of death after amputations for trauma. The correctness of this view is substantiated by the fact that about seventy-five per cent. of so-called pathological amputations are made for chronic inflammatory conditions of either bones or joints, and that under these circumstances the soft parts are usually more or less atrophied, and yet at the same time densely infiltrated with a connective-tissue growth which, when divided in an operation, presents a barrier to the absorption of deleterious elements. It is noteworthy, as Mr. Bryant has pointed out, that this infiltration of the soft parts does not necessarily interfere with the ready union of the wound. While amputations for chronic affections of the nature indicated terminate fatally in only 14 per cent. of the cases, those made for deformity and neoplasms present a mortality of 26.8 per cent. and 46 per cent. respectively (Golding Bird and Spence).

TABLE II.

| Authority. | Amputations for Injury. | | | Amputations for Disease | | | Total Amputations. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number of cases. | Number of deaths. | Mortality, per cent. | Number of cases. | Number of deaths. | Mortality, per cent. | Number of cases. | Number of deaths. | Mortality, per cent. |
| Malgaigne[1] | 182 | 117 | 64 | 378 | 182 | 48 | 560 | 299 | 53 |
| Guy's Hosp. Rep.[2] | 447 | 201 | 45 | 679 | 147 | 22 | 1.126 | 348 | 31 |
| Chadwick[3] | 846 | 202 | 24 | 524 | 102 | 19 | 1.370 | 304 | 22 |
| Billroth (1860-67)[4] | 106 | 57 | 54 | 58 | 18 | 31 | 164 | 75 | 46 |
| Wilms[5] | 144 | 58 | 40 | 94 | 32 | 33 | 238 | 90 | 38 |
| Lücke[6] | 28 | 21 | 75 | 52 | 25 | 48 | 80 | 46 | 57 |
| Volkmann[7] | 130 | 24 | 19 | 187 | 7 | 3 | 317 | 31 | 9+ |
| Ashhurst[8] | 72 | 24 | 33 | 28 | 4 | 14 | 100 | 28 | 28 |
| Spence[9] | 186 | 77 | 41 | 371 | 73 | 19 | 557 | 150 | 27 |
| Glasgow Inf.[10] | 388 | 126 | 32 | 338 | 40 | 12 | 726 | 166 | 23 |
| Leeds Inf.[11] | 355 | 84 | 24 | 305 | 48 | 16 | 660 | 132 | 20 |
| St. George's Hosp.[12] | 159 | 72 | 46 | 409 | 99 | 24 | 568 | 171 | 30 |
| St. Barth. Hosp.[13] | 115 | 33 | 29 | 424 | 55 | 13 | 539 | 88 | 16 |
| Total | 3,158 | 1,096 | 34.7 | 3,847 | 832 | 21.6 | 7,005 | 1,928 | 27.5 |

[1] Malgaigne: Arch. gén. de méd., 1842, 14, p. 52.
[2] Guy's Hospital Reports, published statistics of vol. xxi., 3d S., to which cases since reported have been added.
[3] Amputation, statistics of, in four American hospitals.
[4] Statistics of Surg. Clinic of Zürich. Langenbeck's Arch. f. Chir., vol. x.
[5] P. Güterbock: Statistics of Bethanien. Langenbeck's. Arch. f. Chir., vol. xxii., p. 80.
[6] Lücke: Statistics of Hospitals of Berne. Zeitschr. f. Chir., vol. iii., p. 380.
[7] M. Oberst: Die Amputationen in d. Volkmann'schen Klinik. Halle, 1882. Statistics rearranged to suit this table; 57 complicated cases with 17 deaths are included.
[8] Ashhurst: Encyclop. of Surg., vol. i.
[9] Spence: Med. Times and Gazette; Edinb. Med. Journ. Ashhurst in Internat. Encyl. of Surg., vol. i.
[10] Amputations for eight years, ending December 31, 1881, M. Thomas: Lancet, 1882, vol. i., p. 1067.
[11] Amputations in the Leeds Infirmary by Thomas Nunnely, Lancet, 1870, vol. i., p. 153.
[12] T. Holmes: St. George's Hospital Reports, yols. i. and viii. Also vols. ix. and x.
[13] St. Bartholomew's Hospital Reports, vol. xix., Stat. Tables, p. 92.

TABLE III.—MAJOR AMPUTATIONS DONE AT THE CINCINNATI HOSPITAL FROM JANUARY 1, 1890, TO JANUARY 1, 1900.

| | Injury. | | | | Disease. | | | |
|---|---|---|---|---|---|---|---|---|
| | Recovered. | Died. | Total. | Per cent. | Recovered. | Died. | Total. | Per cent. |
| Leg | 54 | 3 | 57 | 5.2 | 22 | 2 | 24 | 8.3 |
| Knee | 4 | .. | 4 | .. | 2 | 1 | 3 | 33 |
| Thigh | 11 | 5 | 16 | 31.3 | 17 | 3 | 20 | 15 |
| Hip | .. | .. | .. | .. | 1 | .. | 1 | |
| Wrist | 2 | .. | 2 | .. | .. | .. | | |
| Forearm | 11 | 1 | 12 | 8.3 | 3 | .. | *3 | |
| Elbow | .. | .. | .. | .. | .. | .. | .. | |
| Arm | 11 | .. | 11 | .. | 3 | .. | 3 | |
| Shoulder | 2 | 4 | 6 | .. | 1 | .. | 1 | |
| Total | 95 | 13 | 108 | 13.7 | 49 | 6 | 55 | 10.9 |

* One multiple injury.

TABLE IV.—AMPUTATIONS DONE DURING TWELVE YEARS PRIOR TO 1895, NEWCASTLE-ON-TYNE. (PAGE.)

| | Number. | Recovered. | Died. | Per cent. | Number. | Recovered. | Died. | Per cent. |
|---|---|---|---|---|---|---|---|---|
| Double amputation | 13 | 7 | 6 | 46 | | | | |
| Hip joint | 6 | 3 | 3 | 50 | 23 | 14 | 9 | 39 |
| Thigh | 52 | 39 | 13 | 25 | 154 | 144 | 10 | 6.4 |
| Knee | 7 | 7 | .. | .. | 2 | 2 | | |
| Leg | 76 | 69 | 7 | 9.2 | 70 | 67 | 3 | 4.2 |
| Ankle | 26 | 25 | 1 | 3.8 | 122 | 120 | 2 | 1.6 |
| Shoulder | 17 | 16 | 1 | 5.8 | 15 | 14 | 1 | 6.6 |
| Arm | 37 | 34 | 3 | 8.1 | 18 | 17 | 1 | 5.5 |
| Forearm | 36 | 35 | 1 | 2.8 | 31 | 31 | | |
| Wrist | 7 | 7 | | | | | | |
| Total | 277 | 242 | 35 | 12.6 | 435 | 409 | 26 | 5.9 |

Tables III. and IV., while they show the great reduction in the mortality of amputations in general, still demonstrate the greater mortality of operations done for trauma. That the difference is not so marked in my own table (III.) is due to the fact that many of the pathological amputations were made for senile gangrene.

MULTIPLE AMPUTATIONS.—While it is comparatively rare that disease or injury affects more than one extremity in a degree sufficient to warrant double amputations, these are nevertheless occasionally required. It is self-evident that they are of the gravest importance and present a most unfavorable prognosis, on account of the shock associated with the injury. Of 28 double amputations made in the Western Pennsylvania Hospital, 27 were for railroad accidents, and 15 of the patients died. The fact that 11 of the deaths occurred in the first forty-eight hours shows that they were due rather to the injuries than to the amputations. Of 13 multiple amputations done for injury at the Newcastle Infirmary 6, or 46 per cent., died. When multiple amputations are made for disease, which is in about 10 per cent. of all cases, it is usually for frost-bite.

MULTIPLE AMPUTATIONS IN MILITARY PRACTICE.

| | Number of cases. | Recovery. | Deaths. | Undetermined. | Per cent. of mortality. |
|---|---|---|---|---|---|
| Both amputations in the upper extremity | 47 | 31 | 16 | .. | 34 |
| One amputation in upper, one in lower extremity | 43 | 21 | 21 | 1 | 50 |
| Both amputations in lower extremity | 82 | 31 | 50 | 1 | 61.7 |
| Total | 172 | 83 | 87 | 2 | 51.1 |

MULTIPLE AMPUTATIONS IN CIVIL PRACTICE.

| | Number of cases. | Recovered. | Died. | Mortality, per cent. |
|---|---|---|---|---|
| Thighs | 18 | 3 | 15 | 83 |
| Thigh and leg | 21 | 9 | 12 | 57 |
| Thigh and arm | 5 | 2 | 3 | 60 |
| Thigh and forearm | 7 | 4 | 3 | 43 |
| Leg and leg | 42 | 20 | 22 | 52 |
| Leg and arm | 11 | 6 | 5 | 45 |
| Foot and foot | 12 | 10 | 2 | 16 |
| Arm and arm | 9 | 6 | 3 | 33 |
| Forearm and forearm | 15 | 11 | 4 | 27 |
| Total | 140 | 71 | 69 | 49 |

The mortality attending multiple amputations, it will be seen from the preceding tables, is about fifty per cent., amputations through the lower extremities presenting a greater fatality than those of the upper. The first table illustrates the mortality of these amputations in military practice. The second table, made up from German, English, and American reports, shows the relative frequency and fatality of multiple amputations as they are made in different parts of the body.





When the necessity for multiple amputations arises, the question must be considered whether they shall be made at the same time, when they are called synchronous amputations, or whether a longer or shorter interval shall intervene between them. In these cases, as in amputations generally, no definite rules can be formulated. In cases of trauma it is generally advisable to make both amputations at the same time, removing the larger member first, but deferring the closure of the wound until both amputations are completed. If, after the first operation, the condition of the patient is such as to preclude the possibility of recovery if the second is performed at once, the less injured member must be treated as if the injury sustained by it were of a less degree of severity and justified an attempt at conservatism. In cases of disease affecting several extremities (frost-bite, white swelling, etc.), it is generally better to observe a sufficient interval between the operations to permit the constitution to rally from the first before the second amputation is made. In these cases the danger of septic infection from the limb that is spared is not as great as in cases of traumatic origin.

Even triple and quadruple amputations are occasionally performed with success. In a case of railway accident, Dr. G. Koehler, of Schuylkill Haven, Pa., in 1867, removed simultaneously, on account of a railway injury, both legs and one arm from a lad thirteen years of age, recovery taking place. Professor Stone, of New Orleans, had a similar case in a man of thirty, the subject of a railway accident. According to Professor Agnew, successful triple amputations were made in York, Pa., in 1868, and Rochard reported to the Academy the case of De Leseleuc, of Brest, who had successfully amputated a thigh, leg, and arm in a man the subject of trauma. Quadruple amputations, usually made for frost-bite, have been successful in the cases of Muller, of the United States army, Dr. Begg, of Dundee, and M. Champenois, of the French army. Other cases are referred to by Morand, Longmore, and Southam. M. Larrey mentions two cases, one of which, the case of a soldier who had all his extremities removed by heavy ordnance, he had seen in the "Invalides." The other case, which he had seen in Algiers, was that of an Arab, twelve years of age, who had intentionally placed himself on the track in such a position that a passing train mangled both hands and feet. Still another successful quadruple amputation for frost-bite has recently been recorded by Tremaine.

INDIVIDUAL AMPUTATIONS.

AMPUTATION OF THE FINGERS.—When the phalanges of the fingers or thumbs are the seat of incurable disease or of severe injury, amputation often becomes necessary. It is well to remember that if the bone of the distal phalanx alone is affected, its natural exfoliation should be awaited, when the soft parts can often be preserved, to the great advantage of the patient. Particularly in the thumb and index finger is it necessary to save as much as possible. In the third and fourth fingers amputation should not be practised at the second joint, since the preservation of the proximal phalanx leaves a part that is ungainly and does not add to the usefulness of the hand. When a portion of a finger requires removal the operation may be practised either at a joint or in the continuity of a phalanx. In both cases it is important to remember that when the finger is flexed the articulations are below the prominences made by the knuckles, the distal, middle, and proximal articulations being respectively one-sixth, one-fourth, and one-third of an inch below the most prominent lines of the joints. It must also be borne in mind that strong lateral ligaments prevent, until they are divided, the complete exposure of articular surfaces (Fig. 136). When the amputation is to be made at the joint, it can be most expeditiously executed in the following manner: The hand being held in the prone position, the tip of the finger, encased in a piece of gauze, is firmly seized by the operator and flexed. With a long and narrow knife an incision is made from side to side over the dorsal surface. By this the joint is at once opened. With two rapid strokes of the point of the knife the lateral ligaments are next severed. The blade of the knife, with edge directed downward, is then placed behind the flexor surface of the phalanx to be removed, from the soft parts of which a well-rounded flap is to be cut from within outward by a sawing movement. The wound presents the appearance shown in Fig. 137. Only when there is an insufficiency of flap is it proper to remove the head of the proximal bone. The disarticulation of a phalanx can also be effected by transfixion: the hand being held in a supine position and the finger extended, the latter is transfixed on the palmar side of the bone, just below the fold of the joint; a palmar flap of sufficient length is then made. The flap being held out of the way, the joint is made prominent by hyperextension and opened. The soft parts on the dorsal surface of the joint are then divided by a single sweep of the knife. In amputations of the fingers, the soft parts of the palmar aspect are always preferable for a flap, since the cicatrix is then protected from pressure. Where they cannot be utilized,

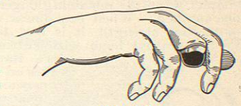

FIG. 136.



FIG. 137.

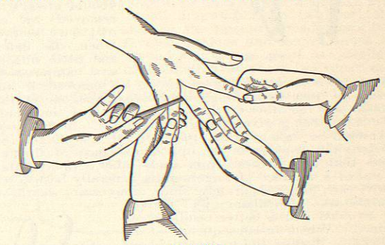

FIG. 138.

a dorsal flap can be made, either by transfixion or, what is preferable, by cutting from without. Lateral flaps, single or double, can likewise be utilized in this amputation. In amputations in the continuity of a phalanx the flap may be cut from the palmar aspect by a transfixion, the dorsal surface being divided by a transverse incision, or a second flap may be formed. The circular operation, with longitudinal lateral cuts, may likewise be successfully practised in this position. After the division of the soft parts, the bone must be divided with a metacarpal saw or the cutting forceps. In all amputations of the fingers two digital arteries usually "spirt." Their ligation is unnecessary; the approximation of the wound surfaces generally suffices for their closure.

Amputation of an entire finger at the metacarpo-phalangeal joint can be readily accomplished as follows: The adjacent fingers being held aside by an assistant, the operator, with his back to the patient, grasps the finger to be removed with the left hand and extends it sufficiently to see its palmar surface. A narrow knife being introduced from the right side divides the soft parts on

the palmar surface on a level with the extended interdigital web. The incision is then carried around the right side of the finger (Fig. 138, Esmarch) in a slight curve into the dorsal surface of the head of the metacarpal bone. The knife is then carried around the left side of the finger in the same manner, the ends of the first incision being thus joined. The tendons, lateral ligaments, and capsule being successively divided, the disarticulation is completed and a heart-shaped wound left. The margins of this wound come accurately into contact when the remaining fingers are approximated to one another. When comeliness of the hand is valued more than strength, it is best to remove the head of the metacarpal bone with cutting forceps (Fig. 139), since its preservation usually leaves an unsightly prominence. In persons who do manual labor its removal should be avoided, since it would materially lessen the strength of the hand.

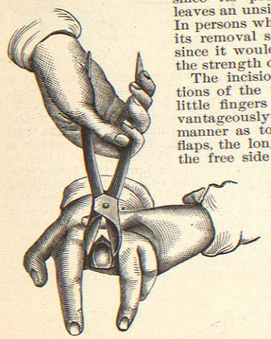

Fig. 139.

The incisions for disarticulations of the thumb, index and little fingers may often be advantageously modified in such a manner as to make two lateral flaps, the longer of which is on the free side of the finger, the shorter being made on the side of the interdigital web. To preserve the symmetry of the hand, the heads of the second and fifth metacarpal bones should always be removed by an oblique section when the index and little fingers are amputated. When two or more fingers are to be removed, it can easily be done by making two convex flaps, one on the dorsal and the other on the palmar aspect of the hand, the latter being given the greater length. A flap may likewise be taken from the side of one finger, or rectangular flaps from the opposite surfaces of the fingers that are farthest from each other. In amputations of a number of fingers it is generally best to remove each finger separately, since unnecessary sacrifices for the sake of brilliancy will thereby be avoided and a better result be obtained. When, in consequence of accident or disease, the metacarpal bone must be removed with the finger, the incisions are like those for the removal of an entire finger, only that the dorsal cut must be continued upward toward the wrist for a varying distance, and that the incision around the root of a finger is to be made above the interdigital web. The extensor tendons being divided as high as possible, and the bone separated from its muscular attachments, this is divided with cutting forceps near its articular extremity or entirely enucleated. When the surgeon has the option, the former practice should be preferred, to avoid opening the articulations of the wrist. Exceptions can be made in the first and fifth metacarpal bones, which, having individual synovial sacs, may be removed without the danger of producing extensive inflammation of the wrist. Amputation of the entire thumb should rarely be practised, for every portion of it that can be saved is of value for opposition to the fingers. When it becomes necessary to remove the thumb with its metacarpal bone, it is best accomplished by the oval method. The point of a knife should be entered above its articulation with the carpus, and a triangular incision (Fig. 140) made along its radial aspect, the sides of the triangle diverging from each other as they approach the

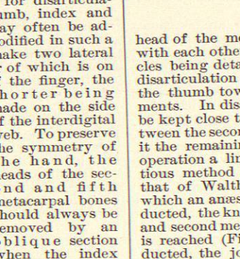

Fig. 140.

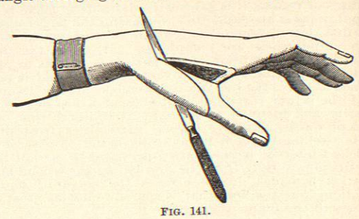

Fig. 141.

head of the metacarpal bone and becoming continuous with each other in the web and index finger. The muscles being detached and the extensor tendons divided, disarticulation is readily effected by forcibly extending the thumb toward the radial side and severing the ligaments. In disarticulating, the edge of the knife should be kept close to the base of the bone, lest the joint between the second metacarpal and trapezium, and through it the remaining carpal joints, be opened. After this operation a linear cicatrix remains. The most expeditious method of amputating the thumb yet devised is that of Walther, and is admirably suited to cases in which an anæsthetic is not used. The thumb being abducted, the knife is made to cut its way between the first and second metacarpal bones until the base of the former is reached (Fig. 141). The thumb being greatly abducted, the joint between its metacarpal bone and trapezium is opened and traversed. The knife is then carried downward upon the radial side of the bone, where, by cutting outward to the level of the interdigital web, a radial flap is made. Amputations of the little finger with its metacarpal bone can be made in the same manner, either by the oval or by the flap method.

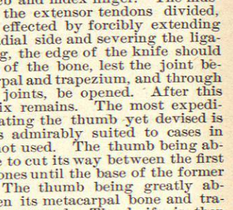

Fig. 142.

Injuries of the palm of the hand are generally of such a nature that by a little ingenuity on the part of the surgeon part of it can be preserved. When in rare cases disarticulation of the last four metacarpal bones becomes necessary, the thumb being left, it may be done as follows: The hand being grasped and held in supine position, a long, narrow blade is passed through the palm from the base of the fifth metacarpal bone to the web of the thumb. By cutting outward, a broad semilunar flap is made (Fig. 142). An incision is next made on the back of the hand, beginning at the web of the thumb and carried obliquely upward to the upper third of the second metacarpal bone, whence it is continued transversely over the three last metacarpal bones until it meets the palmar flap at the ulnar border of the hand. Both flaps are thus reflected to the carpo-metacarpal joints, and disarticulation is effected from the ulnar side, the hand being forcibly abducted.

Amputation at the Wrist.—In amputations at the wrist the surgeon has the choice of the circular and the tegumentary flap methods, both of which leave an excellent stump.





*Circular Method.*—Retracting the skin of the forearm with his left hand, the operator carries the knife in a circular sweep around the hand one inch below the styloid processes. The skin and subcutaneous layers, being

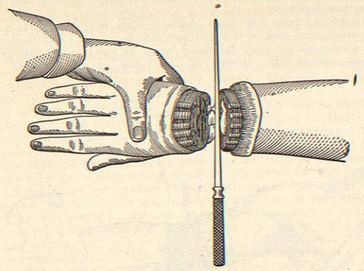

Fig. 143.

liberated by incisions perpendicular to the axis of the limb as far as the styloid processes, should be reflected like a cuff. The hand being then pronated and forcibly flexed, the tendons are divided and the joint opened by an incision over the dorsum from one styloid process to the other. In making this incision the convexity of the upper surface of the carpus must be remembered. The lateral ligaments being next severed, the anterior part of the capsule and all the flexor tendons are cut through with one stroke of the knife (Fig. 143).

*Antero-posterior Flap.*—The operator seizes the lower part of the pronated hand, and after flexing it makes a semilunar incision over the middle of the back of the hand from one styloid process to the other (Fig. 144). After reflection of the flap the joint is opened as in the circular operation, and the operation is completed by cutting a short palmar flap from within outward (Fig. 145). The projection of the pisiform bone often renders this part of the operation embarrassing.

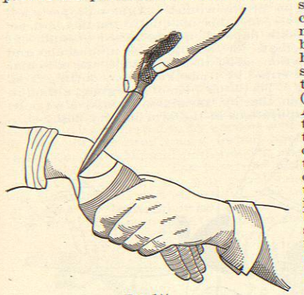

Fig. 144.

*Method of Dubreuil.*—A very excellent result can be obtained by making a single lateral flap, either from the radial surface of the thumb or from the soft parts covering the fifth metacarpal bone, the former being preferable. As will be seen from Fig. 146, the operation consists in making a semilunar flap with broad base, from the integument which covers the first metacarpal bone, the point of the flap reaching the base of the first phalanx. A transverse incision around the wrist is then made and disarticulation is completed as in the other operations.

Amputation of the Forearm may be practised by the circular, tegumentary, or musculo-tegumentary flap method. The lower third of the forearm, containing a large number of tendons, is ill suited for the latter method, the circular operation being preferable (Fig. 147). When the integument is greatly infiltrated and the reflection of a cuff is thereby rendered impracticable, tegumentary flaps can be made, the tendons being divided by a circular incision (Fig. 148). The presence of a large number of synovial sheaths, and the danger of inflammation in them when they are opened should not militate against the value of operations in the lower third of the forearm, since, by operating below the insertion of the *pronator radii teres*, movements of pronation and supination will be preserved.

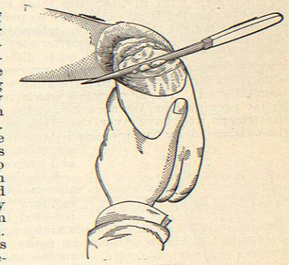

Fig. 145.

A number of surgeons prefer the flap operation in all amputations of the forearm, making both flaps by transfixion in fleshy subjects. Under opposite circumstances the anterior flap can be made in this manner, and the posterior by cutting from within outward. When this method is resorted to, the bones must be divided as high up as possible, to overcome their tendency to protrude at the angles of the wound. Musculo-tegumentary flaps should be used only in the fleshy part of the forearm. In all amputations in this part the catling is to be used, in the manner already described (Fig. 123). The divided tendons and nerves must be drawn from the wound and cut as short as possible. The arteries requiring ligation are the radial, ulnar, and interosseous. It is particularly essential that the latter should be divided *but once*, and carefully secured. When secondary hemorrhage occurs after amputation of the forearm, it is almost always the result of faulty ligation of this vessel.

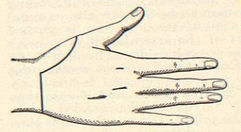

Fig. 146.

Amputation at the Elbow.—The removal of the forearm at its articulation with the humerus is generally acknowledged to have been first performed by Ambrose Paré, in 1536, in the case of a soldier who had received a gunshot wound of the forearm, which was followed by gangrene. The operation did not meet with much favor by surgeons generally, until it was again advised and practised in the second quarter of this century by Textor, of Würzburg, by Dupuytren, and by Liston. With the exception of Chenu's statistics, the results of amputation at the elbow have been very favorable, the death rate not exceeding 14 per cent. (Agnew). The last-named writer,

Fig. 147.

however, gives a mortality of 65 per cent. as that which attended disarticulations of the forearm during the Crimea. On the other hand, of 39 amputations at the

elbow, made during the War of the Rebellion, in which the result was determined, only 3 succumbed; the mortality being less than 8 per cent.

The operations generally resorted to in amputations at the elbow are the circular and musculo-tegumentary flap methods. When the former is practised, a circular incision should divide the skin and subcutaneous cellular layer of the forearm at least two inches below the humeral condyles. When a cuff of sufficient length has been reflected, the anterior surface of the joint is made prominent by hyperextension, and divided by a transverse cut with the end of the knife. When the lateral ligaments are next divided, the joint surfaces are sufficiently separated from each other to permit the knife to be passed behind the olecranon, where the tendon of the triceps is to be divided. The latter step of the operation is sometimes attended with such difficulty that many surgeons preserve the olecranon process by sawing the ulna transversely after disarticulation of the radius has been effected. The advantages which are to be obtained by its preservation, on account of the influence which the triceps will have over the artificial limb, are more than balanced by the increased dangers of retention of secretion in the wound and necrosis.

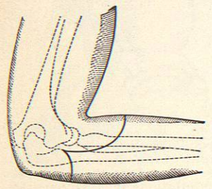

Fig. 148.

Excellent results can also be obtained by tegumentary flaps. As represented in Fig. 148 (Esmarch), a curved incision is made over the flexor surface of the forearm, beginning and ending about one inch below the condyles. The large semilunar flap thus made is reflected to its base. A second, but shorter convex flap is made posteriorly, which, when reflected, exposes the olecranon. The operation is then completed by disarticulation, as in that by the circular method. The most brilliant operation, and at the same time a very satisfactory one, is that by which a long anterior flap is made by transfixion. The knife, being introduced a little less than an inch below the external condyle (for the right arm) of the humerus, is pushed directly across the front of the articulation to a point on the same level on the opposite side. The arm being held in a supine position, a broad, almost rectangular flap, from four to five inches in length, is made by cutting outward. The ends of the wound should then be united by a slightly convex incision carried across the posterior aspect of the joint. Disarticulation is then effected as in the previous operations.

When the soft parts of the anterior portion of the forearm cannot be utilized, the integument of the posterior surface can be shaped into an admirable covering for the end of the bone. Ashhurst thus describes the elliptical incision by which this is accomplished: "The arm being semiflexed, the point of the knife is entered nearly an inch below the internal condyle of the humerus, curved upward over the front of the forearm nearly to the line of the joint, and downward again to a point an inch and a half below the external condyle; the arm being then forcibly flexed, the ellipse is completed on the back of the forearm by a curved incision passing nearly three inches below the tip of the olecranon. The cuff thus marked out is rapidly dissected upward as far as necessary, when the muscles of the front of the forearm are cut about half an inch below, and the ulnar nerve as far above the joint, and disarticulation is effected from the outer side. The wound is closed transversely, forming a small curved cicatrix in front of the bone."

It is probably always advisable, except in cases of disease, to preserve the articular surface of the humerus intact, although Sir William Ferguson believed that a section above the condyles leaves a preferable stump, and one more likely to heal promptly. In all amputations at the elbow, the radial, ulnar, and interosseous arteries require ligation. When the incision through the soft parts anteriorly is made on a higher level than is ordinarily necessary, the brachial may be divided and require ligation.

Amputation of the Arm.—This may be performed at any point below the axillary folds, and all the methods of amputating may be used with advantage in different cases, since the choice of methods often permits the

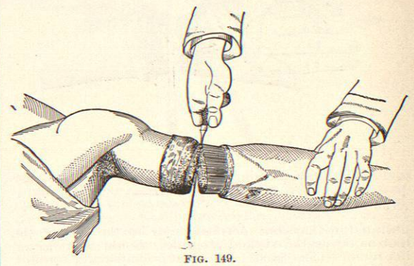

Fig. 149.

operator to save a considerable portion of the arm. On account of the central position of the humerus, the arm is properly considered the typical position for the double musculo-tegumentary flap operation by transfixion, and many surgeons prefer this method in this situation. The objection to be urged against it is the unequal retraction of the integument and underlying muscles, the latter generally protruding a varying distance over the cutaneous margins of the wound. Agnew properly advises that, to overcome this unequal retraction, anteroposterior oval skin flaps should be raised of sufficient length to compensate for the difference in muscular and cutaneous retraction; after these are made, the muscular flaps are formed either by transfixion or by cutting from within outward. The latter plan of operating, although less brilliant than that by transfixion, should always be preferred in amputations of the arm in very fleshy subjects. In making the flaps, the posterior should always be made first, the anterior, containing the important vessels and nerves, being made last. According to the dimensions of the limb, the flaps should be made from two to three inches in length.

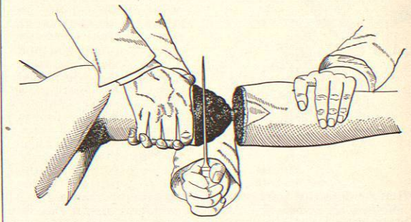

Fig. 150.

In slender subjects, the circular operation answers admirably. In exceptionally thin arms, the integument can be retracted sufficiently to make the operation by a single circular incision. As a rule, however, it is best formally to reflect a cuff (Fig. 149), or to make rectangular cutaneous flaps by slitting the cuff on each side. In dividing the muscles by a circular incision, the biceps generally retracts more than the remaining muscles. The wound is often so irregular in consequence that a second division of the muscles becomes necessary (Fig. 150). In cases of injury attended with great destruction of the soft parts on the dorsal aspect of the arm, the Teale method, by rectangular flaps, offers particular advantages. The incisions for making the long anterior flap must be made in such a manner that the inner one shall be without the brachial artery, which should be contained in the short posterior flap.





In amputations through the middle and lower thirds of the arm, the circulation can be controlled in the ordinary manner by the Esmarch tube or tourniquet. In amputations higher up, where the tourniquet would be in the way of the operator, and liable to slip, the main artery can be compressed against the head of the bone by an assistant, or against the first rib above the clavicle. When a tourniquet is used in amputations in the upper part of the arm, it should be so applied that a roller covers the axillary artery in the arm-pit, while the plate of the tourniquet can be fixed against the acromial process of the scapula. The arteries requiring ligation after amputation of the arm are the brachial, superior or inferior profunda, occasionally the anastomotica, and four or five muscular branches. It should be remembered, likewise, that in every fifth subject, according to Quain, there is a high division of the brachial into radial and ulnar.

In 5,273 cases of amputation of the arm for gunshot injury, 1,246, or 23.6 per cent., terminated fatally. The gravity of amputation of the arm does not increase with the extent of the limb removed, amputations through the lower third presenting a mortality of 35 per cent. against 19 per cent. for amputations in the middle and 22 per cent. for those of the upper third. In the statistics of Gorman, derived from civil practice, this remarkable feature in the prognosis of amputations of the arm is even more pronounced, the mortality following amputations in the upper, middle and lower thirds being 23 per cent., 21 per cent. and 44 per cent. respectively. Of 14 amputations of the arm in the Cincinnati Hospital all recovered. Of 157 amputations of the arm collected from the recent statistics of Erdman, Page, and my own, 20, or 12.8 per cent., died. For the comparative mortality after amputations of the arm for injury and for disease, the reader is referred to Tables I., II., and III.

Amputation at the Shoulder.—Although this operation was referred to by ancient writers on medicine, it was not performed as a formal operation till 1710, when the elder Morand performed it with a fatal result in a case of caries. The case was not recorded until some years later, by the younger Morand. The second operation, which was successful, was made in 1715 by the elder Le Dran, likewise for caries. That the arm had previously been removed at the shoulder in a case

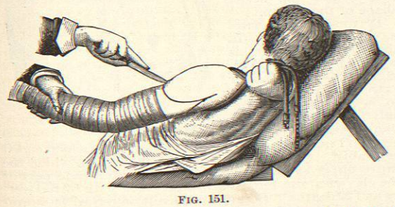

Fig. 151.

of gangrene appears in the *Jour. de Méd. de M. De la Roque*, 1686. "The surgeon took a small saw to remove the bone of the arm, but perceiving that it was loose in the joint, he gave it several slight 'jerks,' when the bone was readily drawn from the socket." Ravaton, La Faye, Heister, and Bromfield repeated the operation from time to time on the Continent and in England, but it remained for the distinguished Larrey to give it a firm footing among surgical procedures. Of 111 amputations made by him at this part, 97 recovered.

In all amputations of the shoulder, the circulation in the axillary artery must be controlled. This can be accomplished by the use of the rubber tube of the Esmarch bandage firmly wound around the axilla and shoulder, and held by an assistant or clasped toward the neck of the patient (Fig. 151). To prevent the slipping of the strap, which is likely to occur when the head of the humerus leaves the socket, two long transfixion pins may be used, the one in front of and the other behind the acromion. The anterior pin is introduced through the middle of the anterior axillary fold near the trunk line. It is made to emerge an inch above the shoulder, one inch to the inner side of the acromial tip. The second pin transfixes the posterior axillary fold in the same manner, emerging behind the acromion (Fig. 152). In all amputations of the shoulder the joint should be approached from the outer side, so that the artery shall not be divided until disarticulation has been effected. In this manner an assistant can, if necessary, pass his thumb into the wound above the knife (Fig. 153) and compress the vessel before it is cut.

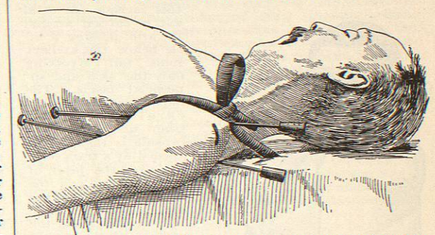

Fig. 152.—Showing Wyeth's Pins and the Rubber Tubing in Place. A piece of black court plaster indicates the tip of the acromion. (Taken, by permission, from Keen's article on shoulder amputations, in the Transactions of the American Surgical Association for 1894.)

Two pairs of pedicle clamp forceps with blades three inches long applied above the line of division of the inner flap, the one from in front and the other from behind, will perfectly control the artery while the operation is being completed. Thereby skilled assistance, and even the Esmarch strap, can be dispensed with. The hemorrhage is from the smaller vessels only and is slight. When the axilla is invaded so high that this plan of hæmostasis is impracticable, the axillary should be tied by dividing the pectoral muscle as suggested by Delpech, or the subclavian should be tied in its third part, as a preliminary step to the amputation. When such precautions as have been described can be taken, it is not necessary to make a preliminary ligation of the artery in the axilla. Amputations at the shoulder joint can be made by the oval or flap method, and likewise by a circular operation with external longitudinal incision.

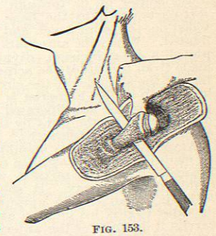

Fig. 153.

*Oval Method.*—This operation, generally designated Larrey's operation (as shown in Fig. 151), is performed as follows: The patient being placed in a semirecumbent