Modern Surgery - Chapter 18. Diseases and Injuries of the Heart and Vessels - Hemorrhage or Loss of Blood

John Chalmers Da Costa
Jefferson Medical College

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common. Traumatic aneurysm and arteriovenous aneurysm are not unusual results.

**Gunshot-wounds** of arteries by pistol balls and the balls of large-caliber rifles are apt to be contusions which may eventuate in sloughing and secondary hemorrhage or thrombosis and gangrene. A shell-fragment makes a lacerated wound. A modern rifle-bullet makes a clean-cut division of an artery. Secondary hemorrhage after gunshot-wounds is most likely to occur during the third week after the injury. Partial rupture of an artery may cause sloughing and secondary hemorrhage, thrombosis and gangrene, or aneurysm. A complete rupture constitutes a lacerated wound, and is a condition accompanied by diffuse hemorrhage into the tissues.

**Wounds of veins** are classified as are wounds of arteries. The symptom of any vascular wound is hemorrhage.

1. **Hemorrhage, or Loss of Blood**.

**Hemorrhage** may arise from wounds of arteries, veins, or capillaries, or from wounds of the three combined. In arterial hemorrhage the blood is scarlet and appears in jets from the proximal end of the vessel, which jets are synchronous with the pulse-beats; the stream, however, never intermits. The stream from the distal end is darker and is not pulsatile. Venous hemorrhage is denoted by the dark hue of the blood and by the continuous stream. In capillary hemorrhage red blood wells up like water from a squeezed sponge, and the color is between the bright red of arterial blood and the dark color of venous blood.

In **subcutaneous hemorrhage** from rupture of a large blood-vessel there are great swelling, cutaneous discoloration, and systemic signs of hemorrhage. If a main artery ruptures in an extremity, there is no pulse below the rupture, and the limb becomes cold and swollen. At the seat of rupture a large fluctuating swelling forms, and sometimes there are bruit and pulsation. If a vein ruptures in an extremity, a large, soft, non-pulsatile swelling arises, there is no bruit, and intense edema occurs below the seat of rupture. Profuse hemorrhage induces constitutional symptoms, and death may occur in a few seconds. Loss of half of the blood will usually cause death (from four to six pounds), though women can stand the loss of a greater relative proportion of blood than men. Young children, old people, individuals exhausted by disease, drunkards, sufferers from Bright's disease, diabetes, and sepsis stand loss of blood very badly. An individual with **obstructive jaundice** is apt to suffer from persistent oozing of blood after operation, an oozing which is particularly persistent and dangerous in obstruction of the bile-ducts due to malignant disease. It not unusually causes death. Generally, after bleeding has gone on for a time, syncope occurs. Syncope is Nature's effort to arrest hemorrhage, for during this state the feeble circulation and the increased coagulability of blood give time for the formation of an external clot. When reaction occurs, the clot may hold and be reinforced by an internal clot, or it may be washed away with a renewal of bleeding and syncope. These episodes may be repeated until death supervenes. Nausea exists and there may be regurgitation from the stomach. Vertigo is present. There is dimness of vision or everything looks black; black specks float before the eyes (muscae volitantes), or the patient sees flashes of light or colors. There is a roaring
sound in the ears (tinnitus aurium). The patient yawns, is restless, tosses to and fro, and great thirst is complained of. The mind may be clear, but delirium is not unusual, and convulsions often occur. After a profuse hemorrhage an individual is intensely pale and his skin has a greenish tinge; the eyes are fixed in a glassy stare and the pupils are widely dilated, and react slowly to light; the respirations are shallow and sighing; the skin is covered with a cold sweat; the legs and arms are extremely cold, and the body-temperature is below normal. The pulse is soft, small,compressible, fluttering, or often cannot be detected; the heart is very weak and fluttering, and the arterial tension is almost abolished. There is muscular tremor; the patient tosses about, and asks often and in a feeble voice for water. The suffering from thirst is terrible and no amount of water gives relief. There is often dreadful dyspnea, and a man who is bleeding to death grasps at his chest, rises up upon his elbow, and then falls back in a dead faint. Usually reaction occurs, though the patient is obviously weaker than before; again a faint may happen, and so there is fainting spell after fainting spell until death ensues. Convulsions frequently precede death. In hemorrhage the hemoglobin is greatly diminished in amount. In an intra-abdominal hemorrhage the above symptoms are noted, and, except in splenic hemorrhage, blood gathers in both loins, and dulness on percussion exists which gradually rises and shifts as the patient's position is shifted. The blood also gathers in the rectovesical pouch in the male, and in the recto-uterine pouch in the female, and may be detected by digital examination. If the spleen is wounded, the blood clots quickly, and an area of dulness, which does not shift and which progressively increases, is noted in the splenic region.

Treatment.—When such a dangerous condition is due to an intra-abdominal hemorrhage, the surgeon at once opens the abdomen and arrests bleeding while the assistants apply the treatment advised in the following remarks. If a large vessel in an extremity has been divided, temporarily arrest bleeding by digital pressure in the wound, or the application of an Esmarch band above the wound (if the bleeding is arterial). In some cases forced flexion is used. In any case lower the head, and have compression made upon the femorals and subclavians, so as to divert more blood to the brain, or bandage the extremities (autotransfusion). Apply artificial heat. The value of adrenalin in restoring or maintaining arterial tension has been demonstrated by Crile. We should give the patient by hypodermoclysis one pint of hot normal salt solution containing one dram of the 1:1000 solution of adrenalin chloride. The fluid is allowed to run in the subcutaneous tissue beneath the breast. The infusion of one pint or more of hot salt solution into a vein is a very valuable remedy; it gives the heart something to contract upon and thus maintains cardiac action. If the depression is very severe, inject ether hypodermatically, then brandy, and then atropin. Strychnin may be given hypodermatically in doses of gr. \(\frac{1}{4}\), but atropin is of more service. Digitalin is advised by some, but it is not sufficiently rapid in action. Give enemata of hot coffee and brandy. Apply mustard over the heart and spine. Lay a hot-water bag over the heart.

In hemorrhage from a vessel of an extremity, we temporarily arrest bleeding while bringing about reaction. As soon as reaction is established permanently arrest bleeding by the ligature. In intra-abdominal or concealed hemorrhage
it is not possible to temporarily arrest it and wait for reaction, but the abdomen
must be opened and the work proceeded with in spite of the patient's condi-
tion. Every moment we wait he is growing worse.

A severe hemorrhage is apt to be followed by fever, due to the absorption
of fibrin ferment from extravasated blood and its action upon a profoundly
debilitated system. After a severe hemorrhage leukocytes are increased, not
only relatively, but absolutely. Red corpuscles are diminished both relatively
and absolutely. Hemoglobin diminishes; many of the corpuscles become
irregular and microcytes are noticed.

In treating a patient who has thoroughly reacted after a severe hemor-
rhage, apply cold to the head. Fluids and ice are grateful. Frequently
sponge the skin with alcohol and water. Milk punch, koumiss, and beef-
peptonoids are given at frequent intervals.

**Hemostatic agents** comprise (1) the ligature and suture; (2) torsion;
(3) acupressure; (4) elevation; (5) compression; (6) styptics; (7) the actual
cautery; and (8) forced flexion of limbs.

*The ligature* was known to the ancients, but was rediscovered by Ambroise
Paré. The ligature may be made of silk, floss-silk, or catgut. Whatever
material is used must, of course, be rendered aseptic. A ligature should
be about ten inches long. The vessel to be tied must be drawn out with
forceps and separated for a short distance from its sheath, but must not be
separated to any considerable extent; to do so may lead to necrosis of the
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vessel and secondary hemorrhage. The hemostatic forceps (Figs. 103, 104, 105) is in most cases a better instrument than the tenaculum (Fig. 106). The tenaculum makes a hole in the vessel, and sometimes a slit-like tear. A portion of this opening may remain back of the tied ligature, the vessel may

retract a little, or the ligature may slip slightly, and bleeding may occur. When the artery lies in dense tissues or is retracted deeply in muscle or fascia, the tenaculum, when carefully used, is the better instrument. The ligature is tied in a reef-knot (Fig. 107), not in a granny-knot (Fig. 108), and not in a surgeon’s knot (Fig. 109). It is often the purpose of the surgeon to divide the internal and middle coats of the vessel, and if such is his desire the first knot is firmly tied. The second knot must not be tied too tightly, or it will cut the ligature. The ligature must not be jerked as it is being tied. If a third

knot overlies the first two, the ligature can be cut off close to the knot; otherwise it is cut off so that short ends are left. Both ends of a divided vessel should be ligated. If a vessel is atheromatous, it is not desirable to divide the internal and middle coats. In this case a ligature should be
applied firmly rather than tightly, and another ligature should be put on above it, or ligation can be effected by the stay knot. If an artery is incompletely divided, a ligature should be applied on each side of the wound, and the vessel divided between the ligatures. If a large vein is slightly torn, try to pinch up the vein-walls around the rent and apply a ligature (lateral ligature, Figs. 111, 123). If a vein is longitudinally torn, close the wound with a Lembert suture of silk (Ricard, Niebergall, the author and others have done this successfully). Murphy, of Chicago, has recently shown that longitudinal wounds or small lateral wounds of either veins or arteries can be closed successfully with silk sutures, and if a transverse wound includes more than one-half of the circumference of the vessel, after the vessel is completely divided, the ends can be successfully united by end-to-end anastomosis.* After such an operation the vessel is probably ultimately obliterated by endothelial proliferation. It carries blood for a time only, but carries it long enough to lessen the danger of gangrene. While the vessel is closing, the collaterals are dilating. Depage successfully sutured the common carotid artery ("Journal de Chir. et Ann. de la Soc. Belge de Chir.," Jan. and Feb., 1902). Pringle successfully sutured an oblique wound of the external iliac artery. The wound was one-quarter of an inch in length. During the operation pressure was made on the aorta ("Scottish Med. and

* See Medical Record, Jan. 16, 1897.
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Surg. Jour., Oct., 1901). Manteuffel, Marchant, and others have performed like operations. Matas ("Annals of Surgery," Feb., 1903) has collected 30 cases of suture of arteries by lateral or circular arteriorrhaphy. Some surgeons use catgut for sutures; others use silk. There is some danger that aneurysm may form at the region sutured. The rule not to suture but rather do end-to-end anastomosis if more than one-half of the circumference of the vessel is divided is contradicted by A. E. Halstead’s case ("Med. Record," July 20, 1901). This surgeon cut two-thirds through the circumference of the axillary artery. He sutured the wound with catgut, passing each stitch through the two outer coats of the vessel. Two months later the radial pulse returned. In longitudinal wounds Halstead recommends the use of a continuous suture. Personally, in suturing vessels I would use fine silk. I have sutured successfully in one case a longitudinal tear in the internal jugular vein and in another case a small transverse cut in the axillary vein. In extensive tears of a vein ligate the vessel in two places and cut between the ligatures. When the parts about an artery are so thickened that the vessel cannot be drawn out, arm a Hagedorn needle (Fig. 110) with catgut and pass the latter around the vessel in such a manner that the catgut will include the vessel with some of the surrounding tissue. Then tie the ligature (Fig. 112). This method is known as the application of a suture-ligature, and is pursued in necrosis, atheroma, scar-tissue, sloughing, etc. Never include a nerve of any size in the ligature. If this mode of ligation fails, try acupressure.

Doyen, when about to tie a thick pedicle, crushes it by means of a very powerful instrument and then ties a ligature about the crushed and attenuated area. The vessels are closed by laceration wide of the ligature and the ligature does not tend to slip. Some trust such a stump without a ligature, but most surgeons prefer to ligate. This instrument is known as the vasotribe or angiotribe and is used particularly in hysterectomy. Fig. 113 shows a vasotribe.
Torsion.—Torsion was practised by the ancients, but was reintroduced in modern times, particularly by Amussat, Velpeau, Syme, and Bryant of London. By means of torsion the internal and middle coats are ruptured, and the external coat is twisted. The middle coat retracts and contracts, and the inner coat inverts into the lumen of the artery. It is a safe procedure, and is practised upon vessels as large as the femoral by many surgeons of high standing. Before the days of asepsis torsion possessed the signal merit of not introducing possible infection in ligatures. At the present time it offers no particular advantage. It is no quicker than the ligature, and damages the vessel so much that necrosis may occur. It cannot be used if the vessels are diseased. In what is known as free torsion the vessel is grasped, drawn out and twisted until the free end of the vessel is twisted off. Limited torsion is more often used. The vessel is drawn out of its sheath by a pair of forceps held horizontally, and is grasped a little distance above its extremity by another pair of forceps held vertically (Fig. 114). The first instrument is used to twist the artery six to eight times.

Acupressure is pressure applied by means of a long pin. The method of hemostasis by acupressure was devised by Sir James Y. Simpson. A pin is simply passed under a vessel (transfixion), leaving a little tissue on each side between the pin and vessel. A pin can be passed under a vessel, and a wire be thrown over the needle and twisted (circumclusion). The pin can be inserted upon one side, passed through half an inch of tissues up to the vessel, be given a quarter-twist, and be driven into the tissues across the artery (torsoclusion). Some tissue may be picked up on the pin, folded over the vessel, and pinned to the other side (retroclusion). Acupressure is occasionally used to arrest hemorrhage in inflamed or atheromatous vessels, in sloughing wounds, in scar-tissue, and when a ligature will not hold firmly.

Elevation is used as a temporary expedient or in association with some other method. It is of use in a wound of a bursa, in bleeding from a ruptured varicose vein, and is frequently used with compression.

Compression is either direct or indirect—that is, in the wound or upon its artery of supply. In the removal of the upper jaw arrest bleeding by plugging. In injury of a cerebral sinus, plug with gauze. Compression and hot water (115°–120° F.) will stop capillary bleeding. A graduated compress was formerly recommended in hemorrhage from the palmar arch. A compress will arrest bleeding from superficial veins. The knotted bandage of the scalp will arrest bleeding from the temporal artery. Long-continued pressure causes pain and inflammation.

Indirect compression is used to prevent hemorrhage or to temporarily arrest it. It may be effected by encircling a limb above a bleeding point with an Esmarch band or by applying a tourniquet or an improvised tourniquet (Fig. 117). It may also be effected by a clamp. Crile has devised a clamp to effect temporary closure of the carotid artery. In operations about the head
one or both carotids may be closed for a considerable time and bleeding may thus be largely prevented. In 10 cases Crile temporarily closed both carotids. A hypodermatic injection of atropin is given to prevent inhibition, the vessels are exposed, and the clamps are applied with just sufficient firmness to approximate the vessel-walls. No clot will form if the walls are not compressed. The patient is in the Trendelenburg position. If it is found that respiratory difficulty occurs, one clamp must be loosened. After the completion of the operation the patient must be brought to the horizontal before the clamps are removed (Crile, in "Annals of Surgery," April, 1902).

Digital compression is a form of indirect compression. It can be maintained for only a few minutes by one person, but a relay of assistants can carry it out for a considerable time. In compressing the subclavian artery, wrap a key as shown in Fig. 118, and compress the artery against the outer surface of the first rib. The shoulder must be depressed and pressure applied in the angle between the posterior border of the sternocleidomastoid and the upper border of the clavicle. The direction of the pressure should be downward, backward, and inward.

The brachial artery can be compressed against the humerus. In the upper part of the course of the artery the pressure should be from within outward (Fig. 119), in the lower part from before backward (Fig. 120). The abdominal aorta can be compressed by Macewen's method (q. v.). The common iliac can be compressed through the rectum by means of a round piece of wood known as Davy's lever. The femoral artery can be compressed just below Poupart's ligament against the psoas muscle and head of the femur.
The pressure should be directly backward. In the middle third of the thigh digital compression is unsatisfactory, and a tourniquet should always be used or an Esmarch band be employed.

**Forced flexion** is a variety of indirect compression introduced by Adelmann. It will arrest bleeding below the point compressed, but soon becomes intensely painful. Forced flexion can be maintained by bandages. Brachial hyperflexion is maintained by tying the forearm to the arm. It is often associated with the use of a pad in front of the elbow.

Genuflexion is maintained by tying the foot to the thigh. It is increased in efficiency by placing a pad in the popliteal space.

**Styptics.**—Chemicals are now rarely used to arrest hemorrhage. In epistaxis we may pack with plugs of gauze saturated with a 10 per cent. solution of antipyrin. In bleeding from a tooth-socket freeze with chlorid of ethyl spray, and then pack with gauze soaked with 10 per cent. solution of antipyrin or pack with dry sponge or styptic cotton (absorbent cotton soaked in Monsel's solution and dried). A bit of cork may be forced into the socket. In bleeding from an incised urinary meatus pack with styptic cotton and compress the lips of the meatus. Cold water, chlorid of ethyl spray, and ice act as styptics by producing reflex vascular contraction. Hot water produces contraction and coagulates the albumin. The temperature should be from 115° to 120° F. A mixture of equal parts of alcohol and water stops capillary oozing.
The Use of Gelatin in Controlling Hemorrhage.—It seems very positively proved that gelatin increases the coagulability of the blood, if given hypodermatically. It has been shown by Horatio C. Wood, Jr. ("American Medicine," May 3, 1902), that, even when administered by the stomach, digestion does not destroy its coagulating effect upon the blood. Carnot, of Paris, used it locally and with success to control epistaxis in a sufferer from hemophilia. He then employed it to arrest bleeding from hemorrhoids, tumors, and incised wounds; and demonstrated in animals that it will arrest oozing from the cut surface of the liver. Carnot used a 5 or 10 per cent. solution. It has been employed with success to control hemorrhage in many situations, is of value when applied locally, and possibly of use when injected subcutaneously.

Intravenous injections are extremely dangerous, and are apt to be followed by embolism. Subcutaneous injections are decidedly painful, and are not altogether safe, producing albuminuria and occasional embolism. Another danger that may follow the subcutaneous administration of gelatin is the development of tetanus, and several cases have been reported. The existence of disease of the kidneys contraindicates the hypodermatic use of gelatin.

It has been successfully used as an enema in intestinal hemorrhage, and as an injection in hemorrhage from the bladder. I have used it with success in arresting bleeding from the cut surface of the human liver; to check bleeding from an incised wound in a victim of leukemia; to arrest the postoperative oozing in sufferers from cholelithiasis; and in several cases of severe epistaxis.

When employed locally in solution, it should be of a strength of from 2 to 5 per cent. in normal salt solution. For hypodermatic use some employ a 5 per cent., some a 2 per cent., and some a 1 per cent. solution. In using a 1 or 2 per cent. solution a very large amount of fluid must be injected. This causes pain; and Sailer maintains that the pain is slight or absent, if the solution is not turbid and if but 10 c.c. of a 10 per cent. solution are injected. The injection may be repeated until from 1 to 3 gm. of gelatin have been administered. It should be injected on the outer side of the thigh, under the breast, or between the shoulder-blades. If the drug is given by mouth, 100 c.c. of a 10 per cent. solution is the dose; and this may be repeated every two or three hours.

On account of the possible danger of the development of lockjaw, great care in sterilizing must always be exercised. The method of preparation suggested by Joseph Sailer will be found of the greatest value. (For the formula for this see page 299.)

In view of the fact that gelatin is such an excellent culture-material, whenever it is used in the rectum, nose, pharynx, vagina, or bladder, it should be mixed with some antiseptic agent.

The exact mode in which gelatin acts in producing coagulation is not certain. Floresco maintains that it acts like an acid. Laborde states that undissolved particles of gelatin serve as centers for coagulation. Other experimenters insist that gelatin destroys the leukocytes, and thus liberates fibrin ferment.
Suprarenal extract is a valuable agent to control capillary oozing. It constricts capillaries, and if applied to a mucous membrane will rapidly blanch it. It is extensively used to check bleeding during operations on the nose, throat, larynx, and ear, and to arrest epistaxis and bleeding from the uterus. The solution to employ is adrenalin chlorid of a strength of from $1:10,000$ to $1:1000$. A piece of cotton soaked in this solution is pressed lightly upon the part or it is sprayed upon the part by an atomizer ("Practical Therapeutics," by H. A. Hare).

Chlorid of calcium, given internally, favors coagulation of the blood and is used to check oozing or to prevent hemorrhage. It is used particularly in jaundice cases when operation must be performed. If given several times a day for two or three days it increases the coagulability of the blood; but if given for more than four days, actually diminishes it. The initial dose is from 15 to 30 grains, then gr. v every hour are given until five or six doses have been taken. It is apt to provoke gastric irritability, and it is often advisable to give it by the rectum.

The actual cautery is a very ancient hemostatic. It is still used occasionally after excising the upper jaw, in bleeding after the removal of some malignant growths, in continued hemorrhage from the prostatic plexus of veins after lateral lithotomy, and to stop oozing after the excision of venereal warts. We are often driven to its use in "bleeders"—that is, those persons who have a hemorrhagic diathesis, and who may die from having a tooth pulled or from receiving a scratch. It will arrest hemorrhage, but the necrosed tissue separates, and when it separates secondary hemorrhage is apt to set in. The iron for hemostatic purposes must be at a cherry heat. The old-fashioned iron, which was heated in a charcoal furnace, is rarely used. It is large, clumsy, and cools quickly if the bleeding is profuse. In an emergency we may heat a poker or a coil of telegraph wire. The best instrument is the Paquelin cautery. The Paquelin cautery consists of an alcohol lamp, a metal chamber containing benzene, a tube of entrance for air containing two bulbs, an exit
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tube, and a wooden-handled cautery instrument, the tip of which is hollow and composed of platinum (Fig. 122). This can be kept hot even when bleeding is profuse. If the iron is very hot, it will not stop bleeding completely. In order to use the Paquelin cautery, light the lamp, heat the cautery-tip in the flame, until it becomes red, remove it from the flame, and squeeze the bulb repeatedly until the tip becomes bright red. Each time the bulb not covered with netting is squeezed air is driven through the metal chamber into the tube and cautery, and this air carries with it the vapor of benzene, which passes to the hot tip and takes fire. The degree of heat maintained depends upon the rapidity with which the bulb is squeezed.

Skene has devised a method known as electrohemostasis. He grasps the vessel or tissue with specially constructed forceps, an electric current generates heat, the tissue is cooked, and the walls of the vessel united. A heat of from 180°–190° F. is required. For the small instrument Skene uses a current of 2 ma. and for the larger instrument a current of 8 ma. *

Downes has devised an instrument to apply electrothermic hemostasis in abdominal and pelvic operations. He asserts that by this method an intra-abdominal operation can be rendered bloodless; that the lymph-ducts are sealed and the stump is sterile; that adhesions are less apt to form; and that there is less post-operative pain than if the ligature were used ("Boston Med. and Surg. Jour.," July 10, 1902).

**Rules for Arresting Primary Hemorrhage.**—1. In arterial hemorrhage tie the artery in the wound, enlarging the wound if necessary (Guthrie's rule). In tying the main artery of the limb in continuity for bleeding from a point below we fail to cut off the bleeding from the distal extremity, and hemorrhage is bound to recur. If the surgeon does not look into the wound, he cannot know what is cut: it may be only a branch, and not a main trunk. The same rule obtains in secondary hemorrhage.†

2. We can safely ligate veins as we would arteries.

3. In a wound of the superficial palmar arch tie both ends of the divided vessel.

4. In a wound of the deep palmar arch enlarge the wound, if necessary, in the direction of the flexor tendons, at the same time maintaining pressure upon the brachial artery. Catch the ends of the arch with hemostatic forceps and tie both ends. If the artery can be caught by, but cannot be tied over the point of, the forceps, leave the instrument in place for four days. If the artery cannot be caught with forceps, use a tenaculum. The ends of the divided vessel can be caught and must be caught even if large incisions are needed to effect it. An incision which will probably always expose the vessel is as follows: Make a cut on a line with the injury from the web of the fingers to above the carpus, separating the metacarpal and carpal bones, until the artery is reached. (This is really Mynter's incision for excision of the wrist.) In former days, if the surgeon found trouble in grasping the ends of the vessel, he applied a graduated compress (Fig. 116). This is applied as follows: Insert a small piece of gauze in the depths of the wound, put over this a larger piece, and keep on adding bit after bit, each successive piece larger than its predecessor, until there exists a conical pad, the apex of which is at the point of hem-

† For Murphy's observations on anastomosis of vessels, see page 312.
orrhage and the base of which is external to the surface of the palm. Bandage each finger and the thumb, put a piece of metal over the pad, wrap the hand in gauze, place the arm upon a straight splint, apply firmly an ascending spiral reverse bandage of the arm, starting as a figure-of-eight of the wrist, and hang the hand in a sling. Instead of applying a splint, we may place a pad in front of the elbow and flex the forearm on the arm. The palmar pad is left in place for six or seven days unless bleeding continues or recurs. The graduated compress is unreliable, hence it is a dangerous method of treatment. It is an evasion. It should be employed at the present time only as a temporary expedient, until ligatures can be applied. The old rule of surgery was as follows: If bleeding is maintained or begins again after application of a graduated compress, ligate the radial and ulnar arteries. If this maneuver fails, we know that the interosseous artery is furnishing the blood and that the brachial must be tied at the bend of the elbow. If this fails, amputate the hand. At the present day it is hard to conceive of such radical procedures being necessary for hemorrhage.

5. In primary hemorrhage, if the bleeding ceases, do not disturb the parts to look for the vessel. If the vessel is clearly seen in the wound, tie it; otherwise do not, as the bleeding may not recur. This rule does not hold good when a large artery is probably cut, when the subject will require transportation (as on the battle-field), when a man has delirium tremens, mania, or delirium, or when he is a heavy drinker. In these cases always look for an artery and tie it.

6. When a person is bleeding to death from a wound of an extremity, arrest hemorrhage temporarily by digital pressure in the wound and apply above the wound a tourniquet or Esmarch bandage. Bring about reaction and then ligate, but do not operate during collapse if the bleeding can be controlled by pressure.

7. If a transverse cut incompletely divides an artery, it may be found possible and may be considered desirable to suture the cut. Longitudinal cuts can certainly be sutured. If suturing is impossible, or if the surgeon prefers not to attempt it, apply a ligature on each side of the vessel-wound and then sever the artery so as to permit of complete retraction.

8. If a branch comes off just below the ligature, tie the branch as well as the main trunk.

9. If a branch of an artery is divided very close to a main trunk, the rule used to be, tie the branch and also the main trunk. It was thought that if
the branch alone were tied, the internal clot, being very short, would be washed away by the blood-current of the larger vessel. We now know that the clot is not required in repair, and under aseptic conditions it is trivial in size and rarely reaches the first collateral branch. Repair is effected by endothelial proliferation.

10. If a large vein is slightly torn, put a lateral ligature upon its wall (Fig. 123). Gather the rent and the tissue around it in a forceps and tie the pursed-up mass of vein-wall. It is a wise plan to pass the ligature through the two outer coats by means of a needle and tie the knot subsequently. This expedient prevents slipping. If a longitudinal wound exists in a large vein, take an intestinal needle and fine silk and sew it up with a Lembert suture. Transverse wounds can also be sutured.

11. When a branch of a large vein is torn close to the main trunk, tie the branch, and not the main trunk. Apply practically a lateral ligature.

12. If, after tying the cardial extremity of a cut artery, the distal extremity cannot be found, even after enlarging the wound and making a careful search, firmly pack the wound.

13. In bleeding from diploë or cancellous bone, use Horsley’s antiseptic wax, or break in bony septa with a chisel, or plug with threads of gauze or scrapings of catgut.

14. In bleeding from a vessel in a bony canal, plug the canal with an antiseptic stick and break the wood, or fill up the orifice of the canal with antiseptic wax; or, if this fails, ligate the artery of supply.

15. In bleeding from the internal mammary artery the old rule was to pass a large curved needle holding a piece of silk into the chest, under the vessel and out again, and tie the thread tightly; but it is better to make an incision and ligate the artery.

16. In bleeding from an intercostal artery make pressure upward and outward, by a tampon (Fig. 115), or throw a ligature by means of a curved needle entirely over a rib, tying it externally; or, what is better, resect a rib and tie the artery.

17. In collapse due to puncture of a deep vessel, the bleeding having ceased, do not hurry reaction by stimulants. Give the clot a chance to hold. Wrap the sufferer in hot blankets. If the condition is dangerous, however, stimulate to save life.

18. In punctured wounds, as a rule, try pressure before using ligation.

19. After a severe hemorrhage always put the patient to bed and elevate the damaged part (if it be an extremity or the head).

20. A clot which holds for twelve hours after a primary hemorrhage will probably hold permanently; but even after twelve hours be watchful and insist on rest.

21. If recurrence of a hemorrhage from a limb is feared, mark with anilin or iodin the spot on the main artery where compression is to be applied, apply a tourniquet loosely, and order the nurse to screw it up and to send for the physician at the first sign of renewed bleeding. This must often be done in gunshot-wounds.

22. When the femoral vein is divided high up, the advice commonly given is to ligate the vein and also the femoral artery. Braune taught that because of the venous valves there is no collateral circulation, and to tie the
vein alone renders gangrene inevitable. Niebergall shows that the valves may be overcome by moderate arterial pressure, and thus collateral circulation be established. Hence, when the femoral vein is divided tie the vein, but leave the artery untied, so as to furnish the necessary pressure.*

23. In extradural hemorrhage, trephine. The side to be trephined is determined by the symptoms, and not by the situation of the injury. The opening is made on a level with the upper orbital border and one and a quarter inches behind the external angular process. This opening exposes the middle meningeal and its anterior branch. If this does not expose a clot, trephine over the posterior branch, on the same level and just below the parietal eminence. When the clot is found, enlarge the opening with the rongeur, scoop out the clot, and arrest the bleeding by passing catgut ligatures on each side of the injury in the vessel through the dura, under the artery and out again, and then tying them. If the artery lies in a bony canal, plug the canal with Horsley's wax. In subdural hemorrhage open the dura and endeavor to ligate. If this procedure is impossible, pack with one piece of iodoform gauze.

24. In hemorrhage from a cerebral sinus catch the edges of the opening with forceps, if possible, and apply a lateral ligature, or leave the forceps in place for forty-eight hours, or compress firmly with one large piece of iodoform gauze.

25. In extramedullary spinal hemorrhage rapidly advancing and threatening life perform a laminectomy and arrest the hemorrhage.

26. In bleeding from a tooth-socket use chlorid of ethyl spray or ice. If this treatment fails, plug with gauze infiltrated with tannin or soaked in antipyrrin solution of a strength of 10 per cent., or in Carnot's solution of gelatin, close the jaws upon the plug, and hold them with Barton's bandage. If this expedient fails, soak the plug in Monsel's solution, or plug with a bit of cork or dry sponge, and if this is futile, use the cautery. Pressure on the carotid and ice over the jaw and neck are indicated. It may be necessary to tie the external carotid artery.

27. In intra-abdominal hemorrhage open the belly. In intra-abdominal hemorrhage it is necessary to operate during shock. If the blood accumulates so rapidly as to prevent the location of the bleeding point, compress the aorta or pack the abdominal cavity with large sponges. In seeking for the bleeding-point remove the sponges one by one, or have the pressure momentarily relaxed from time to time. In parenchymatous hemorrhage from the liver try packing with iodoform gauze. If this fails, suture the torn edge or use the cautery. Severe wounds of the spleen demand splenectomy. Wounds of the kidney may be sutured, but may require partial or complete nephrectomy. Mesenteric vessels are ligated en masse with silk (Senn). Wounds of the stomach and intestines causing hemorrhage require stitching of their edges. When there are a great many points of bleeding, take a number of sponges, tie a piece of tape firmly to each one, pack many places in the belly with the sponges, bring the tapes out of the wound, and remove the sponges from below upward one at a time, securing the bleeding points as they come into view.

28. In abdominal section for disease of the female pelvic organs bleeding

Hemostatic Methods

is limited by the clamp or by pressure-forceps. Ligation *en masse* is often practised. Use silk. A large mass can be transfixed and tied in sections. Bleeding edges are stitched. Areas of oozing are treated with temporary pressure and hot water, or, if this fails, by the cautery. Packing can be used as a tamponade, which is a gauze pouch, pieces of gauze being packed into this pouch after its insertion into the belly (Fig. 23).

29. A ruptured varicose vein requires a compress, a bandage from the periphery up, and elevation.

30. Most cases of capillary bleeding can be controlled by compression with gauze pads soaked in water at a temperature of 115° to 120° F. This contracts the vessels and seals them with coagulated albumin. Keetly in 1878 impressed the profession with the value of hot water as a styptic. Centuries ago surgeons used hot oil for the same purpose. Capillary bleeding can often be controlled by the application of gauze soaked in Carnot’s solution of gelatin. A solution of suprarenal extract may control capillary oozing. If other means fail to control capillary hemorrhage, the cautery must be used. Understand that the term capillary bleeding does not so much mean bleeding from genuine capillaries as it does bleeding from arterioles and venules.

31. Pressure above a wound arrests arterial hemorrhage, but aggravates venous bleeding. Pressure below a wound arrests venous hemorrhage, but increases arterial bleeding. Remember these facts when applying pressure.

32. A moderate epistaxis may be arrested by an injection of peroxid of hydrogen, an injection of a solution of antipyrin, or an injection of Carnot’s solution of salt and gelatin. Favorite domestic expedients are keeping the arms raised above the head and applying ice to the back of the neck. In severe epistaxis, or bleeding from the nose, examine the nose by means of a head-mirror and a speculum. If a little point of ulceration is found, touch it with a hot iron. If the bleeding is a general ooze, if it is high up, or if the cautery does not arrest it, pack the nares. It may be necessary to pack one
Diseases and Injuries of the Heart and Vessels

nostril or both. Pass a Bellocq cannula (Fig. 124) along the floor of one nostril into the pharynx, project the stem into the mouth, tie a plug of lint or gauze wet with Carnot’s solution of salt and gelatin to the stem, and withdraw it. Hold the double string which emerges from the nostril in the hand and pack gauze wet with gelatin solution from before backward. Tie the strings together over the plug; if both nostrils are plugged, the strings from one nostril are fastened to the strings from the other. Do not use subsulphate of iron, as it forms a disgusting, clotty, adherent mass. If a Bellocq cannula is not obtainable, push a soft catheter into the pharynx, catch it with a finger, pull it forward, and tie the plug to it. Remove the plug in two or three days. Do not leave it longer. It blocks up decomposing fluids and may lead to blood-poisoning. Pick out the front plug first, hold the string of the second plug in the hand, push the plug back into the pharynx, catch it with forceps, and withdraw plug and string through the mouth.

33. In gunshot-wounds the primary hemorrhage is slight unless a large vessel is cut. The bleeding may be visible or may be internal (concealed), the blood running into a natural cavity or among the muscles. Capillary oozing is arrested by very hot water and compression. Venous bleeding is usually arrested by compression. If a large vessel is the source of bleeding, enlarge the wound and tie the vessel. If the artery cannot be found in the wound, tie the main trunk.

34. In prolonged bleeding from a leech-bite try compression over a plug saturated with alum or with tannin. If this fails, pass under the wound a harelip pin and encircle it with a piece of silk. If this fails, use the actual cautery or excise the bite and suture the incision.

35. In severe bleeding from the ear elevate the head, put an ice-bag over the mastoid, give opium and acetate of lead, and, if blood runs into the mouth, plug the Eustachian tube with a piece of catheter.

36. Umbilical hemorrhage in infants requires pressure over a plug containing tannin, alum, or gelatin solution. If compression fails, pass harelip pins under the navel and apply a twisted suture. If this fails, use the actual cautery.

37. Rectal bleeding requires elevation of the buttocks, insertion of plugs of ice, ice to the anus and perineum, astringent injections (alum), and the internal use of opium and acetate of lead. If these means fail, plug the bowel over a catheter, or insert and inflate a Peterson bag or a colpeurynter, or tampon and use a T-bandage. If the bleeding persists or if a considerable vessel is bleeding, stretch the sphincter, catch the bowel and draw it down, seize the vessel, and tie it if possible; if not, leave the forceps in place. Failing in this, the actual cautery must be used.

38. Subcutaneous hemorrhage, if severe and persistent, demands that an incision be made and ligatures be applied.

39. Bleeding from a cut urethral meatus requires the insertion of styptic cotton and the application of pressure. Moderate bleeding from the deeper urethra can usually be arrested by a very warm bougie, by very warm injections, or by tying a condom over a catheter, and, after inserting it, inflating the condom by blowing through the catheter and plugging the orifice of the instrument, thus using pressure. Sitting with the perineum on a thickly folded towel is useful. Ice to the perineum does good. The patient can
lie down, have a folded towel applied to the perineum, and a crutch-handle pushed upon the towel, the lower end of the crutch being jammed against the foot of the bed. If a solid bougie has been first introduced, firm pressure can be made by this method. If these means are futile, perform an external urethrotomy and reach the bleeding point.

40. Hemorrhage from the prostate requires hot injections, the introduction of a large bougie first dipped in very warm water, and the retention of a catheter for two days. Perineal section may be required, or suprapubic cystotomy with packing which does not occlude the ureteral orifices.

41. Vesical hemorrhage usually ceases spontaneously, in which case the urine must be drawn off and the viscus be washed out frequently with a solution of boric acid, to prevent septic cystitis. If blood-clots prevent the flow of urine, break them up with a catheter or a lithotrite and inject vinegar and water, a 2 per cent. solution of carbolic acid, or a solution of bicarbonate of sodium. Perfect quiet is to be maintained, cold acid drinks given, ice-bags put to the perineum and hypogastric region, and opium with acetate of lead, or gallic acid to be given by the mouth. If the hemorrhage is severe or persistent, perform a suprapubic cystotomy, wash out the bladder, and, if necessary, plug the bladder with gauze, leaving the ureters uncovered.

42. In hemorrhage after lateral lithotomy, ligate if possible. If the vessel can be caught but cannot be ligated, leave the forceps in place. If it is not possible to catch the vessel with forceps, use a tenaculum. If the tenaculum fails, pass a threaded curved needle through the tissues around the vessel and tie the ligature (suture ligature). Plugs of ice and injections of hot water may be tried. These means failing, pressure is indicated. Take a cannula, fasten to it a chemise (Fig. 125), empty clots from the bladder, insert the instrument into the viscus, and pack gauze between the sides of the cannula and the chemise. The chemise is bulged out and pressure is made. Tie the cannula by means of tapes to a T-bandage. Pressure is thus combined with vesical drainage. Buckstone Brown makes pressure by inflating a rubber bag with air. The hot iron may occasionally be demanded.

43. Renal bleeding requires ice to the loin, tannic acid and opium, gallic acid or sulphuric acid internally, and perfect quiet. The use of a cystoscope will show from which ureter blood is emerging. If the bleeding threatens life and the diseased organ is identified, make a lumbar incision, and suture or perform nephrectomy; if not sure which organ is diseased, perform an exploratory laparotomy.

44. Vaginal hemorrhage requires the ligature or the tampon.

45. Severe uterine hemorrhage (unconnected with pregnancy) requires the tampon. Persistent hemorrhage due to morbid growths may require removal of the tubes and appendages, ligation of the uterine and ovarian arteries, or hysterectomy.
46. Hematemesis, or bleeding from the stomach, is treated by the swallow-
ing of ice, giving tannic acid (dose, 20 or 30 grains) or Monsel's solution (3 drops). Gelatin by the mouth is recommended. Never give tannic acid and Monsel's solution at the same time, as they mix and form ink. Opium is usually ordered. Acetate of lead and opium and gallic acid are favorite remedies, and ergot is used by many. Give no food by the stomach. If life is threatened by bleeding from an ulcer, open the belly and excise the ulcer and suture the wound. If severe hemorrhage follows injury, perform an exploratory laparotomy. Always remember that furious and even fatal gastro-intestinal hemorrhage may be due to cirrhosis of the liver, and a slight injury may be the exciting cause of such a hemorrhage. In this condition, of course, operation is useless.

47. In bleeding from the small bowel give acetate of lead and opium, sulphuric acid, or Monsel's salt in pill form (3 grains), allow no food for a time, and insist on liquid diet for a considerable period. If hemorrhage threatens life, do a celiotomy and find the cause. If ulcer exists, excise it and suture, or suture a perforation without previously excising. If violent hemorrhage follows injury, explore to discover the cause.

48. In bleeding from the large bowel, use styptic injections (10 grains of alum or 5 grains of bluestone to \( \frac{3}{4} \) of water). If bleeding is low down, use small amounts of the solution; if high up, large amounts. Do not use absorbable poisons. In dangerous cases perform an exploratory operation to find the cause. (For rectal bleeding see 37, p. 324).

49. Hemoptysis or bleeding from the lung, is treated by morphin hypoder-matically, by perfect rest, by dry cups or ice over the affected spot if it can be located, and by the administration of gallic acid, which drug aids coagulation.* Of late, nitrite of amyl by inhalation has given good results.

50. In hemorrhage from wound of the lung do not open the chest unless life is threatened. If life is endangered, resect a rib, allow the lung to collapse, and see if this arrests bleeding. If bleeding still continues, remove several ribs, find the bleeding point, ligate or employ forcipressure. A small cavity may be packed with gauze. If a large surface is bleeding, fill the pleural sac with gauze and pack more gauze against the oozing surface.†

**Reactionary or Recurrent Hemorrhage** (called also Consecutive, Intermediate, or Intercurrent).—This form of hemorrhage comes on during reaction from an accident or an operation—that is, during the first forty-eight hours, but usually within twelve hours. It is bleeding from a vessel or vessels which did not bleed during the shock which accompanied operation, and which vessels were overlooked and not tied. It may be due to faultily applied ligatures. It is favored by vascular excitement or hypertrophied heart. The bleeding is rarely sudden and severe, but is usually a gradual drop or trickle. The Esmarch apparatus is not unusually the cause. The constricting band paralyses the smaller arteries, which do not bleed during shock and do not contract as shock departs; hence bleeding comes on with reaction. To lessen the danger of the Esmarch apparatus use a broad con-
Secondary Hemorrhage

Secondary hemorrhage may occur at any time in the period between forty-eight hours after the accident or operation and the complete cicatrization of the wound. Secondary hemorrhage may be due to atheroma, to slipping of a ligature, to inclusion of nerve, fascia, or muscle in the ligature, to sloughing, to erysipelas, to septicemia, to pyemia, to gangrene, and to overaction of the heart. The great majority of cases of secondary hemorrhage are due to infection, and the application of modern surgical principles has rendered secondary bleeding a rare calamity. If during an operation the vessels are found atheromatous, a thread should be passed, by means of a Hagedorn needle, around the vessel, including a cushion of tissue in the loop of the ligature (this prevents cutting through, Fig. 112). Acupressure may be used in such a case. If the surgeon decides to employ the ligature, he must not tie tightly, but must endeavor to approximate the coats rather than to cut them. Two ligatures can be applied or the stay-knot may be used. One great trouble with atheromatous arteries is that their coats cannot contract; another trouble is that the ligature cuts entirely through them. If after an operation the pulse is found to be forcible, rapid, and jerking, give aconite, opium, and low diet. The bleeding may come on suddenly and furiously, but is usually preceded by a bloody stain in wound-fluids which had become free from blood.

Treatment of Secondary Hemorrhage.—Suppose a case of leg-amputation in which, several days after the operation, a little oozing is detected: the treatment is to elevate the stump, apply two compresses over the flaps, and carry a firm bandage up the leg. If the bleeding is profuse or becomes so, make pressure on the main artery, open and tear the flaps apart with the fingers, find the bleeding vessel and tie it, turn out the clots, asepticize, close, drain, and dress. If the bleeding begins at a period when the stump is nearly healed, cut down on the main artery just above the stump and ligate. In secondary hemorrhage from a blood-vessel in nodular tissue, apply a suture-ligature or tie higher up, or, if this fails, amputate. When secondary hemorrhage arises in a sloughing wound apply a tourniquet or an Esmarch bandage, tear the wound open to the bottom with a grooved director, look for the orifice of the vessel, dissect the artery up until a healthy point is reached, cut it across, and tie both ends. If this fails, apply a suture-ligature or use acupressure. In secondary hemorrhage from atheromatous vessels, use the suture-ligature, double ligature with a stay-knot, or employ acupressure.

Secondary hemorrhage may occur after ligation in continuity, the blood usually coming from the distal side. If the dressings are slightly stained with blood, put on a graduated compress. If the bleeding continues or is
severe, make pressure on the main artery of the limb, open the wound and ligate, wrap the part in cotton, elevate, and surround with hot bottles. If this religation is done on the femoral and fails, do not ligate higher up, as gangrene will certainly occur, but amputate at once, above the point of hemorrhage. If dealing with the brachial artery, do not amputate, but ligate higher up and make compression in the wound. In a secondary hemorrhage from the innominate, tie the innominate again and also tie the vertebral.


Paracentesis auriculi, or tapping the heart-cavity, has been suggested for the relief of an overdistended heart from pulmonary congestion. The right auricle can be tapped. Push the aspirator needle directly backward at the right edge of the sternum, in the third interspace. This operation is not recommended, as it is highly dangerous and is of questionable value.

Paracentesis pericardii, or tapping the pericardial sac, is done only when life is endangered by effusion. Introduce the needle two inches to the left of the left edge of the sternum, in the fifth interspace, and push it directly backward (thus avoiding the internal mammary artery). The operation of tapping is extremely dangerous. The heart is lifted up and pushed forward by an effusion and the needle is apt to enter it. The puncture of a ventricle may do no harm, although it is apt to, but the puncture of an auricle is liable to be followed by fatal hemorrhage. It is wiser and safer to expose the pericardium and incise it, as is done for pericardial suppuration.

Operation for Pericardial Effusion or Suppuration.—The operation of tapping should be abandoned in favor of a safer but more radical procedure. There is no spot where we can introduce the needle with perfect safety, and the heart or pleura may be wounded; further, as Brentano shows,* tapping will not completely empty the sac. In a purulent case tapping gives practically no chance of cure. No general anesthetic should be used. A portion of the fifth rib or the cartilage on the fifth rib should be excised, the pericardium exposed and punctured in order to determine the nature of the fluid present. If the fluid is serous, it can be drained away through a small incision, and the pericardium may either be sutured or drained with gauze. If the fluid be purulent, the pericardium should be stitched to the chest-wall and opened. Clots should be removed by irrigation with hot salt solution and a drainage-tube should be introduced.

Operation for Wound of the Heart.—In many cases it is obviously impossible to administer an anesthetic, but when possible it should be given because the movements of the patient while under the knife make operation difficult and increase bleeding. Ether may be used or we may take Hill's advice and give chloroform. Hill would give an anesthetic unless the patient is unconscious and the corneal reflex is abolished. Personally, I would be disposed to use local anesthesia unless the patient's general condition were good or at least fair. The pericardium is exposed freely and Rotter's incision gives excellent access. This exposure is described by Hill in the "Medical Record," November 29, 1902, and was employed in his successful case. Begin an incision over the third rib five-eighths of an inch from the left edge of the sternum and carry it outward along the rib for four inches. Begin an

* Deut. med. Woch., Feb. 11, 1890.