and consolidate the parts.

Malgaigne, Roux, Verneuil and Nelaton are each reported to prefer a different line of incision in the performance of the operation in question. By each, a flap is circumscribed and dissected up before the joint is attacked.

Malgaigne severs the skin and tendo-Achillis, grazing the upper margin of the calcaneum by a horizontal cut, which continues its direction on the outside, passing one-third of an inch below the malleolus, then turns abruptly over the back of the foot, an inch in front of the ankle-joint, to descend within and reach to the middle of the sole. At this point, it is met by an incision prolonged from its place of commencement across the inside of the foot, so as to outline an internal inferior flap, four or five inches wide at its base and two or three at its rounded termination.

The incisions of Roux, Verneuil and Nelaton are all of more or less elliptical, or rather of battledore, outline. Each is begun and ended on the outside of the os calcis, near its upper margin, and half way between its posterior extremity and the outer malleolus; each crosses the dorsum of the foot in an oblique curve and descends on the tibial side of that organ. Roux retraces on the sole the cut on the back, advancing on both surfaces half an inch in front of the junction between the astragalus and scaphoid bones. Verneuil carries forward his dorsal cut to within an inch of the fifth metatarsal bone on one side, and over the middle of the first cuneiform on the other. He makes the plantar part of the incision more decidedly oblique. Nelaton crosses the sole more transversely. All the incisions referred to, divide the soft structures down to the bone, and all have for their object the conservation of a well-nourished covering for the face of the stump, well adapted to sustain pressure without detriment to its integrity.

Observing Malgaigne's directions, the following steps succeed the detachment and elevation of the flap. The surgeon, assured of the lateral limits of the medio-tarsal articulation, opens widely the scapho-astragalean joint, so wielding the knife as to incise, at the same time, the outer ligament of this joint and enter the anterior synovial cavity beneath the astragalus. He should also cut that part of the inner ankle ligament which descends to the calcaneum and open the posterior articulation of the latter bone with the astragalus. Subsequently, the long flexor tendons are severed.

The interosseous ligament, which occupies the calcaneo-astragalean canal, still remains untouched. Its destruction is thus accomplished: The point of the knife, with the blade held flatwise and the edge directed backwards and outwards, enters and is pushed beyond the anterior joint of the os calcis with the astragalus. The section of a few fibres of the ligament attacked causes the others to yield and complete separation of the bones is soon effected. The arteries tied, the flap is adjusted and the margins of the wound sutured. Malgaigne highly lauds his process, which he practised with success in two cases, and which has been repeated by other surgeons. The method of Malgaigne gives easy access to the joint, but Legouest (*Chirurgie d'Armee*) seems to prefer the incisions of Verneuil.

In figure 68, plate XI, the line of Roux's incision is traced.

The partial amputations of the tarsus, although rarely fatal, have fallen into disfavor with many surgeons, because of their ultimate results.

The medio-tarsal operation is especially reprehended as of doubtful propriety, because of the disposition of the stump to dip in front and rise behind. This tilting throws the weight of the body more or less on its anterior extremity, producing pain and lameness; and where the cicatrix is too low, causes ulceration and other unpleasant complications.

As section of the tendo-Achillis, either during or after the operation, does not prevent the permanent elevation of the heel, Legouest concludes this deviation from the natural condition to be the effect of a general retraction of the fibrous tissues behind the tibio-tarsal joint. (*Cherurgie d'armee.*) He seems to forget that the post-tibial and long peroneal tendons, folded over the end of the bony stump in bringing up the plantar flap, very probably gain, from their new attachments, a considerable levérage, which may be manifest after division of the tendo-Achillis. The degree of power with which the foot is extended after complete ablation of the os calcis, affords some foundation for this belief. The writer, with all proper modesty, suggests the clipping of the tendons of the tibialis and peroneus, in addition to division of the tendo-Achillis, as a possible means of preventing the deformity and consequent interference to easy progression referred to.

The necessarily tedious character of the sub-astragalean operation, does not recommend it for field-practice.

Pirogoff's resection is performed with greater facility, gives as long a stump, and so far as at present known, is quite as successful.

AMPUTATION AT THE ANKLE-JOINT. — The astragalus tibia and fibula enter into the formation of this joint. The lower surface of the tibia rests upon the astragalus, and the two malleoli embrace its sides.

Three strong fibrous fasciculi descend from the outer malleolus. The anterior and posterior attach the astragalus, the middle one connects the os calcis with the fibula. The three taken together constitute the *external* lateral ligament. The *internal*, broader below than above, is called the deltoid ligament, and ties the inner malleolus to both bones of the posterior-tarsal group.

A feeble fibrous band closes the front of the joint, which is crossed by the tendons of the tibialis anticus, peroneus tertius, and long extensors of the toes, as well as by the anterior tibial vessels and nerve.

The tendons of the two longer peroneal muscles, of the tibialis posticus and long flexor of the toes, descend laterally: the former behind the outer, the latter in the rear of the *inner* malleolus. The proper flexor of the big toe grooves behind, both tibia and astragalus. The post-tibial and peroneal arteries are placed at opposite sides in the rear.

The principal methods of amputating at the tibio-tarsal articulation, are two in number. Each is a candidate for the favor of the profession. Each has its advocates. One is a Russian, the other a Scotch invention. They bear the names of the surgeons who have suggested and practised them. One is called Syme's, and the other Pirogoff's operation. As will be learned from their description, neither is necessarily a tibio-tarsal disarticulation. The operation of Mr. Syme is one of such theoretical excellence, and gives, when successful, so useful a stump, that we prefer to transcribe bodily the account of its different steps furnished by Joseph Lister, Professor of Surgery in the University of Glasgow. (Holmes' System of Surgery.)

*Syme's Ankle Operation.*—"In the amputation of the ankle, devised by Mr. Syme, the bones of the leg are divided just *above* the malleoli; a covering for the osseous surface being provided from the integuments of the heel, fitted by the character of its epidermic investment and subcutaneous cushion, for bearing the weight of the body.

" Hence, the end of the stump becomes as capable of sustaining pressure as the natural sole; and when the deficient spring of the arch of the foot is compensated by some elastic material contained in a very simple boot, the limb proves nearly as useful as in the normal condition. At the same time, the parts likely to originate carious disease are completely got rid of, so that this operation is calculated to supersede entirely that of Chopart, beside taking the place of amputation of the leg in the majority of cases formerly supposed to demand it.

" The operation should be performed as follows: Provision being made against hemorrhage from the anterior and posterior tibial arteries, by pressure of the thumb and finger of an assistant, placed respectively on the middle of the fore part of the limb and behind the tibia, about two inches above the joint, or by a tourniquet applied over two rollers, occupying these situations, and the foot being held at right angles to the leg, the surgeon puts his left hand behind the heel, with the finger and thumb on the places where the incisions are to commence and terminate; these being the tip of the external malleolus, and the point exactly opposite on the inner side, *i. e. not* at the tip of the internal malleolus, but considerably below and behind it. With a knife short and strong, both in blade and handle, he now cuts down to the bone across the sole, from one of these points to the other, in a plane not quite vertical, but sloping slightly toward the heel, especially when that part is unusually prominent; and then, extending the foot, joins the horns of this incision by another, running as straight as possible across the front of the ankle."

He next dissects up the posterior flap from the os calcis, keeping the edge of the knife close to the bone, with the guidance of the left thumb nail, till the point of the calcaneum is fairly turned, when he proceeds to open the joint in front, divides each lateral ligament with the knife applied between the malleolus and the astragalus, and completes the removal of the foot by severing the tendo-Achillis. He then prepares the bones of the leg for the application of the saw, taking care, when cutting behind the tibia, to keep close to its surface, from which the posterior tibial artery is separated only by a little loose cellular tissue; and lastly, he takes off the malleoli, with a thin slice of the intervening part of the tibia, sawing perpendicularly to the axis of the limb."

"It is a common mistake to make the inner end of the incision at the internal malleolus, instead of opposite to the extremity of the outer one. This has two bad effects: it renders the flap unsymmetrical, and what is far worse, it makes it unnecessarily long, and thus introduces an element of difficulty and risk into an easy and safe operation. For when the incision is carried forwards to the hollow of the foot, it becomes a most troublesome task to turn back the integument over the prominence of the heel, and the knife being thrust, the operator knows not where, the subcutaneous tissue, on which the skin depends for its nourishment, is punctured and scored; and perhaps the point of the instrument appears occasionally through the skin itself, while the flap is subjected to violent wrenching in the effort to draw it back over the bony projection. Under such a combination of unfavorable circumstances, it is but natural that it should slough.

"On the other hand, when the flap has been made as above recommended, it applies itself with perfect uniformity to the surface it is designed to cover, and has no disposition to shift to one side in the after progress of the case; and every stroke of the knife by which it is raised being made under the eye of the surgeon, without any forcible traction, it is as little liable to slough as any other portion of integument, with an equally broad base and equally rich vascular supply. Even the integrity of the posterior tibial artery, though desirable, is by no means essential, provided the rest of the subcutaneous tissue has been left uninjured. Many persons, in discussing the merits of this operation, seem to assume as an axiom, that the sloughing of the flap must occasionally take place; but I am persuaded, from very extensive experience, especially in Mr. Syme's practice, that if the skin of the heel be sound, such an occurrence will always be the fault of the operator

"Traumatic cases, in which the integuments are thinner than in chronic disease, are considered the most unfavorable; but though I have had occasion to perform the operation in several cases of this kind, *I have never met with the slightest sloughing*. The last instance was that of a young man, who, lying in a state of intoxication with his feet upon a rail, had the fore parts of both crushed by a train, and I amputated both at the ankle. The last intelligence that I have received of him is, that he was able not only to walk, but to run, and even to dance the Highland fling."

Quain, Handyside, McKenzie, Teale, Roux, Baudens, Se-
dillot has each proposed his own method of limiting the in-
tegument in the amputation of the foot.  Quain's first inci-
sion resembles that of Syme, but is met by a horizontal cut
over the outside of the os calcis, reaching to the tip of the
heel.  Handyside makes two lateral flaps which join in front
of the tibio-tarsal articulation, and on the back of the calca-
neum.  Teal divides the plantar structures transversely, three
quarters of an inch in advance of the malleoli, and bi-sects
the parts in the rear of this section as far back as the tendo-
Achillis.  Roux limits the tissues to be retained by two inci-
sions, beginning one inch and a half behind the outer malleo-
lus, and terminating three lines in front of the inner malleo-
lus.  One crosses the dorsum just before the ankle-joint, the
other descends to the sole and slopes obliquely backwards.

McKenzie also practises two cuts.  The first courses be-
neath the malleolus externus, stretching from the tendo-Achillis
to the inner side of the tibialis anticus, two inches in advance
of the malleolus internus.  At these points, it joins the se-
cond, which outlines a large rounded flap on the sole, of suffi-
cient extent to afford an abundant covering for the stump.
Sedillot fashions a quadrilateral flap from the inner and plan-
tar regions, while the outer and anterior structures are divided
just below the joint.

The condition of the integument makes it occasionally
necessary to adopt one or the other variety of incision just
mentioned, or demands of the ingenuity of the operator an
extemporaneous method for the adaptation of the uninjured
parts to the ends in view.  The incisions which will not ex-
pose the line of cicatrix to pressure, and which give a covering
of the *plantar* integument for the face of the stump, are to be
preferred.

Figures 69, 70, plate XI. are opposite aspects of the same
foot, the dotted lines tracing in each the incisions of Syme.
In figure 71, plate XI. the operation is seen at an advanced
stage.  The heel flap is turned up and disarticulation has be-
gun.  Figure 72, plate XII. indicates the position of the foot
and the inner cut adopted by McKenzie; figure 73, the outer
cut of the same surgeon; figure 74 is the inside view of a foot
removed in accordance with Roux's method; figure 75 shows
the stump after the ankle-joint operation.

*Pirogoff's method* is thus translated from the description

given by its inventor in the *Medical Times and Gazette.* I commence my incision close in front of the outer malleolus, carry it vertically downwards to the sole of the foot, then transversely across the sole, and obliquely upwards to the inner malleolus. Thus, all the soft parts are divided at once quite down to the os calcis. I now connect the outer and inner extremity of the first incision by a second semilunar incision, the convexity of which looks forwards, carried a few lines anterior to the tibio-tarsal articulation. I cut through all the soft parts at once down to the bones, and then proceed to open the joint from the front, cutting through the lateral ligaments, and thus exarticulate the head of the astragalus. I now place a small, narrow amputation saw obliquely upon the os calcis, behind the astragalus, exactly upon the sustentaculum tali, and saw through the os calcis, so that the saw passes into the first incision through the soft parts. Saw carefully, or the anterior surface of the tendo-Achillis, (posterior tibial artery,) which is only covered by a layer of fat and a thin fibrous sheath, might be injured. I separate the short anterior flap from the two malleoli, and saw through them at the same time close to their base. I turn this flap forwards, and bring the cut surface of the os calcis in apposition with the articular end of the tibia.

Croft, of the Dreadnought hospital, (*London Lancet*,) adopts the following modifications of Pirogoff: The tissues are first divided across the front of the joint, carrying the ends of the requisite curved incision to opposite points *behind* both malleoli. The second cut, connecting the extremities of the first, *advances* toward the toes before traversing the sole, and is, therefore, *oblique forwards* during its descent to the plantar surface. After disarticulation, the soft parts are sufficiently detached from the os calcis to permit its section in the direction of a line connecting the posterior margin of its larger facet with the under edge of the articular surface for the cuboid.

It has also been proposed to saw off the back part of the calcaneum immediately after making the cut across the sole. Figure 75, plate XII. is an external view of the os calcis, the dotted lines indicating the different sections that have been practiced; *b, f,* is that proposed by Pirogoff; *a, c,* is Croft's line. Figure 77 shows the clearing of the bones previous to the application of the saw, according to Pirogoff.

11

It will be observed by the reader that Syme *always* saws the *tibia*. Handyside imitates him, and Pirogoff recommends the section of this bone in some cases, although he is usually satisfied to remove the malleoli. The difference is only three or four lines in the length of the resulting stump. A very natural question hence arises as to the necessity for disarticulating in the performance of either operation. The interrogation is especially pertinent when the removal of a slice of the tibia is demanded by the condition of its articular surface. Why subject the patient to the tedium of two operative procedures, when one will suffice? Disjunction at the ankle has already been proved not a pre-requisite to the section of the calcaneum. It is, indeed, even of doubtful convenience to the operator. The saw can be more easily steadied, and the bone to be cut more firmly supported previous to than after the separation of the foot from the leg. Why not, therefore, in *all* cases of Syme's operation, shorten the bones *without entering the ankle joint?* Will it not also be better to modify the process of Pirogoff, by always sawing both tibia and calcaneum, *without disturbing the articulation?*

In estimating the relative value of the operations of Syme and Pirogoff, it is well to refer to Mr. Lister's views, given above, (see page 238,) in relation to the sloughing of the heel flap, after the amputation of Syme. If this can be avoided by proper care in its dissection, Pirogoff's method will still recommend itself to the field surgeon as a more expeditious procedure. The comparative length of stump furnished by the latter is not, however, so advantageous as might be supposed. Some mechanical aid will be demanded in either case to bring the limbs to the same level. The piece of the os calcis, retained by the Russian surgeon, is said to encroach inconveniently on the space to be occupied by an artificial foot; besides which, the bone in question, in virtue of its structure and exposed position, is very subject to carious degeneration and other disturbances of nutrition exacting its entire removal. Lastly, while the stump of Mr. Syme is covered with integument, adapted by nature to sustain the weight of the body, that of Prof. Pirogoff presents tissues unaccustomed to constant pressure.

The very oblique line of section for the os calcis, adopted by Croft and others, tends to throw the line of support behind the axis of the tibia; and, by so much, to assist the power of

the extensor muscles connected with the tendo-Achillis, in straining the new structures which bind the fragment of the calcaneum to the bones of the leg. The experience of the profession, with regard to the relative merit of these operations, is not sufficiently extended to warrant an appeal to statistics

AMPUTATION OF THE LEG in the continuity may be performed at any point between the tubercle of the tibia and the ankle-joint. The French place "the point of election" at from two to four fingers' breadth below the tubercle of the tibia. The English surgeons, in the Eastern campaign, are said to have paid but little attention to this point, usually operating as low as the nature of the injury would permit. The proclivity of the latter toward conservatism, seems to have been followed by no bad result as to mortality. They lost only *thirty-three* per cent. of their cases, while the French per centage amounted to *fifty-four*.

Along its upper half the muscular structures of the leg are greatly accumulated behind. In front the soft tissues project but little beyond the bones. The two peronei give a slender covering to the fibula without, while the tibia is sub-aponeuristic from knee to ankle. Tendons form a large part of the subcutaneous mass on the lower third of the limb.

The anterior and posterior tibial arteries always, and the peroneal usually, are cut in amputation at or below the point of election. When the bones are sawed as high as the tubercle of the tibia, the popliteal may be the only vascular trunk requiring ligature. The tourniquet may be applied over the popliteal just above the knee, or if this be found inconvenient, to the femoral artery. The patient is placed on a table of sufficient height, with the part to be removed well projected beyond its edge, and supported by an assistant. The circular, double and single flap, and oval method of amputation, has each been practised on the leg.

SUPRA MALLEOLAR AMPUTATION.—This expression is intended to include all operations on the lower half of the limb. *The circular method* has to be modified in this region. The skin, divided by a circular cut, is with difficulty reversed. Lenoir, therefore, counsels a vertical incision along the crest of the tibia, reaching the level of the intended bone section. The integument is then dissected up obliquely, and reflected in the form of an open collar. (Figure 78, plate XII.) The

musculo-tendinous parts are severed down to the bones on a
line with the reflected collar, and drawn up. The interosse-
ous mass is transversely divided, a retractor introduced, and
the bones sawed on the same level. (Section of the fibula in
this, and all other amputations of the leg, is completed first.)
The edges of the vertical cut are sewed, and the integument
is then adjusted as after the usual circular operation.

*Flaps.*—Guerin transfixes *close* behind the bones and cuts
a flap of four fingers' length. An anterior curved incision
terminates, on either side, at its base. The flap is dissected
and reversed. The other steps are as for the circular method.

Mr. Teale has applied his rectangular flap method (see
page 223) to the lower part of the leg. Double semi-ellipti-
cal flaps are sometimes made by transfixing behind, and cut-
ting from the skin in front. Figure 78, plate XII. shows
Lenoir's operation. The skin collar is laid open, and the mus-
cular division begun. Figure 79 traces Guerin's incisions.
Figure 80, the usual double flap method, and Figure 81, Mr.
Teale's rectangles.

AMPUTATION AT THE "POINT OF ELECTION"—*Circular
Method.*—1st. The skin, superficial fascia and fat are divided
three or four inches below where the bones are to be sawed.
The circular incision begins and ends on the crest of the
tibia, and is made without removing the knife. The integu-
ment is dissected one and a half to two inches, and then re-
flected. 2d. The muscles are cut circularly down to the
bones at the margin of the skin cuff, with a sawing motion
of the knife. 3d. The interosseous structures are divided
transversely. A three-tailed retractor is applied, the soft
parts drawn up, and the periosteum incised around each bone.
4th. The saw is applied to the tibia, which it first grooves be-
fore the fibula is attacked. The section of the latter, as be-
fore mentioned, is first completed. 5th. The arteries are
tied, and the lips of the wound brought together.

The following directions are given for the severance of the
interosseous mass and the clearing of the bones, (although, to
say the truth, the writer can scarcely conceive that the neces-
sary steps would not suggest themselves to the mind of any
operator:) The heel of the knife is applied to the outer sur-
face of the fibula, and the instrument is drawn across the
front of both bones. The interosseous space is next pierced
from before backwards, with the blade held transversely to

the long axis of the limb. The opposite edges of the catlin are made to act alternately on the opposed surfaces and margins of either bone. The knife being withdrawn, is now applied to the inner aspect of the tibia, and drawn across the back of both bones. The interosseous space is transfixed from behind, and there is a reversed repetition of the steps already indicated. This is the method of Guerin, figure 83, plate III. The dotted lines, *a, b, c,* &c., and Nos. 1, 2, are intended to mark the different positions assumed by the catlin.

When the bones are sawn transversely, the angle formed by the crest of the tibia, with its cut surface, is very sharp.

This prominence is unsightly, and, what is worse, disposes the integument covering it to ulceration. Therefore, some surgeons remove the bony angle *after* the transverse section of the hard tissues is completed, while others *precede* this cross cut with an oblique application of the saw to the *inner surface* of the tibia.

*The Single Flap Operation.*—The operator, standing on the right of the limb, gathers up and grasps the integument over its posterior aspect, so as to stretch evenly the skin in front. The fingers and thumb mark the points of transfixion. The knife is thrust transversely and *horizontally* from side to side, grazing the fibula, (which occupies a plane somewhat in the rear of the other bone,) or, in very muscular subjects, still farther back. A flap, four or five inches long, is now cut. A slightly curved, or perfectly transverse incision, divides the structures on the fore part and sides of the leg, at the base of the flap. The latter is turned up and retracted. The remaining steps proceed as in the circular operation.

*The double flap operation* of the English surgeons, as practised by Luke, Guthrie and others, is similar to that described above, except that the integument is not stretched backwards; the knife in transfixing is made to graze *both* bones, and an anterior flap, by cutting from the surface, is shaped, equal in length to the fleshy one behind.

Mr. Skey transfixes horizontally three-quarters of an inch *above the palm of the left hand,* used to support the calf of the limb to be sacrificed; thus spreading out and flattening the soft parts behind and against the bones. This manœuvre iss aid to rid the posterior flap of an unwieldy bulk of muscular fibre, while sufficient integument is preserved to form a thorough covering for the stump. The grasping of the skin,

as above directed, with transfixion on a plane posterior to the
bones, effects the same end. A similar result is obtained by
first tracing through the skin the outline of the desired flap.
After the retraction of the integument, the muscles are trans-
fixed and cut in contact with its margin.

AMPUTATIONS ABOVE THE POINT OF ELECTION are exe-
cuted by one or other of the methods just described. In
these Larrey removed the fragment of the fibula, a proceeding
deprecated by Liston and Syme, as destroying the attachments
of the external lateral ligament, and as sometimes opening the
synovial cavity of the knee-joint. The bone section should
in no case be made above the tubercle of the tibia.

DISARTICULATION AT THE KNEE.—The statistics of both
French and English armies in the Crimea would seem to de-
monstrate *this* to be a less successful operation than section in
the lower third of the femur; indeed, it is almost as fatal as
amputation at the middle of the thigh. A more extended
comparison, however, of the results of European and Ameri-
can practice, military and civil, gives a per centage of six and
a half in favor of the knee-joint operation. Its advocates
claim that the liability to hurtful retraction of the soft struc-
tures, to ulceration of the cicatrix, and to pyæmia, is not so
great as when the femoral condyles are removed; and that,
when successful, it gives a longer and more useful stump.

The knee-joint, although a somewhat complex structure in
an anatomical point of view, is, when considered with refe-
rence to amputation, sufficiently simple. Usually, the line of
articulation is readily recognized, the joint is easily entered,
and the bones forming it are separated with facility. The
femur, tibia and patella furnish the articular surfaces. The
os femoris presents below two condyles, adapted, by the inter-
position of fibro cartilages, to two shallow elliptical cavities on
the upper end of the tibia. The femoral condyles are sepa-
rated by a deep notch behind, but join in front to be pro-
longed upwards, and form a trochlea, fitted to the posterior
surface of the patella.

The immediate bonds of union are a broad ligament, closing
in the posterior aspect of the articulation; an internal liga-
ment, tying the inside condyle to the tibia; an external liga-
ment, connecting the fibula and outer condyle; and a very
stout continuation of the rectus femoris tendon to the tubercle
of the tibia, called ligamentum patellæ. Filling up the in-

tervals that would otherwise exist between the last three fibrous bands, are found expansions from the vasti muscles, blended with the fascia femoris.

Beside the circumferential fastenings just enumerated, there are two other ligaments within the joint, which descend from the opposed sides of the intercondyloid notch, and attach themselves, one in front of the other, to spaces between the glenoid cavities of the tibia.  These are the crucial ligaments.

The articulation is still farther strengthened and crossed by the muscles of the leg and foot.  In addition to the vasti and rectus, whose arrangement has already been indicated, the sartorius, gracilis, semi-tendinous and semi-membranous muscles descend within, to seek connection with the tibia ; the biceps cruris without, to be inserted on the fibula.

The respective condyles of the femur give origin to the corresponding heads of the gastrocnemius ; and the outer one, also, to the plantaris and popliteus muscles.  Traversing behind the joint are the popliteal vessels and nerves.

Three bony prominences and the lower end of the patella form the guides of the articular interline   These are the tuberosities of the os femoris and the tubercle of the tibia. The two former project from the respective femoral condyles, attach the lateral ligaments, and of course occupy opposite lateral aspects of the limb ; the latter is on the fore part of the tibia.  The tuberosities are said to be each half an inch above, and the tubercle three-quarters of an inch below the joint, while the lower margin of the patella exactly overlies it.

All the standard methods of amputating have been applied by operators at the tibio-femoral articulation.  Unless injured or diseased, the patella is usually retained.

*The circular operation* in this region implies a circular division of the integument four fingers' breadth below the joint, the skin being previously retracted, and subsequently reflected to its level.  The joint is entered from the front by division of the ligamentum patellæ.  The leg *extended* during the cut, though the skin is slightly *flexed* pending the division of the anterior ligament.

*Oval Method.*—In this an incision from without inwards traverses the front and sides of the limb, reaching at its centre two inches below the tubercle of the tibia, terminating laterally within two fingers' breadth of the joint.  The integu-

ment thus circumscribed is turned up, the leg bent, the ante-
rior and lateral ligaments cut, the joint entered, the crucial
bonds divided, and the parts behind transversely severed from
within.   This gives, in effect, an anterior flap.

*Posterior Flap.*—Syme prefers to make a posterior flap,
and saws off the condyles.   Fergusson recommends the ope-
ration, which is thus performed : The limb being extended, a
lunated cut, convex downwards, is made by drawing the knife
from over one condyle across to the other, on a level with the
middle of the patella.   The short lip thus fashioned is drawn
up, the extensor tendons are divided above the knee-pan, the
parts behind the joint transfixed at the extremities of the
first incision, and a six inch flap shaped from the fleshy part
of the gastrocnemius.   This retracted, a circular sweep of the
knife clears the femur, just above the condyles, and permits
the application of the saw.   A similar division of the soft
tissues lower down may be combined with disarticulation.

The condition of the tissues may demand two flaps of equal
or unequal dimensions.   These can be easily shaped from op-
posite sides of the part, although it is always desirable, if
pressure is to be borne by the face of the stump, to have the
line of cicatrix at its margin.   A single long flap begets this
result.   Figure 86, plate XIII. shows the oval or anterior
flap operation at the moment the joint is entered.   Figure
87 traces the cuts in the posterior flap method.

AMPUTATION OF THE THIGH.—The os femoris, constitu-
ting the skeleton of this segment of the lower extremity, is
well clothed with soft parts in nearly every aspect.   It is pro-
per, however, to bear in mind, that the fibres of the muscles
on its inner and posterior regions are very *long*, reaching in
some, as in the case of the sartorius from the pelvis to the
knee.   Since the retraction of a muscle after section is just
in proportion to the length of those fibres, which retain their
attachment, we may anticipate what may always be observed
in practice : 1st, that the nearer amputation is to the leg, the
greater must be the allowance made for muscular recession ;
2d, that as the ascent of the tissues will be most obvious in
the regions embracing the longest fibred muscles, an *evenly*
shaped stump can only be secured by an *oblique* section of
the limb.   The cut should incline *toward* the knee in travers-
ing the more *retractile* structures.

In all amputations of the thigh the tourniquet, if used to

control the circulation, should be applied as *far* as possible from the seat of operation.  The skin should be strongly and evenly retracted by a careful assistant, previous to and pending its division; and, in order to secure more certainly against protrusion of the bone, it is well to detach the deep tissues from the periosteum an inch or more above their point of section.  Here, as in the arm, the easy sliding of the skin in its healthy state upon the subjacent parts, ordinarily obviates the necessity for its reflection in the performance of the circular operation.  The French surgeons rarely turn up a skin cuff. The English generally reverse about two inches of integument.  The superficial and deep tissues are separately incised at different levels, the edge of the knife being slightly directed towards the proximal end of the limb, so as more effectually to shape the hollow cone, at whose apex the bone is to be sawed.  Many operators divide with a *single* circular sweep of the knife, the whole muscular thickness of the limb.

*A single flap* may be fashioned by transfixing on one side of the bone, and dividing all the tissues on the opposite semi-circumference of the limb by a transverse cut.  If this flap be taken from behind, the line of cicatrix will be drawn to the face of the stump; because of the superior retractility of the flexors of the leg.  On the other hand, and for the same reason, if shaped from the front of the limb, it will hug and pad the end of the bone.  In amputation in the upper third, where the bone is tilted forward by the action of the psoas-iliac, a good anterior flap is regarded as especially desirable.

Mr. Guthrie, in his surgical commentaries, manifests a decided partiality for the *double flap operation*, as practised by Mr. Luke.  He describes it at length.  The following paraphrase will give the substance of his directions:  The patient is so placed that the thigh projects beyond the table.  The surgeon stands on the *right* of the limb to be removed.  The knife to be used should be narrow, pointed, and two or three inches longer than the diameter of the limb at the seat of operation.  The posterior flap is first to be formed by transfixing "transversely" behind the bone, and "midway" between the upper and lower surfaces of the thigh.  The anterior flap is fashioned by repeated cuts from without inwards, curving evenly across the front of the limb and terminating at either end "near" the base of the first flap.  The length of the anterior flap is determined by that of the posterior,

11*

and varies accordingly "from four to six inches." The remaining soft tissues are incised by a circular sweep of the knife "where it is intended to saw the bone." The flaps being retracted, the bone is divided by the saw.*

*Double skin flaps* are preferred by Mr. Skey. He directs that they should not be redundant. After their detachment and reflection, the long-fibred muscles are *first* severed and allowed to *recede*, when the remaining mass is divided by a firm circular sawing movement on a line with their retracted extremities.

*Mr. Teale's rectangular operation* is said to have been practised, with excellent results, at the lower third of the thigh. The specific directions for its performance will be found in the general considerations. (See page 202.) In figure 88, plate XIII. the upper dotted lines indicate the character of the anterior and posterior flaps. The lower lines trace lateral flaps. In figure 89, A, E, G, D, show the posterior flap and cut in Mr. Luke's operation. G, F, his anterior incision.

AMPUTATION AT THE HIP.—The hip, like the shoulder-joint, is an enarthrodial articulation. The os innominatum and the os femoris furnish the articular surfaces. The one presents a hemispherical concavity, (the acetabulum or cotyloid cavity,) deepened by a circumferential fibro-cartilage; the other, a spheroidal head, supported by a compressed neck, set at an angle of 125° to the shaft of the thigh bone.

One bond of union, the ligamentum teres, lies in the joint, and attaches its extremities near the centre of the respective articular surfaces; another, the capsular ligament, embraces the margin of the acetabulum and the neck of the femur.

A large muscular mass clothes the inner, outer and posterior aspects of the joint. At its fore part the articulation is comparatively superficial. Here, in thin subjects, the femoral head can be distinguished by the touch during the movement of the limb. Six bony prominences are found in the neighborhood of this joint. Two are deep seated and concealed; four are subcutaneous and easily recognized. The former are the trochanter minor and the anterior inferior spine of the ilium; the latter, the trochanter major, the anterior superior spine of the ilium, the spine of the pubes, and the tuberosity

---

* It will be found better to transfix *obliquely*, so that the knife shall enter, or emerge lower on the inside than without.

of the ischium.  These last, with the pubic symphysis, are
generally regarded as points of reference in seeking the posi-
tion of the joint.  The trochanter major is not a good guide,
because its position and relations are modified by the posture
of the limb.  When the weight of the body is equally sup-
ported by both extremities, and the toes are directed slightly
outwards, the heels nearly touching, its most projecting point
is two and a half inches outside of a vertical line drawn
through the centre of the articulation, and is two inches be-
low the level of the anterior margin of the acetabulum.

The other points of reference are relatively immoveable,
and furnish reliable indications.  The following statements are
made by some authorities :

The anterior superior spine of the ilium is one and three-
quarter inches above the upper margin of the cotyloid cavity,
and three-quarters of an inch to its outer side.

A straight line, connecting the superior iliac spine and
ischial tuberosity, crosses the acetabulum at the junction of
its posterior with its anterior two-thirds.

The skin of the pubis is from one to one and a quarter
inches from the anterior margin of the cotyloid cavity.

A line, coinciding with the axis of the horizontal pubic
ramus, has one-third of the acetabulum above it.

The following measurements, obtained from a fully de-
veloped male skeleton, five feet nine and a half inches in
height, are also presented :

The anterior superior spine of the ilium is two and a quarter
inches above the highest point of the cotyloid cavity, and
half an inch in advance of its anterior margin.  The spine of
the pubis is two inches, and the symphysis pubis three inches
from the inmost point of the acetabulum.  Both are one inch
in advance of the joint.

The most dependent part of the ischial tuberosity is one
inch and a half beneath the lower margin of the acetabulum.

As these data are all the result of observation made upon
the bones, some allowance must be added for the possible
thickness of the fascial and integumental coverings.

The three gluteal muscles and all the outward rotators get
insertion on the trochanter major.  The psoas-iliac, passing
beneath Poupart's ligament (with the crural nerve in front of
it) to seek attachment at the trochanter minor, covers the fore
part of the fibrous capsule, and winds its tendon around the

neck of the os femoris. The femoral vessels descend verti-
cally within the margin of this compound muscle, and ap-
proach the femoral shaft, forming, meanwhile, with it and the
neck of the femur, a triangle of surgical value.

The obturator artery, escaping from the pelvis under the
horizontal branch of the pubis, and the ischiatic, descending
behind, between the ischial tuberosity and the greater tro-
chanter, form with one another, with the circumflex and per-
forating vessels, numerous and free anastomoses, which pre-
clude the power to control the circulation, at the upper part
of the thigh, by pressure on the *femoral* artery.

Although formidable, on account of the immense wound
inflicted, the size and number of the vessels cut, the usual
incomplete command of the circulation of the part, the con-
sequent unavoidable and sometimes profuse hemorrhage, the
great attendant nervous shock, and the demonstrated fatality
of its results, the removal of the whole lower limb at the hip
presents the surgeon with as few difficulties as does the analo-
gous operation on the upper extremity. Every variety of
method has been practised in disarticulation at the coxo-
femoral joint, each mode possessing some special advantage
in the eye of the operator who recommends it. Here, how-
ever, as elsewhere, it is improper to advocate, with unyielding
tenacity, the exclusive adoption of any one process, because
it is clearly impossible to foresee what special conditions may
arise demanding its modificaiion or rejection. The standard
methods are each and all applicable to amputation at this ar-
ticulation. But when the state of the soft parts will permit,
a single flap operation is to be preferred.

AN ANTERO–INTERNAL FLAP is thus obtained: The pa-
tient, on his back, is supported with his hips projecting be-
yond the margin of the table. The thigh to be removed
slightly flexed, and the other, with the scrotum, withdrawn
and protected, the operator takes position on the side most con-
venient to himself. If he prefer to stand on the outside, the
limb is transfixed, from a line connecting the superior front
spine of the ilium with the great trochanter, to a point one
inch in front, and the same distance below the ischial tube-
rosity. The knife enters nearer to the ilium than to the tro-
chanter. But if the surgeon stand on the inside, the points
of entrance and emergence for the knife are reversed. In
traversing the limb, the knife should graze the lower margin

of the femoral neck, and enter the surgical triangle already indicated. As a consequence, the chief artery will not be cut at the base of the flap, but some distance lower down.

After transfixion, the knife is carried downwards, with a rapid sawing movement, to cut its way out *at least* six inches below. During this step, the fingers of an assistant's hand follow the blade, and are thrust into the wound to support the femoral artery, which is compressed upon them, previous to its section, by the thumb placed on the anterior integument.

Both of the assistant's hands may be thus employed if thought necessary. So soon as completed, the flap is elevated and retracted, (the hands continuing to grasp the artery,) the head of the femur is rendered prominent, and the capsule of the joint stretched by abduction and outward rotation of the limb. The knife incises the capsule over the femoral head, the joint is entered, the bone dislocated, the ligamentum teres severed, the knife passed behind the bone, and the postero-external mass divided as quickly as possible from the centre toward the surface. If the flap first formed be deficient in length, the section of the tissues of the posterior region is made obliquely downwards; if full and sufficient, transversely outwards.

In the first case a second flap is shaped, varying in dimensions in accordance with the length of its fellow. The arteries severed *after* disarticulation generally first engage the surgeon's attention, the femoral being subsequently tied. If, however, the assistant who grasps this vessel is unreliable, it is best to secure it as soon as possible; perhaps, previous to entering the joint.

We have the authority of Larrey and Delpech for tying the artery before commencing the operation. Some surgeons vary the operation just described by making a posterior transverse or circular cut at the base of the reflected flap *previous* to disarticulation. The division of the ligaments and separation of the limb forms the last step of their process. The English surgeons seem to have a special fancy for two flaps. The necessary modification for the formation of the one behind has already been described. Lisfranc made double lateral flaps.

*Lisfranc's Method.*—The patient is dorsally recumbent, with the ischial tuberosities projected beyond the operating table. The limb is neither adducted nor the reverse. The

knife is entered vertically between the superior iliac spine and greater trochanter, and passed obliquely around and behind the femoral head to make exit below the tuberosity of the ischium. The tissues over the trochanter are grasped and slid backwards, and the knife is carried outwards and down-wards to form an external flap. The structures within are next grasped and elevated. The knife passed "below the head of the femur" across the front and inner side of its neck, emerges at the same point as before, and is again made to cut out, avoiding the trochanter minor. The flaps being elevated and retracted, the arteries are at once secured, and division of the ligaments, with dislocation of the femoral head, com-pletes the operation. In this operation the circulation in the femoral artery is controlled by pressure, where it escapes from the pelvis.

Mr. Guthrie, in his surgical commentaries, makes most judicious reflections on the methods of operating at the hip. He also gives an account of his own practice in a successful case, with good suggestions as to the character of the injury, compelling the sacrifice of the whole lower limb. So much practical sagacity, and such commendable regard for the wel-fare of the patient are manifested, that it is thought advisable to offer the substance of his remarks.

"It may be laid down as a principle," says this apostle of military surgery, " in all cases of accident, whether from shot, shell, or railway carriages, that no man should suffer amputa-tion at the hip-joint when the thigh bone is entire. It should never be done in cases of injury when the bone can be sawn through immediately below the trochanter major, and suffi-cient flaps can be preserved to close the wound. An injury warranting this operation should extend to the neck or head of the bone ;" and it may even be possible to avoid it, by the removal of the bony fragments.

The usual instructions of the books are apt to be drawn from post-mortem experiments on subjects which have not sus-tained injury in the neighborhood of the articulation. Thus, for instance, the recommendation for the varied rotations of the limb, most excellent in theory, would be practically im-possible, because " no person should suffer this operation who has a knee or half a thigh, or even a third of one, to move by the rotatory process." Where choice of integument per-mits, a large anterior flap is best, but the necessary soft

parts are apt to be deficient in cases demanding primary amputation.

*Guthrie's Oval Method.*—The patient is placed on a low table in a horizontal position. The femoral artery is pressed against the pubis. The surgeon stands on the inside of the limb. The incision dividing the integuments is begun three or four inches beneath and on a line with the anterior superior iliac spine, and is carried around the thigh obliquely inwards, backwards and outwards, the same distance below the ischial tuberosity to a point "exactly opposite" to where it was begun A second cut, one-third the length of the first, whose extremities it connects, ascends in a gentle curve behind the great trochanter. The divided integuments are retracted and the glutei incised to the bone. The knife, now placed in contact with the margin of the skin, severs the whole mass on the inner and front part of the thigh. The femoral artery is ligated, the capsular ligament opened, the ligamentum teres cut, and the knife passed behind the dislocated bone, completes the section of the remaining soft tissues, care being taken not to preserve too much muscle. The obturator, ischiatic, and other bleeding vessels, are secured. The nerves are clipped short, the wound cleansed, and its lips confined with "three or more soft leaden sutures." The dressing must be light.

The imperfect control of the circulation attained by pressure upon the femoral artery at the pubes, and the necessity for husbanding the vital fluids in the successful infliction of so serious and large a wound, would seem to demand the utmost possible celerity in its execution as a chief feature in any method of operation to be practised at the hip-joint; yet, it will be observed, that Mr. Guthrie's process, for which the advantage of special applicability to the circumstances warranting the removal of the whole limb is claimed, is a slow process. In this connection we must again refer to Mr. Joseph Lister, of Glasgow. This surgeon has caused a large horse-shoe tourniquet to be made, and, with it, he finds he can thoroughly command the whole pelvic circulation. The instrument is used to compress the lower part of the abdominal aorta against the vertebral column, which it is said to do without causing much pain to the patient. The idea was suggested by the account of an American amputation at the hip for bony tumor, exacting a slow dissection. The aorta in

this case was successfully compressed by the fingers of an assistant. The name of the operator does not transpire.

Figure 93, plate XIV. shows the catlin entered for the antero-internal flap operation. The dotted line (*arrow* C) indicates the position first assumed by the instrument, according to Guerin and Malgaigne, who pierce the joint before carrying the knife through the limb. C, B, traces the subsequent curve of the knife's point in its descent and before its emergence. In figure 94 the transverse cut behind the limb is begun. Figure 95 gives the position of Lisfranc's flaps. Figure 96 outlines the double flap of Mr. Fergusson.