

JOSEPH BELL

A MANUAL OF THE
OPERATIONS OF
SURGERY

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Operations of Surgery**

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Содержание

PREFACE TO FIFTH EDITION	6
PREFACE TO THE FIRST EDITION	7
CHAPTER I.	15
CHAPTER II.	36
Конец ознакомительного фрагмента.	49

Joseph Bell
A Manual of the Operations of Surgery /
For the Use of Senior Students, House
Surgeons, and Junior Practitioners

TO THE MEMORY OF
JAMES SYME, ESQ., F.R.C.S. AND F.R.S.E.
SURGEON TO THE QUEEN IN SCOTLAND
PROFESSOR OF CLINICAL SURGERY IN THE UNIVERSITY OF
EDINBURGH ETC. ETC.

THIS BOOK IS DEDICATED BY HIS OLD HOUSE-SURGEON AND
ASSISTANT
THE AUTHOR.

PREFACE TO FIFTH EDITION

To retain the small size of the work and to keep it up to date have been the Author's aim in the Fifth Edition.

*20 Melville Street, Edinburgh,
August 1883.*

PREFACE TO THE FIRST EDITION

Having been asked, year after year, by the members of my Class for Operative Surgery, to recommend to them some Manual of Surgical Operations which might at once guide them in their choice of operations, and give minute details as to the mode of performance, I have been gradually led to undertake the production of this little work.

My aim has been to describe as simply as possible those operations which are most likely to prove useful, and especially those which, from their nature, admit of being practised on the dead body.

In accordance with this plan, neither historical completeness of detail, nor much variety in the methods of performing any given operation, is to be expected. Hence, also, many omissions which would be unpardonable in the briefest system of Surgery are unavoidable. For example, excision of tumours and operations for necrosis are hardly mentioned, because for these no special instructions can well be given; for, while general principles may guide us to *what* should be done, the special circumstances of each case must dictate *how* it is to be done.

In such a work as this, to attempt originality would be undesirable and intrusive; a judicious selection, a faithful compilation, are all that can be expected.

That the selection of operations may sometimes show "Northern Proclivities" is possible; and this is perhaps not unnatural to a scholar and teacher in the Edinburgh School.

An earnest endeavour has been used to make the references correct and copious: for any mistakes or omissions the author would crave indulgence.

The four plates which precede the letterpress were drawn on wood (from original photographs) by Mr. D.W. Williamson, Melbourne Place, and the lines of incision for the various operations were added by the author.

The rough woodcuts scattered through the work were drawn on wood by the author, and for their roughness he, not his engraver, is responsible. He also hopes that the references in the letterpress will be accepted as sufficient acknowledgment of the true ownership, in those few instances in which the idea of the diagram has been borrowed.

It has been thought unnecessary to introduce woodcuts of surgical instruments, as the illustrated catalogues lately published by Weiss, Maw, and others, are sufficiently accurate.

In excuse of the frequent baldness and brevity of the style, the author must point to the size and price of the work. Its composition would have been easier had its dimensions been greater.

Though intended chiefly to guide the studies, on the dead subject, of students and junior practitioners, the author ventures to hope that the Manual may be useful to those who, in the public services, in the colonies, or in lonely country districts, find themselves constrained to attempt the performance of operations which, in the towns, usually fall to the lot of a few Hospital Surgeons.

JOSEPH BELL.

5 Castle Terrace, Edinburgh,
July 1866.

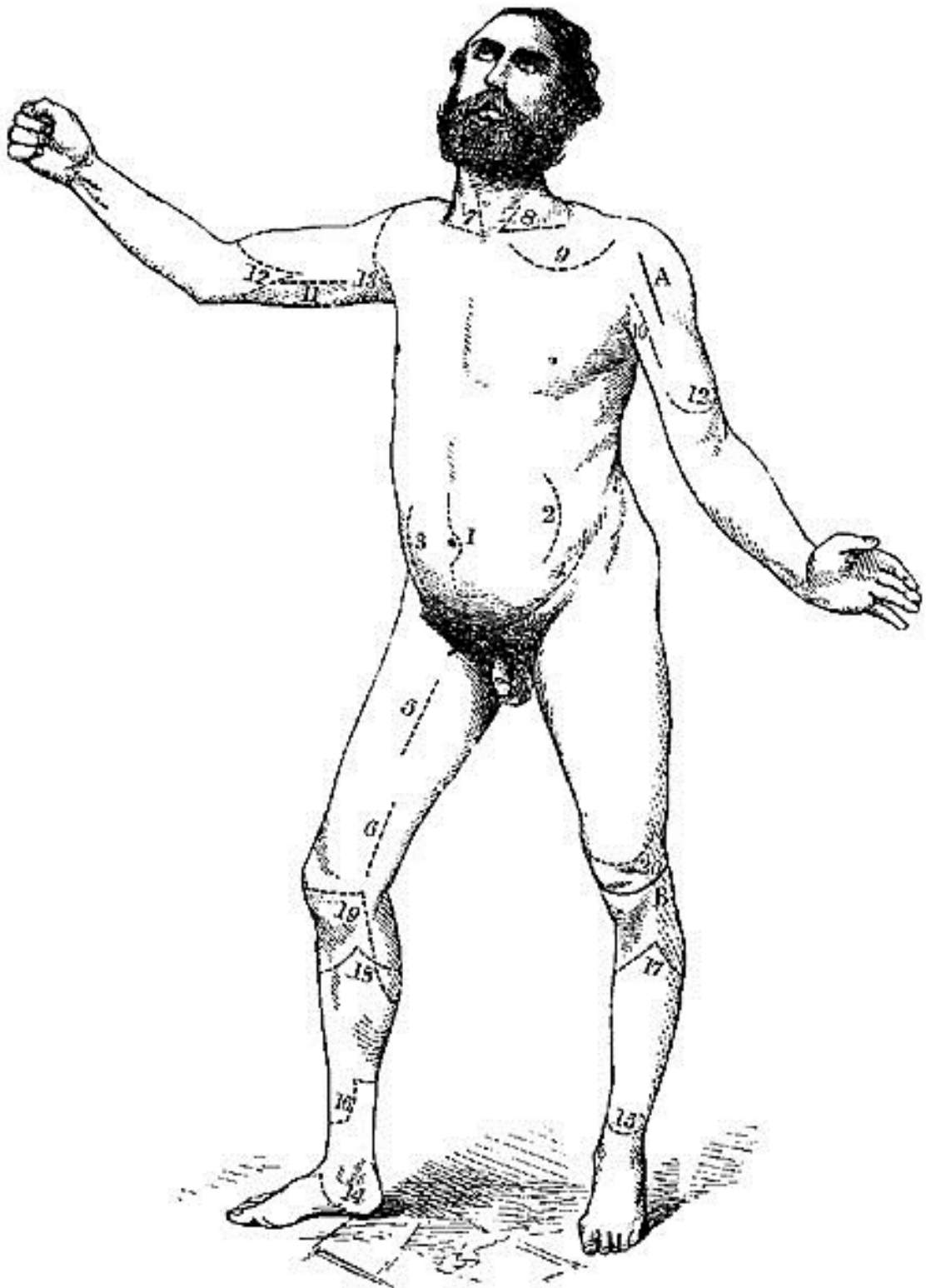


PLATE I.

1. Ligature of Aorta—Sir A. Cooper's incision.
2. Ligature of Aorta—South and Murray's incision.
3. Ligature of Common Iliac.
4. Ligature of External Iliac—Sir A. Cooper's.
5. Ligature of Femoral in Scarpa's triangle.

6. Ligature of Femoral below Sartorius.¹
 7. Ligature of Innominate.
 8. Ligature of third part of Left Subclavian.
 9. Ligature of Axillary in its first part.
 10. Ligature of Axillary in its third part.
 11. Ligature of Brachial.
 12. Amputation of Arm by double flaps.
 13. Amputation at Shoulder-joint (1st method), showing portion of skin left uncut till the conclusion of the disarticulation.
 14. Amputation at Ankle-joint by internal flap—Mackenzie's.
 - 15-16. Amputation of Leg just above the Ankle-joint.
 - 17-18. Amputation below Knee—modified circular.
 19. Amputation through Condyles of Femur—Syme, and Pl. III. 5.
 20. Amputation at lower third of Thigh—Syme, and Pl. III. 6.
- A. Excision of Head of Humerus.
- B. Excision of Knee-joint; semilunar incision.

¹ This line is placed too low down; it should be in the middle third of the thigh.

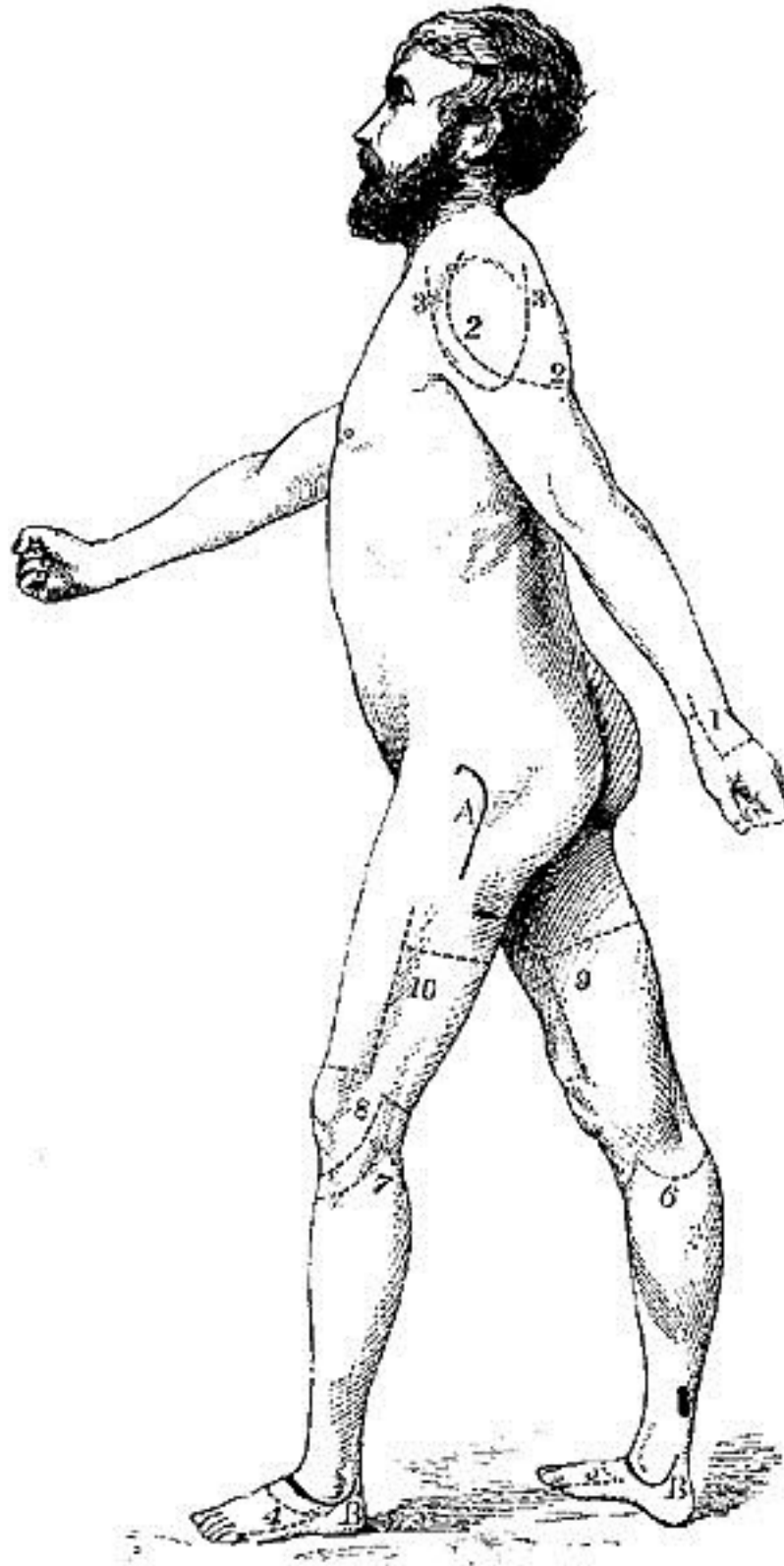


PLATE II.

1. Amputation at lower third of Fore-arm—Teale's.
- 2-2. Amputation at Shoulder-joint by large postero-external flap—2d method.
- 3-3. Amputation at Shoulder-joint by triangular flap from deltoid—3d method.
- 4-5. Amputation through Tarsus—Chopart's.
- 6-7. Amputation at Knee-joint.
8. Amputation by Single Flap—Carden's, and Pl. IV. 16.

9-10. Amputation of Thigh—Teale's.

A. Excision of Hip-joint.

B-B. Excision of Ankle-joint—Hancock's incisions.

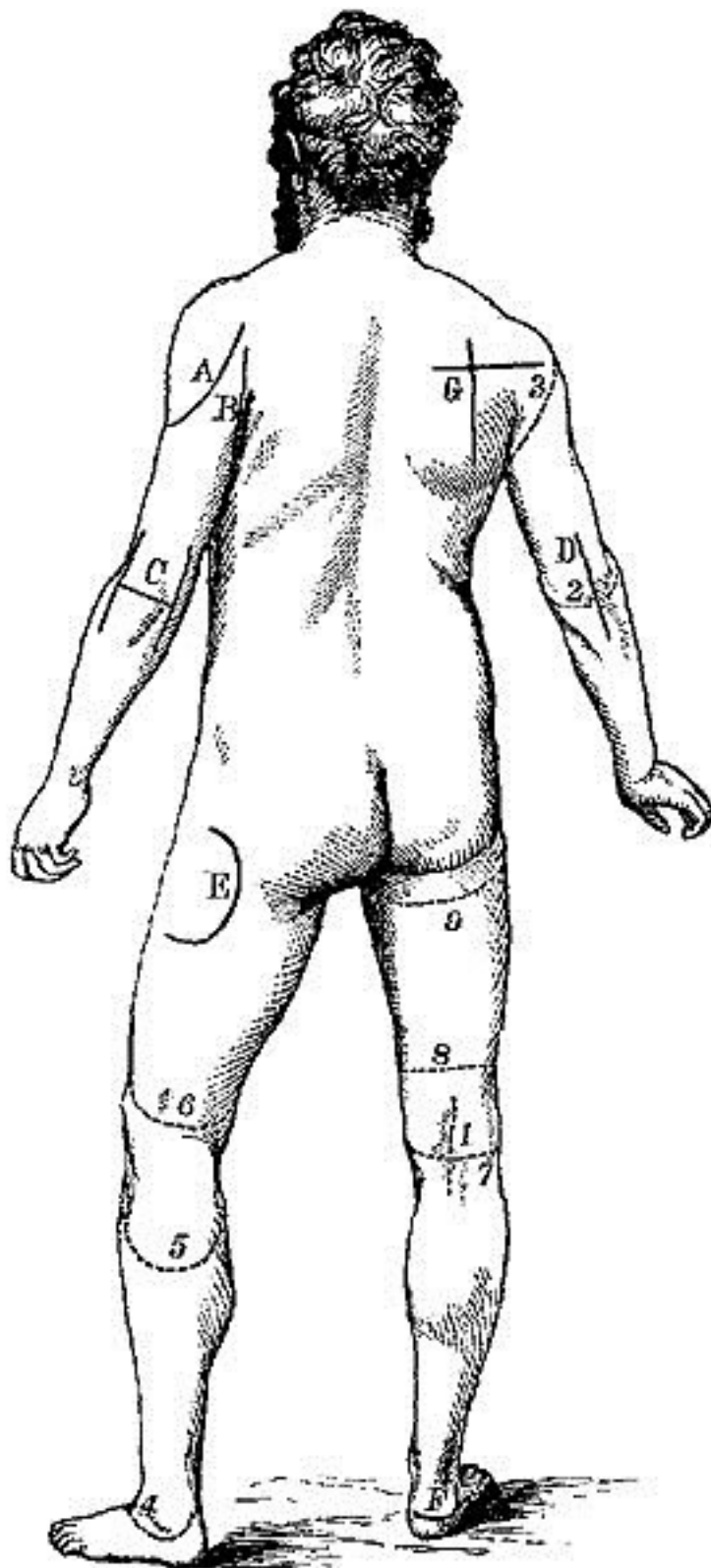


PLATE III.

1. Ligature of Popliteal.

2. Amputation at Elbow-joint—posterior flap.
3. Amputation at Shoulder-joint—posterior incision of first method, and Pl. I. 13.
4. Amputation at Ankle-joint—Mackenzie's, and Pl. I. 14.
5. Amputation through Condyles of Femur—Syme, and Pl. I. 19.
6. Amputation at lower third of Thigh—Syme, and Pl. I. 20.
7. Amputation at Knee—posterior incision.
8. Amputation of Thigh—Spence's, and at Pl. IV. 18.
9. Amputation at Hip-joint, and Pl. IV. 20.

- A. Excision of Shoulder-joint—deltoid flap.
- B. Excision of Shoulder-joint by posterior incision.
- C. Excision of Elbow-joint—H-shaped incision.
- D. Excision of Elbow-joint—linear incision.
- E. Excision of Hip-joint—Gross's.
- F. Excision of Os Calcis.
- G. Excision of Scapula.



PLATE IV.

1. Ligature of Carotid.
2. Ligature of Subclavian (3d stage)—Skey's incision.
3. Amputation at Wrist-joint—dorsal incision.
4. Amputation at Wrist-joint—palmar incision.
5. Amputation at Fore-arm—dorsal incision.
6. Amputation at Fore-arm—palmar incision.
7. Amputation at Elbow-joint—Anterior flap, and Pl. III. 3.
8. Amputation at Arm—Teale's method.
9. Amputation at Shoulder-joint—1st method, and Pl. III. 3.
- 10-11. Amputation of Metatarsus—Hey's.
- 12-13. Amputation at Ankle—Syme's.

- 14-15. Amputation of Leg—posterior flap—Lee's.
 - 16. Amputation at Knee-joint—Carden's, and Pl. II. 8.
 - 17. Amputation of Thigh—B. Bell's.
 - 18. Amputation of Thigh—Spence's, and Pl. III. 8.
 - 19. Amputation of Thigh in middle third.
 - 20-20. Amputation at Hip-joint, and Pl. III. 9.
-
- A. Excision of Wrist—radial incision.
 - B. Excision of Wrist—ulnar incision.

CHAPTER I. LIGATURE OF ARTERIES

Ligature of Arteries.—In a work of this nature there is no room for any discussion of the principles which should guide us in the selection of cases, or of the pathology of aneurism, or the local effects of the ligature on the vessels. One or two fundamental axioms may be given in a few words:—

1. In selecting the spot for the application of the ligature, avoid as far as possible bifurcations, or the neighbourhood of large collateral branches.

2. A free incision should be made through the skin and subjacent textures, till the sheath of the artery is reached and fairly exposed.

3. The sheath must be opened and the artery cleaned with a sharp knife till the white external coat is clearly seen. The portion cleaned should, however, be as small as possible, consistent with thorough exposure, so that the ligature may be passed round the vessel without force.

4. As the artery should never be raised from its bed, it is generally advisable to pass the needle only so far as just to permit the eye to be seen past the vessel. The ligature should then be seized by a pair of forceps and gently pulled through, the needle being cautiously withdrawn. When catgut is used, it is better to pass the unarmed needle till the eye is visible, then thread and withdraw it, thus pulling the catgut through.

5. As a rule, the needle should be passed from the side of the vessel at which the chief dangers exist. This will generally be in the side at which the vein is.

6. The ligature should be single, and consist of strong well-waxed silk, and should always be drawn as tight as possible, so as to divide the internal and middle coats of the vessel. In cases where the wound is to be treated with antiseptic precautions and an attempt at immediate union made, the ligature may be of strong catgut properly prepared, and both ends of it may be cut off.

7. Before the ligature is tightened, it is well to feel that pressure between the ligature and the finger arrests the pulsation of the tumour.

Ligature of the Aorta.—It has been found necessary in a few rare cases to place a ligature on the abdominal aorta; no case has as yet survived the operation beyond a very few days, but they have in their progress sufficiently proved that the circulation can be carried on, and gangrene does not necessarily result even after such a decided interference with vascular supply.

Operation.—The ligature may be applied in one of two ways, the choice being influenced by the nature of the disease for which it is done.

1. A straight incision ([Plate I. fig. 1](#)) in the linea alba, just avoiding the umbilicus by a curve, and dividing the peritoneum, allows the intestines to be pushed aside, and the aorta exposed still covered by the peritoneum, as it lies in front of the lumbar vertebræ. The peritoneum must again be divided very cautiously at the point selected, and the aortic plexus of nerves carefully dissected off, in order that they may not be interfered with by the ligature. The ligature should then be passed round, tied, cut short, and the wound accurately sewed up.

2. Without wounding the peritoneum.

A curved incision ([Plate I. fig. 2](#)), with its convexity backwards, from the projecting end of the tenth rib to a point a little in front of the anterior superior spinous process of the ilium. At first through the skin and fascia only, this incision must be continued through the muscles of the abdominal wall, one by one, till the transversalis fascia is exposed, which must then be scraped through very cautiously, so as not to injure the peritoneum, which is to be detached from the fascia covering the psoas and iliacus muscles, and must be held inwards and out of the way by bent copper spatulæ. The common iliac will then be felt pulsating, and on it the finger may easily be guided up until the aorta is reached.

The really difficult part of the operation now begins: to isolate the vessel from the spine behind, the inferior cava on the right side, and the plexus of nerves in the cellular tissue all round. The cleaning of the vessel must be done in great measure by the finger-nail, and much dexterity will be required to pass the ligature without unnecessarily raising the vessel from its bed, especially as the vessel itself may very possibly be diseased, and the aneurism of the iliac trunk for which the operation is required will displace and confuse the parts, and may have set up adhesive inflammation.

Results.—Operation has been performed at least ten times. By the first method by Sir Astley Cooper and Mr. James; by the second by Drs. Murray and Monteiro, M'Guire, Heron Watson, and Stokes, and Mr. South, and Czerny of Heidelberg. All the cases proved fatal; Dr. Monteiro's survived for ten days, and eventually perished from hæmorrhage; the rest all died at shorter intervals.

Ligature of Common Iliac.—Anatomical Note.—This short thick trunk varies slightly in its relations on the two sides of the body. As the aorta bifurcates on the left side of the body of the fourth lumbar vertebra, the common iliac of the right side would have a longer course to pursue than that on the left, if both ended at corresponding points. However, this is not always the case, as has been pointed out by Mr. Adams of Dublin, as the right common iliac often bifurcates sooner than the left does. With this slight difference, the position of the two vessels is precisely similar, each extending along the brim of the pelvis from the bifurcation of the aorta towards the sacro-iliac synchondrosis for about two inches. Sometimes the division takes place a little higher, even at the junction of the last lumbar vertebra and the sacrum. This variation depends chiefly on the length of the artery, which, as Quain has shown, varies from one inch and a half to more than three inches.

The anterior surface of both arteries is covered by the peritoneum, and each is crossed by the ureter just as it bifurcates into its branches.

The artery of the right side is in close contact behind with its corresponding vein, which at its upper part projects to the outside, and below to the inner side. The artery of the left side is less involved with its vein, which lies below it, and to the inside. The right is in contact with a coil of ileum, the left with the colon. The inferior mesenteric artery crosses the left one, while to the outside of both, and behind them, lie the sympathetic and obdurator nerves.

There are no named branches from the common iliac.

Operation.—The chief difficulties to be encountered are—1. The close proximity of the peritoneum, and specially the risk there is that it has become adherent to the sac of the aneurism; 2. The depth of the parts, and tendency of the intestines to roll into the wound; 3. Specially on the right side, the proximity of the great veins. With these exceptions the passing of the ligature is not so difficult as in some situations, the lax cellular tissue in which the vessel lies generally yielding much more easily than the tough sheath which elsewhere, as in the femoral, requires accurate dissection.

Incision.—(*Plate I*, fig. 3.)—From a point about half an inch above the centre of Poupart's ligament, a crescentic incision should be made, at first extending upwards and outwards, so as to pass about one inch inside of the anterior superior spine of the ilium, and then prolonged upwards and inwards, as far as may be rendered necessary by the size of the aneurism or the depth of parts. It must extend through skin and superficial fascia, exposing the tendon of the external oblique, which must then be slit up to the full extent visible. The spermatic cord may then be easily exposed under the edge of the internal oblique, and the forefinger of the left hand inserted on the cord, and thus beneath the internal oblique and transversalis muscles, the peritoneum being quite safe below.

On the finger these muscles may be safely divided to the full extent of the external incision. The deep circumflex iliac artery if possible should not be divided, but may bleed smartly and require a ligature.

The peritoneum must then be very cautiously raised from the tumour, and supported, along with the intestines, by copper spatulæ. The surgeon will rarely succeed in obtaining anything like a satisfactory view of the vessel, but can expose it for the ligature by the aid of his finger-nail. An ordinary aneurism-needle will generally suffice for the conveyance of the ligature.

The difficulties may occasionally be much increased by special circumstances, such as great stoutness of the patient, and consequent thickness of the abdominal wall; or large size of the aneurism, which may cause alterations in the relation of parts and adhesion of the peritoneum. The ureter generally gives no trouble, as in pressing back the peritoneum it is adherent to it, and is removed along with it towards the middle line.

Results.—Are not by any means satisfactory.

Out of twenty-two cases in which the common iliac has been tied for aneurism, eight recovered and fourteen died; while out of thirteen cases where it required ligature for hæmorrhage after amputation, rupture of aneurism, etc., only one recovered.

Ligature of Internal Iliac.—Little need be added to the account just given of the operation for ligature of the common iliac, as precisely the same incisions are required. The operator having reached the bifurcation of the vessel, must, instead of tracing it upwards, endeavour to trace it downwards, and the same time inwards, into the basin of the pelvis. To do this his finger must cross the external iliac artery, which will pulsate under the joint of the ungual phalanx, while the pulp of the finger is touching the internal iliac,—the external iliac vein, which occupies the angle formed by the bifurcation of the artery, lying between these two points. The ligature should be applied within three-quarters of an inch from the bifurcation.

Anatomical Note.—This short thick trunk extends backwards and inwards (Ellis); downwards and backwards (Harrison), in front of the sacro-iliac synchondrosis, as far as the upper extremity of the great sacro-sciatic notch, a distance varying in the adult from one and a half to two inches in length. It forms a curve with its concavity forwards, and at its termination divides into, rather than gives off, its two or three principal branches. Its corresponding vein is in close contact behind, as also the lumbo-sacral nerve, the obturator nerve to its outer side. The peritoneum covers it anteriorly, and it is crossed just at its commencement by the ureter. On the left side it is covered anteriorly by the rectum. Of its anatomical relations, that of the external iliac vein is perhaps the most important, as it is apt to interfere with the passing of the needle.

Results.—This vessel has been tied for aneurism of one or other of its branches, or for wound, about seventeen times.² Of these seven recovered; in ten the operation proved fatal, in most of them from secondary hæmorrhage. In one case the hæmorrhage occurred within twelve hours after the operation. The circulation of the parts supplied after the ligature is carried on mainly by the lumbar and lateral sacral branches, which become much developed even before the operation, in cases of aneurism.

Ligature of External Iliac.—*Anatomical Note.*—This artery extends from the bifurcation of the common iliac to the centre of Poupart's ligament, where it leaves the abdomen, passing under the ligament, and becomes the common femoral. Its upper extremity is thus not always constant, varying in position from the sacro-lumbar fibro-cartilage to the upper end of the sacro-iliac synchondrosis, or even a little lower down. Thus, though the position of the lower end is at a fixed point, the artery varies in length. In an adult male of moderate stature it is from three and a half to four inches in length. On the surface of the abdomen the position of this vessel would be indicated by a line drawn from about an inch on either side of the umbilicus to the middle of the space between the symphysis pubis and the crest of the ilium. Its relations to neighbouring parts are as follows:—The peritoneum lies *in front* of it, separated from it only by a subperitoneal layer of loose fascia, in which the artery and vein lie, which varies much in consistence and amount, and which occasionally gives a good deal of trouble in the operation of ligature. Near its origin it is sometimes crossed by the ureter, and near its termination the genito-crural nerve lies on it. The spermatic vessels cross it, and occasionally a quantity of subperitoneal fat marks its course. *Externally.*—The fascia-iliaca and some fibres of the psoas muscle separate it from the anterior crural nerve, which lies outside of the vessel, and at a

² Erichsen, *Surgery*. Sixth edition, vol. ii. p. 121.

somewhat deeper level, hidden amid the fibres of psoas and iliacus. *Internally*.—The external iliac vein lies on the same plane, and to the inner side of the artery, at Poupart's ligament, on both sides of the body. As we trace it upwards we find that on the left side it lies internal to the artery in its whole course, while on the right side it becomes posterior to the artery as it approaches the bifurcation of the common iliac. Lastly, just before the vessel reaches Poupart, the circumflex iliac vein crosses it from within outwards.

Branches.—The two large branches to the wall of the abdomen, the epigastric and the circumflex iliac, rise a few lines above Poupart's ligament. Their position is unfortunately apt to vary upwards, to the extent of an inch and a half or even two inches, and they are important, as, besides being liable to be cut during the operation, their position very materially modifies the prognosis, as, if too high up, they interfere with the proper formation of the coagulum.

Operation.—Various plans of incision through the skin have been recommended by various operators, the chief difference being with regard to the part of the artery aimed at; the plan known as that of Mr. Abernethy, with various modifications, being intended to expose the artery pretty high up, and enable the surgeon to reach it from above; while the method going by the name of Sir Astley Cooper's exposes the lower part of the artery, and enables the surgeon to reach it from below. Though the latter is in some respects easier, the former method is generally to be preferred, being further from the seat of disease, and especially more out of the way of the epigastric and circumflex arteries.

The higher operation (Abernethy's modified).—An incision must be made through the skin about four inches in length, but longer in proportion to the amount of subcutaneous fat, and the depth of the pelvis, extending from a point one inch to the inside of the anterior superior spine of the ilium, to a point half an inch above the middle line of Poupart's ligament. It must be slightly curved, with its convexity looking outwards and downwards.³

The subcutaneous cellular tissue and the tendon of the external oblique may then be divided freely in the same line. Then at some one point or other (generally easiest below), the internal oblique and transversalis muscles must be cautiously scraped through with the aid of the forceps, till the transversalis fascia is reached; they may then be freely divided by a probe-pointed bistoury (guarded by the finger pushed up below the muscles) to the required extent. The muscles being held aside by flat copper spatulæ, the fascia transversalis must be carefully scratched through near the crest of the ilium, and thus the operator will be enabled to push the peritoneum inwards, and by the forefinger will easily recognise the pulsation of the artery lying on the soft brim of the pelvis.

A branch of the circumflex iliac artery will very likely be cut in dissecting through the muscles, and must be secured, as also any branches of the epigastric which may be divided in the incisions through the abdominal wall (*ut supra*, p. 5).

The operator should then, by pressing the peritoneum and its contents gently inwards, endeavour to see the vessel; if, from the depth of the pelvis, this cannot be done, the sense of touch will be in most cases sufficient to enable him to isolate the artery by the point of his finger-nail, or by the blunt aneurism-needle, from the vein. The ligature should be passed from the inner side to avoid including the vein, and thus there will be less chance of wounding the peritoneum from the convexity of the needle being applied to it. If possible, the genito-crural nerve should not be included in the ligature, but probably such an accident would do no great harm.

It is of much more consequence to avoid injuring the peritoneum. This is sometimes very difficult, from the adhesions which are set up between the peritoneum, the artery, and especially the aneurism, as the result of pressure and inflammation. The accident of wounding the peritoneum has happened to Keate, Tait, Post, and others, and in some cases with perfect impunity. However, the peritoneum should be displaced as little as possible from its cellular connections, as such displacement

³ The line 3 in [Plate I](#) shows the direction required. It will not be necessary to carry the incision so far up for the external as for the common iliac.

increases the risk of diffuse inflammation of that membrane; and the vessel itself should be raised and disturbed as little as possible, lest destruction of the vasa vasorum cause ulceration of the weak coats and secondary hæmorrhage.

The operation from below ([Plate I. fig. 4](#)), Sir Astley Cooper's, is thus described by Mr. Hodgson:⁴—"A semilunar incision is made through the integuments in the direction of the fibres of the aponeurosis of the external oblique muscle. One extremity of the incision will be situated near the spine of the ilium; the other will terminate a little above the inner margin of the abdominal ring. The aponeurosis of the external oblique muscles will be exposed, and is to be divided throughout the extent, and in the direction of the external wound. The flap which is thus formed being raised, the spermatic cord will be seen passing under the margin of the internal oblique and transverse muscles. The opening in the fascia which lines the transverse muscle through which the spermatic cord passes, is situated in the mid space between the anterior superior spine of the ilium and the symphysis pubis. The epigastric artery runs precisely along the inner margin of this opening, beneath which the external iliac artery is situated. If the finger therefore be passed under the spermatic cord through this opening in the fascia, it will come in immediate contact with the artery which lies on the outside of the external iliac vein. The artery and vein are connected by dense cellular tissue, which must be separated to allow of the ligature being passed round the former."

In comparing the two methods of operating, we find that while the latter is in some respects easier, and the vessel in it lies more superficial, it has certain disadvantages which more than counterbalance its advantages. Thus, first, the epigastric artery is very likely to be wounded. It may be said, Well, if so, the ends can be tied; but this tying is sometimes very difficult; and, as shown in Dupuytren's case of this accident, involves considerable interference with the peritoneum, and a possibly fatal peritonitis. Besides this, by cutting the epigastric you destroy an important agent which would have carried on the anastomosing circulation, and thus greatly increase the risk of gangrene. By this method, also, the artery is exposed too near to the seat of disease; and if found to be enlarged and involved in the aneurism, considerable difficulty may be experienced in reaching the upper part of the vessel. Again, ligature of the lower third or half of the vessel, which this method implies, is dangerous from the occasional high origin of the circumflex or epigastric, or both, rendering the formation of a clot much more difficult, and secondary hæmorrhage much more likely.

The circumflex iliac vein must also be remembered, as it crosses the artery from within outwards in the lower end of it, just before it goes under Poupart's ligament.

However, the method may occasionally vary with the individual case. In every case of ligature of the great vessels of the abdomen, the bowels should be carefully evacuated before the operation, and the bladder emptied. A properly managed position, with the shoulders raised and the knees semiflexed, will greatly facilitate the gaining access to the vessel.

In sewing up the wounds in the abdominal walls, advantage will be gained by putting in a certain number of stitches so deeply as to include the whole thickness of the muscles, and in the intervals between these deep ones to insert others less deeply, so as accurately to approximate the edges of the skin. This will both facilitate union and also render the occurrence of hernia less probable. This latter accident did occur in a case, otherwise successful, in which Mr. Kirby tied the external iliac.

Both external iliacs have been tied in the same patient with success, on at least two occasions, once by Arendt, with an interval of only eight days between the operations; and a second time by Tait, at an interval of rather more than eleven months.

This operation is in the great majority of cases performed for femoral aneurism, and naturally secondary hæmorrhage is a too frequent result. Wounds of these great vessels generally result in so rapid death from hæmorrhage as to give no time for surgical interference. One case, however, is

⁴ *On the Arteries and Veins*, p. 421.

recorded,⁵ in which the external iliac was cut in a lad of seventeen by an accidental stab, and in which Drs. Layraud and Durand, who were almost instantly on the spot, succeeded in stopping the bleeding by compresses, till Velpeau arrived, who tied the vessel above with perfect success.

Of the first twenty-two cases collected by Hodgson, fifteen recovered—a mortality of 31.81 per cent.; and of 153 in Norris's collection, including Cutter's cases, forty-seven died—a mortality of only 32.5 per cent.,—a very satisfactory result, considering the size of the vessel and the importance of its relations.

Ligature of Gluteal.—This vessel, though one of the branches of the internal iliac, approaches the surface so nearly as to be occasionally wounded. It is also, though very rarely, the subject of spontaneous aneurism. The principle of treatment and the operation to be selected in any given case, depends upon its origin, whether traumatic or spontaneous. For if traumatic, the wound must almost necessarily be accessible from the outside; the neighbouring part of the artery is probably healthy, and hence the case can be treated by the old operation, slitting up the tumour, and tying the vessel above and below the wound. When the aneurism is spontaneous, there is no guide to tell us where the aneurism may have first originated; it may be that it is high up in the pelvis, and that the visible tumour is only its expansion in the direction of least resistance, or the coats of the vessel may be extensively diseased. The only chance is ligature of the internal iliac.

1. The old operation, or ligature of the gluteal artery in the hip.

Anatomical Note.—The gluteal is the largest branch of the internal iliac, and leaves the pelvis by the great sacro-sciatic notch just at the upper edge of the pyriformis muscle. After a very short course, it divides into superficial and deep branches opposite the posterior margin of the glutens minimus, between it and the pyriformis muscles.

Very precise rules have been given to enable the operator to hit on the exact spot where the artery leaves the pelvis. These, though perhaps interesting anatomically, are quite useless in a surgical point of view, for the only reasons which could possibly induce a surgeon to cut down upon the gluteal in the living body, are the existence either of a wound of the vessel or an aneurism. In the first the flow of blood, in the second the tumour, would give sufficient guidance.

In cases of traumatic aneurism the operation should be something like the following:—A free incision should be made into the tumour, dividing it in its long direction; the contents should be rapidly scooped out, and a finger placed on the bleeding point, just at the upper corner of the sciatic notch. This will at once stop the hæmorrhage till the vessel can be secured. This sounds easy enough, and has been done several times with success. Thus, John Bell, by an incision two feet long, as he tells us in his hyperbolic language, was enabled to tie the vessel in the case of the leech-gatherer who had punctured the artery by a pair of long scissors. Carmichael of Dublin used a smaller incision, removed one or two pounds of clots, and tied the vessel, in a case of wound by a penknife.⁶

Now, though both of these cases were eventually successful, both patients lost during the operation a very large quantity of blood; John Bell's especially could not be removed from the operating-table for a considerable time after the operation. The period at which the great loss of blood took place was the interval after the incision was made, and before the artery was exposed to view, *i.e.* the interval in which the surgeon was busy dislodging the clots from the cellular membrane, the sac of the false aneurism. The procedure devised by Mr. Syme to obviate this difficulty, and which was put in practice by him in several very trying cases, is best given in his own terse description of an operation in a case of traumatic gluteal aneurism:—

"The patient having been rendered unconscious, and placed on his right side, I thrust a bistoury into the tumour, over the situation of the gluteal artery, and introduced my finger so as to prevent the blood from flowing, except by occasional gushes, which showed what would have been the effect

⁵ *Cyclopædia of Practical Surgery*, vol. i. p. 277.

⁶ John Bell's *Prin. of Surg.*, vol. i. 421; *Dublin Jour.*, vol. iv. 321.

of neglecting this precaution, while I searched for the vessel. Finding it impossible to accomplish the object in this way, I enlarged the wound by degrees sufficiently for the introduction of my fingers in succession, until the whole hand was admitted into the cavity, of which the orifice was still so small as to embrace the wrist with a tightness that prevented any continuous hæmorrhage. Being now able to explore the state of matters satisfactorily, I found that there was a large mass of dense fibrinous coagulum firmly impacted into the sciatic notch; and, not without using considerable force, succeeded in disengaging the whole of this obstacle to reaching the artery, which would have proved very serious if it had been allowed to exist after the sac was laid open. The compact mass, which was afterwards found to be not less than a pound in weight, having been thus detached, so that it moved freely in the fluid contents of the sac, and the gentleman who assisted me being prepared for the next step of the process, I ran my knife rapidly through the whole extent of the tumour, turned out all that was within it, and had the bleeding orifice instantly under subjection by the pressure of a finger. Nothing then remained but to pass a double thread under the vessel, and tie it on both sides of the aperture."

The bleeding in this case was thus rendered comparatively trifling, and the patient made a speedy and complete recovery. He returned home within six weeks after the operation.⁷

2. In one case, at least, the gluteal artery has been tied with success (for traumatic aneurism) just where it leaves the pelvis, without the tumour being opened. This was in the practice of Professor Campbell of Montreal. The operation was a very difficult one, and while possible only in cases seen very early, and where the tumour is very small, does not appear to have any advantage over the old method.

Cases of spontaneous aneurism of the gluteal artery should be treated by ligature of the internal iliac. Steven's and Syme's cases of ligature of the internal iliac were of this nature.

Manuals of operative surgery occasionally devote pages to the description of special operations for the ligature of such arteries as the sciatic, epigastric, circumflex ilii, and pudic. They do not require ligature, except in cases of wound either of the vessels themselves or their branches; and, according to the modern principles of surgery in such cases, the ligature should be applied to the bleeding point, rather than to the vessel at a distance above it.

Ligature of Femoral.—Under this head we practically mean cases of ligature of the superficial femoral, for the common femoral, or (as called by some anatomists) the femoral, before the profunda is given off, very rarely requires to be tied. If it is wounded, of course the bleeding point must be sought, and the artery tied above and below it, but if an aneurism on the superficial femoral renders ligature of that trunk impossible, experience teaches that ligature of the external iliac gives better results than ligature of the common femoral. Erichsen asserts that out of twelve cases in which the common femoral has been tied, only three have succeeded, the others dying from secondary hæmorrhage. The experience of the Dublin surgeons, Porter, Smyly, and Macnamara, has been more satisfactory, as in eight cases of this operation six were successful.⁸ A ninth case was unsuccessful. Reasons to explain the danger are not far to seek, for the numerous small muscular branches, along with the superficial epigastric, circumflex, and pudic trunks, reduce the chances of a good coagulum in the common femoral to a minimum, even without taking into consideration the shortness of the trunk before the great profunda femoris is given off. For the common femoral artery is only from one to two inches in length, and if there are some rare cases in which it is a little later in its bifurcation, there are others in which it divides nearer to Poupart's ligament.

The superficial femoral is the name given to the main trunk between the origin of the profunda, and the point at which, passing through the tendon of the adductor magnus, it receives the name of popliteal. During this long course it gives off no branch large enough or regular enough to receive a name, except one, the anastomotica magna, which rises in Hunter's canal, close to the end of the

⁷ *Observations in Clinical Surgery*, Syme, pp. 171-3.

⁸ *Brit. Med. Jour.* 1867, Oct. 5.

vessel, so in that respect it is peculiarly suitable for the application of a ligature. Again, in the upper part of its course, it is superficial, being covered only by skin and fascia. A short notice of its most important anatomical relations is necessary.

For the first two inches or two inches and a half of its separate existence, the superficial femoral lies in Scarpa's triangle, covered, as we said, only by skin and fascia. This triangle is formed by the sartorius and adductor longus muscles which meet at its apex, and by Poupart's ligament, which defines its base. The artery lies almost exactly in the centre of the space, and at the apex is covered by the sartorius muscle. The spot where it goes under the sartorius is the one selected for the application of the ligature. The femoral vein lies to the inner side of the femoral artery in this triangle, but their mutual relations vary with the portion of the limb; for, on the level of Poupart's ligament, the artery and vein lie side by side on the same plane, but in different compartments of their sheath; as the artery dives below the sartorius, the vein is still on the inside, but on a plane slightly posterior; while, by the time they reach Hunter's canal, the vein has got completely behind the artery. The separate compartments of the sheath in which the vessels lie are much less marked as the vessels go down the limb, the septum between the artery and the vein being in most cases very ill marked, even at the level where the ligature is applied. The anterior crural nerve, which on the level of Poupart's ligament lay outside of the artery and on a plane somewhat posterior, has divided into numerous branches before it reaches the point of ligature. One of its branches requires to be mentioned, and may sometimes be noticed and avoided during the operation, namely the internal saphenous nerve, which, first lying external to the artery, crosses it in front, reaching its inner side just before it enters Hunter's canal, where it leaves the vessel accompanying the anastomotica magna branch.

Operation of Ligature of the Femoral—Scarpa's Space.—The patient being placed on his back, and being brought very thoroughly under chloroform, the knee of the affected limb should be bent at an angle of about 120° , and supported on a pillow. Having previously ascertained the angle of junction of the sartorius and adductor, the surgeon should make an incision ([Plate I. fig. 5](#)) just over the pulsations of the vessel, in the middle line of the space, having its lower end quite over the sartorius muscle, and its upper one, at a distance from two and a half to three and a half inches, varying according to the amount of fat and muscle. The saphena vein can generally be recognised, and is almost always safe out of the way of this incision at its inner side.

The first incision should divide the skin, superficial fascia, and fat, quite down to the fascia lata. The edges of the wound being held apart, the fascia should be carefully divided, and the sartorius exposed; its fibres can generally be easily enough recognised by their oblique direction; once recognised, the fascia should be dissected from it till its inner edge be gained, the corner of which should then be turned so that it may be held outwards by an assistant with a blunt hook. The sheath of the vessels is now exposed, and after having thoroughly satisfied himself of the position of the artery by the pulsation, the surgeon should carefully raise a portion of the sheath with the dissecting forceps, and open it freely enough to allow the coats of the artery to be distinctly seen. If the parts are deep, as in a fat or muscular patient, great advantage will be gained by seizing one edge of the sheath by a pair of spring forceps, and committing it to the care of an assistant, while the operator holds the other in his dissecting forceps; there is thus no fear of losing the orifice of the sheath, which without this precaution may easily happen, from the parts being confused with blood, or the position altered by movements of the patient. Now comes the stage of the operation on which, more than on anything else, success or failure depends. A *small* portion of the vessel must be cleaned for the reception of the ligature, and it must be *thoroughly* cleaned, so that the needle may be passed round it without bruising of the coats, or rupture of an unnecessary number of the vasa vasorum by rough attempts to force a passage for it. Hence all compromises, such as blunted instruments, silver knives, and the like, are dangerous, for in trying to avoid the Scylla of wounding the artery, they fall into the Charybdis, on the one hand, of isolating too much of the vessel and causing gangrene from want of

vascular supply, or, on the other, expose the vein to the danger of injury by the aneurism-needle in their attempts to force it round an uncleaned vessel.

The needle should in most cases be passed from the inner side, care being taken to avoid including the vein which is on the inner side and behind the vessel; the internal saphenous nerve, if seen, should be avoided. The needle must not be passed quite round the vessel raising it up, still less must the vessel be held up on the needle, as used to be done, as if the surgeon was surprised at his own success, but the needle should be passed just far enough to expose the end of the ligature, which must be seized by forceps and cautiously drawn through. It must then be tied very firmly and secured with a reef knot.

The edges of the wound must be brought into accurate apposition, and secured by one or two stitches. If antiseptics are used, drainage should be provided for.

From the very fact that ligature of the superficial femoral is a remarkably successful operation in causing consolidation of the aneurism and a rapid cure, there is also a corresponding danger that the limb be not sufficiently supplied with blood at first. The limb may very possibly become cold, and remain so for some hours at least after the operation. To avoid this as far as possible, it should be wrapped in cotton wadding, and very great care should be taken that it be not over-stimulated by hot applications, friction, or the like, any of which measures might very likely excite reaction, which would result in gangrene.

Complete rest of the limb and of the whole body must be enjoined; the food must be nourishing and in moderate quantity. The chief danger is from gangrene of the limb, which is especially apt to result when the vein is wounded, or even too much handled during the operation.

When properly performed, and in suitable cases, the operation is very successful. Mr. Syme tied this artery for aneurism thirty-seven times, and of these every one recovered. The statistics of Norris and Porta, who collected all the cases in which ligature of the femoral had been employed for *any* cause, show a mortality of somewhat less than one in four. Rabe's table up to 1869 with the additional cases collected by Mr. Barwell to 1880 gives 297 cases with 53 deaths.⁹ Mr. Hutchinson's table, again, of fifty cases collected from the records of Metropolitan Hospitals, shows the very startling result of sixteen deaths out of the fifty cases, or a mortality, in round numbers, of one-third.

Certain anomalies have been observed in the distribution of the femoral vessels, of some importance as affecting the possibility of applying, and the result of, ligature; such as—1. A high division of the branches which afterwards become posterior tibial and peroneal. 2. A double superficial femoral, both branches of which may unite and form the popliteal, as in Sir Charles Bell's well-known case. 3. Absence of the artery altogether, as in Manec's case, where the popliteal was a continuation of an immensely enlarged sciatic.

In such a case the absence of pulsation in front, and the presence of increased pulsation behind the limb, ought to prevent any fruitless attempt at search.

Ligature of the Superficial Femoral below the Sartorius Muscle.—This operation, though once common in France, and though the one recommended by Hunter himself, is now comparatively little used in this country; and rightly so; for while it has no advantage over the upper position, it is at once nearer the seat of disease, and the vessel is more deeply buried under muscles, and has a more distinct fibrous sheath, which requires division.

It is, however, by no means a difficult operation, and is thus performed:—

The limb being laid as before on the outside, and slightly bent, the skin shaved and the pulsation of the artery detected, an incision ([Plate I. fig. 6](#)) must be made from the lower edge of the sartorius muscle just as it crosses the vessel, along the course of the vessel, avoiding if possible the internal saphena vein.

⁹ *International Encyclopædia of Surgery*, vol. iii. p. 466.

The sartorius when exposed must be drawn inwards. The fibrous canal filling the interspace between the abductor magnus and vastus internus is then recognised, and must be fairly opened; the artery is now seen lying in it, and over the vein which is posterior to it, but projects slightly on its outer side; the internal saphenous nerve is lying on the artery. The needle is best passed from without inwards so as to avoid the vein. The anastomotica magna is sometimes a large trunk, and has been mistaken for the femoral in this situation, and tied instead of it.

Ligature of the Popliteal.—This operation is now hardly ever performed for aneurism, ligature of the superficial femoral having quite superseded it, and it is very rarely required for wounds, from the manner in which the vessel is protected by its position.

Before the invention of the Hunterian principle of ligature at a distance, the old operation for popliteal aneurism consisted in cutting into the space, clearing out the contents of the aneurismal sac, and tying both ends of the vessel; from the depth of parts and the close connection of the popliteal vein, this operation was very rarely successful, and is now quite given up. If the vessel is wounded the bleeding point is the object to be aimed at, and is generally sufficient guide.

In cases of hæmorrhage for suppuration of an aneurismal sac, it might possibly be advisable, and there are certain cases of rupture of the artery, without the existence of an external wound, in which attempts have been made to save the limb by tying the vessel.¹⁰ From the complexity of the parts, the numerous tendons, veins, and nerves crowded together in a narrow hollow, and chiefly from the great depth at which the artery lies, any attempt at ligature is very difficult. It is least so at the lower angle of the space, where, between the heads of the gastrocnemius, the vessel comes more to the surface, but is still overlapped by muscle.

Operation.—The patient lying on his face, a straight incision ([Plate III. fig. 1](#)), at least four inches in length, should be made over the artery, and thus nearer the inner than the outer hamstring; a strong fibrous aponeurosis will require division after the skin and superficial fascia are cut through, the limb is then to be flexed, and the tendons drawn aside with strong retractors; fat and lymphatic glands must next be dissected through, and then the vein and artery, lying on a sort of sheath of condensed cellular tissue, are seen, the vein lying above the artery and obscuring it. The vein must be drawn to the outside, and the thread passed round the artery, which lies close to the bone, on the ligamentum posticum of Winslowe.

It is a very difficult subject to decide what operations should be described in a work of this character, on the vessels of the leg and foot. A very large number of distinct methods of operations on the various parts of the three chief arteries of the leg have been described by surgeons and anatomists, but specially by the latter.

The fact is, however, that these complicated procedures are rarely required, for aneurisms of the arteries of the leg and foot are almost unknown, while in cases of wound of the vessel, or rupture resulting in traumatic aneurism, the proper treatment is not to tie the vessel higher up, but by dilating the wound and clearing out the clots, if required, to secure the bleeding point, and tie the vessel above and below.

Again, a wound of the sole of the foot often gives rise to very severe and persistent hæmorrhage, while the fasciæ and complicated tendons render ligature of the vessel at the spot very difficult; yet ligature of either the anterior or posterior tibial would probably be insufficient; and to tie both these vessels, with possibly the peroneal and interosseous as well, would be a much more severe and dangerous procedure than ligature of the superficial femoral; while probably careful plugging of the wound, combined with flexion of the knee, will be found to stop the hæmorrhage sooner than either of the more formidable methods.

A competent knowledge of the anatomy of the part, and of the ordinary methods of checking hæmorrhage, such as ligatures, graduated compresses, and styptics, aided by position, specially

¹⁰ Poland, *Guy's Hosp. Report*, ser. iii. vol. vi.

flexion of the knee after Mr. Ernest Hart's method, will suffice to enable the surgeon to check any hæmorrhage of the foot or leg, without it being necessary to burden the memory with the three positions in which to tie the peroneal, or the various methods, more or less bloody and tedious, by which the posterior tibial in its upper third may be secured.

Note.—While, as a matter of surgical principle to guide our practice on the living, I still hold very strongly the opinions here expressed against special operations for ligature of the arteries of the leg, and allow the sentences to stand as in the first edition of this work, I insert in a note a brief description of the more important ones, in deference to the advice of friends and the urgent request of pupils, as these operations are used by Examining Boards as tests of the operative dexterity of candidates:—

1. Anterior Tibial Artery in lower half of Leg.—*Anatomical Note.*—This vessel is related on its tibial side to the tibialis anticus, and on its fibular, to the extensor longus digitorum above, and the extensor pollicis below. The anterior tibial nerve lies first on its outer side, then crosses the artery, and eventually reaches its inner side near the foot. *Operation.*—An incision, at least three inches long, parallel with the outer edge of the tibia, and about three-quarters of an inch from it, exposes the deep fascia. This being divided, the outer edge of the tibialis anticus must be found, and will be the guide to the artery, which, surrounded by its venæ comites, lies very deeply between the muscles.

2. Posterior Tibial.—A. In middle third of leg. Here the artery is separated from the inner border of the tibia, by the flexor longus digitorum, and is covered by the soleus. *Operation.*—An incision at least four inches long, along the inner margin of the tibia, exposes the edge of the gastrocnemius; then divide the tendinous attachment, then expose the soleus, and divide its attachment also; the deep fascia will then be seen; slit it up, and the vessel will be found about an inch internal to the edge of the bone. The nerve is there just crossing it.

Guthrie's, or the direct operation, has the very high authority of the late Professor Spence in its favour. An incision through skin and fascia in the middle of the back of the leg allows the two heads of the gastrocnemius to be separated to the same extent. The soleus is then to be scraped through in same direction, and its deep aponeurotic surface carefully slit up. The artery and vein are then easily seen.

B. In lower third of leg.—This is an easier and more scientific operation, as it does not involve the division of great tendons. An incision midway between the internal malleolus and the tendo Achillis, parallel with both, will expose the very deep and strong fascia in which the tendons lie. The artery, with its venæ comites, occupies a central position, having the tendons of the tibialis posticus and flexor communis in front between it and the internal malleolus, and the posterior tibial nerve behind it, while the flexor longus pollicis lies still nearer the tendo Achillis.

Table illustrating anastomotic circulation after ligature of arteries of lower limb.

1. Aorta.—Epigastric and mammary of both sides. Hæmorrhoidal and spermatic, with branches of pudic both deep and superficial.

2. Common Iliac.—Internal iliac and branches, with those of the other side, along with the following:—

3. External Iliac.—Internal mammary and deep epigastric.

Iliolumbar and lumbar branches of aorta, with deep circumflex ilii.

Pudic from internal iliac, with superficial pudic of common femoral.

Gluteal, sciatic, and obturator, with the circumflex and perforating branches or deep femoral.

4. Femoral.—External circumflex, with external articular of popliteal.

Perforating, with branches of gluteal and sciatic.

Profunda branches with anastomotica and articular branches.

Obturator and internal circumflex with anastomotica and superior internal articular.

Note.—The importance of the articular branches of the popliteal explain the danger of gangrene after a sudden rupture or increase in size of a popliteal aneurism.

Ligature of the Innominate.—The performance of this extremely dangerous, in fact almost hopeless operation, is by no means so difficult as might be expected.

The patient lying down with the shoulders raised and head thrown well back, the sternal attachment of the right sterno-mastoid must be very freely exposed. This may be done by an incision ([Plate I](#), fig. 7) along its anterior edge from the upper edge of the sternum, as far as may be necessary; another about the same length along the upper edge of the clavicle, will meet the former at an acute angle, and will include a triangular flap of skin, which must be carefully dissected up. The sternal, and probably a portion of the clavicular attachment of the right sterno-mastoid, must then be cautiously divided. This being done, the sterno-hyoid and sterno-thyroid muscles require division immediately above their sternal attachments.

A dense process of cervical fascia (just becoming thoracic) now covers the vessel, binding it on the right side to the right innominate vein, and on the left maintaining the relation of the innominate artery to the trachea. The inferior thyroid veins lie on this fascia, and must be drawn aside, not cut. The fascia is then to be scraped through very cautiously, exposing the root of the right carotid, which, being traced downwards, will lead to the innominate. The following parts lie in close relation to the vessel at the point of ligature, and must be avoided:—1. The left innominate vein crosses the artery in front from left to right, and must be drawn down. 2. The right innominate vein and right pneumogastric are in close contact with the artery on the right side; to avoid them the aneurism-needle must be entered on the outside (right of the vessel). 3. The apex of the right pleura and the trachea are in close contact behind, requiring the point of the needle to be kept close to the artery in bringing the thread round.

It might have been expected that the sudden arrest of so large a proportion of the vascular supply of the body, so very near the heart, would cause serious, or even fatal symptoms; this, however, is not the case, no serious inconvenience of this sort being experienced; yet hitherto every case has proved fatal, either from secondary hæmorrhage or inflammation of lungs and pleura.

In fifteen well-authenticated, and in three more doubtful cases, the ligature has been applied; all of these died at periods varying from twelve hours (as in Hutin's case), to forty-two days as in Thomson's, and sixty-seven days (Graefe's).¹¹

A successful case of ligature of the innominate along with the right carotid and (after secondary hæmorrhage) the right vertebral, in a mulatto aged thirty-two, for a subclavian aneurism, has been put on record by Dr. Smyth of New Orleans, in the *American Journal of Medical Science* for July 1866.

And here we may also note that Mr. Heath has lately treated a case of innominate aneurism by simultaneous ligature of the third part of the subclavian and the carotid. Both ligatures separated on the eighteenth day, and the tumour was much smaller some months afterwards.¹²

Mr. R. Barwell has reported several most interesting cases in which simultaneous ligature of carotid and subclavian have proved of marked benefit in aortic as well as in innominate aneurisms.¹³

¹¹ Mr. W. Thomson's most interesting paper on this subject is full of information down to the latest date.

¹² *Lancet*, Jan. 5, 1867.

¹³ *Lancet*, May 1879.

In four cases the operation was attempted, but the operators had to desist before the application of the ligature, in consequence of the diseased state of the arterial coats. Of these, three died, and one (Professor Porter's of Dublin) case recovered, the patient leaving the hospital with the aneurism nearly consolidated.

Dr. Peixotto of Portugal applied a precautionary ligature to the innominate in a case where secondary hæmorrhage occurred from the carotid. The ligature was not tightened beyond what was necessary merely to cause flattening of the vessel. The patient made a good recovery.

Professor George Porter of Dublin records an interesting case of subclavian aneurism, in which, after failing to close the axillary artery by acupressure, he applied L'Estrange's compressor to the innominate itself for three days, with temporary benefit. The patient eventually died of hæmorrhage.¹⁴

For a very full and interesting account of ligatures of vessels in root of neck we may refer to vol. iii. of the 1883 edition of *Holmes' Surgery*, pp. 119-122.

Ligature of Common Carotid.—Though the anatomical relations of the right and left carotid are different at their origin, they so precisely resemble each other in the whole of that part of their course which is at all amenable to surgical treatment, that one description will suffice for both, and the necessary anatomy will be brought out quite sufficiently in the description of each operation.

From its giving off no collateral branches, the common carotid artery may be tied at any part of its course.

It has been tied successfully at the distance of only three-quarters, or, in one case by Porter, hardly to be imitated, one-eighth of an inch from the innominate, and up to an equal distance from its bifurcation. In choosing the part of the vessel for operation, the operator must be guided by the position of the aneurism, if on the vessel itself, but if the aneurism be distant, as in scalp or orbit, he need have regard to position simply as facilitating the operation.

The easiest position in which to apply the ligature is just above the omohyoid muscle, the vessel being there superficial.

Ligature above Omohyoid.—Using the anterior border of the sterno-mastoid as a guide, but leaving it gradually above to a little nearer the mesial line, an incision ([Plate IV. fig. 1](#)), varying in length according to the depth of fat and cellular tissue in the neck, but with its central point opposite the upper border of the cricoid cartilage, must be made through skin, platysma, and superficial fascia. While making the incision the head should be held back, and the face slightly turned to the opposite side; the parts being now relaxed by position, the edges of the wound must be held apart by blunt hooks or copper spatulæ, and the deep fascia carefully divided over the vessel, which will be recognised by the pulsation. It may be noted here that even in thin subjects the sterno-mastoid edge *invariably* overlaps the vessel, though in many anatomical diagrams it would appear to be in part subcutaneous.

The descendens noni may possibly be seen, but this is by no means invariably the case, crossing the sheath of the vessel very gradually from without inwards in its progress down the neck. It must be carefully displaced outwards.

The sheath of the vessel is then to be cautiously opened to the extent of about half an inch. The internal jugular vein, possibly much distended, may overlap the artery on its outer side, and will require to be pressed, emptied, and held out of the way. A small portion of the artery being thoroughly separated from the sheath, the aneurism-needle must be passed from without inwards to avoid the vein, and keep as close to the artery as possible to avoid the vagus.

The tendon of the omohyoid muscle, or, in muscular subjects, a portion of its anterior fleshy belly, may be seen crossing the vessel from above downwards and outwards at the lower angle of the wound.

¹⁴ *Dublin Quarterly Journal*, Nov. 1867.

An enlarged lymphatic gland has occasionally given much trouble, by being mistaken for the vessel and cleaned, while the ligature has even been placed on a carefully isolated fasciculus of muscular fibres.

Ligature of Carotid below the Omohyoid.—An incision in precisely the same direction as the former, but at a slightly lower level, is required, but the dissection is rather more difficult. The edge of the sterno-mastoid when exposed must be drawn outwards; the sterno-hyoid and thyroid inwards; the omohyoid upwards; the sheath opened, and the descendens noni or its branches drawn to the tracheal side. The jugular vein and vagus are both at the outer side, and must be avoided, while the inferior thyroid artery and sympathetic nerve both lie behind the vessel, and may be included in the ligature if care be not taken.

Varieties.—*Sedillot's Operation*.—To secure the artery still lower in the neck: An incision two and a half inches long, from the inner end of the clavicle obliquely upwards and outwards in the interval between the sternal and clavicular attachments of the sterno-mastoid; this divides the superficial textures; the two portions of muscle must then be drawn apart. The internal jugular vein lies in the interval, and must be drawn to the outside before the artery can be seen at all, and it is this that makes this operation very difficult and dangerous, especially on the left side, where the vein is close to the artery, and probably even crossing it from left to right. The thoracic duct is behind.

Malgaigne's modification of the above is an improvement: to expose the external attachment of the muscle, to cut it through and turn it to the outside, as in the operation for ligature of the innominate, then to divide or pull inwards sterno-hyoid and sterno-thyroid, thus exposing the sheath. The needle must be passed from without inwards.

Results.—Pilz has collected 600 cases, of which 43.16 per cent. died. The united tables of Norris and Wood give 188 cases, with a mortality of sixty, or nearly one in three. These tables include cases in which the vessel was tied for wounds, and as a preparatory step in the operation of removal of tumours of the jaw, etc. Later statistics give a very much lessened mortality, due chiefly to the use of animal ligatures.

Of thirty-one cases in which it was tied for pulsating tumours of the orbit, only two died from the operation.¹⁵ Rivington's statistics to a later date give forty-six cases on forty-four patients with six deaths.

Both carotids have been tied in the same patient twenty-five times, at intervals of less than a year; and it is a very remarkable fact that only five of these fifty ligatures proved fatal,—two in which both were tied on the same day, and three in which the operation was performed to arrest hæmorrhage from malignant disease of the face and jaws—from gunshot wound,—and from syphilitic ulceration.

The external carotid, and also most of its principal branches, have been tied for aneurisms, wounds, goitres, enlargement of the tongue, vascular tumours on occiput and other lesions; also as a first stage in the operation of extirpation of the upper jaw, for the purpose of preventing hæmorrhage. However, such operations are rare, and will probably become rarer still, and it is hardly necessary to describe the operations on each *seriatim*.

Aneurism of the external carotid or branches are rare; if idiopathic, ligature of the common carotid will be found at once easier, not more dangerous, and more effectual than ligature of the branch; if traumatic, the aneurism itself should be attacked, and the bleeding point secured by a double ligature. Wounds are common enough, but if accessible at all, the injured vessel should be

¹⁵ W. Zehender—Monatsbl. für Augenheilkunde. 1868.

tied at the bleeding point; if inaccessible (and under this head we may include wounds of the internal carotid), the common carotid must be tied.

No one would think of trying the superior thyroids for goitre, unless they were so manifestly enlarged, tortuous, and pulsating, as to render the operation so simple (from their superficial position) as to require no special directions; besides this, the cases in which it has been already done have given very little encouragement to repeat it.

As cases may occur in which any diminution of the cerebral supply is contra-indicated, and thus the more difficult ligature of the external carotid may be preferred to the more simple operation on the common trunk, and as the lingual may require ligature near its root, in consequence of obstinate hæmorrhage from the tongue, short directions are given for the performance of both these operations.

1. Ligature of External Carotid.—Head in same position as for the common carotid. A straight incision parallel with the anterior edge of sterno-mastoid, but about half an inch in front of it, must begin almost at angle of jaw, and extend downwards nearly to the level of the thyroid cartilage. Cautiously divide skin, platysma, and fascia; the lower end of the parotid must be pulled upwards, and the veins, which are numerous, cautiously separated. The anterior border of the sterno-mastoid must be pulled backwards, and the digastric and stylo-hyoid forwards and inwards. The superior laryngeal nerve which lies behind the vessel must be avoided.

2. Ligature of Lingual.—To secure this vessel either before it becomes concealed by the hyo-glossus, or after it is under the muscle, a curved incision is necessary, following the line of the hyoid bone, and especially of its greater cornu, but a line or two above its upper border. After the skin and platysma are divided, the posterior belly of the digastric must be recognised, which again will guide to the posterior edge of the hyo-glossus. The edge of the sub-maxillary gland may very probably require to be raised out of the way. The artery can then be secured, either before it dips under the hyo-glossus muscle, or after it has done so, by the division of a few of its fibres on a director. Care is needed to avoid injury of the hypo-glossal nerve, which lies above the muscle.

The internal carotid artery occasionally, but very rarely, is the subject of aneurism. It may, like any other artery, be wounded, especially from the fauces. The treatment of either of these lesions is ligature of the common carotid itself, in preference to ligature of the internal carotid. Guthrie's operation for securing the bleeding internal carotid at the injured spot, by dividing and turning up the ramus of the lower jaw, has never been performed in the living body, and is so difficult, dangerous, and unnecessary, as not to merit description.

Ligature of Subclavian.—*Note.*—In consequence of the difference in the origin, and variety in the anatomical relations of the right and left subclavian arteries, in so far at least as their first stage is concerned, it is necessary to give a very brief separate account of each.

Right Subclavian.—The innominate artery divides into the right subclavian and right carotid exactly behind the sterno-clavicular articulation. The right subclavian extends from this point in an arched form across the neck, between the scalene muscles, over the apex of the pleura, till, passing under cover of the clavicle, it changes its name to axillary at the lower end of the first rib. For convenience of description, the artery is divided into three parts, which have very various anatomical relations, and differ from each other much in their amenability to surgical treatment by ligature. The anterior scalenus muscle defines the three parts, the first extending to the inner border of the muscle, the second being concealed by the muscle, and the third reaching from its outer border to the lower border of the first rib.

Branches of the Subclavian.—While the deep relations of pleura, veins, and nerves can be noticed under the head of each operation in detail, one anatomical point must never be forgotten as influencing very much the success of all surgical interference with the subclavian arteries—*i.e.* the branches given off. To give any chance of success in the application of a ligature to such a large vessel, so near the heart, a large portion of artery free from branches is required, that the clot may be long, firm, and undisturbed. The first part of the subclavian gives off the vertebral, thyroid axis,

and internal mammary; the second, the superior intercostal; while the third part has in most cases no branch whatever. In these anatomical differences we find the reason for the almost invariable fatality resulting on any interference with the first and second parts, and the comparative safety of ligature of the third part, without requiring to account for the difference on other grounds, such as depth of part, importance of nervous relations, or nearer proximity to the heart.

The second and third parts of both arteries are so similar to each other, that a separate account is not required for the two sides.

Ligature of Right Subclavian.—First Part.—Operation.—An incision just at upper edge of sternum and right clavicle, extending from inner edge of *left* sterno-mastoid transversely to outer border of right sterno-mastoid through skin, platysma, and exposing sterno-mastoid, to be joined at an angle by a second incision, which, two, three, or even four inches long, must extend along inner border of right sterno-mastoid. Flap to be raised upwards and outwards. The sternal attachment of the sterno-mastoid must then be cautiously divided, as also part or the whole of its clavicular attachment, according as room is required. The sterno-hyoid and thyroid muscles will then require similar division. The internal jugular will then be seen very prominent,¹⁶ and will require to be drawn inwards or outwards, according to circumstances. The carotid and right subclavian arteries will then be felt lying close together crossed by the pneumogastric and recurrent nerves, the latter turning behind the subclavian. The nerves must be drawn inwards; the cardiac filaments of the sympathetic will then be observed, and drawn outwards. The subclavian vein lies below, concealed by the clavicle, and will probably not be seen during the operation. The needle should be passed round the artery from below upwards, care being taken not to injure the pleura, which lies beneath and behind the artery.

Results.—Twelve cases, all of which died; ten of hæmorrhage, one of pleurisy and pericarditis, and one from pyæmia. Attempted in one case by Mr. Butcher, but the artery was too much diseased to bear a ligature. The patient died on the fourth day.

Ligature of Left Subclavian.—First Part.—This operation, which has been described by some as impossible, has, I believe, been only once performed on the living body. *Operation.*—Incisions as for the preceding operation, except being on the opposite side. After the skin, platysma, and muscles have been divided, as already described, the deep cervical fascia requires division close to the inner edge of the scalenus anticus. The artery lies excessively deep, and great difficulty is experienced in avoiding injury to the pleura and the thoracic duct.

Results.—Once performed by Dr. Rodgers of New York; death from hæmorrhage on fifteenth day.

Anatomical Note.—The course of the left subclavian in its first stage is much straighter, as its origin is much deeper, than on the right side. The pneumogastric, phrenic, and cardiac nerves lie parallel to its course; the œsophagus and thoracic duct lie behind it, and to its inner side.

Ligature of Subclavian.—Second Part.—This very rare operation hardly requires a separate description, as the incisions necessary for ligature of the artery in its third part will, with very slight modifications, be sufficient for the purpose.

It has, however, special elements of danger in it, involved in the unavoidable division, of part at least, or probably the whole, of the scalenus anticus. The phrenic nerve, from its position on that muscle, requires special care to avoid dividing it, and in most cases the internal jugular vein is also in the way. The branches of the thyroid axis, which cross the neck, are quite in the line of the incision. The lowest cord of the brachial plexus lies immediately behind the artery, between it and the middle scalenus. The pleura lies just below it. The subclavian vein is generally quite safe, running in front of the scalenus anticus, and at a lower level.

The presence of the superior intercostal branch adds greatly to the danger of ligature of the vessel in this position, from its interfering with a proper clot.

¹⁶ Butcher, *Op. and Cons. Surgery*, p. 861.

Results.—Dupuytren¹⁷ performed it successfully for a traumatic axillary aneurism. Auchincloss¹⁸ did it for a large true aneurism, but the patient died sixty-eight and a half hours after the operation. Liston cut through the outer portion of the scalenus with success for an idiopathic aneurism. Thirteen have been collected by Wyeth with four recoveries and nine deaths.

Ligature of Subclavian.—Third Part.—For this comparatively common operation, various methods of procedure have been suggested and employed.

In the dead body, where the axilla is free from swelling, and in thin patients, the artery in this third stage is tolerably superficial, and can be secured with ease. But in very muscular men, with short necks and well curved clavicles, and specially when the axilla is filled up with an aneurism, and the shoulder cannot be depressed, the operation becomes very difficult.

Operation of Ramsden, Liston, and Syme.—Position.—The patient lying on his back with his shoulders supported by pillows, and his head lying back, and drawn to the opposite side; the shoulder of the affected side must be depressed as much as possible.

Incisions.—(Plate I. fig. 8.)—One through skin, superficial fascia, and platysma, along the upper edge of the clavicle, for at least three inches from the anterior edge of the trapezius to the posterior border of the sterno-mastoid, and in muscular subjects freely overlapping the edges of both muscles. Another two inches in length along posterior border of sterno-mastoid meets the first at an angle. On reflecting the chief flap thus made upwards and backwards, the external jugular will be seen, and, if possible, must be drawn to a side; if not, it must be divided, and both ends tied. The lower edge of the posterior belly of the omohyoid must then be sought; this leads at once to the posterior or outer margin of the scalenus anticus. The connection of the deep fascia to that muscle must then be very carefully scraped through, and by tracing the muscle to its insertion to the first rib, the artery is at once reached, lying behind the insertion. The pulsation of the vessel between the forefinger and the first rib will prove a great assistance; yet care is required, lest one of the branches of the brachial plexus be secured instead of the artery. The lowest cord lies very close to the vessel. The subclavian vein is not likely to give much trouble, from its being on a lower level, and (unless very much dilated) nearly concealed by the clavicle. The suprascapular artery is also hidden, but the transverse cervical crosses the very line of incision, and may give trouble, being occasionally much enlarged, so much so as even for a time to have been mistaken for the subclavian itself. If possible, both these branches should be saved, as being important means of carrying on the anastomosis for the future support of the limb.

An absorbent gland is occasionally in the way, and has even been mistaken for the vessel and carefully cleaned. Such may be removed without scruple.

Care must be taken not to injure the pleura, which lies immediately behind and below the vessel at the seat of ligature. Various instrumental devices have been invented for passing the ligature. The simplest seems still to be best, a common aneurism-needle with a considerable curve.

Other methods of operating.—A single curved incision above the clavicle, with its concavity upwards, of about three or four inches long, with its inner end rather higher than the outer (Green, Fergusson).

A linear transverse incision in the same situation (Velpeau).

A single linear incision perpendicular to the clavicle (Roux).

An arched incision (Plate IV. fig. 2) with its convexity outwards, and its base on the posterior edge of the sterno-mastoid, from three inches above the clavicle to the clavicular attachment of the muscle (Skey).

Results.—Dr. Wyeth's Tables in 1877 give 251 cases with 134 or 53 per cent. of deaths.

¹⁷ *Leçons Orales*, iv. 530.

¹⁸ *Ed. Med. and Surg. Journ.* vol. xlv.

The late Mr. Furner of Brighton reported a most interesting case, in which he tied both subclavian arteries at an interval of two years in the same patient, for axillary aneurisms, with success.

Ligature of Axillary.—*Anatomical Note.*—This vessel, the next stage in the continuation of the subclavian downwards, may be defined surgically as extending from the clavicle to the lower border of the teres major. From the depth of the vessel at its upper part, the numerous nerves, and the close proximity of the vein, the surgeon has carefully to study the anatomical relations. It, like the subclavian, is commonly divided into three stages, and, also like the subclavian, these stages are defined by the relations of the artery to a muscle, the pectoralis minor. Surgically we may draw a very close parallel between the two vessels, for we find that in the axillary, as in the subclavian, the first stage is very deep, and very rarely amenable to ligature; the second, still deeper and more rarely attempted, as in both the operation involves division of a deep muscle; while the third stage in each is the one most frequently chosen by the surgeon.

First Stage.—Between the lower edge of the first rib and upper border of the pectoralis minor the vessel is deeply seated, contained in that process of deep fascia called the costo-coracoid membrane, and covered above by skin, platysma, and the clavicular portion of the pectoralis major. It lies on the first intercostal muscle and the upper digitation of the serratus magnus, while the cords of the brachial plexus are on its acromial side, and the axillary vein in close contact with it on its thoracic side, and frequently overlapping the artery.

Operation.—The great desideratum is free access. An incision ([Plate I.](#) fig. 9), semilunar in shape, with its convexity downwards, must extend from half an inch outside of the sterno-clavicular articulation to very near the coracoid process, stopping just before it arrives at the edge of the deltoid, in order to avoid injury of the cephalic vein. It must include skin, fascia, and platysma, and the flap must be thrown upwards. The clavicular portion of the pectoralis major must then be divided right across its fibres, which will retract. The arm must then be brought close to the side to relax the pectoralis minor, which must be drawn aside. The artery will then be felt pulsating, but hidden by the costo-coracoid membrane, which acts as its sheath. This must be carefully scratched through, the nerves pulled outwards, the vein avoided and pulled downwards and inwards, and the thread passed round from within outwards. (Manec, Hodgson, and, with slight modification in the incision through the skin, Chamberlaine.)

Ligature has been performed in this position by separating the pectoralis and deltoid muscles, without dividing the muscular fibres (Roux, Desault).

To attempt to gain access between the clavicular and sternal portions of pectoralis major, as has been proposed by some, is almost impracticable in the living body, from the position of the vein, to which, rather than to the artery, this incision leads.

Ligature of Axillary, *in its second stage*, is not an advisable operation, when it is merely intended to throw a ligature round the artery for an aneurism lower down.

It has been performed at least twice by Delpach, but it is a rude procedure; in his cases, after the muscle was cut, a dive with the finger was made to collect the whole mass of vessels and nerves, and bring them to the surface near the collar-bone; in this position it is said the artery was easily isolated and tied.

In Mr. Syme's operation of cutting into large axillary aneurisms, and tying both ends of the vessel, the pectoralis minor may, indeed generally has, to be divided, and must take its chance without any special notice or precaution, in the sweeping, free incisions required.

Ligature of Axillary *in its third stage.*—This is an operation very much more common, more easy of accomplishment, and safer in its results than either of the preceding; the artery in this stage being more superficial, in fact almost subcutaneous.

Operation.—The arm being extended and supinated, an incision ([Plate I.](#) fig. 10) two and a half or three inches long, must be made in the base of the axilla over the artery, involving at first skin and superficial fascia only; the deep fascia is then exposed and must be carefully scraped through, avoiding injury of the basilic vein, if (as sometimes occurs) it has not yet dipped through the fascia. The vessel can now be felt; the median nerve which lies over the artery, or slightly to its outer side, must be drawn outwards, and the axillary vein, which lies at the thoracic side, but often overlaps the vessel, must be carefully drawn inwards. The ligature must then be passed from within outwards.

When the patient is very fat or muscular, the coraco-brachialis muscle may be required as a guide to the vessel; but in general its superficial position renders any guide quite unnecessary, even in the dead body.

Anatomical Note.—While in each stage the axillary artery gives off branches, those arising from the third stage are by far the most important, especially the subscapular, which leaves it at the edge of the muscle of the same name. To avoid these the ligature should be applied as low down on the vessel as possible, and, in point of fact, the operation called ligature of the third stage of the axillary is, anatomically speaking, really ligature of the brachial high up, and where there is room at all, there will be the less chance of secondary hæmorrhage, the greater the distance is between the ligature and the great subscapular branch.

Mr. Syme's Operation for Axillary Aneurism.—Description of the operation in his own words:—

"Chloroform being administered, I made an incision along the outer edge of the sterno-mastoid muscle, through the platysma myoides and fascia of the neck, so as to allow a finger to be pushed down to the situation where the subclavian artery issues from under the scalenus anticus and lies upon the first rib. I then opened the tumour, when a tremendous gush of blood showed that the artery was not effectually compressed; but while I plugged the aperture with my hand, Mr. Lister, who assisted me, by a slight movement of his finger, which had been thrust deeply under the upper edge of the tumour, and through the clots contained in it, at length succeeded in getting command of the vessel. I then laid the cavity freely open, and with both hands scooped out nearly seven pounds of coagulated blood, as was ascertained by measurement. The axillary artery appeared to have been torn across, and as the lower orifice still bled freely, I tied it in the first instance. I next cut through the lessor pectoral muscle close up to the clavicle, and holding the upper end of the vessel between my finger and thumb, passed an aneurism-needle, so as to apply a ligature about half an inch above the orifice."¹⁹

In a similar operation lately performed by the author for traumatic aneurism, the result of a stab, very little blood was lost, though no incision was made above the clavicle. The patient made a good recovery.²⁰

Ligature of Brachial.—To arrest hæmorrhage from a wound of the artery itself, no special directions are required, except to enlarge the wound, and secure the vessel above and below the bleeding point. There are, however, rare cases in which for bleeding in the palm (after all other means have failed), or for aneurism lower down the arm, a ligature may be necessary.

Operation.—The biceps muscle, at its inner edge, is the best guide to the position of the incision, or if it be obscured by fat or œdema, a line extending from the axilla, just over the head of the humerus to the middle of the bend of the elbow will define its course. An incision ([Plate I.](#), fig. 11) three inches in length, about the middle of the arm (when you have the choice of position), through skin and superficial fascia, will expose the deep fascia, and probably the basilic vein. Drawing the latter aside, cautiously divide the deep fascia. The artery is then exposed, but in close relation to various nerves; of these the ones most likely to come in the way are—1. The median, which lies in front of, but a little to the outside of the artery, though in some rare cases it lies behind it; 2. The internal cutaneous; 3. The ulnar, both of which ought to be rather to the inside of the artery. Two

¹⁹ *Observations in Clinical Surgery*, pp. 148, 149.

²⁰ *Edin. Med. Journal*, March 1879.

brachial veins accompany and wind round the vessel, occasionally interlacing. Pulsation will, in the living body, usually suffice to distinguish the artery from the other textures, and the ligature may be passed from whichever side is most convenient.

Note.—The relation of the median nerve to the vessel varies according to the part of the arm—thus, as low as the insertion of the coraco-brachialis it is to the outer side, as has been described, it then crosses the vessel obliquely, and two inches above the elbow it is on the inner side of the artery. Again, the operator must never forget the possibility of there being a high division of the artery. This occurs, Mr. Quain has shown, perhaps once in every ten or eleven cases, and may necessitate ligature of both trunks.

In those cases (once much more frequent than at present) where an aneurism has formed after a wound of the brachial at the bend of the arm in venesection, the aneurism may be either circumscribed or diffuse.

If circumscribed, it is advised by some surgeons, specially by the late Professor Colles of Dublin, that the brachial should be tied immediately above the tumour. In most cases of circumscribed, and in all such cases of diffuse aneurism, the preferable operation is boldly to lay open the tumour, turn out all the clots, seek for the wound in the artery, and tie the vessel above and below. A tourniquet above, or, better still, a trustworthy assistant, prevents all fear of hæmorrhage, and such a radical operation exposes the limb to far less chance of gangrene than do any attempts at removing or lessening the tumour by pressure (as recommended by Cusack, Tyrrell, Harrison), and is much more certain than a mere ligature above.²¹

Ligature of Vessels in Fore-arm.—Here, as also we found is the case in the leg, it is almost useless to go on giving exact directions as to the method of throwing a ligature round the vessels in all possible situations.

For below the elbow spontaneous aneurism is almost unknown, and even traumatic aneurisms are extremely rare. It is therefore for hæmorrhage only that the vessels are likely to require ligature, and it is a rule in surgery that to enlarge the wound and to apply a ligature above and below the bleeding point is better practice than to apply a ligature at a distance.

In the case of wounds of the palmar arch, it is extremely difficult, and very apt to injure the future usefulness of the hand, thus to seek for the bleeding point under the palmar fascia, and for *these*, ligatures of radial and ulnar have occasionally been practised. However, as even this has proved ineffectual, and the interosseous has proved sufficient to continue the bleeding, ligature of the brachial at once is preferable to ligature of so many branches in the fore-arm.

The use of graduated compresses, carefully applied, combined with flexion of the elbow over a bandage, will generally prove sufficient to check such hæmorrhage from the palm, without having recourse to either of the above more severe measures.

Note.—As in the lower limb at page 24, and for the same reasons, I here insert a brief account of the methods of tying the ulnar and radial arteries.

1. *Ligature of Ulnar.*—Only admissible in the lower half of its course.

Operation.—Use the tendon of the flexor carpi ulnaris as a guide, and make an incision along its radial edge, at least two inches in length; expose the deep fascia of the arm and then cautiously divide it; then bending the hand, the flexor carpi ulnaris is relaxed, and the artery is found lying pretty deeply between it and the flexor sublimis digitorum. The ulnar nerve lies at its ulnar side, and the venæ comites accompany the artery. In a tolerably muscular arm, the incision will have to be about an inch inside of the ulnar border of the limb.

²¹ See case of recurrence, Fergusson's *Practical Surgery* 1st ed. p. 222.

2. Radial.—This artery lies more superficial than the preceding, and may be tied at any part of its course.

A. Operation in upper part of fore-arm. Here the artery lies in the interval between the supinator longus and the pronator radii teres. In a muscular arm, the edge of the former muscle is the best guide; in a fat one, the incision may be made in a line extending from the centre of the bend of the arm to the inner edge of the styloid process of the radius. The deep fascia must be exposed and opened, and the muscles relaxed and held aside. The radial nerve lies on the radial side of the vessel.

B. Operation in lower half of arm. Here the vessel is more superficial, lying in the groove between the flexor carpi radialis and supinator longus. An incision two inches in length, and parallel with these tendons, easily exposes the artery. The nerve is still on its radial side.

C. Operation at first metacarpal. The artery may be tied easily enough in the triangular space bounded by the extensors of the thumb, on the dorsum of the proximal end of the first metacarpal bone. Skey²² recommends a transverse, —Stephen Smith²³ and others, a longitudinal incision. The author had lately to secure the radial in its lower third, the superficialis volæ, and the radial again in the triangular space, in a case where division of the artery by a transverse cut had caused a large aneurism to form close above the annular ligament.

Table illustrating anastomotic circulation after ligature of arteries of neck and upper limb.

1. Common carotid.

(a) Across middle line: thyroids, linguals, facials, occipitals; also terminal branches of external carotids; also internal carotids by circle of Willis.

(b) Of same side: occipital with vertebral; superior thyroid with inferior thyroid, etc.

2. Subclavian, 3d part.

Suprascapular with dorsal branches of subscapular; posterior scapular with costal and muscular branches of subscapular. Thoracic anastomosis between internal mammary and intercostals, with branches of axillary.

3. Axillary and brachial. Anastomosis varies with the position of the ligature, but is very free between the various muscular branches of these vessels.

²² *Operative Surgery*, p. 279.

²³ *Surgical Operations*, p. 50.

CHAPTER II. AMPUTATIONS

In ordinary surgical language the name Amputation is applied to all cases of removal of limbs, or portions of limbs, by the knife, though in strict accuracy it should be restricted to those cases in which a limb is removed *in the continuity of a bone*, its removal *at a joint* being called a Disarticulation.

The briefest outline of a history of amputation would fill a work much larger than the present. I may be allowed in a few sentences to attempt to show the principle on which such a sketch should be written, in describing the three great eras of progress in improvement of the methods of amputating.²⁴

I. Prior to the invention, or at least prior to the general introduction, of the ligature and the tourniquet, the great barrier to all improvement in operating was the impossibility of checking hæmorrhage during an operation, and after its conclusion. Many surgeons would not amputate at all, others only through gangrenous parts; others more bold, only at the confines of parts in which gangrene had been artificially induced by tight ligatures.

With the exception of Celsus, who in one place recommends a flap to be dissected up, and the bone thus divided at a higher level, all were in too great a hurry to get the operation completed to think of flaps. Cut through all the parts at the same level with a red-hot knife, if you will, like Fabricius Hildanus; by a single blow with a chisel and mallet, like Scultetus; or by a crushing guillotine, like Purmannus: or by two butchers' chopping-knives fixed in heavy blocks of wood, one fixed, the other falling in a groove, like Botal; and then try to check the bleeding by tying a pig's bladder over the face of the stump, like Hans de Gersdorf; or tying it up in the inside of a hen newly killed; or by plunging it at once into boiling pitch.

We are the less surprised to read of Celsus's description of a flap operation, when we remember that it is almost certain that Celsus *was* acquainted with the ligature as a means of checking hæmorrhage.²⁵

II. A new era was ushered in when, about 1560, Ambrose Paré invented, or re-introduced, the ligature as a means of arresting hæmorrhage, but not for more than a century after this did the full benefit of his discovery begin to be felt, when the tourniquet was introduced by Morel at Besançon in 1674, and James Young of Plymouth in 1678, and improved by Petit in 1708-10.

Now surgeons had time to look about them during an amputation, and to try to get a good covering for the bone, so that the stump might heal more rapidly and bear pressure better. Great improvements were rapidly made, and any history of these improvements would need to trace two great parallel lines, one the circular method, the other the flap operation.

1. The old method in which the limb was lopped off by one sweep, all the tissues being divided at the same level, might be called the true circular. This, however, was soon improved—

A. By Cheselden and Petit, who invented the double circular incision, in which first the skin and fat were cut and retracted, and then the muscle and bone were divided as high as exposed.

B. By Louis, who improved this by making the first incision include the muscles also, the bone alone being divided at the higher level.

C. By Mynors of Birmingham, who dissected the skin back like the sleeve of a coat, and thus gained more covering.

²⁴ For details see article "Amputation" in Cooper's *Surgical Dictionary*, and the short sketch of the history in Mr. Lister's paper in the third volume of Holmes's *System of Surgery*.

²⁵ See a most interesting foot-note to Professor Lister's paper on "Amputation," in Holmes's *System of Surgery*, vol. iii. pp. 52, 53.

D. Then comes the great improvement of Alanson, who first cut through skin and fat, and allowing them to retract, next exposed the bone still further up by cutting the muscles obliquely so as to leave the cut end of the bone in the apex of a conical cavity.

E. An easier mode, fulfilling the same indications, is found in the triple incision of Benjamin Bell of Edinburgh, who in 1792 taught that first the skin and fat should be divided and retracted, next the muscles, and lastly the bone.

F. A slight improvement on *E*, made by Hey of Leeds, who advised that the posterior muscles of the limb should be divided at a lower level than the anterior, to compensate for their greater range of contraction.

2. In the progress of the flap operation fewer stages can be defined. Made by cutting from within outwards, after transfixion of the limb, the flaps varied in shape, size, position, and numbers, from the single posterior one of Verduyn of Amsterdam, to the two equal lateral ones of Vermale, and the equal anterior and posterior ones of the Edinburgh school.

Then came the battle of the schools: flap or circular.

Flap.—Speedy, easy, and less painful; apt to retract, and that unequally.

Circular.—Leaving a smaller wound, but more slow in performance, and apt to leave a central adherent cicatrix.

3. The last era in amputation began after the introduction of anæsthetics. Now speed in amputation is no object, and the surgeon has full time to shape and carve his flaps into the curves most suited for accurate apposition, and suitable relation of the cicatrix to the bone. It has also been brought clearly out that different methods of operating are suitable for different positions, and also that even in the same operation it is possible to unite the advantages of both the flap and the circular method.

In the modified circular, which is best suited for amputation below the knee, in the long anterior flaps of Teale, Spence, and Carden, we have illustrations of the manner in which the advantages of both the flap and circular methods have been secured, without the disadvantages of either. The long anterior flap, not like Teale's to fold upon itself, but like Spence's and Carden's to hang over and shield the end of the bones, and the face of a transversely-cut short posterior flap, seems to be now the typical method for successful amputations. There may be exceptions, as when the anterior skin is more injured than the posterior, or where an anterior flap would demand too great sacrifice of length of limb, but as a rule it will be found the best method for the patient.

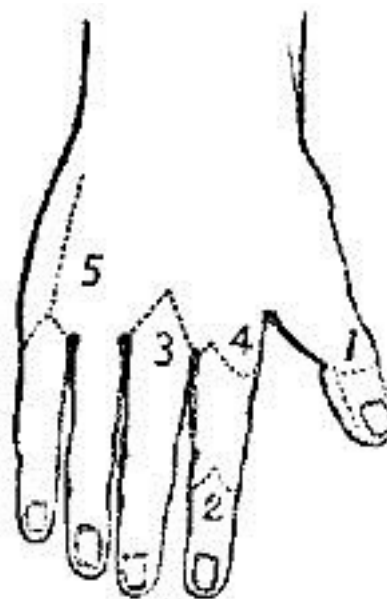


Fig. i.

Amputation of the Upper Extremity.—The extreme importance of the human hand, its tactile sensibility, its grasping power, and the irreparable loss sustained by its removal, render the greatest caution necessary, lest we should remove a single digit or portion of one that might be saved. In cases of severe smashing injuries involving the fingers, it is the surgeon's bounden duty not recklessly to amputate the limb with neat flaps at the wrist-joint, but carefully to endeavour to save even a single finger from the wreck, though at the risk of a longer convalescence, or even of a profuse suppuration. While a toe or two, or a small longitudinal segment of the foot, may be comparatively useless, and a good artificial foot, with an ankle-joint stump, certainly preferable, a single finger, provided its motions are tolerably intact, will prove much more valuable to its possessor than the most ingeniously contrived artificial hand.

However, while in cases of extensive smash we endeavour to save anything we can, the case is very much altered when it is only one or two fingers that are injured. Here we find another principle brought into play, and our conservative surgery must be limited by the following consideration. In endeavouring to save a portion of the injured finger or fingers, will the saved portion interfere with the important movements of the uninjured ones? These two principles—1. Generally to save as much as we can; 2. Not to save anything which may be detrimental or in the way,—will guide us in describing the amputations of the upper extremity.



Fig. ii.

Amputation of a distal phalanx.—This small operation is not very often required. In cases of whitlow in which the distal phalanx alone has necrosed, removal of the necrosed bone by forceps is

generally all that is necessary. In cases of injury, however, in which nail and distal phalanx are both reduced to pulp, it will hasten recovery much to remove the extremity. There is no choice as to flap, the nail preventing an anterior one, so a flap long enough to fold over must be cut from the pulp of the finger in either of two ways (Fig. i. 1):—1. Holding the fragment to be removed in the left hand, and bending the joint, the surgeon makes a transverse cut across the back of the finger, right into and through the joint, cutting a long palmar flap from within outwards as he withdraws the knife.

Note.—Some difficulty is often felt in making the dorsal incision so as exactly and at once to hit the joint; the most common mistake being, that the transverse incision is made too high, and the knife, instead of striking the joint, only saws fruitlessly at the neck of the bone above. To avoid this, the surgeon should take as a guide to the joint, not the well-marked and tempting-looking *dorsal* fold in the skin, but the *palmar* one, which exactly corresponds with the joint between the proximal and middle phalanges, and is only about a line above the distal articulation.—(Fig. ii.)

2. Making the long flap by transfixion, it may be held back by an assistant, and the joint cut into.

Amputation through the second phalanx.—If the distal phalanx be so much crushed that a flap cannot be obtained, two short semilunar lateral flaps may be dissected (Fig. i. 2) from the sides of the second phalanx, which may then be divided by the bone-pliers at the spot required.

In cases of injury which do not admit of either of the preceding operations, it is quite possible to amputate either at the first joint, or even through the proximal phalanx. Patients are sometimes anxious for such operations in preference to amputation of the whole finger. The surgeon should, however, never amputate through a finger higher up than the distal end of the second phalanx, unless absolutely compelled by the patient, for the resulting stump, being no longer commanded by the tendons, will prove merely an incumbrance, and may possibly require a secondary operation at no distant date for its removal.

This rule is applicable in cases in which a single finger is injured, and two or three complete ones are left; in cases where all the fingers have been mutilated every morsel should be left, and may be of use.

Amputation of a whole finger.—(Fig. i. 3)—This is an operation of great importance, from its frequency.

If the third or fourth digits require amputation, it should be performed as follows:—The vessels of the arm being commanded, an assistant holds the hand, separating the fingers at each side of the one to be removed. The surgeon holding the finger to be removed, enters the point of a long straight bistoury exactly (some authorities say half an inch) above the metacarpo-phalangeal joint, and cuts from the prominence of the knuckle right into the angle of the web, then, turning inwards there, cuts obliquely into the palm to a point nearly opposite the one at which he set out.

Note.—While most authorities agree with the direction in the text regarding the palmar termination of the incision, I believe, in most cases, it is not necessary to go so far, and that the incisions may fitly meet in the palm at a point midway between a point opposite to the knuckle, and the centre of the well-marked "sulcus of flexion."

He then repeats this incision on the other side, makes tense the ligaments, first at one side and then at the other, by drawing the finger to the opposite side, and cuts them. The tendons being cut, the finger is detached. The vessels being tied, one point of suture is put in on the dorsal aspect, and the fingers on each side tied together at their extremities, with a pad of lint between them.

Modification.—Lisfranc's method is too long in its minute description to give in detail. The principle is to make a semilunar flap at one side (the one opposite the

operator's right hand), by cutting from without inwards, then to open the joint from this cut, and, still keeping the edge of the knife close to the head of the phalanx, cutting the other flap from within outwards. This can be very rapidly done, but the last flap is apt to be irregular and deficient, especially in those common cases, in which, after whitlow or the like, the tissues are hard and brawny, and the skin does not play freely.

It is quite unnecessary to remove the head of the metacarpal, either for the sake of appearance, or to render healing more rapid, and its removal weakens the arch of the hand; where the cartilage is eroded by disease, the cartilage-covered portion can be scooped off by a gouge or removed entire by pliers, without interfering with the broad end to which the transverse ligament of the palm is attached. If required either for injury or disease, the metacarpal head may be easily removed by a single straight incision from the knuckle upwards, as far as the point at which it may be deemed necessary to saw it through, or better still, divide it with the bone-pliers. This incision should be made as a first step in the first incision for amputation of the finger, and the finger should not be disarticulated, but kept on, to aid by its leverage in separating the metacarpal head.

Amputation of the index or little fingers.—This operation differs from the preceding only in this, that care must be taken to make a good large flap on the free side of each; making the incision, which begins at the knuckle (Fig. i. 4), enclose a well-rounded flap, and not allowing it to enter the palm till it reaches the level of the web between the fingers. The metacarpal heads may here be cut obliquely with the bone-pliers, to prevent undue projection.

Amputation of one or more metacarpals.—These operations may be rendered necessary by disease or injury. If the latter demands their performance, no rules can be given for incisions or flaps, they must just be obtained where and how they can best be got. If for disease, a single dorsal incision (Fig. i. 5) over the bone will allow it to be dissected out of the hand.

N.B.—In no case, except that of the thumb, should any attempt be made to save a finger while its metacarpal is removed. (See *Excisions of Bones*.)

Amputation of first and fifth metacarpals.—Various special operations have been devised for speedy and elegant removal of these bones. Their disadvantages, etc., are fully detailed under *Amputations of the Foot*.

The vascularity and consequent vitality of the tissues of the hand and arm sometimes afford very encouraging and satisfactory results in conservative operations.

The following is an instance of what may be accomplished in a young healthy subject.

A. A., æt. 18, ploughman, was harnessing a vicious horse, when it caught his right hand between its teeth, and gave a severe bite. On admission, I found the middle and ring fingers completely separated at the metacarpal joints, but each hanging on by a portion of skin, the middle by the skin on its radial side, the ring by that on its ulnar. The back and the palm were both stripped of skin up to the middle of the third and fourth metacarpal bones, which were exposed, but not fractured. As it was important for him to maintain the transverse arch of the hand intact, I determined to make an attempt to save the metacarpals, and finding that the skin on the radial side of the middle, and ulnar side of the ring fingers, was still warm, and apparently alive, I carefully dissected as long a flap as possible from each, and then folded them down, one at the front, the other at the back of the hand. The flaps survived, and the result was admirable, the patient being able in a very few weeks to guide the plough. The sensation in his new palm and back of the hand is very peculiar, they being still the fingers, so far as nervous supply is concerned.

In amputations involving the metacarpals for injury, it is always important to avoid entering the carpo-metacarpal joint, hence if it can be done it is best to saw through the bones at the required level, rather than disarticulate. This rule should be observed even in those cases in which the thumb alone can be saved, for notwithstanding the isolation of the joint between the first metacarpal and

the trapezium, it is very important for the future use of this one digit that the motions both of the wrist and carpal joints should be preserved entire.

No exact rules can be given for the performance of these operations, as the size and positions of the flaps must be determined by the nature of the accident and the amount of skin left uninjured.

In the rare condition where the greater part of the metacarpus is destroyed, and yet carpal joints are uninjured, a most useful artificial band, preserving the movements of the wrist, may be fitted on; and as much as possible should be saved, but in cases of injury, where the carpus is opened and the hand irreparably destroyed, the question arises, Where ought amputation to be performed? To this we answer that there appears no conceivable advantage to be gained by leaving all or any of the carpal bones. If successful, it would result only in the retention of a flapping joint, unless from there being no tendons to act upon it, except the tendon of the flexor carpi ulnaris attached to the pisiform, and there are several risks it would run in the inflammation of all the carpal joints, and the almost certain spread of this inflammation to the bursa underneath the flexor tendons, beyond the annular ligament, and up the arm among the muscles.

Amputation at the Wrist-Joint.—This is an operation by no means frequent, and it has the advantages of preserving a long stump, and retaining the full movements of pronation and supination, in cases where the radio-ulnar joint is sound and uninjured, but in practice it is often found that fibrous adhesions limit to a great extent the motions of the two bones on each other, specially in those cases where the radio-ulnar joint has been diseased or injured.

Another advantage is the extreme ease with which disarticulation may be performed on emergency, no saw being required, and the ordinary bistoury of the pocket-case being quite sufficient for cutting the flaps.

Operation.—By double flap. An incision ([Plate IV. fig. 3](#)) on the dorsal surface, extending in a semilunar direction from one styloid process to the other, will define a flap of skin only, which must be raised; the joint must then be opened by a transverse incision, and a long semilunar flap of skin and fascia should be shaped ([Plate IV. fig. 4](#)) from the palm. Disarticulation is facilitated by the surgeon forcibly bending the wrist when he makes the transverse cut, and it will be found easier to shape the palmar flap from the outside by dissection, than to do it by transfixion after disarticulation, on account of the prominence of the pisiform on the inner side of the palm.



Fig. iii.²⁶

²⁶ This line is placed too low down; it should be in the middle third of the thigh.



Fig. iv.²⁷

In the thin wasted wrists of the aged, or in any case where the skin is very lax, this amputation may be very easily performed by the circular method. While an assistant draws up the skin as much as possible, the surgeon makes an accurate circular incision through the skin, about an inch below the styloid processes, just grazing the thenar and hypothenar eminences. Another circular sweep just above the pisiform and unciform bones divides all the soft textures, after which the joint may be opened, and, if necessary, the styloid processes cut away with saw or pliers.

Amputation by a long single flap, either dorsal or palmar, may be rendered necessary by accident. The palmar one of the two is preferable; indeed, rather than trust for a covering to the thin skin of the back of the hand, with its numerous tendons, it is better to amputate an inch or two higher up through the fore arm.

The following amputation by external flap has been described (so far as I can discover, for the first time) by Dr. Dubrueil, in his work on operative Surgery:²⁸—"Commencing just below the level of the articulation, while the hand is pronated, the surgeon makes a convex incision, beginning at the junction of the outer and middle thirds of the arm behind, reaching at its summit the middle of the dorsal surface of the first metacarpal, and terminating in front just below the palmar surface of the joint, again at the junction of the outer and middle thirds of the breadth of the arm. This flap being raised, the wrist is disarticulated, beginning at the radial side. A circular incision finishes the cutting of the skin." (Figs. iii. and iv.)

²⁷ This line is placed too low down; it should be in the middle third of the thigh.

²⁸ *Manuel d'Opérations chirurgicales.*

Amputation through the Fore-arm.—The method of operating must, in the fore-arm, depend a good deal upon the part of the arm where you require to amputate, the muscularity of the limb, and the condition of the skin and subcutaneous cellular tissue.

It must be remembered that a section of the fore-arm involves two bones, not, like the tibia and fibula, on a constant permanent relation in position to each other, but which rotate one upon another to an amount which varies with the part of the limb divided, and which rotation is a very important element in the future usefulness of the stump; again, that two sets of muscles occupy, one the back, the other the front of the limb, that these two are unequal in size, and that the outer sides or rather edges of each bone are subcutaneous; again, that these sets of muscles are comparatively fleshy in the upper two-thirds of the limb, and almost entirely tendinous in the lower third.

Remembering these points, we find that certain things require our attention, and certain difficulties are present in amputation of the fore-arm, from which amputation of the arm, with its single bone and copious muscular covering on all sides, is completely free.

Thus our flaps in the fore-arm must be antero-posterior; lateral flaps are an impossibility. Great care is requisite to cut them at all equal, from the inequality of the muscles on the two sides. In the lower third we cannot obtain available muscular flaps. Lastly, care must be taken lest, from the ever-varying relations of the two bones to each other in the varying positions of the limb, the surgeon mistake their position and pass his knife between them.

The next question that arises is, Where are we to operate? In cases where we have a choice, is there here, as in the leg, any "point of election"? *No*. As a rule in the fore-arm, the surgeon should endeavour to save as much as possible; especially when nearing the middle of the fore-arm, he should try to save the insertion of the pronator teres, so important in its function of pronating the radius.

Amputation in Lower Third of the Fore-arm.—By two flaps. These antero-posterior flaps must consist of skin only, as the tendons are only in the way, and thus should be made by dissection from without.²⁹ Making the dorsal one first, the surgeon should enter his knife at the palmar edge of the bone that is further from him, and cut a semilunar flap of skin only, finishing the incision quite on the palmar edge of the inner bone. The two ends of this incision must then be united by a similar semilunar flap of skin on the palmar side. The two flaps having been dissected back, he then clears the bones by a circular incision through tendons and muscles, not forgetting to pass the knife between the bones, and retracting all the soft parts, saws through the bones, at least half or probably three-quarters of an inch higher up. It is generally easiest to saw through both bones at once.

Long Dorsal Flap.—Where it is possible from laxity of the soft parts and the wrist not being much destroyed, to get a long flap from the back of the arm after Mr. Teale's method, a very good stump will result. This rule is, "In tracing the long flap a longitudinal line is drawn over the radius, so as to leave the radial vessels for the short flap ([Plate II. fig. 1](#)). At a distance equal to half the circumference of the limb, another line parallel to the former is drawn along the ulna. These are then joined at their lower ends, across the dorsal aspect of the wrist or fore-arm, by a transverse line equal in length to half the circumference of the fore-arm. The short flap is marked by a transverse line on the palmar aspect, uniting the long ones at their upper fourth.

"The operator, in forming the long flap, makes the two longitudinal incisions merely through the integuments, but the transverse one is carried directly down to the bones. In dissecting the long flap from below upwards, the tissues of which it is composed must be separated close to the periosteum and interosseous membrane. The short flap is made by a transverse incision through all the structures down to the bones, care being taken to separate the parts upwards close to the periosteum and

²⁹ As the surgeon will find it most convenient to stand on his own right side of the limb to be removed, the knife will be entered on the palmar side of the radius of the right arm, of the ulna of the left.

membrane." The stump must be placed in the prone position, "to allow the long dorsal flap to be the superior when the patient is recumbent, and thus fall over the ends of the bones."³⁰

The principal objection to the long dorsal rectangular flap (which makes an excellent covering) is, that unless it can be obtained from over the wrist-joint it requires the bones to be sawn so very high up. This may be avoided, to some extent, by making it shorter and rounded off, as in Carden's Amputation, *q. v.*

Amputation in Upper Two-Thirds.—Where the fore-arm is very fat or fleshy, this amputation can be very easily performed by two equal antero-posterior flaps made by transfixion. In most cases, however, from the comparative leanness of the dorsal aspect of the limb, the following method will have the best result. The surgeon must, as in the former case, shape a rounded dorsal flap by dissection from without ([Plate IV](#), fig. 5), embracing the whole breadth of the limb down to the palmar edge of both bones. Then at once he transfixes the two points of this dorsal flap, and cuts out an equal one from the anterior aspect of the limb ([Plate IV](#), fig. 6). Dissecting up the dorsal flap he clears the bones at least half an inch above as before, and applies the saw.

N.B.—This operation should be performed even in cases where only an inch of radius can be retained, as the attachment of the biceps makes a very small stump of fore-arm wonderfully useful.

Amputation at Elbow-Joint.—In cases where it is found impossible to save any portion of the fore-arm, disarticulation at the elbow-joint may be easily performed. This operation was proposed and performed so long ago as the days of Ambrose Paré,³¹ was much approved by Dupuytren, Baudens, and Velpeau, had fallen into disuse for a time, but is now again recommended by some excellent surgeons, especially by Gross³² and Ashhurst,³³ both of Philadelphia.

It is tolerably easy to perform, and does not involve any sawing of bones, but the flaps are apt to be cut too short, unless care be taken, from the manner in which the trochlea projects downwards beyond the line of the condyles, so that if the base of an ordinary-shaped flap be made on a level with the condyles, it will prove insufficient to cover the bone. It may be performed either by the circular method (Velpeau), oval (Baudens), or by a long anterior and short posterior flap (Textor and Dupuytren). Probably the best method is by a long anterior flap when it can be obtained, thus:—The arm being placed in a slightly flexed position, the surgeon transfixes in front of the joint, in a line extending from the level of the external condyle to a point one inch below the internal condyle ([Plate IV](#), fig. 7); the tissue should be held well forward at the moment of transfixion. The flap should be at least two and a half inches deep at its apex, which must be rounded off. The two ends of this flap may then be united behind by a semilunar incision ([Plate III](#), fig. 2), which will separate the radial attachments. The ulna must then be cleared, and the triceps divided at its insertion.

Modifications.—Dupuytren used to saw through the ulna, leaving the olecranon attached. Velpeau opposed this, but it is again recommended by Gross, who leaves the olecranon, and at the same time improves the shape of the stump by sawing off the "inner trochlea" on a level with the general surface.

Amputation of the Arm.—This amputation is best performed by double flap, and is the typical instance which exhibits all the advantages of two equal flaps made by transfixion, without any of the disadvantages of that method. These advantages are, easiness of performance, rapidity, excellent covering for the bone, with as little sacrifice of tissue as is possible, while the fact that the cicatrix is opposite the end of the bone is hardly a disadvantage in the arm (as it certainly is in the leg), as no weight has to be borne on it. When they can be obtained, anterior and posterior flaps are generally considered most satisfactory, but Mr. Spence prefers lateral ones, lest the line of union should be

³⁰ Teale, *On Amputation by Rectangular Flaps*, pp. 46-48.

³¹ Johnson's folio ed., p. 342.

³² Gross's *Surgery*, 6th ed. vol. ii. p. 1103.

³³ *International Encyclopedia of Surgery*, vol. i. p. 641.

interfered with by the deltoid raising the bone. If the right arm has to be amputated, the operator standing at the inner side raises the anterior muscles with his left hand, and enters the knife just in front of the brachial vessels ([Plate I](#), fig. 12); keeping as close as possible to the bone, he brings out the knife at a point exactly opposite, then with a brisk sawing motion, cuts a semicircular flap, taking care to bring out the knife more suddenly just at the end, in order to cut through the skin as perpendicularly to the arm as possible. The knife is again entered at the same point, carried behind the bone, and brought out at the same angle, and an exactly corresponding flap cut from the other side of the limb, the flaps are then retracted, the bone cleared by circular incision and sawn through as high up as it is exposed. In primary cases, where the muscles are firm and developed, the flaps should be cut a little concave.

Modifications and Varieties.—Teale's method may of course be used here as elsewhere. The internal line of incision ([Plate IV](#), fig. 8) should be made just in front of the brachial vessels. This method requires the amputation to be performed higher up than would otherwise be necessary (from the length of the anterior flap), and this disadvantage is not counterbalanced by any special advantage in the posterior retraction of the cicatrix.

In feeble flabby arms, the true circular operation is very easily performed, and with good results. A circular sweep of the knife is made through the skin alone, which is drawn up by an assistant, while the surgeon separates it from the fascia; another circular cut through fascia and muscles exposes the bone, which must then be cleared and cut through at a still higher level.

Amputation at the Shoulder-Joint.—This operation, like that at the hip joint, can, from the nature of the joint to be covered, and the abundant soft parts in the normal state of the tissues, be performed on the dead in very various ways, by single, double, or triple flaps, by transfixion or dissection, rapidly or slowly. Hence manuals of operative surgery might collect at least twenty different methods, most of which have some recommendation, and all of which are practicable enough.

When, however, we reflect that in the living body, in cases where amputation at the shoulder-joint is required at all, the severity of the accident, or the urgency of the disease, will, in general, leave no room for selection, we shall see how utterly valueless is any knowledge of mere methods of operating, and of how much greater importance it is that we should be simply thoroughly familiar with the anatomy of the joint.

For example, an accident which necessitates amputation so high up has, in all probability, opened into the joint and destroyed the soft parts on at least one aspect; in such a case the flaps must be cut from the uninjured soft parts only. If an aneurism has rendered amputation through it and through the joint a last resource, the flap must be gained chiefly at least from the outside; a malignant tumour of the humerus will almost certainly prevent any transfixion, and require flaps to be made by dissection, wherever the skin is least likely to be involved. Again, some of the most vaunted and most rapid operations almost require for their success the integrity of the humerus, which has to make itself useful as a lever in disarticulation, while in most cases of accident we are amputating for compound injury of the humerus, almost certainly implying fracture with comminution.

From its proximity to the trunk, hæmorrhage is one of the chief dangers to be apprehended during this operation, especially from the axillary artery. As far as possible to obviate this danger, most plans of operating are based on the principle that the vessels and nerves should be the last tissues to be cut; in some they are not divided till after disarticulation.

While a good assistant, to make pressure on the subclavian above the clavicle, is a most advisable precaution, too much must not be trusted to this pressure above, as the struggles of the patient and

the spasmodic movements of the limb, which are so apt to occur under the stimulus of the knife, are apt to render futile the best efforts at compression.

The operator should trust rather to making the incisions in such a manner that the great vessel be not divided till the hand of an assistant, or in default of a suitable one, his own left hand, is able to follow the knife and grasp the flap.

The bleeding from the circumflex, subscapular, and posterior scapular arteries can easily be arrested by a dossil of lint till the great vessel is tied, and they can be secured.

In cases where proper assistants cannot be had, temporary closure of the axillary vessel could easily be made by carrying a strong silver wire or silk ligature completely round the vessel by a curved needle before the incisions are commenced, and by tying this firmly over a pad of lint.

Pressure on the artery above the clavicle is best made by the thumb of a strong assistant, who endeavours to compress it against the first rib; where the parts are deep and muscular, the padded handle of the tourniquet, or of a large door-key, will do as the agent of pressure.

A brief notice of three of the best methods of operating will be quite sufficient to show what should be aimed at in shoulder-joint amputations:—

1. In cases where the surgeon can choose his flaps, the following method will be found the most satisfactory, as resulting in the smallest possible wound, in having less risk of hæmorrhage during the operation than any other method, and in providing excellent flaps.

It is Larrey's method slightly modified.

Operation.—With a moderate-sized amputating knife an incision of about two inches in length, extending through all the tissues down to the bone, should be made from the edge of the acromion process to a point about one inch below the top of the humerus; from this latter point a curved incision, enclosing a semilunar flap, should be made on each side of the limb to the anterior and posterior folds of the axilla respectively ([Plate IV. fig. 9](#), and [Plate III. fig. 3](#)). These flaps should then be dissected back, including the muscles and exposing the joint. When thoroughly exposed, the joint must then be opened from above, and the bone separated. One small portion of skin lying above the artery, vein, and nerves still remains to be divided ([Plate I. fig. 13](#)). This may be done by an oblique cut from within outwards, in such a direction as to form part of the anterior or internal incision, and with the precaution of having an assistant to command the vessels before they are divided. The resulting wound is almost perfectly ovoid, the flaps come together with great ease in a straight vertical line, which admits of easy and thorough drainage. Union is generally rapid. Larrey's success by this method was very remarkable: ninety out of a hundred cases in military practice were saved, notwithstanding the well-known risks of such operations.

2. As good as the former, and nearly as universally applicable, is the method devised by Professor Spence, and practised by him in nearly every case:—"With a broad strong bistoury I cut down upon the inner aspect of the head of the humerus, immediately external to the coracoid process, and carry the incision down through the clavicular fibres of the deltoid and pectoralis major muscles till I reach the humeral attachment of the latter muscle, which I divide. I then with a gentle curve carry my incision across and fairly through the lower fibres of the deltoid towards, but not through, the posterior border of the axilla. Unless the textures be much torn, I next mark out the line of the lower part of the inner section by carrying an incision through the *skin and fat only*, from the point where my straight incision terminated, across the inside of the arm to meet the incision at the outer part. This insures accuracy in the line of union, but is not essential. If the fibres of the deltoid have been thoroughly divided in the line of incision, the flap so marked out, along with the posterior circumflex trunk, which enters its deep surface, can be easily separated from the bone and joint, and drawn upwards and backwards so as to expose the head and tuberosities, by the point of the finger without further use of the knife. The tendinous insertions of the capsular muscles, the long head of the biceps, and the capsule, are next divided by cutting directly upon the tuberosities and head of the bone; and the broad subscapular tendon especially, being very fully exposed by the incision, can be much more

easily and completely divided than in the double-flap method. By keeping the large posterior flap out of the way by a broad copper spatula or the fingers of an assistant, and taking care to keep the edge of the knife close to the bone, the trunk of the posterior circumflex is protected. In regard to the axillary vessels, they can either be compressed by an assistant before completing the division of the soft parts on the axillary aspect, or to avoid all risk, the axillary artery may be exposed, tied, and divided between two ligatures so as to allow it to retract before dividing the other textures."³⁴

Another, but not so good method of making an external flap, is the following:—(a.) For the right arm.—The patient lying well over on his left side, the surgeon stands to the inside of the arm to be removed. Seizing the deltoid in the left, with the right he passes an amputating knife, seven or eight inches in length, from a point a little nearer the clavicle than the middle space between the acromion and coracoid processes; then, transfixing the base of the deltoid, and just grazing the posterior surface of the humerus, thrusts the knife downwards and backwards till it protrudes at the posterior margin of the axilla. When doing this, it is important that the arm be held outwards and backwards, and even upwards, as far as possible to relax the deltoid; without this it will be impossible to make the flap of the full size. The flap must then be cut of as full length as can be obtained, four or five inches at least. An assistant then holds it upwards, while the surgeon, or (if the arm is very muscular) another assistant, brings the arm forwards well across the patient's chest, thus exposing the posterior aspect of the joint. This may have very possibly been already opened during the transfixion; the attachments of muscles must now be divided, the knife passed behind the head of the bone, which is dislocated forwards, and a suitable flap of the tissues in front cut from within outwards. The assistant is to follow the knife with his finger and compress the vessels.

(b.) If the left shoulder is to be amputated, the patient lying on his right side, the surgeon stands behind him, and raising the elbow of the limb to be removed from the side, and pulling it slightly backwards, enters the knife at the posterior fold of the axilla ([Plate II](#), fig. 2), and passing the posterior aspect of the head of the humerus, endeavours to protrude it as near the acromion as possible; the flaps must be cut and the rest of the operation performed in the manner we have just described for the other arm.

3. Where the destruction of tissue has been chiefly below the joint, a very good flap may be obtained from above, composed chiefly of the deltoid muscle, and the skin over it. This may be made by transfixion at its base, but is better obtained by dissection from without.

The surgeon cuts ([Plate II](#), figs. 3, 3) in a semilunar direction (with the convexity downwards) from one side of the deltoid to the other, viz., from the root of the acromion to near the coracoid process; he then raises the large flap upwards and throws it back, opens the joint, disarticulates, passes the knife behind the head of the bone, and cuts out without attempting to save any flaps below, in a transverse direction. By this means the artery is still almost the last structure to be divided, and can be secured by a ready assistant. In cases where much injury has been done to the floor of the axilla and wall of chest, the deltoid flap must be made large in proportion, and triangular rather than semilunar in shape.

N.B.—The statistics of amputation at the shoulder-joint bring out some interesting facts: 1. That the primary amputations here are far more successful than secondary ones. Guthrie records nineteen cases of the former out of which only one died, while out of a similar number in which the

³⁴ Spence's *Surgery*, pp. 800, 801.

amputation was secondary, fifteen died. In the Crimea, British surgeons had thirty-nine cases, with thirteen deaths; of thirty-three primary, nine died; and of six secondary, four were fatal.

S.W. Gross's³⁵ statistics confirm this: of one hundred and seventy-eight primary, forty-six died—25.8 per cent.; ninety-five secondary, sixty-one died—64.2 per cent.

Amputations above the Shoulder-Joint.—Under this head we may group the comparatively rare cases in which, from accident or disease, the removal of portions of the scapula and clavicle, or even the entire bones, is rendered necessary. That it is quite possible to survive such injuries has been frequently shown in cases of accident when the scapula along with the arm has been torn off, and yet the patient recovered.

Encouraged by such cases, Gaetani Bey of Cairo removed the whole of scapula and part of the clavicle in a case where he had amputated at the shoulder for smash. The patient recovered. Heron Watson has had a similar case. Dr. George M'Lellan amputated arm and scapula in a youth of seventeen for an enormous encephaloid tumour. Fifty-one such cases are now on record.

³⁵ Gross's *Surgery*, 8vo., 6th ed., vol. ii., p. 1106.

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