

of the arm and passed down to the thigh on the opposite side.

Treatment.—The first efforts of the surgeon are directed to control the hæmorrhage, and to arouse the patient from the state of collapse by stimulants. When this is done, foreign bodies, such as pieces of clothing, bullets, splinters of wood or bone, are to be extracted. The presence of a bullet may be made out in deep wounds by the use of Nélaton's probe. This instrument consists of a silver shaft and a bulbous extremity formed of porcelain. When the bullet is touched a leaden-colored mark is produced on the porcelain. The wound is afterward syringed with a weak solution of carbolic acid, and covered with cloths dipped in an ice-water solution of the acid. Ice-bags are then found serviceable in limiting the amount of inflammation. When suppuration commences, warm fomentations may be used to hasten its progress, and the *débris* prevented from remaining by frequent syringing. In the suppurative stage, there is great danger from secondary hæmorrhage. Therefore, when the wound is in the vicinity of large vessels, it should be carefully watched, and a compress or tourniquet should be placed loosely around the limb, ready to be used at a moment's warning.

Gunshot-wounds of viscera are treated in the same manner that ordinary wounds are after extraction of foreign bodies.

CHAPTER V.

WOUNDS OF ARTERIES AND VEINS.

Ligation of large Arteries.—Air in Veins, etc.—Causes of Sudden Death.—Treatment.

WHEN large vessels are wounded, there is a great and immediate danger to life. The blood may be poured out externally, or become diffused in the tissues near the artery, or dissect up the sheath of the vessel. Efforts should in every case be made to tie both ends of the bleeding artery in the wound. (*See* article on Hæmorrhage.) If this cannot be done, the artery is then tied between the wound and the heart. Ligation of large vessels is generally followed by complete obliteration of their canals. The ligature divides the middle and internal coats, and brings the external walls together. The blood coagulates at each end of the ligature. The coloring matter of the clot is absorbed. Lymph is poured out between each coat of the artery, between the clot and the lining membrane, and external to the vessels, blending all these parts together, and becoming ultimately a fibrous cord. The ligature, meanwhile, makes its way out by a process of ulceration, and the space formerly occupied by it is filled up by granulation. From ten to fourteen days after the operation the ligature comes away, and then there is the greatest danger of secondary hæmorrhage.

As wounds may involve any of the arteries in the body, a short description of the operation in different locations, upon important arteries, will be necessary in this connection.

In wounds of the common carotid or subclavian, it may be necessary to place a ligature on the arteria innominata, an operation rarely attended with success.

When the patient is fully anaesthetized and in position, an incision about two inches in length is made along the inner edge of the sterno-mastoid muscle to the articulation of the clavicle with the sternum, meeting it with a second incision commencing about half an inch from the posterior border of the same muscle, and carrying it along the clavicle. When the integument is turned back, the platysma myoides and sterno-mastoid muscles are divided on a director, the platysma being first cut. The handle of the scalpel is now used to push aside some thick cellular tissue, and the sterno-thyroid and thyro-hyoid muscles are brought into view and carefully divided. A plexus of veins, composed principally of branches of the inferior thyroid, next appears, and must be moved upward and kept out of the way. A thick layer of deep cervical fascia is next incised; the fingers can now be carried down, using the common carotid as a guide, until the arteria innominata is reached. This vessel is situated behind the right sterno-clavicular articulation of the right side. The right vena innominata, internal jugular vein, and pneumogastric nerve, are displaced to the right, and the left vena innominata pressed downward and to the left. An aneurism-needle, armed with a ligature, is then passed around the vessel from below upward.

The *common carotid* artery is ligated either above or

below the omo-hyoid muscle. When the vessel is ligated above the omo-hyoid, an incision is made from the angle of the jaw to the cricoid cartilage. This incision is carried three inches farther than this point when the artery is tied below that muscle. The inner edge of the sterno-mastoid is the guide for both incisions. The integument, superficial fascia, platysma, and deep fascia, are cut through (the three latter on a director); the descendens-noni nerve is moved aside, and the sheath of the vessels lifted with a forceps and opened. The internal jugular vein swells up in the wound as the sheath is cut; it should be compressed above and below the opening, and drawn outward. The pneumogastric nerve is situated here between the artery and vein, and on a plane posterior to both, and great care is necessary to avoid it in passing the ligature. The needle is carried from without inward around the artery. In ligating the carotid on the left side in its lower portion, the jugular vein will be found to have altered its relation to the artery. Instead of lying external to it, it crosses in front of it. Another point to be remembered in connection with the operation below the omo-hyoid is, that the sterno-mastoid artery and the middle thyroid vein run along in the course of the incision, and must be avoided. The sterno-thyroid and sterno-hyoid are drawn toward the median line of the neck. Ligation of the common carotid arteries is sometimes followed by hemiplegia.

The *subclavian artery* is usually ligated in the third portion. In this operation the shoulder is depressed as much as possible, the integument drawn down on the clavicle, and an incision made through it, extending from the anterior margin of the trapezius to the posterior border of the

sterno-mastoid. The fascia and platysma having been divided, the external jugular vein is seen near the edge of the sterno-mastoid muscle, and the supra-scapular and transversalis colli nerves and vessels running across the space. These are pushed aside, the deep fascia scratched through, and the finger of the operator carried along the edge of the scalenus-anticus muscle to the tubercle of the first rib, at which point the subclavian artery will be found. The aneurism-needle is carried around the vessel from before backward, and the ligature tied.

The third portion of the *axillary artery* is the most convenient part for ligation. An incision is made about two inches in length, over the head of the humerus, near the centre of the axillary space. The integument and fascia are cut through, the axillary vein drawn inward, the median nerve outward, and the ligature passed from within outward.

The *brachial artery*, in the upper part of its course, is exposed by cutting through the integument and fascia at the inner margin of the coraco-brachialis muscle. The ulnar and internal cutaneous nerves, which lie at the inner side of the artery, and the median nerve, which is situated externally, are separated from the vessel, and the ligature applied.

The brachial may also be tied at the bend of the elbow. The incision is made at the inner border of the biceps muscle. At this joint the artery lies internal to the tendon, with the median nerve still farther inside, close to the vessel. The median basilic vein passes over the artery, separated from it by the bicipital fascia.

The *radial artery* should not be tied at its upper portion, because of its depth from the surface. In the middle

third it is exposed by cutting along the inner margin of the supinator longus. The radial nerve, a continuation of the muscle spiral, is found in close relation with it externally. The ligature is passed from the radial to the ulnar side.

In the lower portion of the forearm, the artery is found between the flexor carpi radialis and supinator longus. It is superficial at this point, and easily tied by cutting between those two muscles.

The *ulnar artery*, in its lower portion, is located between the flexor carpi ulnaris and the flexor sublimis digitorum. The ulnar nerve is found at the inner side of the former muscle. The incision is carried through the integument and fascia between these muscles, and the artery tied.

WOUNDS OF THE PALMAR ARCH are difficult to manage, owing to the numerous anastomoses of the arteries. The hæmorrhage may persist after ligation of the ulnar, radial, and brachial arteries. Some surgeons keep a compress on the wound for two or three days, and, if this does not succeed, ligate the vessels in the forearm or arm. When compression fails, the bleeding vessels should be *tied in the wound*, if possible.

Ligation of the femoral artery is commonly performed in the lower portion of "Scarpa's space." The integument and fascia are divided at the inner margin of the Sartorius muscle. After the sheath is opened, the femoral vein will be found at the inner side of the artery. The ligature is carried around from within outward.

After ligation of the femoral artery, the limb should be encased in a thick roll of cotton, to keep up its normal temperature, until the collateral circulation is established.

Ligation of the popliteal artery.—This vessel is rarely tied except for wounds which involve its walls. In the upper third of the artery the operation is performed by cutting the integument and fascia, at the edge of the semi-membranous. The muscle is drawn inward and the artery exposed. The popliteal vein is external, and superficial to the artery, and the internal popliteal nerve external and superficial to the vein.

In the lower third, the incision is made in the median line, immediately behind the joint. The deep fascia is here very thick, and there is considerable cellular tissue around the vessels, which requires some time and trouble to clear away, so as to bring them into view. When this has been done the limb is flexed, and the needle passed around the artery from without inward.

The *anterior tibial artery* is usually tied in its lower portion above the ankle-joint. The artery is here found between the tibialis anticus and extensor proprius pollicis, and is covered by the integument and fascia. These latter are incised—the tendons separated, and the artery exposed. The nerve is in this situation superficial to the artery. The venæ comites are separated from each side of the vessel, and the ligature applied in the usual manner.

Posterior tibial.—It is extremely difficult to reach this artery in its middle third, because of its depth from the surface. The operation is performed by extending the foot, making an incision at the inner border of the tibia about three inches in length. When the integument and fascia have been cut, the edge of the gastrocnemius muscle is turned aside, and the soleus detached from the tibia by cutting its fibres on a director. The fascia underneath this

muscle is next divided, and the artery exposed from three-quarters of an inch to an inch from the inner border of the tibia.

The tibial nerve in this region is situated on the outside of the artery, and should be separated from the vessel before tying.

The vessel is sometimes tied as it passes around the ankle, by making a curved incision midway between the internal malleolus and the heel. The integument and superficial fascia having been divided, the needle is passed from without inward, as in the previous case.

WOUNDS OF VEINS, ENTRANCE OF AIR.—Fatal hæmorrhage takes place in a short time when large veins, as the jugular or vena innominata, are wounded, unless immediate assistance is rendered, and the wound closed by ligation or pressure. In wounds of small veins the danger from hæmorrhage is slight.

Wounds of veins may be followed by phlebitis or by the entrance of air. The latter complication occurs particularly in the veins of the upper extremity and neck, during operations for the removal of tumors. The air enters the opening in the vein with a loud hiss, and the patient, in many cases, expires instantly. If only a small quantity of air enter, there is a tendency to syncope, difficult breathing, and convulsive movements of the body, which may last for several hours before a fatal termination is produced. In the majority of cases sudden death ensues.

A number of explanations have been offered to account for the suddenness of death in this accident. Bell thought it due to the action of air upon the medulla oblongata. Moore ascribed it to irregular action of the valves of the

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heart from the presence of air; * others, again, ascribed it to the impossibility of a frothy liquid passing through the lungs.

In the absence of any accepted theory, I would suggest the following: In the great majority of cases the accident occurs in removing tumors from the neck or axillary region. These tumors by their pressure empty the veins upon which they lie. As the knife of the surgeon passes into the vein, and the weight of the tumor is removed, air rushes in to fill up the vacuum, and the heart ceases. When it is considered that the pressure of the atmosphere is equal to fifteen pounds to the square inch, and the force-pump action of the heart only thirteen pounds and a half to the square inch, it will be seen that the column of air by its own direct pressure is sufficient to overcome and paralyze the muscular force of the heart. The stoppage is instantaneous. Subsequent pressure on the wound fails to do good, because of the presence of air in the heart, which cannot be disposed of with sufficient rapidity to enable the organ to recover itself. The distention of the right side of the heart, which is usually found after death, is accounted for on these grounds.

When only a small portion of air enters, and pressure is made on the wounded vein, there is sometimes recovery.

Whenever operations are performed about the neck or axilla, every vein in the vicinity of the surgeon's knife should be closed by assistants. Both before and after the removal of the tumor, this precautionary measure is called for.

Treatment.—Immediate efforts to restore the respiratory movements, and with them the action of the heart, should

* Holmes's Surgery, article Wounds of Veins.

be made. Marshall Hall's or Sylvester's methods of artificial respiration can be tried. Stimulant enemata and friction of the surface are always necessary. Galvanism may also be tried. In mild cases, brandy and ammonia may be given by the stomach. Hot plates over the epigastric and precordial regions are also serviceable.

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