Modern Surgery - Chapter 18. Diseases and Injuries of the Heart and Vessels - Ligation of Arteries in Continuity

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discovery of the existence of such a condition may not be made until a tooth is pulled, and extraction is followed by persistent bleeding. It is alleged that the tendency may disappear in middle life.

The cause of the condition is unknown. It has been assumed that there is a condition of the blood which prevents coagulation, but the blood of a hemophiliac coagulates outside of the body as well as any other blood. Furthermore, Agnew had a case in which hemophilia was limited to the head and neck, and there have been cases in which the bleeding occurred from one kidney. Some maintain that there is structural defect in the capillaries. In a case of hemophilia in the Jefferson Medical College Hospital in which it was absolutely necessary to amputate a finger because of a crush, a careful study of the vessels of the finger by Dr. Coplin failed to show any disease of the blood-vessels. A surgeon must be on the lookout for this condition, and should inquire for it before deciding to do an operation. If it exists, only an operation of imperative necessity should be undertaken.

A child who is a "bleeder" must be unceasingly watched and guarded. A tendency to profuse oozing exists in leukemia because of the condition of the blood, but this is not hemophilia. A tendency to oozing also exists during jaundice.

**Treatment.**—The oozing is difficult and often impossible to control. The internal administration of such drugs as ergot, gallic acid, and acetate of lead is useless. It is claimed that chlorid of calcium internally is of service. The local use of astringents is of no avail. Prolonged elevation may in rare cases succeed. In the case in the Jefferson Medical College Hospital the bleeding was arrested, after numerous expedients failed, by compression and hot water. Nurses sat by the bed for several days, constantly compressed the wound with gauze pads soaked in hot water, and changed the pads as soon as they cooled. The local use of Carnot's solution of gelatin has saved several cases from death. It has been advised to take some blood from a healthy man and put it in the cut, in the hope that a firm clot will form.

3. **LIGATION OF ARTERIES IN CONTINUITY.**

The **instruments** used in this operation are two scalpels (one small, one medium), two dissecting forceps, several hemostatic forceps, blunt hooks or broad metal retractor, an Allis dissector, an aneurysm needle, for superficial arteries the instrument of Saviard (Fig. 130), for deep vessels the needle of Dupuytren (Fig. 131), ligatures of catgut, of chromicized gut, or of silk, curved needles and a needle-holder, sutures of silkworm-gut, and the reflector or electric forehead-lamp for deep vessels.

The **position** in which the patient is placed varies according to the vessel to be ligated, though the body is supine except when ligation is to be performed.
Ligation of Arteries

on the gluteal, sciatic, or popliteal artery. The operator, as a rule, stands upon the affected side, cutting from above downward on the right side, and from below upward on the left side.

Operation.—Accurately determine the line of the artery, and make an incision at a slight angle to this line, avoiding subcutaneous veins, and holding the scalpel like a fiddle-bow or a dinner-knife while cutting the superficial parts, and like a pen while incising the deeper parts. On reaching the deep fascia make out the required muscular gap by the eye and finger, so moving the extremity as to bring individual muscles into action. Treves cautions us not to depend upon the yellow line of fat, which often cannot be seen in emaciated people or when an Esmarch bandage is employed; nor upon the white line due to attachment to the fascia of an intermuscular septum. In opening the deep portion of the wound relax the bounding muscles by altering the posture. Open a muscular interspace with a sharp knife, not with a dissector. Make the depths of the wound as long as the superficial incision. Do not tear structures apart with a grooved director; cut them. Arrest hemorrhage as it occurs. Try to find the situation of the artery with the finger. Pulsation is present, but it may be very feeble and hard to detect. The artery feels like a very thin rubber tube; it is compressible, though not so easily as a vein, and when compressed feels like a flat band which is thinner in the center than at the edges (Treves). A nerve feels like a hard, round cord. The veins are soft, larger than their related arteries, and so very compressible that they can scarcely be felt when pressed upon, and compression causes distal distention. If the wound can be seen into clearly, it will be noted, as Treves asserts, that "the nerves stand out as clear, rounded, white cords; that the veins are of a purple color and of somewhat uneven and wavy contour; that the artery is regular in outline and of a pale-pink or pinkish-yellow tint, the large vessels being of lighter color than the small." Each artery of the upper extremity and each artery below the knee is accompanied by two veins, known as "venae comites." The arteries of the head and neck, except the lingual, have each a single attending vein; the lingual has venae comites. Most of the smaller arteries of the trunk ( pudic, internal mammary, etc.) have venae comites. These companion veins may lie on each side of the artery or in front and back of it, and they communicate with one another by transverse branches crossing the artery. On reaching the sheath pick up this structure with toothed forceps so as to make a transverse fold, and thus avoid catching the artery or vein; lift the fold to see that it is free, and open the sheath by cutting toward the edge of the forceps with a scalpel held obliquely with its back toward the vessel, thus making a small longitudinal incision (Pl. 2, Figs. 1, 2). Hold the edge of the incised sheath with the forceps; pass a metal dissector under the vessel and from the forceps; this clears one-half of the vessel. Grasp the other edge of the sheath and pass
the blunt dissector all the way around the vessel. Pass an aneurysm needle under the cleared vessel, away from the forceps holding the sheath and away from the vessel's most dangerous neighbor. Thread the needle and withdraw it. If venæ comites are in the way, try to separate them; but if this proves difficult, include them in the ligature. In small vessels always include them if they are in the way, as this saves trouble. If, in passing the needle, a large vein is severely wounded (such as the femoral), Jacobson advises the employment of digital pressure in the lower portion of the wound while the artery is being tied on a level above or below that of the vein-injury, and after ligation the maintenance of pressure on the wound for a couple of days.

A slight puncture in a vein merely requires a lateral ligature. A small wound can be closed with Lembert sutures of fine silk. After getting a ligature under an artery press for a moment upon the artery over the ligature, which is held taut; this pressure will arrest pulsation below if the ligature is around the main artery and there is not a double vessel. Tie the thread at right angles to the vessel with a reef-knot (Fig. 132), rupturing the internal and middle coats. As the ligature is tightened place the extended index-fingers along the ligature up to the artery (Pl. 2, Fig. 3), using the middle joints as the fulcrum of a lever by placing them against each other.

Ballance and Edmunds have recently claimed, as Scarpa and Sir Philip Crampton did long since, that it is not necessary to divide the internal and middle coats to insure obliteration. If this claim be true, the danger of secondary hemorrhage can be greatly lessened. Holmes, however, thinks the older method the more certain of the two. Ballance and Edmunds use floss silk as a ligature material, because it is soft, broad, and flat, and they surround the artery with a double ligature. Ballance and Edmunds thus describe the application of the stay-knot: "The best way of tying two ligatures is to make on each separately, and in the same way, the first hitch of a reef-knot, and to tighten each separately so that the loop lies in contact with the vessel without constricting it. Then taking the ends on one side together in one hand and the two ends on the other side in the other hand, constrict the vessel sufficiently to occlude it, and finally complete the reef-knot. The simplest way of completing the knot is to treat the two ends in each hand as a single thread and to tie as if completing a single reef-knot." This knot is shown in Pl. 2, Figs. 5, 6. The stay-knot applied by this method is of great value if a vessel be atheromatous. Fig. 133 shows an arterial scar after ligation. Fig. 134 shows an intravenous scar.

The chief dangers after ligation are secondary hemorrhage and gangrene. Rigid asepsis usually prevents the first; rest, elevation, and heat antagonize the second.

Radial Artery.—The line of the radial artery is from the middle of the front of elbow-joint to the ulnar side of the styloid process of the radius. The line in the tabatière is from the apex of the styloid process to the posterior angle of the first interosseous space (Fig. 135).

Anatomy (Pl. 3, Fig. 5).—The radial artery, though smaller than the
1. Opening the Sheath for Ligation of an Artery (Guerin).
2. Sheath of Artery Open (Guerin).
3. Tightening the Knot in Ligation (Guerin).
4. Anatomy of the Iliac Arteries, and showing the lines of incision for their ligation: 1. Abernethy's incision (Guerin).
Intravascular and Intravenous Scar

Fig. 133.—Cross-section of obliterated artery, exhibiting the histologic appearances of the intravascular scar ($\times$ 240) (Senn).

Fig. 134.—Histologic structure of intravenous scar, right internal jugular vein, forty-nine days after ligation. Transverse section between ligatures ($\times$ 240) (Senn).
ulnar, is the direct continuation of the brachial. It arises from the bifurcation of the brachial half an inch below the bend of the elbow, runs down the radial side of the forearm to the front of the styloid process of the radius, passes beneath the extensor muscles of the first metacarpal bone and of the first phalanx of the thumb, and over the carpus to the first interosseous space. It is crossed by the tendon of the extensor secundi internodii pollicis, enters into the palm between the heads of the first dorsal interosseous muscle, and forms the deep palmar arch. The artery in the upper two-thirds of its course is somewhat overlaid by the supinator longus muscle; in the lower one-third of the forearm it is superficial. In the upper third of the forearm it lies between the supinator longus on the outside and the pronator radii teres on the inside; in the lower two-thirds of the forearm it lies between the supinator longus on the outside and the flexor carpi radialis on the inside. Two venæ comites attend the vessel. The radial nerve is to the outer, or radial, side of the artery, well removed from the artery in the upper third, nearer to the artery in the middle third, far external to the artery in the lower third, the nerve at this point passing beneath the supinator longus muscle. The radial artery, from above downward rests upon the biceps tendon, the supinator brevis, the flexor sublimis, the pronator radii teres, the flexor longus pollicis, the pronator quadratus muscles, and the radius. The best guide to the radial artery in the forearm is the outer edge of the flexor carpi radialis muscle or the inner edge of the supinator longus muscle.

The tabatière anatomique of Cloquet, or the anatomical snuff-box, is a triangle whose base is the lower edge of the posterior annular ligament, the ulnar side being formed by the extensor secundi internodii pollicis tendon, the radial side by the extensor ossis metacarpi and the extensor primi internodii pollicis tendons; the floor consists of the trapezium, scaphoid, their dorsal ligaments, and the base of the first metacarpal bone.

Operations.—Ligation in the tabatière is a dissecting-room operation of but little practical use. The patient is placed in a recumbent position, the arm is abducted, and the forearm is placed midway between pronation and supination (Barker). The surgeon stands upon the side operated upon. An incision two inches in length is made along the radial border of the extensor secundi internodii pollicis muscle. The skin and superficial fascia are cut and some venous branches are divided. The deep fascia is incised and the vessel is easily found and tied before it passes between the heads of the first dorsal interosseous muscle (Barker).

Ligation of the Lower Third.—In this operation (Pl. 3, Fig. 6, and Fig. 135) the patient is placed supine, the arm is abducted, the forearm is supinated, is rested upon a table, and is held by an assistant. The surgeon stands on the side operated upon, and cuts from above downward on the right forearm and from below upward on the left forearm. The line of the vessel should be determined, and may be indicated with iodin or anilin. An incision one and a half inches long is made at a slight angle to this line and midway between the supinator longus and the flexor carpi radialis muscles, which incision must not extend below the level of the tuberosity of the scaphoid bone. In the superficial fascia watch for the superficial radial vein, and if it comes into view push it aside. Incise the superficial fascia and locate each guide-tendon. Open the deep fascia in the length of the first cut; try to separate the veins,
but if they strongly adhere include them in the ligature. There is no special fascial sheath. The radial nerve will not be seen, but a division of the anterior cutaneous nerve is frequently found in relation with the vessel. The needle can be passed in either direction. A high origin of the superficialis volæ artery is confusing.

**Ligation of the Middle Third.**—In this operation the position of the patient should be the same as in the preceding. A two-inch incision is made. Veins of the subcutaneous tissues are avoided. Lying upon the deep fascia is the anterior division of the musculocutaneous nerve. Open the fascia; find the inner edge of the supinator longus muscle and draw it outward, flexing the elbow partly if necessary. Be sure not to cut external to this muscle. Find the vessel where it is bound down by connective tissue to the pronator radii teres muscle, separate the veins, and pass the ligature from without inward. The nerve is external.

**Ligation of the Upper Third (Pl. 3, Fig. 6, and Fig. 135).**—In this operation the incision is as described above, only higher up. The artery is between the supinator longus and the pronator radii teres, which muscles are at once differentiated by the different direction of their fibers. The artery is usually covered by the supinator longus muscle, which must be retracted externally. The nerve is not seen. The ligature may be passed in either direction.

**Ulnar Artery.**—No one line will overlie the entire ulnar artery. The line of the upper third runs from the middle of the front of the elbow-joint to the point of junction of the upper and middle thirds of the ulna. The line of the lower two-thirds runs from the tip of the internal condyle of the humerus to the radial side of the pisiform bone (Pl. 3, Figs. 5, 6; Fig. 135).

**Anatomy (Pl. 3, Fig. 5).**—The ulnar artery arises from the brachial bifurcation and runs obliquely inward under the median nerve and a group of muscles from the internal condyle; it turns down the arm, being covered in the middle third of its course by the flexor carpi ulnaris muscle. In the lower third it is superficial, between the tendons of the flexor carpi ulnaris on the inside and the flexor sublimis digitorum on the outside, the vessel being a little overlapped by the flexor carpi ulnaris. This vessel rests first upon the brachialis anticus muscle, next upon the flexor profundus, to which it is bound by a distinct process of fascia, and next upon the annular ligament, which structure it crosses to become the superficial palmar arch. Two venæ comites attend the vessel. In the upper third the nerve is well internal, but in the lower two-thirds the nerve lies near the artery and to its ulnar side. The guide is the outer edge of the flexor carpi ulnaris.

**Operations (Pl. 3, Fig. 6, and Fig. 135).**—**Ligation of the Lower Third.**—The position in this operation is the same as for ligation of the radial artery. Make a two-inch incision to the radial side of the tendon of the flexor carpi ulnaris, which incision should not be taken lower than a point one inch above the pisiform bone. Avoid the superficial ulnar vein in the subcutaneous tissue. Open the deep fascia, find the tendon of the flexor carpi ulnaris, flex the wrist and draw the tendon inward, open a second layer of fascia, clear the vessel, separate the veins, and pass the ligature from within outward to avoid the nerve. On the artery is the palmar cutaneous branch of the ulnar nerve, and this branch must not be included in the ligature.
Ligation of the Middle Third (Pl. 3, Fig. 6).—In this operation the position is the same as in the preceding one, the incision being three inches long. Avoid the anterior ulnar vein and the branches of the internal cutaneous nerve in the superficial fascia. Open the deep fascia a little external to the superficial cut (Treves). Find the space between the flexor carpi ulnaris and the superficial flexor, feeling with the index-finger, and when the space is discovered flex the wrist, retract the flexor carpi ulnaris inward and the flexor sublimis digitorum outward, open the fascia, find the ulnar nerve, look external to it for the artery, clear the vessel, separate the venae comites, and pass the needle from within outward. The ulnar artery should not be ligated in continuity in the upper third of its course.

Brachial Artery.—The line of the brachial artery is from the junction of the anterior and middle thirds of the outlet of the axilla, the arm being abducted and the forearm supinated, to the middle of the front of the elbow-joint (Fig. 135).

Anatomy (Pl. 3, Fig. 1).—The brachial artery is the prolongation of the axillary, and extends from the lower edge of the teres major muscle to half an inch below the bend of the elbow, where it divides into the radial and ulnar arteries. It lies first to the inner side of the arm, but passes to the front of the elbow. It is crossed by no muscle, and is, in fact, superficial, barring its being somewhat overlaid in part of its course by the edge of the biceps muscle. The median nerve is external above, crosses over the vessel about the middle of the arm, and reaches the inner side of the artery. The coracobrachialis and biceps muscles are external, and both often overlap the vessel. The ulnar nerve is internal above, and the median nerve is internal below the middle. The basilic vein is to the inner side of the artery, being outside the deep fascia to near the middle of the arm, at which point it pierces it. The artery above is separated from the long head of the triceps by the musculospiral nerve and superior profunda artery and vein; it rests from above down on the inner head of the triceps, the coracobrachialis, and the brachialis anticus muscles. The artery is covered by skin, by superficial fascia, and by deep fascia. The internal cutaneous nerve lies in front of the artery, upon the deep fascia, until it pierces the fascia along with the basilic vein. The artery has venae comites, and in its upper half has also the basilic vein to its inner side. The guide to the brachial is the inner edge of the biceps muscle. Just in front of the elbow-joint the artery lies in a triangle, the base of which is formed by an imaginary transverse line above the condyles, and the apex by the junction of the pronator radii teres and the supinator longus muscles. The outer line is the supinator longus, the inner line is the pronator radii teres, and the floor is formed by the brachialis anticus and the supinator brevis muscles. From within outward the triangle contains the median nerve, brachial artery, tendon of the biceps, anastomosis of the superior profunda and radial recurrent arteries, and the musculospiral nerve.

Operations.—Ligation at the Bend of the Elbow.—In this operation (Pl. 3, Fig. 2, and Fig. 135) the patient is placed supine, the arm is moderately abducted and extended, and is allowed to lie upon its posterior aspect. The forearm is supinated. The surgeon stands upon the side operated upon, and cuts from above downward on the right side and from below upward on the left.
side. The tendon of the biceps and the median basilic vein must be accurately located. An incision is made parallel with the inner edge of the biceps tendon and two inches in length, the center of this cut being in the crease of the elbow. On exposing the median basilic vein, retract it downward and inward, open the bicipital fascia, clear the artery of fat, separate the veins comites, and pass the ligature from within outward to avoid the median nerve. The above operation is not frequently performed.

**Ligation in the Middle of the Arm (Fig. 135).**—In this operation the patient is placed supine, the arm is abducted, and the forearm is supinated. An assistant holds the forearm, but the arm should not rest upon the table, because, if it be allowed to do so, the inner head of the triceps will be forced forward and may overlie the artery, and thus complicate the operation. Locate the inner edge of the biceps, which is the guide. Make an incision three inches long in the line of the artery. Incise the skin and fascia, flex the elbow slightly, retract the biceps outward, feel for the artery, open the sheath, separate its veins comites, and, having located the median nerve, pass the ligature from it. In the middle of the arm the nerve is in front of the vessel, above the middle it is external to it, and below the middle it is internal to it. High up the arm the inner edge of the coracobrachialis is the guide, rather than the biceps. Above the middle of the arm the basilic vein is beneath the deep fascia and passes along by the inner side of the artery; hence, high up, the artery has three companion veins, the veins comites and the basilic vein, and there is seen the ulnar nerve to the inside of the artery.

**Axillary Artery.**—To determine the line of the axillary artery place the arm at a right angle to the body, with the patient supine, and lay down a line from the middle of the clavicle to the humerus near the inner border of the coracobrachialis. The line of the third portion can be approximated by projecting the line of the brachial upward (Fig. 135).

**Anatomy (Pl. 3, Fig. 3; Pl. 4, Fig. 1).**—The axillary artery is the continuation of the subclavian, and runs from the lower margin of the first rib to the inferior border of the teres major muscle. It is divided into three portions by the pectoralis minor muscle. The first portion is above, the second portion is behind, and the third portion is below, the pectoralis minor. The position of the artery varies with the position of the limb. When the arm is parallel with the body the artery is far from the surface and forms a curve whose convexity is upward and outward. When the arm is at a right angle to the body the vessel is nearer the surface and straight. When the arm is raised above a right angle the artery comes near the surface and forms a curve with the convexity downward.

The first portion of the axillary artery is occasionally ligated. It lies upon the first intercostal muscle and the first serration of the great serratus muscle, and has behind it the posterior thoracic nerve; the brachial plexus is external and posterior to the vessel; on its inner side is the axillary vein; in front of it are the clavicle, the great pectoral muscle, the subclavius muscle, the costocoracoid membrane, the cephalic and acromiothoracic veins, and the external anterior thoracic nerve. The branches of the first part of the axillary artery are the superior thoracic and the acromiothoracic. The second part of the artery is not ligated. The brachial plexus surrounds the second portion. The third part is covered in front, above, by the great pectoral, but is covered
below by skin and fascia; behind, it has the tendon of the subscapularis, the latissimus dorsi, and the teres major muscles; the coracobrachialis is on the outer side; the axillary vein is on the inner side. It is important to remember that there may be three veins, one external and two internal. The axillary vein is formed by the venae comites of the brachial artery joining, and this new vein effecting a junction with the basilic vein. The median nerve lies upon the axillary artery in the upper part of the third portion of the vessel's course, and passes to the outer side. The musculocutaneous nerve is external, but it is only seen high up; the ulnar nerve is internal; the lesser internal and the internal cutaneous nerves are internal; the musculospiral and the circumflex nerves are behind. The branches of the third portion of the axillary artery are the subscapular and the anterior and posterior circumflex.

**Operations.**—Ligation of the Third Portion (Pl. 3, Fig. 4, and Fig. 135).—
The position of the patient should be supine, with the shoulders raised and the arm abducted to a right angle. The surgeon stands between the patient's arm and side, with his back toward the subject's feet. An incision is made three inches in length. It begins half-way up the axilla opposite to the head of the humerus, and is taken downward parallel to the lower edge of the great pectoral muscle and crosses the junction of the anterior and middle thirds of the outlet of the axilla. The integuments and fascia are incised. The vein or veins will be prominent to the inner side and may overlap the vessel. To the inner side with the veins are the ulnar and internal cutaneous nerves. The median nerve is upon, and the external cutaneous is to the outer side of, the artery. Feel for the pulsations of the artery, find the median nerve, and draw it outward, draw the nerves and veins which lie to the inner side inward, clear the artery from the venae comites, and pass the ligature from within outward. Apply the ligature well below the circumflex branches.

**Ligation of the First Part.**—This operation (Pl. 4, Fig. 2, and Fig. 137) was first performed in 1815 by Chamberlain, of Jamaica. The patient is placed supine, the upper part of the body being raised, a sand-pillow being placed between the scapula to insure carrying back of the point of the shoulder, and the arm being brought down along the side. In operating on the left side the surgeon stands on the outer side of the left arm; in operating on the right side he stands to the right of the subject's head and leans over his shoulder. The incision, which is
slightly curved downward, begins external to the sternoclavicular joint and ends internal to the margin of the deltoid, thus avoiding the cephalic vein. The incision is half an inch below the clavicle (Fig. 137). Incise the skin, platysma myoides muscle, and deep fascia. In the outer angle of the wound watch for the acrinothoracic artery and the cephalic vein. Incise the pectoralis major; draw the pectoralis minor downward; retract the lower margin of the wound, cut through the costocoracoid membrane close to the coracoid process and the upper border of the lesser pectoral muscle. Bring the arm to the side so as to relax the structures. Find the brachial plexus, feel for the artery internal to it, clear the vessel, draw the vein internally, and pass the needle from within outward. This avoids the dangerous neighbor, which is the axillary vein. This operation is difficult, dangerous, and unusual, and in its performance the axillary vein, which has a close attachment to the costocoracoid membrane, is apt to be torn.

Subclavian Artery.—The subclavian artery was first successfully tied by Post, of New York, who applied a ligature about the third portion of the vessel in 1817. The first part of the subclavian was first tied by Colles in 1818 (Treves's "Manual of Surgery"). At the present day the first and second portions are rarely ligated. Professor Halsted successfully tied the first portion of the left side for aneurysm. Schumpert tied it successfully for aneurysm. I assisted Dr. Nassau, of St. Joseph's Hospital, Philadelphia, in a ligation of first part of the right subclavian. The man suffered from a ruptured traumatic aneurysm of the third portion of the vessel. The operation was followed by recovery. Chilton produced a cure of an aneurysm of the third portion of the subclavian of the right side by tying the first portion and twenty-four hours later tying the first portion of the axillary. There is no line for this vessel.

Anatomy (Pl. 4, Fig. 1).—The subclavian artery of the right side arises from the innominate; that of the left side, from the arch of the aorta. The subclavian is divided into three parts. The first part runs from the origin of the vessel to the inner border of the scalenus anticus muscle; the second part lies behind the scalenus anticus muscle; and the third part runs from the outer edge of the muscle to the lower border of the first rib. The third portion is contained in the subclavian triangle (Fig. 136), and is superficial. It rises, as a rule, to half an inch above the clavicle. The subclavian vein is below the artery, being separated from it by the scalenus anticus muscle. The brachial plexus is above and external to the artery. The vessel rests upon the first rib, and behind it is the scalenus medius muscle. The suprascapular and transversalis colli arteries and veins and branches of the cervical plexus of nerves lie in front of the artery, and the external jugular vein crosses it at its inner side. The third portion gives off no branches.

Ligation of the Third Part.—(See Pl. 4, Fig. 2, and Fig. 137). The patient is placed upon his back, the shoulders are raised, the head is extended and turned toward the opposite side, the arm is pulled down and held by pushing the forearm under the patient's back (Treves). This pulls down the clavicle, thus increasing the size of the subclavian triangle. The operator stands facing the shoulder, with his back toward the patient's feet. The skin over the subclavian triangle, at a point half an inch above the clavicle, is drawn down until it overlies the bone and is incised. This maneuver enables the surgeon
to avoid the external jugular vein and to make an incision in the skin half an inch above the collar-bone. The incision reaches from the anterior edge of the trapezius to the posterior border of the sternocleidomastoid (Pl. 4, Fig. 2, and Fig. 137), and is about three inches long. This incision divides the skin, superficial fascia, the platysma myoides, the vein running from the cephalic to the external jugular, and some superficial nerves. The deep fascia is opened.

The external jugular vein is drawn into the inner angle of the wound, and is not divided unnecessarily if forced to divide the vein, tie with two ligatures and cut between them. The surgeon seeks to find the outer edge of the anterior scalene muscle, and runs the finger down along it to the tubercle on the first rib. The posterior belly of the omohyoid muscle is drawn upward by an assistant. The surgeon, with a finger on the tubercle, recalls the facts that the vein is in front of the finger and the artery is behind it, and that the subclavian vein is on a lower plane than the artery. The artery is felt beating as it lies upon the rib. The artery is cleared and the lower cord of the brachial plexus is exposed. The vein must be guarded with the finger and the needle is passed from above downward, as the plexus, which is in more danger than the vein, is to be avoided. In this operation the transversalis colli and suprascapular arteries must not be cut, as they are necessary to the future anastomotic circulation. If the field of operation is too small, the trapezius or sternocleidomastoid, or both, should be incised transversely.

Results.—According to Joseph D. Bryant, there have been 134 deaths in 250 ligations ("Operative Surgery"). I have twice tied this vessel with success.

The vertebral artery was first successfully ligated by Smythe, of New Orleans, in 1864. He had ligated the innominate for aneurysm of the subclavian and at the same time tied the common carotid. Secondary hemorrhage occurred, the blood coming from the brain. He arrested it by tying the vertebral.

Anatomy.—This vessel is the largest branch of the subclavian, and is the first branch coming from the first portion of the subclavian. The vertebral artery ascends and enters the foramen in the transverse process of the sixth cervical vertebra (in rare cases the fifth or the seventh), and ascends through foramina in the cervical vertebrae, passes behind the articular process of the atlas and over the posterior arch of this first vertebra, pierces the posterior occipito-atloid ligament, and enters the skull by way of the foramen magnum (see Gray). It joins its fellow of the opposite side to form the basilar artery. At its point of origin the vertebral artery has in front of it the internal jugular vein and inferior thyroid artery. Gray says that near the spine it lies between the longus colli and scalenus anticus muscles, with the thoracic duct to the left and in front.

Ligation.—The position of the patient is the same as for ligation of the carotid artery. Alexander thus describes the operation: "An incision 3 or 4 inches long is made in an upward and outward direction along the hollow which exists between the scalenus anticus and the sternomastoid muscles. The incision should begin just outside and on a level with the point where the external jugular vein dips over the edge of the sternomastoid muscle, or, if the vein is invisible, about half an inch above the clavicle. The external jugular vein is drawn inward with the sternomastoid muscle. The connective
LIGATIONS.

tissue now appearing, the wound is opened by a blunt dissector, until the scalenus anticus muscle, the phrenic nerve, and the transverse cervical artery are seen. It cannot be too well remembered that the pleura is at the inner side of the wound, while below lies the subclavian artery. It is now only necessary to separate the edges of the scalenus anticus and the longus colli muscles to see the vertebral artery lying in the space between them. The artery is generally completely covered by the vein, which is drawn aside, and the artery is then ligatured” (quoted in Bryant’s “Operative Surgery”). When the vessel is cleared and tied, branches of the inferior cervical ganglion are damaged and possibly included in the ligature, and as a consequence the pupil contracts. Jacobson tells us to remember that the phrenic nerve lies on the scalene muscle, the pleura is internal, the internal jugular, inferior thyroid, and vertebral veins are over the vessel, and the thoracic duct on the left side crosses it from within outward.

Results.—In 36 ligations of the vertebral artery there were 3 deaths (Joseph D. Bryant).

The Inferior Thyroid Artery. — Anatomy. — The inferior thyroid artery is a branch of the thyroid axis. It ascends the neck, passes back of the carotid sheath and the sympathetic nerve, and reaches the thyroid gland. The recurrent laryngeal nerve lies behind the artery. The phrenic nerve is external to the artery and near to it in the first part of its course (up to the point of origin of the ascending cervical branch). The ascending cervical branch takes origin just before the artery begins to dip behind the carotid. In front of the beginning of the inferior thyroid artery of the left side the thoracic duct crosses. The artery is ligated in the second part of its course (between its distribution and the origin of the above-named branch).

Ligation.—The position of patient and the incision are the same as for the ligation of the common carotid artery in the triangle of necessity (page 348). After exposing the sternocleidomastoid muscle retract it outward, and then draw outward the common carotid artery and also the internal jugular vein. The inferior thyroid artery will lie found a little below the carotid tubercle. It is cleared and ligated. Treves advises ligation close to the level of the carotid, so as to avoid the recurrent laryngeal nerve.

Innominate Artery. — First successfully ligated by Smythe, of New Orleans, in 1864. It is an extremely fatal operation.

Anatomy. — The innominate artery arises from the beginning of the transverse portion of the arch of the aorta, passes to the back of the right sternoclavicular joint, and divides into the common carotid and subclavian vessels. It rests upon the trachea. It has upon its outer side the pleura, the right innominate vein, and the pneumogastric nerve. Upon its inner side are the remnant of the thymus gland and the beginning of the left carotid artery. In front of it are the inferior thyroid veins of the right side, the left innominate vein, the sternohyoid and sternothyroid muscles, the remnant of the thymus gland, and sometimes a branch from the right pneumogastric nerve.

Ligation.—Place the patient supine, with the shoulders a little raised, and the head thrown back. Carry an incision from the upper margin of the sternum for three inches along the anterior margin of the sternomastoid.
Make another cut of the same length along the upper border of the clavicle to meet the first cut. Dissect up the flap of skin and fascia. Divide the sternal origin and a part of the clavicular portion of the sternocleidomastoid muscle, and cut the sternohyoid and sternothyroid muscles just above their sternal origins (Joseph Bell). Retract the inferior thyroid veins. Divide the dense leaflet of cervical fascia. Find the common carotid artery, and trace back along this vessel until the innominate comes into view. Retract the left innominate vein downward. The needle is passed from without inward to avoid the right innominate vein and right pneumogastric nerve. If the needle is kept close to the artery, the pleura and trachea will not be injured.*

Results.—Three cases have recovered out of 31 reported (Burrell's, Banks's, and Smythe's). Burrell ligated the innominate in 1895 and the patient lived over three months, dying finally from cardiac disease. Mitchell Banks's case lived over three months.

Region of the Neck.—Anatomy.—The side of the neck is that space between the median line in front and the anterior edge of the trapezius muscle behind, which space is limited below by the clavicle and above by the body of the jaw and an imaginary line running from the angle of the jaw to the mastoid process. The sternocleidomastoid muscle divides this space into an anterior and a posterior triangle, and each of the triangles is subdivided by other structures, the anterior into four spaces and the posterior into two (Fig. 136).

Anterior Triangle.—The anterior triangle is bounded in front by the median line of the neck, behind by the anterior margin of the sternocleidomastoid muscle, and above by the body of the lower jaw and an imaginary line drawn from the angle of the jaw to the mastoid process. This space is subdivided into four smaller triangles—namely, the inferior carotid, the superior carotid, the submaxillary, and the submental.

The inferior carotid triangle is called the “triangle of necessity,” because the common carotid artery in this region is ligated, not from choice, but through force of necessity. It is bounded in front by the median line, above by the anterior belly of the omohyoid muscle and the hyoid bone, and below by the anterior edge of the sternomastoid muscle. The floor of this triangle is composed of the longus colli, the scalenus anticus, the rectus capitis anticus major, the sternohyoid, and sternothyroid muscles.

The superior carotid triangle is known as the “triangle of election,” because, if the carotid artery must be tied, the surgeon, whenever possible, elects or chooses to tie it in this triangle. In this region the carotid is superficial, and there can be tied either the external, the internal, or the common

* See the exceedingly clear and terse account in that excellent book, “A Manual of Surgical Operations,” by Joseph Bell.
carotid artery, as may be desired. The triangle is bounded behind by the anterior edge of the sternocleidomastoid, above by the posterior belly of the digastric, and below by the anterior belly of the omohyoid muscles. Its floor is composed of the inferior and middle constrictors of the pharynx and the thyrohyoid and hyoglossus muscles.

The submaxillary triangle is bounded above by the body of the jaw and an imaginary line drawn from the angle of the jaw to the mastoid process, behind by the posterior belly of the digastric muscle and the stylohyoid muscle, and in front by the anterior belly of the digastric muscle. Its floor is composed of the mylohyoid and hyoglossus muscles.

The submental triangle is bounded on either side by the anterior belly of one digastric muscle; its base is the hyoid bone and its floor is the mylohyoid muscle.

The posterior triangle is bounded in front by the posterior border of the sternocleidomastoid muscle, behind by the anterior edge of the trapezius muscle, and below by the clavicle. The posterior belly of the omohyoid muscle subdivides it into two smaller spaces, the occipital and subclavian triangles.

The occipital triangle is bounded in front by the posterior edge of the sternocleidomastoid muscle, behind by the anterior border of the trapezius muscle, and below by the posterior belly of the omohyoid muscle.

The subclavian triangle is bounded above by the posterior belly of the omohyoid muscle, below by the clavicle, and in front by the posterior border of the sternocleidomastoid muscle. Its floor is formed by the first rib and the first serration of the serratus magnus muscle.

Common Carotid Artery.—The common carotid was tied to arrest bleeding by Abernethy in 1798, and was first ligated successfully for aneurysm by Sir Astley Cooper in 1806. The line of the common carotid artery is from the sternoclavicular articulation to midway between the angle of the jaw and the mastoid process, the head being turned toward the opposite side. Anatomy (Pl. 4, Fig. 3).—The right common carotid arises from the innominate opposite the sternoclavicular joint; the left common carotid arises from the arch of the aorta. In the neck the two carotids possess identical relations. The common carotid runs upward and outward from behind the sternoclavicular articulation to a level with the upper border of the thyroid cartilage, at which point it divides into the external and internal carotid. The common carotid is contained in a sheath derived from the cervical fascia. This sheath also contains, in separate compartments, the internal jugular vein on the outer side of the artery and the pneumogastric nerve between the vein and artery, but more deeply placed. The anterior edge of the sternocleidomastoid muscle lies over the artery and is a guide. Low in the neck the common carotid is deep, being covered by skin, superficial fascia, platysma, deep fascia, and the sternocleidomastoid, sternohyoid, and the sternothyroid muscles. Above the omohyoid muscle the vessel is more superficial, being covered by the skin, superficial fascia, platysma, deep fascia, and the anterior edge of the sternocleidomastoid muscle. Upon the sheath (occasionally within it), above the crossing of the omohyoid muscle, lies the descendens noni nerve—the descending branch of the ninth pair of Willis (the hypoglossal). This nerve is a valuable guide to the sheath in the triangle of election.
The sternomastoid branch of the superior thyroid artery crosses the carotid artery a little below its bifurcation, and the superior thyroid vein also crosses it in this region; the middle thyroid vein crosses the artery near its middle, and the anterior jugular vein crosses low down. The common carotid rests upon the longus colli and rectus capitis anticus major muscles, the sympathetic nerve lying between the last-named muscle and the vessel, outside the carotid sheath. The recurrent laryngeal nerve passes behind the carotid below the omohyoid muscle, and the inferior thyroid artery passes behind the carotid just above the omohyoid muscle. The common carotid is in relation internally with the trachea, thyroid gland, larynx, and pharynx. To the outer side are the pneumogastric nerve (which is on a posterior plane) and the internal jugular vein. On the left side, low down in the neck, the jugular vein often lies in front, or partly in front, of the artery.

Ligation in the Triangle of Necessity.—In this operation the patient is placed supine, with the shoulders raised, a sand-pillow under the neck, and the head turned to the opposite side, with the chin raised. The operator stands upon the side operated upon. The incision, three inches long, at a slight angle to the arterial line, runs from the level of the cricoid cartilage downward and inward toward the sternoclavicular joint, following the inner border of the sternocleidomastoid muscle. The surgeon opens the deep fascia, draws the sternocleidomastoid outward, retracts the sternohyoid and sternothyroid muscles inward, and feels for the carotid tubercle of Chasaignac. This tubercle is the costal process of the sixth cervical vertebra, and lies directly under the artery. The tubercle is found about the point at which the omohyoid crosses the carotid. When the tubercle is found we know the situation of the artery, and that the triangle of necessity is below, and the triangle of election above the tubercle. The operator draws the omohyoid muscle upward, opens the sheath of the artery on its inner side, clears the vessel, and passes the needle from without inward to avoid the internal jugular vein, remembering that the pneumogastric nerve is in the same sheath as the artery and vein, posterior and external to the artery. In this operation the inferior thyroid veins are much in the way, the anterior jugular vein crosses low down, and on the left side, at the root of the neck, the internal jugular vein may be in front of the carotid artery. If the incision is not sufficiently wide, partially divide the sternocleidomastoid or the sternothyroid muscles. In the triangle of necessity the descendens noni nerve does not serve as a guide to the sheath of the vessels. (See Pl. 4, Fig. 4.)

Ligation in the Triangle of Election (Fig. 137).—The position of the patient for this operation is the same as in the preceding one. An incision, three inches in length, is made along the anterior edge of the sternocleidomastoid muscle in the line of the artery, the middle of this incision being opposite the cricoid cartilage (Fig. 137). In cutting the superficial fascia, the surgeon avoids the external jugular vein, the course of which should be outlined before making the incision. The line of the external jugular is from the angle of the jaw to the middle of the clavicle. The operator opens the deep fascia, retracts the sternocleidomastoid muscle outward, feels for the carotid tubercle, draws the omohyoid muscle downward, finds the descendens noni nerve upon the sheath, opens the sheath at its inner side, and passes the needle from without
Internal Carotid Artery

inward. This incision permits ligation of either the superior thyroid or the external, internal, or common carotid, and if it be extended up a little there can be tied through it the lingual, and even the facial and occipital, arteries. (See Pl. 4, Fig. 4.)

Results.—In from 20 to 25 per cent. of cases after ligation of the common carotid artery there is cerebral softening or some other intracranial complication. Crile states that of the cases that develop cerebral trouble, one-half die. The operative mortality, according to Crile, is only 3 per cent.

External Carotid Artery.—Burke ligated the external carotid in 1827 (Treves, from Chelius). The line of the external carotid artery is the upper portion of the common carotid line.  

Anatomy (Pl. 4, Fig. 3).—The external carotid artery, which is one of the terminal branches of the common carotid, arises on a level with the upper border of the thyroid cartilage and runs to the level of the neck of the condyle of the lower jaw. At its point of origin it is covered only by skin, platysma, and fascia, and the edge of the sternomastoid, but as it ascends it passes beneath the digastric and stylohyoid muscles and into the parotid gland. The glossopharyngeal nerve, styloid process, and stylopharyngeus muscle lie between the external and internal carotid arteries. The hypoglossal nerve crosses the vessel just below the digastic muscle, and the facial and lingual veins cross it a little below the nerve. The first branch is the superior thyroid, which arises from the very beginning of the trunk. The lingual arises on a level with the greater cornu of the hyoid bone. The facial and occipital take origin above the lingual. Each of them can be ligated through the incision made for ligation of the external carotid.

Operation.—Place the patient in the same position as for ligation of the common carotid. The point of election is between the superior thyroid and the lingual arteries. Make an incision three inches in length at a slight angle to the arterial line, from near the angle of the jaw to opposite the middle of the thyroid cartilage. Cut through the skin, superficial fascia, platysma, and deep fascia, and retract the sternocleidomastoid muscle outward. Watch for the digastic muscle, find the hypoglossal nerve, and feel for the greater cornu of the hyoid bone. Open the sheath a little below the hyoid cornu and pass the needle from without inward. Ligation of the external carotid has been neglected because ligation of the common carotid is easier.

Results.—Crile believes the operative mortality to be 2 per cent.

Internal Carotid Artery.—The internal carotid was tied by Keith, of Aberdeen, in 1851 (Ashhurst’s “International Encyclopedia of Surgery”). The line of the internal carotid is parallel with and half an inch external to the line of the external carotid.  

Anatomy (Pl. 4, Fig. 3).—The internal carotid artery, the other terminal branch of the common carotid, arises on a level with the upper border of the thyroid cartilage and enters the carotid canal. The first inch of the artery is the only point where a ligature is ever applied, this point being covered only by skin, platysma, fascia, and the sternocleidomastoid muscle; higher up it is more deeply placed. It rests upon the vertebrae and the rectus capitis anticus major muscle. The internal jugular vein is in the same sheath and external to the artery; the pneumogastric is in the same sheath, between the artery and the vein, but posterior to both. The superior cervical ganglion
of the sympathetic lies behind the origin of the internal carotid, and between
the ganglion and the artery is the superior laryngeal nerve.

Operation.—In this operation the position of the patient is the same as
for ligation of the external carotid. The incision is of the same length and
direction as that for ligation of the external carotid, and is half an inch
external. The sternocleidomastoid muscle is drawn outward, the external
carotid artery is found and drawn inward, the internal carotid is found and
cleared, and the needle is passed from without inward. The internal carotid
is known by its more external position and by the fact that it gives off no
branches.

Results.—There is the same danger of cerebral complications after this
operation as after ligation of the common carotid. The operative mortality
is probably as great.

Superior Thyroid Artery (Pl. 4, Fig. 3).—This branches off from
the external carotid below the level of the greater cornu of the hyoid bone, in
the triangle of election. It is primarily superficial, runs first upward and
inward, next downward and forward, passes underneath the omohyoid,
sternohyoid, and sternothyroid muscles, and reaches the thyroid gland.

Ligation.—The position of the patient and of the surgeon is the same as
for ligation of the carotid. The artery may be reached through the incision
employed for ligation of the external carotid. Gross made an incision be-
ginning at the edge of the hyoid bone, and running downward and outward
to the sternomastoid muscle. The skin and superficial and deep fasciae are
divided, and the artery is found deeply placed in the triangle of election be-
tween the carotid sheath and the thyroid gland.

Lingual Artery.—Charles Bell ligated the first part of the lingual
artery in 1814. The operation beneath the hyoglossus muscle was devised
by Pirogoff in 1836. (See Treves's "Manual of Operative Surgery."

Anatomy (Pl. 4, Fig. 3).—The lingual artery arises from the external
carotid opposite the greater cornu of the hyoid bone, passes beneath the di-
agastric and stylohyoid muscles, reaches the margin of the hyoglossus muscle,
passes under that muscle, and emerges from beneath it to run along the under
surface of the tongue. The place of election for ligation is where the artery
is beneath the hyoglossus muscle. Its guide is the hypoglossal nerve, which
lies upon the muscle, but at a slightly higher level than the artery.

Operation.—In this operation the patient is placed recumbent with the
shoulders raised and the face turned away from the side to be operated upon.
The surgeon stands upon the affected side. A curved incision is made from
a little external to the symphysis of the lower jaw, downward and outward,
to just above the greater cornu of the hyoid bone, and upward and outward
to just in front of the facial artery at the lower edge of the lower jaw. The
skin, the superficial fascia and platysma, and the deep fascia are incised.
The submaxillary gland is cleared and retracted well upward. The fascia
below the gland is divided by a transverse incision. The posterior edge of
the mylohyoid muscle and the bellies of the digastric muscle are sought for
and identified. One of the digastric tendons is retracted down and out
(Treves). The hyoglossus muscle is cleared with a dissector; the hypo-
glossal nerve and ranine vein are found and drawn a little upward. The
hyoglossus muscle is divided transversely a little above the hyoid bone and
below the level of the hypoglossal nerve. The artery is found under the muscle and the needle is passed from above downward.

**Facial Artery.**—**Anatomy** (Pl. 4, Fig. 3).—Arises from the external carotid a little above the lingual, runs upward and forward beneath the body of the inferior maxillary bone, passes along a groove in the posterior and upper surface of the submaxillary gland, crosses the body of the lower jaw at the lower anterior edge of the masseter muscle, and passes forward and upward to the angle of the mouth and side of the nose.

**Ligation** (Pl. 4, Fig. 4).—The facial artery is rarely ligated in the cervical portion, but may be reached through the incision employed for ligation of the external carotid. The vessel may be tied before it crosses the submaxillary gland, the stylohyoid and digastric muscles being drawn aside. The vessel is reached in the facial portion of its course by a one-inch cut at the anterior edge of the masseter muscle (Fig. 137). Branches of the facial nerve are pushed aside. The needle is passed from behind forward to avoid the vein (Jacobson).

**Temporal Artery.**—

The line of the temporal artery passes "upward over the root of the zygoma, midway between the condyle of the jaw and the tragus" (Jacobson).

**Anatomy.**—The temporal artery arises from the external carotid behind the condyle of the jaw and in the parotid gland, passes over the zygoma, and divides into two terminal branches.

**Ligation.**—The patient is placed recumbent and the head is turned to the opposite side. An incision an inch in length is made (Fig. 137), the superficial structures and dense fascia are divided, the vein is retracted backward, and the needle is passed from behind forward.

**Occipital Artery.**—Takes origin from the posterior surface of the external carotid, below the digastric muscle and opposite the point of origin of the facial artery. It ascends beneath the digastric and stylohyoid muscles and parotid gland; the hypoglossal nerve hooks around it from behind forward. It crosses the internal carotid artery, the internal jugular vein, the pneumogastric and spinal accessory nerves; passes between the mastoid process of the temporal bone and the atlas; grooves the temporal bones; penetrates the trapezius muscle, and ascends over the occiput.
Ligation.—This vessel can be ligated near its origin through the same incision as is employed to reach the external carotid. The hypoglossal nerve is avoided. To tie back of the mastoid process, place the patient in the same position as for ligation of the carotid. Carry an incision from the tip of the mastoid upward and backward, reaching a point midway between the mastoid and the occipital protuberance (Jacobson). Cut the skin, the fascia, the sternocleidomastoid, the splenius capitis, and possibly a portion of the tracheo-mastoid muscles. Bring the head toward the operator in order to relax the structures, retract the edges of the wound, and clear the artery where it lies between the mastoid process and the transverse process of the atlas (Jacobson). An electric forehead light is of great assistance in finding the vessel. Pass the needle away from the vein or veins (there are often several).

Dorsalis Pedis Artery.—The line of the dorsalis pedis artery is from the middle of the front of the ankle-joint to the middle of the base of the first interosseous space.

Anatomy (Pl. 5, Fig. 1).—The dorsalis pedis is a continuation of the anterior tibial artery, and it runs from the bend of the ankle to the proximal extremity of the first interosseous space, where it divides into the dorsalis hallucis and the communicating arteries. The artery rests, from above downward, upon the astragalus, scaphoid, and internal cuneiform bones, and at its point of bifurcation lies between the heads of the first dorsal interosseous muscle. It may lie in some persons a little external to this course. It is held upon the bones by a distinct layer derived from the deep fascia. This artery is covered by skin, by superficial and deep fascia, and by the annular ligament above, and is sometimes partly overlaid by the extensor proprius pollicis muscle, and is crossed, just before its bifurcation, by the innermost tendon of the extensor brevis muscle. The inner tendon of the extensor communis digitorum is to the outer side of the vessel; the tendon of the extensor proprius pollicis is to the inner side, and is a guide. The artery is ligated in the dorsal triangle of the foot—a space which is bounded above by the lower edge of the annular ligament, externally by the inner tendon of the extensor brevis, and internally by the tendon of the extensor proprius pollicis. The artery has venae comites; the anterior tibial nerve lies, as a rule, to its inner side, but may be found upon the artery or to its outer side, and the inner division of the musculocutaneous nerve is external to the vessel in the superficial parts.

Operation (Pl. 5, Fig. 2).—In this operation the patient is placed supine with the leg and foot extended. Heath flexes the leg partly and rests the sole of the foot directly upon the table. The surgeon stands below the extremity, and cuts from above downward. Make an incision two inches in length along the arterial line, beginning opposite the lower edge of the annular ligament and running along by the tendon of the extensor proprius pollicis; cut through the skin and superficial and deep fascia; have the toes extended; retract the tendon of the extensor proprius pollicis inward, and the tendon of the extensor communis digitorum outward; clear the artery, find the nerve, try to separate the venae comites, and pass the needle from the nerve.

Anterior Tibial Artery.—To locate the line of the anterior tibial mark a point midway between the head of the fibula and the tuberosity of the tibia, drop one inch, and draw a line from the second point to the middle of the front of the ankle-joint.
Anatomy.—The anterior tibial artery is one of the terminal branches of the popliteal. It arises opposite the lower border of the popliteus muscle, passes forward between the two heads of the posterior tibial muscle, comes to the front of the leg through an opening in the interosseous membrane, and runs down to the middle of the front of the ankle-joint. In the upper two-thirds of its course it rests upon the interosseous membrane, to which it is fastened by firm fascia; in the lower third it lies first upon the front of the tibia and then upon the anterior ligament of the ankle-joint. For its upper two-thirds the artery has the tibialis anticus muscle just external to it; at the junction of the middle and lower thirds the extensor proprius pollicis comes from the outside and lies either upon the artery or to its inner side for the rest of its course. Externally in its upper third is the extensor communis digitorum; in the middle third is the extensor proprius pollicis; in the lower third, the proprius pollicis having crossed to the inner side, the extensor communis digitorum again becomes the outer boundary. The artery is covered by skin and by superficial and deep fascia. In its upper third it is deeply placed between the muscles; in its middle third it is less overlaid by muscle; in its lower third it is superficial except where it is crossed by the extensor proprius and where it is covered by the annular ligament. The artery has venæ comites. In the lower three-fourths of its course it is accompanied by the anterior tibial nerve, which in its course in the upper third of the leg is external to the artery; in the middle third it is external and a little in front of the artery; and in the lower third it is external to or upon the artery (Pl. 4, Fig. 5).

Operations.—The ligations of the anterior tibial (Pl. 4, Fig. 6) are (1) of the lower third; (2) of the middle third; and (3) of the upper third. In all these ligations the patient is placed recumbent with the leg extended, and the surgeon stands to the outer side of the extremity, cutting from above downward on the right side and from below upward on the left side.

Ligation of the Lower Third.—Make an incision three inches long in the line of the artery and over the annular ligament. This incision is external to the tibialis anticus muscle and half an inch from the outer border of the tibia (Barker). Divide the skin and fascia, retract the tendon of the tibialis anticus inward, and the tendon of the extensor proprius pollicis outward, along with the tendons of the extensor communis. Flex the ankle-joint to relax the tendons, and clear the artery. Draw the nerve external and pass the ligature from without inward. In order to recognize the muscles in this as in other ligations, rely largely upon the finger while the muscles are being moved.

Ligation of the Middle Third.—In this operation the procedure is similar to the above. Remember that the nerve lies in front of the vessel and that the extensor proprius pollicis muscle is external. The nerve is retracted outward and the needle is passed from the nerve. A good rule for detecting the artery is to find the outer edge of the tibia and by this locate the interosseous membrane, and then, by passing out along this membrane, discover the artery.

Ligation of the Upper Third.—Make an incision three inches long in the arterial line. On opening the deep fascia, do not rely on the eye for finding the muscular interspace, as often the latter cannot be seen, and neither a white
nor a yellow line is reliable. Place the index-finger deep in the wound and have the tibialis anticus and extensor communis digitorum muscles successively rendered tense by an assistant. In opening the interspace use the handle of the knife. Relax the muscles, retract the tibialis anticus inward and draw the extensor communis digitorum outward. Find the interosseous membrane where it is attached to the edge of the tibia, and the artery will be found upon this membrane, between the tibia and the nerve. Clear the vessel and pass the ligature from without inward to avoid the nerve.

**Posterior Tibial Artery.**—The line of the posterior tibial is from the middle of the popliteal space to a point midway between the tip of the inner malleolus and the point of the heel (Pl. 5, Figs. 5, 6).

**Anatomy.**—The posterior tibial is the larger of the two terminal branches of the popliteal. It arises opposite the lower border of the popliteus muscle, passes down between the deep and superficial flexor muscles to midway between the tip of the malleolus and the point of the heel, and divides into the external and internal plantar vessels. In the upper third of its course it is very deeply placed midway between the tibia and fibula; in its middle third it is less deep, having passed inward; and in its lower third it is superficial. At the ankle the artery is beneath the annular ligament. From above downward the posterior tibial artery rests upon the posterior tibial muscle, the flexor longus digitorum muscle, the posterior surface of the tibia, and the internal lateral ligament of the ankle-joint. For the first inch or two of the course of the artery the posterior tibial nerve is to the inner side; the nerve then crosses to the outer side, and remains in that relative position throughout the rest of the course of the artery. When the knee is partly flexed and the leg is laid upon its outer surface the artery is between the operator and the nerve, and the nerve is between the artery and the table. Back of the malleolus, in the first compartment, lies the posterior tibial muscle; in the next compartment is the flexor longus digitorum muscle; in the next compartment are the artery and nerve; and in the most posterior is the flexor longus pollicis muscle.

**Operations.**—**Ligation Back of the Malleolus.**—In this operation the patient is placed recumbent with the thigh abducted and the leg flexed and resting upon its outer surface. The surgeon stands to the outer side. Make a two-inch semilunar incision corresponding in its curve to the malleolus and half an inch posterior to its margin (Fig. 140). Cut down to the annular ligament, incise the ligament, and find the artery and venae comitantes. Clear the vessel and pass the needle from behind forward (to avoid the nerve, which is here posterior and external). Do not make the preliminary incision nearer the malleolus than half an inch, as the sheath of the tibialis posterior muscle will then surely be opened. In closing the wound, suture the ligament by buried sutures of catgut before closing the superficial parts (Pl. 5, Fig. 6).

**Ligation in the Middle of the Leg.**—In this operation the patient is placed in the same position as for the ligation back of the malleolus. Feel for the inner border of the tibia, and make an incision four inches long one inch behind the osseous border, parallel with it, and extending through skin and superficial and deep fascia (Fig. 140). Draw the gastrocnemius muscle outward. Incise the soleus muscle, but not the fascia beneath the soleus; cut this fascia, after dropping the handle of the knife so that the blade is at right
angles with the plane of the tibia. Clear the artery; pass the needle from without inward (Pl. 5, Fig. 6).

The **popliteal artery** is almost never ligated in continuity. It can be tied at the upper portion of the popliteal space, at the lower portion of the popliteal space, or at the inner side of the thigh.

**Anatomy** (Fig. 138).—The popliteal artery is the continuation of the femoral, and runs from the opening in the adductor magnus muscle to the lower margin of the popliteus muscle. This vessel runs downward and outward behind the knee-joint and in the popliteal space. The ham, or popliteal space, is a lozenge-shaped space, which above the joint is bounded on the outer side by the biceps muscle, and on the inner side by the semitendinosus, semimembranosus, gracilis, and sartorius muscles, while below the joint it is bounded externally by the plantaris and outer head of the gastrocnemius muscles, and internally by the inner head of the gastrocnemius muscle. The floor of this space is formed by the surface of the femur, the posterior ligament of the knee-joint, the end of the tibia, and the popliteus fascia. The internal popliteal nerve passes down the middle of the popliteal space; it is superficial to the vessels in the upper half of the space, and is external to them; it is internal to the vessels in the lower half of the space. The external popliteal nerve is in the outer side of the space. The popliteal vein is between the nerve and the artery. Above the knee-joint it is to the outer side of the artery, but below the knee-joint it is to the inner side. The artery lies deeply in the space.

**Ligation in Upper Third.**—Place the patient prone. The surgeon stands to the outer side of the limb and makes a vertical incision three inches in length along the outer margin of the semimembranosus muscle, exposes the popliteal nerve, retracts the muscle inward and the nerve outward, exposes the artery,
separates it from the other structures, and passes the needle from without inward (Fig. 139).

Ligation in Lower Third.—Make a three-inch vertical incision between the heads of the gastrocnemius muscle. Avoid the external saphenous vein and nerve, and retract them with the popliteal nerve. Separate the artery from the vein and pass the needle from within outward.

Femoral Artery.—The line of the femoral artery is from midway between the anterior superior spine of the ilium and the symphysis pubis to the adductor tubercle on the inner condyle of the femur, the thigh being abducted and resting upon its outer surface (Pl. 5, Fig. 3).

Anatomy.—The femoral artery is the continuation of the external iliac trunk; it extends from the lower border of Poupart's ligament to the opening in the adductor magnus muscle, and hence occupies the upper two-thirds of the thigh. The artery for its first five inches is superficial, lying in Scarpa's triangle, a space which is bounded externally by the sartorius muscle and internally by the adductor longus, its base being Poupart's ligament and its floor being composed of the psoas, iliacus, pectineus, and adductor longus muscles, and often the adductor brevis. The artery enters the triangle as the common femoral, but after a two-inch course it divides into the profunda (which passes deeply) and the superficial femoral. The latter vessel is the one alluded to in this section.

At the base of Scarpa's triangle the vein is internal, the artery is between, and the nerve is external (v. A. N.). At the apex of the triangle the vein is internal and a little, posterior. At the apex of the triangle the superficial femoral passes under the sartorius muscle and enters into Hunter's canal, which occupies the middle third of the thigh and which terminates at an opening in the adductor magnus muscle. Hunter's canal is bounded externally by the vastus internus muscle, internally by the adductors longus and magnus, and its roof is fascia which stretches from the adductor longus to the vastus internus. In Hunter's canal the vein is behind the artery in the upper part, but external to it in the lower part, and is firmly attached to the artery. There may be two veins. Inside Hunter's canal, but outside the femoral sheath, is the long saphenous nerve, which crosses the artery from without inward.

A way to remember the relation of the femoral vein to the femoral artery is to recall the fact that the relation of the vein to the artery is always contrary to the relation of the sartorius muscle to the artery: when the sartorius muscle is external to the artery, the vein is internal, as at the base of Scarpa's triangle; when the sartorius muscle is crossing in front toward the inside of the artery, the vein is passing at the back to the outside, as at the apex of Scarpa's triangle; when the muscle is over the artery, the vein is back of it, as in the upper third of Hunter's canal; and when the muscle is to the inside of the artery, the vein is to the outside, as in the lower two-thirds of Hunter's canal. In a ligation at the apex of Scarpa's triangle the inner edge of the sartorius is the guide. In a ligation in Hunter's canal the long saphenous nerve is the guide.

Operations.—Ligation of the Superficial Femoral at the Apex of Scarpa's Triangle.—In this operation the position of the patient is supine with the thigh and leg partly flexed, and the thigh abducted, everted, and rested upon
its outer surface on a pillow. The operator stands to the outer side of the extremity. From a point corresponding to the middle of Scarpa's triangle, and two and a half inches below Poupart's ligament, make a three-inch incision in the arterial line (Fig. 140). Cut the skin and superficial fascia. The saphenous vein will not be seen unless the incision is internal to the arterial line; if this vein is seen, draw it inward. Open the fascia lata, find the inner border of the sartorius muscle, and draw it outward. The fibers of this muscle run downward and inward, thus distinguishing it from the adductor longus, whose fibers run downward and outward. Open the common sheath for the artery and vein, and then incise the individual arterial sheath. Clear the artery and pass the ligature from within outward (Pl. 5, Fig. 4).

**Ligation of the Superficial Femoral in Hunter's Canal.**—This operation was first performed for aneurysm by John Hunter in 1785. In this operation the **position** of the patient is the same as in the ligation at the apex of Scarpa's triangle. Make a three-inch incision in the middle third of the thigh, parallel with the arterial line and half an inch internal to it (Barker) (Fig. 140). Incise the skin and superficial fascia, look out for the internal saphenous vein, open the fascia lata, find the sartorius muscle, and retract it inward, thus exposing the roof of Hunter's canal, which is to be opened for an inch or more. Within the canal is seen the long saphenous nerve, usually upon the sheath. Open the sheath of the artery, clear the vessel, and pass the needle from without inward.

**Results.**—The favorite operation at the present time for popliteal aneurysm is ligation at the apex of Scarpa's triangle. It is a very successful procedure. I have performed it twice with success and have assisted other operators in 3 successful cases. Syme successfully ligated the femoral about its middle twenty-three consecutive times, and in Guy's Hospital the same
operation was done, twenty-four times with 1 death ("Practice of Surgery," by Thomas D. Bryant).

**Iliac Arteries.**—The line of the common and external iliac arteries is from a point half an inch below and half an inch to the left of the umbilicus to midway between the anterior superior spine of the ilium and the pubic symphysis. The upper third of this line represents the common iliac, and the lower two-thirds the external iliac (Pl. 2, Fig. 4).

**Anatomy.**—The common iliac arteries arise from the aorta opposite the left side and lower border of the fourth lumbar vertebra, and extend to the upper margin of the right and left sacro-iliac joints, where they each bifurcate into an external and an internal iliac. The common iliac arteries lie upon the fifth lumbar vertebra, are covered with peritoneum, and are crossed by the ureters. In women the ovarian arteries cross the common iliacs. Each common iliac vein lies to the right side of its associated artery. The right common iliac artery has in front of it, besides the peritoneum and ureter (in women also the ovarian artery), the ileum, branches of the superior mesenteric artery, and branches of the sympathetic nerve. The left common iliac artery has in front of it, in addition to structures common to both sides (ureter, ovarian artery, sympathetic branches), branches of the inferior mesenteric artery and the sigmoid flexure with its mesocolon. The internal iliac artery runs from the sacro-iliac joint to the upper margin of the great saccrosciatic foramen. It is very rarely ligated (only for gluteal aneurysm, for uncontrollable hemorrhage from the gluteal or sciatic arteries, or to produce atrophy of the prostate gland). The external iliac artery runs from the sacro-iliac joint along the pelvic brim, upon the inner edge of the psoas muscle, to Poupart's ligament. The external iliac vein is internal to the artery. On the right side, high up, it passes behind the artery. The external iliac artery has in front of it peritoneum and subserous tissue (Abernethy's fascia). The ileum crosses the right, and the sigmoid flexure crosses the left, external iliac artery. The genital branch of the genitocrural nerve crosses the artery low down, and the circumflex iliac vein crosses it just before it terminates in the femoral. The spermatic vessels and the vas deferens in the male, and the ovarian vessels in the female, lie upon the artery near its termination. Sometimes the ureter crosses the vessel near its point of origin.

**Ligation of the Iliac Arteries after Abdominal Section.**—The best method for ligating the common, the external, or the internal iliac is by abdominal section. The patient is placed in the Trendelenburg position. The abdomen is opened in the midline below the umbilicus or in the semilunar line of the diseased side. The intestines are lifted toward the diaphragm, and are held up by gauze pads. The edges of the incision are retracted. The vessel to be tied is located and the point for ligation is selected. The posterior layer of the peritoneum is opened over the selected point, the vessel is cleared, and the threaded Dupuytren's aneurysm needle is passed in a direction away from the vein. In ligating either common iliac, pass the needle from right to left. In ligating the external iliac, pass the ligature from within outward. It is not necessary to suture the posterior layer of peritoneum. The abdomen is closed without a drain. In these operations be sure to push the ureter out of the way. This method of operating is indorsed by Dennis, Hearn, Marmaduke Shield, Mitchell Banks, and others who have employed it.
Iliac Arteries

Results: Bryant ("Operative Surgery") alludes to 5 reported cases of transperitoneal ligation of the common iliac artery with 1 death.

Ligation of the Common Iliac Artery by the Extraperitoneal Method.—The common iliac artery was tied unsuccessfully by Dr. Wm. Gibson in 1812. It was first successfully ligated by Valentine Mott in 1827. The patient is placed recumbent or in the Trendelenburg position. The body is then turned a little to the opposite side and the thighs are partly flexed. Bryant says there are two linear guides for this artery. Crampton's line is drawn from "the apex of the cartilage of the last rib downward and a little forward nearly to the crest of the ilium, then carried forward parallel with it to a little below the anterior superior spine" ("Operative Surgery," by Joseph D. Bryant). McKees' line is "drawn from the tip of the cartilage of the eleventh rib to a point an inch and a half within the anterior superior spine, then curved downward, forward, and inward, and terminating abruptly above the internal abdominal ring" ("Operative Surgery," by Joseph D. Bryant).

The incision can be begun just external to the internal abdominal ring and be curved upward and outward as in ligation of the external iliac, but Crampton's incision gives more room. The superficial tissues are divided down to the transversalis fascia, this structure is nicked and divided, and the exposed and unopened peritoneum is rolled upward and inward. The muscular guide is the inner border of the psoas magnus muscle. By its side an artery is felt. If the sacrovertebral prominence is above the vessel touched, the artery is the external iliac; otherwise it is the common iliac. If the external iliac is the vessel first exposed, follow it up to find the common trunk. When the common iliac is found, separate the fatty tissue about it and pass the ligature from the right toward the left in order to avoid the associated vein.

Results: Jos. D. Bryant tells us that this vessel has been ligated by the extraperitoneal method sixty-nine times with only 16 recoveries, but it is to be remembered that many of these operations were in preantiseptic days.

Ligation of the Internal Iliac Artery.—This operation was first performed by Stevens, of Vera Cruz, in 1812 ("Practice of Surgery," by Thomas Bryant). The incision and the method of exposing the vessel are identical with like steps in the ligation of the common iliac.

Results: Of 26 ligations of this vessel recorded, 18 were fatal, but only a few of the cases were done antiseptically (Joseph D. Bryant's "Operative Surgery").

Ligation of the External Iliac by Abernethy's Extraperitoneal Method (Pl. 2, Fig. 4).—The external iliac artery was first ligated by Abernethy in 1796. The operation failed, but he did the first successful operation in 1806. The patient is placed recumbent with the thighs extended during the first incisions; but in the later stages of the operation the thighs are flexed a little, to relax the abdominal structures. The operator stands to the outer side. The surgeon will find the artery by the side of the psoas muscle. Mark a point one inch above and one inch external to the middle of Poupart's ligament, and another point one inch above and one inch internal to the anterior superior iliac spine (Barker). Join these two points by a curved incision four inches long and convex downward. Cut the skin, the fat, the two oblique muscles, and the transversalis muscle; open the transversalis fascia, separate the peritoneum
toward the vessels, and draw it inward by a broad retractor, and look for the artery along the pelvic brim. The anterior crural nerve is seen to the outer side of the artery, the external iliac vein is to the inner side of the artery, and the genitocrural nerve is upon the artery. Clear the artery near its middle and pass the ligature from within outward. In Sir Astley Cooper's method of ligation the inguinal canal is opened; in Abernethy's method the inguinal canal is not opened.

The Gluteal Artery.—This vessel is a continuation of the posterior division of the internal iliac. It emerges from the great sacrosciatic foramen at the upper border of the pyriformis muscle. It rests upon the glutaeus minimus, divides into three branches, and is covered by the glutaeus maximus muscle. The superior gluteal nerve lies inferior to the artery (Fig. 141).
Ligation.—The patient should be prone. The surgeon stands to the outer side. The incision corresponds to a line drawn from the posterior superior iliac spine to the upper border of the great trochanter (Fig. 142). Divide the skin, fascia, gluteus maximus muscle, and the fascia over the gluteus medius muscle, and retract the gluteus medius upward. Feel for the great sacrosciatic foramen, and at this point the artery is found above the pyriformis muscle. Clear the vessel and pass the needle from below upward (see Kocher’s “Operative Surgery”). There is practically no mortality from this operation.

The Sciatic Artery.—This artery is the larger of the terminal branches of the anterior division of the internal iliac artery. It passes to the lower portion of the great sacrosciatic foramen, lying back of the internal pudic artery, and resting upon the sacral plexus of nerves and pyriformis muscle (Gray). It leaves the pelvis between the pyriformis and coccygeus muscles, and passes downward between the ischial tuberosity and great trochanter. It is covered by the gluteus maximus muscle, rests upon the gemelli, internal obturator and quadratus femoris muscles, has the great sciatic nerve external to it, and the small sciatic nerve external and posterior (Fig. 141).

Ligation.—The patient lies prone. The surgeon stands to the outer side. The incision corresponds to the middle two-thirds of a line extending from the posterior inferior iliac spine to the base of the great trochanter. MacCormac advises the incision shown in Fig. 142. Divide the skin, fat, fascia, and the gluteus maximus muscle. Find the artery at the lower border of the pyriformis muscle and trace it to

* Kocher’s "Operative Surgery," by Stiles.
its point of emergence from the pelvis. Pass the ligature from without inward. There is practically no mortality from this operation.

**Internal Pudic Artery.**—This artery is one of the terminal branches of the anterior trunk of the internal iliac. It passes to the lower margin of the great sacrosciatic foramen, and leaves the pelvis between the pyriformis and coccygeus muscles, crosses the ischial spine, and again enters the pelvis by the lesser sacrosciatic foramen. The vessel is accompanied by the internal pudic nerve (Fig. 141).

*Ligation.*—The position of the patient and the incision are the same as for ligation of the sciatic artery (Fig. 142). The artery is found below the ischial spine. Pass the needle from below upward to avoid the nerve. There is practically no mortality from this operation.

**Ligation of the Abdominal Aorta.**—This operation was first performed by Sir Astley Cooper in 1817. The patient lived but a few hours. Fifteen cases of ligation of the aorta have been published, and there were 15 deaths, but only 4 of these cases were aseptic operations. The patient of Monteiro, of Rio Janeiro, lived for ten days. The circulation was entirely restored in the limbs, and the man died from hemorrhage resulting from the ulceration produced by a septic ligature. Keen’s case lived for forty-eight days after ligation just below the diaphragm. The urinary secretion was plentiful and the circulation in the lower extremities was restored, death resulting from cutting through of the ligature. Robt. T. Morris performed distal ligation below an aneurysm. He encircled the aorta with a soft-rubber catheter and clamped it with forceps. Twenty-two hours after operation the aneurysm began to shrink, and in three hours more had apparently disappeared. Twenty-seven hours after operation the clamp and catheter were removed. The patient died of septicemia fifty-three hours after operation. The necropsy disclosed gangrene of a bit of intestine which had been in contact with the forceps, but the dissecting aneurysm was filled with solid clot, the aorta was patent, and the circulation in the extremities was re-established (“Amer. Jour. of Med. Sciences,” Sept., 1900). These cases prove that under certain circumstances the operation is feasible, and in desperate cases it must be considered as a possible means of treatment.

**Murray Operation.**—This procedure aims to avoid opening the peritoneum. An incision is made from just below the tip of the tenth rib to a point one inch internal to the anterior superior iliac spine. The peritoneum is separated from the abdominal wall until the vessel is reached. Cooper’s operation by abdominal section is the preferable procedure.

**Operation by Abdominal Section (Cooper’s Operation); Instruments Required.**—Those used in any ligation, with the addition of an aneurysm needle with a large curve and a very long handle. With an ordinary instrument it is extremely difficult to pass the ligature. It would be a great advantage to use an instrument which, after being passed under the vessel, could have a central eyed shaft projected, as is the center shaft of a Bellocq cannula. Floss silk is probably the best ligature material.

If the patient is much exhausted, an assistant should infuse salt solution in a vein during the operation. In Keen’s case there was profound shock, but the moment the ligature was tightened it passed away.

**Operation.**—The patient should be placed upon his back. The surgeon
stands to the right of the patient and opens the abdomen in the median line, a little above the level of the aneurysm. The intestines are packed aside, the posterior layer of the peritoneum is divided, the surface of the aorta over a small area is cleared of nerves, the plexuses being separated with a blunt dissector.

The needle is passed from right to left. A double ligature of floss silk should be passed and the ends should be tied with a stay-knot. The wound is closed and dressed.

It has been suggested—I think by Wyeth—that it might be wise to only partially tighten the ligature at first, completing the occlusion of the artery after a day or two. Such a procedure would certainly give a better chance for the collaterals to dilate, and restore circulation in the legs.

Unfortunately, in an aneurysm, the vessel will usually be extensively diseased, and ligation will be out of the question. If, however, a normal region is found, the chance of success in a case of aneurysm will be greater than in a case of hemorrhage from a branch of the aorta, because, in a case of aneurysm, the probabilities are that the collaterals are somewhat distended before a ligature is applied.