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Modern Surgery - Chapter 18. Diseases and Injuries of the Heart and Vessels - Heart and Pericardium

John Chalmers Da Costa
Jefferson Medical College

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XVIII. DISEASES AND INJURIES OF THE HEART AND VESSELS.

Heart and Pericardium.—In acute pulmonary congestion the venous side of the heart is overdistended with blood, and the surgeon in desperate cases may tap the right auricle (see Paracentesis Auriculi). Pericardial effusion, if severe, calls for aspiration or incision, and purulent pericarditis demands incision and drainage.

Rupture, Wounds and Injuries.—Rupture.—The heart may rupture and cause instant death, but rupture may not be instantly fatal. Curtin reported a case in which death did not occur for over twenty-four hours. Elsner reported a case of rupture in which life was prolonged for ten days. One case lived eleven days. In cases in which death does not occur rapidly the rupture must be so small that very little blood escapes. Rupture occurs in a damaged heart, a heart in which the muscular fiber is fatty, is fibroid, or is necrotic from suppuration. It may be traumatic, resulting from a fall or a blow upon the chest, or non-traumatic, following a great effort or strain. If death does not at once take place the pulse becomes very rapid, there is precordial pain, dyspnea, cyanosis, feeble heart-sounds, rapid respiration, great restlessness, collapse, and syncope, and the development of a triangular area of dulness. Positive diagnosis is impossible. Meyer collected 36 cases of rupture of heart reported since 1870. Death occurs from accumulation of blood in the pericardium. Aspiration is useless, as fresh blood replaces what is withdrawn. Suturing must fail in non-traumatic cases because of the badly diseased myocardium. In traumatic cases it may possibly succeed.

Wounds of the Pericardium and Heart.—Severe wounds usually, though not always, produce death, but slight wounds may not prove fatal. It is a popular impression that the expression "stabbed to the heart" is another way of saying that instant death has occurred. This view was accepted even by surgeons during many centuries. During the sixteenth century sportsmen found now and then bullets and arrow-tips healed in the heart-walls of animals they had slain. At this time the famous case of a duelist was published by Paré. This man received a sword thrust in the heart, but was able to run after his opponent many hundred feet before falling down in death. (See "An Experimental Investigation of the Treatment of Wounds of the Heart," by Charles A. Elsberg, in "The Journal of Experimental Medicine," Sept. and Nov., 1899.) From Paré's time until our own it has been recognized by surgeons that a wound of the heart does not of necessity produce immediate death and may even be recovered from.

In 1867 G. Fisher published a study of 452 cases of wound of the heart, and pointed out the surprising fact that from 7 to 10 per cent. of such cases recover. In recent years Rosenthal, Block, Del Vechio, and others have proved by animal experimentation not only that cardiac wounds are not of necessity instantly fatal, and that in some cases they may be recovered from, but that the suturing of such wounds is possible and greatly enhances the chance of recovery. L. L. Hill ("Med. Record," Nov. 29, 1902) shows that although 90 per cent. of heart-wounds are penetrating, only 19 per cent. are
immediately fatal. Sudden death occurs when Kronecker's coordination center is damaged. Several times during post-mortem examinations on human beings healed scars have been found upon the heart. The heart has been punctured a number of times accidentally or intentionally, and death has not ensued. John B. Roberts,* of Philadelphia, suggested in 1881 that it would be proper to try to suture wounds of the heart.

**Symptoms.**—A wound of the heart causes hemorrhage, usually copious; but owing to the interlocking of muscular fibers the hemorrhage is often slight. Bleeding may take place into the pericardial sac in some cases where the pericardium has been injured and the heart has escaped. Such an injury is occasionally inflicted by the sharp end of a fractured rib. The wound is rarely at or near the apex of the sac. In most cases the pleural cavity is opened and severe hemothorax occurs. The lung may or may not be injured. A wound of the pericardium or heart causes profound shock, irregular or very weak pulse, sighing respiration, dyspnea, and, it may be, the signs of hemopericardium or hemothorax. There may or may not be serious external bleeding. Fatal concealed hemorrhage may occur. Pain is constant, and attacks of syncope are the rule. Death is apt to occur suddenly from shock, hemorrhage, and inability of the heart to contract because of the severed fibers, or inability of the heart to dilate because of the pressure of blood in the pericardial sac. If a wound of the pericardium or heart does not cause death during the first day or two, inflammation follows (traumatic pericarditis or carditis).

**Treatment.**—Wounds of the pericardium and heart should be sutured. The cutaneous surface should be rapidly disinfected, and every effort must be made to antagonize shock during the operation. The patient should be wrapped in hot blankets and surrounded with hot bottles or hot water-bags, or should be placed upon a table composed of pipes in which hot water circulates. The foot of the bed should be raised. Hot saline fluid should be infused into a vein. Adrenalin chlorid may prove of service. The extremities, except the one selected to infuse salt solution in, should be bandaged (auto-transfusion), an enema of hot coffee and whiskey should be given, and atropin should be given hypodermatically. It is rarely proper to give an anesthetic. If there has been a wound of the cardiac region and the symptoms are threatening to life, at once do an exploratory operation (G. T. Vaughan, "Med. News," Dec. 7, 1901). The heart is exposed by resecting several ribs, and usually the pleural sac is opened. Parrozzani makes a trap-door in the chest, the hinges of the door being the rib-cartilages. The heart is exposed, clots are removed from the pericardial sac, and the sac is irrigated with hot saline fluid. The bleeding may be furious. A non-penetrating wound of the ventricle may bleed so profusely during systole as to resemble a penetrating wound (Sherman). A penetrating wound may bleed most during diastole. The motion of the chest makes manipulation difficult. It is wise to insert two traction sutures in order to lift the heart toward the operator. A wound in the heart is sutured with interrupted sutures of silk, which are passed by means of a round, curved needle, and if a cavity of the heart is open, each suture includes the whole thickness of the heart-wall except the endocardium. If possible, the

*The author, in Progressive Medicine, vol. i, 1899.
sutures should be tied during diastole, otherwise they are apt to cut out. The pericardium is sutured with silk, or, as was done in one successful case, the sac is packed with iodoform gauze (Rehn's case). It is not absolutely necessary to drain the pericardial sac. Clots are removed from the pleural sac by irrigation with hot saline solution, pulmonary bleeding is arrested by the suture or by packing, and a wound in the lung, especially if it communicates with the air-passages, is sutured if the patient's condition justifies prolonging the operation.*

After such an operation the patient is in great danger, and every effort should be made to save him from shock. In performing operations upon the heart the pleura may be opened by design or by accident. When the pleura is opened, there is always danger of pneumothorax, pulmonary collapse, and overwhelming shock. It is a great advantage in such cases to have at hand the Fell-O'Dwyer apparatus, which will prevent or amend pulmonary collapse.

Dalton has sutured the pericardium. Rehn sutured a wound of the heart and packed the pericardium with gauze, and the patient recovered. Parrozani successfully sutured a wound of the ventricle. Williams reports recovery after a stab-wound of the heart, the pericardium having been sutured. Farenzi sutured a stab-wound of the left ventricle, and the patient lived several days. Cappelan sutured a wound of the heart, and the patient lived two and one-half days. Sherman, in the address on Surgery delivered before the American Medical Association in 1902 ("Jour. Am. Med. Assoc.," June 14, 1902), gave a table containing 34 cases of heart suture since 1896. Only 2 of these were bullet-wounds, 32 were incised or lacerated wounds. In 32 cases the ventricle was injured; in 2, the auricle. The left ventricle suffered 17 times and the right ventricle 13 times. In 7 cases it was necessary to drain the pericardial and the pleural cavity after suturing; in 4 the pleura only was drained; the other cases were not drained. Five died during the operation; 10 died soon afterward. In 19 the suturing was successfully carried out, and although 6 died later of infection, secondary hemorrhage did not occur. Thirteen recovered and 4 of these recovered in spite of infection. L. L. Hill, of Montgomery, Alabama ("Med. Record," Nov. 29, 1902), reports the successful suturing of a stab-wound of the left ventricle of a boy thirteen years of age. The operation was performed eight hours after the stabbing. Hill publishes a table of 39 cases with 14 recoveries, and concludes that: The right ventricle is most often, the left auricle least often, injured; wound of the auricle is more dangerous than wound of the ventricle; and wound of the apex is less dangerous than either. A needle puncture rarely causes serious bleeding from a ventricle, but is very apt to cause severe bleeding from an auricle. A wound received during diastole is less dangerous than one received during systole. Wounds of the right heart bleed more than wounds of the left heart. If operation is performed, the mortality is about 63 per cent.; otherwise it is 90 per cent.

If there is suspicion of a heart-wound, perform an exploratory operation. The immediate dangers of the operation are hemorrhage, shock, and the entrance of air. The late dangers are pericarditis, empyema, and pneumonia (Vaughan). Traumatic carditis or pericarditis is treated in the same way as

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idiopathic cases. Pus in the pericardial sac should be evacuated by resection of the fourth left costal cartilage and incision of the pericardium (von Eiselsberg's case).

**Pericarditis.**—Pericarditis is an infectious condition that may be traumatic or non-traumatic. If pericarditis follows an open wound, it is obvious how the infection must have entered; if it follows a bruise or a contusion, the injury has rendered the pericardium a point of least resistance. In some few cases, which are known as primary pericarditis, it is impossible to determine how the micro-organisms gained entrance. The ordinary form appears as a complication of certain infectious diseases, such as septicemia, pneumonia, rheumatism, and tuberculosis. It may be secondary to some adjacent infection, such as an empyema. A tuberculous abscess may break into the pericardium, and an abscess even from a distant point may burrow into it. A great variety of bacteria may be responsible for pericarditis. The discharge may be serofibrinous; this is an evidence of its being a mild infection, and such a discharge may undergo absorption. On the other hand, the discharge may be purulent, and in such a case cure will never follow absorption. In pericarditis there is usually some pain in the region of the heart, and this pain is apt to extend into the left arm. The heart is overacting, the heart-sounds are indistinct, the pulse is strong and very rapid, there is an increased area of cardiac dulness, and the patient complains of dyspnea. The temperature is elevated, and a double friction-sound may be made out upon auscultation.

**Treatment.**—Ordinary pericarditis, without pus-formation or extensive effusion, is managed by the physician; but when there is extensive effusion, it may be necessary to open the pericardium, and if there is purulent effusion the pericardium must be opened. The procedure usually practised in the past to relieve pericarditis with marked effusion was aspiration. This, however, is extremely dangerous. The heart is not pushed back by the pericardial effusion, but is lifted upward and forward; and it is impossible to select any place for aspiration that assures us that there will be no danger of puncturing the heart. In cases of extensive pericardial effusion, and also in cases of suppuration within the pericardium, an inch or more of the cartilage of the fourth rib of the left side should be removed or two inches of the fourth rib itself, and the pericardial sac should be formally incised. In this operation it may be necessary to tie the internal mammary artery. The pericardial sac is cleared of purulent material and fibrinous masses by irrigation, and the edges of the pericardial wound are sutured to the edges of the superficial wound and gauze drainage is introduced. Incision is safer and more certainly curative than aspiration; for whereas aspiration might be curative in pericardial effusion, it cannot be so if the effusion is purulent.

**Phlebitis, or Inflammation of a Vein.**—**Acute Phlebitis.**—Phlebitis may be *plastic* or it may be *injective*. Plastic phlebitis, while occasionally due to rheumatism, to gout, to advanced phthisis, to a febrile malady, or to some other constitutional condition, usually takes its origin from a wound or other injury, from the extension to the vein of a perivascular inflammation, or, in the portal region, from an embolus. Varicose veins are particularly liable to phlebitis. When phlebitis begins a thrombus usually forms because of the destruction of the endothelial coat of the vessel, and this clot may give
rise to emboli, may be absorbed, or may be organized. An aseptic clot organizes and the vein becomes permanently narrowed or blocked. A septic clot is apt to soften and break up. In the lower extremities paraphlebitis is common with slight involvement of coats, and no clot may form. Clot-formation causes edema. Infective phlebitis is a suppurative inflammation of a vein, arising by infection from suppurating perivascular tissues (infective thrombophlebitis). It is not unusually met with in cellulitis or phlegmonous erysipelas, may arise in the lateral sinus as a result of mastoid suppuration, or in the liver from appendicitis or phlebitis of the rectal veins. A thrombus forms, the vein-wall suppurates, is softened and in part destroyed, and the infected clot softens and gives rise to emboli. No bleeding occurs when the vein ruptures, as a barrier of clot keeps back the blood-stream. The clot of suppurative phlebitis cannot be absorbed and cannot organize. Septic phlebitis causes pyemia, and the infected clots of pyemia cause phlebitis at the points of lodgment.

Phlebitis of the iliac vein may follow an abdominal operation when there is no evidence of infection. Strange to say, it is most apt to attack the left iliac vein; it matters not upon which side the operation was performed. It may be due to toxins damaging the inner coat of the vein, but feeble circulation is a powerful factor in its production. Vandevere reported 4 cases in which sepsis was positively absent ("American Medicine," July 13, 1901). I have seen it occur in the left iliac vein after an interval operation for appendicitis. Phlebitis may arise in the vein of one extremity, a clot may form, and this may be absorbed or may organize. Another extremity may be involved afterward or simultaneously.

**Symptoms.**—The symptoms of plastic phlebitis are pain, tenderness in and around a vein, discoloration over it, and edema below the seat of the disease. Suppurative phlebitis, besides these conditions, causes the constitutional symptoms of pyemia (page 164).

**Treatment.**—The treatment of phlebitis of an extremity comprises rest in bed for from four to six weeks, slight elevation of the part, the use of cold for the first twenty-four hours, and then the application of external heat and a flannel bandage. If the patient is gouty or rheumatic appropriate remedies should be given. A clot does not always form in a vein, but if one forms there is danger of embolism; hence massage and both active and passive movement are dangerous until the clot becomes firm. When a vein is involved in a suppurative process and septic thrombophlebitis exists, ligate the vein, if possible, above and below the clot, open the vessel, and wash out the infected clot, or, if dealing with an accessible vein, extirpate the involved portion. This plan of treatment is always to be applied in infective thrombophlebitis of the lateral sinus and of the internal saphenous vein. The constitutional treatment is that of pyemia.

**Chronic Phlebitis.**—This rare condition is known as phlebosclerosis and it is a chronic inflammation of the wall of a vein, producing a fibrous change in the vascular coats. It may arise in a part the seat of chronic venous engorgement, but its most frequent cause is syphilis.

**Varicose Veins; Phlebectasis, Phlebectasia, or Varix.**—**Definition and Causes.**—Varicose veins are unnatural, irregular, and permanently dilated veins which are elongated and pursue a tortuous course.
This condition is very common, and 20 per cent. of adults exhibit it in some degree in one region or another. Some facts indicate hereditary predisposition. In over 80 per cent. of cases the trouble begins before the age of twenty-five. The causes of varicose veins are said to be obstruction to venous return and weakness of cardiac action, which lessens the propulsion of the blood-stream. A. Pearce Gould says obstruction is not a cause, because in pregnancy varicose veins may be seen early, before the womb is much enlarged. The real cause is probably a predisposition to the growth of vein-tissue, which leads to valve failure and a regurgitation of blood from the deep veins into the superficial venous channels (A. Pearce Gould, in "Lancet," March 1 and 15 and June 7, 1902). As Billroth said over thirty years ago, sudden obstruction causes edema and gradual obstruction a

Fig. 93.—Varicose veins.

free collateral circulation. Neither sudden nor gradual obstruction can cause varicosity unless the veins are predisposed by a tendency hereditary or acquired.

Varicose veins may occur in any portion of the body, but are chiefly met with on the inner side of the lower extremity, in the spermatic cord, and in the rectum. Varix in the leg is met with during and after pregnancy and in persons who stand upon their feet for long periods. It is especially common in the long saphenous vein, which, being subcutaneous, has no muscular aid in supporting the blood-column and in urging it on. The deep as well as the superficial veins may become varicose. Verneuil maintained that varix of the superficial veins is almost always secondary to varix of the deep veins, a radical view which seems improbable. It is certain, however, that after
Varicose Veins; Phlebectasis, Phlebectasia, or Varix

contusions of the leg it is not unusual for the deep veins to become filled with clot and for the superficial veins to dilate notably. By the term “caput meduse” is meant dilated veins radiating from the umbilicus. The veins of the esophagus may become varicose, and this malady is commonly unrecognized clinically. Varicose veins are in rare instances congenital; but they are most often seen in the aged, and usually begin between the ages of twenty and forty. They are more common in women than in men, owing, it is believed, to the influence of pregnancy.

Varix of the spermatic cord is known as “varicocele.” It is apt to appear about the time of puberty, and most adult men have at least a slight varicocele. Varix is more likely to appear in the left spermatic vein than in the vein of the right side, because the left spermatic vein has no valves (Brinton).

Varicose tumors of the rectum constitute “hemorrhoids” or “piles.” Piles are caused by obstruction to the upward flow in the hemorrhoidal veins, either by obstructive liver disease, enlargement of the uterus or prostate, or the presence in the rectum of fecal masses in a person habitually constipated.

A vein under pressure may dilate more at one spot than at another, the distention being greatest back of a valve or near the mouth of a tributary. The valves become incompetent and the dilatation becomes still greater. Callender has pointed out that varix is apt to begin where the deep vessels join the superficial veins. At this point Treves says three forces meet: the blood-column above, the valve below, and the force of the blood-current. At the spot where the pressure is greatest the vein-wall dilates, and from this dilatation the blood-current is deflected and causes another dilatation higher up and on the opposite side of the vessel. The blood is again deflected and causes another dilatation, and so on (Agnew). The vein-wall may become fibrous, but usually it is thin and sometimes it ruptures. The veins not only dilate, but they also become longer, and hence do not remain straight, but twist and assume a characteristic form. It seems probable that the first step in the process is a growth of new venous tissue (A. Pearce Gould) and then follow lengthening, tortuosity, incompetence of the valves, and dilatation of the vessel.

Delbet * points out that varicose veins of the leg, which begin in the thigh, result from valvular incompetence, and ulcers arise from variations of pressure due to valvular incompetence. This incompetence of the valves does harm by allowing the intravenous pressure to equal the pressure in the arterioles, a condition which arrests capillary circulation, causes congestion, and greatly lowers tissue-resistance. Incompetent valves also favor ulceration by developing a vicious venous circle first described by Trendelenburg. Blood passing through this circle loses nutritive elements. Trendelenburg has described the vicious circle as follows: Blood in the saphenous vein flows toward the periphery instead of toward the center, it passes into the veins which connect the superficial veins with the deep veins and then enters the tibial and peroneal veins. It passes from the tibial and peroneal into the popliteal and femoral veins, and some of it leaves the femoral vein and again enters the saphenous.

The skin over varicose veins in the leg is often discolored by pigmentation due to the red blood-cells having escaped from the vessel and broken up.

The tissues around a varicose vein become atrophied from pressure, and it is not unusual to meet with a very large vein whose thin walls are in close contact with skin. In this condition rupture and hemorrhage are probable. When the vein-wall forms a pouch-like dilatation the condition is spoken of as a cyst. Varicose veins are apt to inflame, and thrombosis frequently occurs. When a thrombus forms, especially if the patient walks about, emboli may be broken off and carried into the circulation, but embolic formation is not nearly so common as a result of thrombosis in a varicose vein as in thrombosis in an undistended and unelongated vessel. In varicose veins of the thigh, however, the chance of embolism following thrombosis is much greater than when the veins of the leg alone are involved. In some elderly people thrombus actually effects spontaneous cure. When a thrombus organizes, more or less calcification is apt to ensue, and a vein-stone or phlebolith is formed. After middle life many varicosities remain stationary or cease to give trouble. The chief complications of varicose veins of an extremity are thrombosis, edema, violent hemorrhage from rupture, phlebitis, eczema, and chronic ulceration.

Treatment.—The treatment of varix may be palliative or curative, but whichever plan is followed, the surgeon should endeavor first of all to remove the exciting cause. An essential part of palliative treatment is to attend to the general health, to keep up the force and activity of the circulation, and to prevent constipation. The patient should exercise in the open air and should lie down for a time, if possible, every afternoon. Instead of lying down for a time during each day, he may sit down and elevate the legs, resting them on a table, and thus assuming a position supposed to be peculiarly American. Locally, in varix of the leg, use a flannel roller or Martin’s rubber bandage to support the veins and drive the blood into the deeper vessels which have muscular support. The use of a rubber pad filled with glycerin and applied over the saphenous vein so as to support the blood-column and act as a valve, has been recommended. Locally, in varicocele, pour cold water upon the scrotum twice a day and order the patient to wear a suspensory bandage. Locally, in hemorrhoids, use injections of ice-water and astringent suppositories. A purely local varix should be excised, because there is always danger of injury, and consequently of hemorrhage or thrombosis. If the superficial veins have dilated because of thrombosis of the deep veins and edema exists, operation is contraindicated, as its performance might lead to permanent edema. If the disease involves the leg only, operative treatment is rarely required and may even do harm. Such cases are operated upon if there are cyst-like dilatations, if thrombi form, and, as Bennett points out, if a thin-walled vein crosses the tibia, and is thus exposed to the danger of injury and thrombosis.*

If the leg is involved in the process, and the saphena in the thigh is also varicose, operation should be performed.

If a thrombus forms in a varicose vein, tie the vein above and below the clot, divide the vessel in two places, and remove the vein and the clot within it. Thrombosis of a varicose vein is not so apt to lead to emboli as thrombosis in a non-varicose vein, but it may do so, and the condition is dangerous.

Arteritis

If edema is marked, and increases in spite of properly applied bandages, etc., it probably signifies clot-formation, and the patient should remain in bed until this question is determined. Hemorrhage from a ruptured varicose vein of an extremity is usually readily arrested by compression and elevation.

The radical treatment of varix of the leg often does good, often relieves some annoying condition, but rarely absolutely cures (W. H. Bennett). There are several methods of operation: ligation with excision of part of the vein, exposure and ligation of the vein below the saphenous opening, or circular incision around the leg (see Operations upon Vessels).

Nevus.—(See Tumors.)

Arteritis, or inflammation of an artery, is acute or chronic.

Acute Arteritis.—Slight inflammation is by no means unusual, but severe arteritis is decidedly rare. It may follow direct injury or arise secondarily to a perivascular inflammation. An artery is very resistant to the spread of inflammation, but we sometimes encounter suppurative arteritis in a suppurating area. Arteritis may arise in the course of an infective malady, being produced by germs, but it is also found in intoxications, and is then due purely to toxins. It may occur in the eruptive fevers, in influenza, typhoid fever, acute rheumatism, gout, syphilis, and diphtheria, septicemia and septic intoxication. Ford points out that acute arteritis developing during acute or chronic infections is particularly apt to arise in the lower extremities (Ford, "Thése de Paris," 1901). Toxins or bacteria usually reach the artery in the main blood-stream, but may be lodged in the vessel-wall by the lymph or the flow in the vasa vasorum. The inner coat of the artery becomes lined with inflammatory exudate and the coats are infiltrated with small cells. Often parietal thrombi form. Sometimes, though rarely, the vessel is completely blocked by thrombosis. In acute suppurative arteritis pus accumulates in the arterial wall, a clot forms in the lumen, and the coats of the vessel undergo necrosis and give way. Violent hemorrhage may thus arise, but often, in thrombo-arteritis as in thrombophlebitis, rupture does not cause hemorrhage. Acute arteritis, if non-bacterial in origin, is usually recovered from with slight structural change. Infective arteritis is recovered from if the causative germ is not very virulent or if the toxin is not present in excessive quantity. Acute arteritis may terminate in arterial obstruction with or without gangrene, permanent dilatation, arterial rupture, or chronic arteritis.

Symptoms.—The symptoms may be merged with those of an acute or chronic intoxication or infection, or with those of a local perivascular inflammation. In arteritis arising during infections the symptoms appear abruptly and the onset is marked by great pain. Ford studied 18 cases in influenza. He says it attacks particularly persons over thirty years of age, occurs in one leg or both, usually arises during convalescence, but may not begin until the individual is apparently well. There is pain and tenderness over the vessels, low surface temperature, paresthesia, and mottled skin (Ford, "Thése de Paris," 1901). The artery may be obstructed, and if a large vessel is blocked, the pulse below the clot is lost. The block may be temporary or persistent. Gangrene may follow. Ford points out that if the artery only is blocked, the gangrene is dry; but if the vein also is occluded, it may be moist. I have seen two cases of dry gangrene following influenza.
Treatment.—Secure rest in bed; elevate the extremity slightly, relax it, smear the skin over the inflamed vessel with ichthyol ointment, or mercurial ointment, or follow Ford's advice and use methyl salicylate or an ointment of salicylic acid, turpentine, and belladonna. Wrap the part in cotton and surround it with bottles or bags filled with warm water. If a patient is very restless, a splint must be used. It may be necessary to give morphin for pain, and any infection or toxemia must be combated with appropriate remedies.

If gout, rheumatism, or syphilis is regarded as causative, proper remedies must be given. It is most important to maintain the secretion of the kidneys. If abscesses form in a septic case, they must be opened and drained. If a large artery of an extremity become occluded, raise the foot about two inches from the bed, wrap the foot and leg in cotton wool, apply a flannel bandage from the toes up, and surround the limb with bags of warm water—not hot water. Hot water would take more blood to the region of the block than could be distributed. If gangrene occurs, amputation is necessary.

Chronic Endarteritis (Arteriosclerosis, Atheroma, Arterio-capillary Fibrosis).—By these terms we mean thickening of the walls of the arteries, limited in area or widespread, due to inflammation or degeneration of the middle coats. Atheroma is used to designate the disease when it attacks the large vessels and is characterized by advanced degeneration. Chronic endarteritis is due to increase of blood-pressure. Increase of blood-pressure may be brought about by kidney disease, hard work, violent strains, heart disease, care and anxiety, worry and mental strain, habitual gluttony, syphilis, gout, rheumatism, lead-poisoning, diabetes, and acute infections like typhoid fever and influenza. It may arise in an old man who has not suffered particularly from any of the above-named causes, or may occur prematurely from heredity. It is a true saying of Cazalis that "A man is as old as his arteries," and a young man dilapidated by syphilitic disease or alcohol may have diseased arteries, and hence be really older than a healthy man of sixty. The aorta, of all vessels, is most prone to suffer. The large vessels are more apt to be diseased than the small, but even the capillaries can be involved. The arteries of the stomach, liver, and mesentery are rarely sclerotic. In arteriosclerosis connective tissue is substituted for the normal elements of the vascular wall and this tissue undergoes hyperplasia and subsequent contraction and induration. If the mass of proliferating fibroblasts undergoes fatty degeneration, atheroma is said to exist, and an atheromatous vessel may be calcified by deposition of lime salts. When fatty degeneration occurs, the endothelium is destroyed, the vessel-wall is damaged, and the blood may obtain access to the deeper coats. Calcaneous change may follow fatty degeneration.

A sclerosed artery is rigid, non-contractile, and inelastic, and the parts it supplies are cold, congested, and ill-nourished, and often edematous. The heart at first hypertrophies and then dilates. Atheroma is a frequent cause of thrombosis, aneurysm, senile gangrene, and apoplexy. If a hypertrophied heart exists with diseased arteries, apoplexy or aneurysm is apt to occur (Nammack, "Med. Record," Oct. 26, 1901). Syphilitic arteritis is characterized by an enormous growth of granulation tissue from the inner coats of arteries of small size (obliterative endarteritis). Calcification of an artery may be secondary to fatty change, or may occur primarily from deposit of
lime salts in the middle coat. Periarteritis is inflammation of the sheath and outer coat. An acute arteritis is always local, but a chronic arteritis may be general.

_Treatment of Chronic Arteritis._—In treating chronic arteritis, endeavor to antagonize the dangers to which the patient is obviously liable. Forbid alcohol as a beverage, though a little whiskey may be taken at meals to aid digestion. Maintain the activity of the skin by daily baths, and of the kidneys by diuretic waters. A daily bowel movement should be secured. The diet is to be plain and is to contain a minimum of nitrogen. If syphilis has existed, occasional courses of iodid of potassium are to be given. If the arterial tension at any time becomes inordinately high, administer nitroglycerin. One danger to which the patient is liable is apoplexy; hence excitement and violent exercise are to be avoided. Another danger is senile gangrene; hence the patient should wear woolen stockings, put a bottle or bag of warm water to his feet at night, and be careful to avoid injuring his toes or feet, especially when cutting his corns. A bag of very warm water is dangerous and may actually excite gangrene. When a patient with atheroma has dyspnea and is of a livid color, or when the arterial tension is very high, a moderate blood-letting (sixteen to eighteen ounces) does good, and may prevent or arrest edema of the lungs. Still another danger is aneurysm, which may appear suddenly from rupture or gradually from progressive distention.

_Aneurysm._—An aneurysm is a pulsating sac containing blood and communicating with the cavity of an artery, and formed partly or entirely by the arterial walls or a fusiform dilatation of an artery. Some restrict the term "true aneurysm" to a condition of dilatation involving all the coats of the vessel. We shall consider, with Heath, a true aneurysm to be one in which the blood is included in one or more of the arterial coats, and a false aneurysm to be a condition in which the vessel has ruptured or has atrophied and the aneurysmal wall is formed by a condensation of the perivascular tissues.

Forms of Aneurysm.—The following forms of aneurysm are recognized:

1. _True aneurysm—one whose sac is formed of one or more arterial coats._
2. _False aneurysm—one whose sac is formed of condensed perivascular tissues and contains no arterial coat._
3. _Traumatic aneurysm—a false aneurysm due to traumatic rupture some time before, the blood being in a sac of condensed tissue and any wound being healed._ A traumatic aneurysm may follow a puncture or an incised wound of an artery, the injury causing the aneurysm directly. It may follow an effort or a strain, the injury indirectly causing the aneurysm by acting on a diseased vessel.
4. _Fusiform aneurysm—a variety of true aneurysm, the sac being spindle-shaped._
5. _Consecutive aneurysm—a sacculated aneurysm diffused by rupture, or a false aneurysm due to gradual destruction or atrophy of a true aneurysmal sac or to vascular rupture._
6. _Sacculated aneurysm—a common form of aneurysm, in which the dilatation is like a pouch, arising from a part of the arterial circumference and joining the lumen of the vessel by an aperture._
7. _Dissecting aneurysm (Shekelton’s aneurysm)—a pouch-like dilatation of an artery due to the blood which has gained access to the middle coat through
an atheromatous ulcer or a minute rupture of the inner coat. It used to be taught that the blood flows between the media and adventitia; we now know that it flows between the layers of the middle coat. The outer wall of the aneurysm consists of adventitia and a portion of the middle coat. It may or may not join the lumen of the artery at another point by a fresh aperture in the intima. Dissecting aneurysm is practically only met with in the aorta. It is most common in the thoracic aorta. About eighty cases have been reported.  

8. Arteriosgenous aneurysm, which is divided into aneurysmal varix, or Pott's aneurysm, where there is direct communication between a vein and an artery; and varicose aneurysm, where there is communication between an artery and a vein by means of an interposed sac.  

9. Acute aneurysm—a cavity in the walls of the heart, which cavity communicates with the interior of this organ, and which is due to suppuration in the course of acute endocarditis or myocarditis.  

10. Aneurysm by anastomosis (see Angiomata).  

11. Aneurysm of bone—an inaccurate clinical term used to designate a pulsatile tumor of bone.  

12. Circumscribed aneurysm—when the blood is circumscribed by distinct walls.  

13. Circoind aneurysm—a mass of dilated and elongated arteries shaped like varicose veins and pulsating with each heart-beat.  

14. Cylindrical aneurysm—a dilatation which maintains the same dimensions for a considerable space.  

15. Embolic or capillary aneurysm—dilatation of terminal arteries due to emboli.  


17. Millitary aneurysm—a minute dilatation of an arteriole.  

18. Secondary aneurysm—one which, after apparent cure, again pulsates, the blood entering by means of the anastomotic circulation.  

19. Vermimos aneurysm—one containing a parasite. This form of aneurysm is met with in the mesenteric artery of the horse.  

The sac of a sacculated aneurysm is at first composed of at least two of the arterial coats, reinforced by the sheath and perivascular tissues. After a time the blood-pressure distends the sac, and the inner and middle coats either stretch with interstitial growth or—what is more common—are worn away and lost. When all the coats are lost, and the blood is sustained only by the sheath and surrounding tissue, a true aneurysm becomes a false, diffuse, or consecutive aneurysm, the limiting tissues and sheath being condensed, thickened, and glued together. This limiting process is deficient in the brain; hence cerebral aneurysms break soon after their formation. When all the arterial coats are lost, the blood-pressure, acting on the tissues, finds some spots less resistant than others, the blood follows the lines of least resistance, the aneurysm grows with great rapidity, and soon ruptures externally or into a cavity.  

An aneurysm may rupture into a cavity (pleural, pericardial, or peritoneal), into the perivascular tissues, or through the skin. Rupture into the tissues may produce pressure-gangrene. When rupture occurs through the skin the

Causes of Aneurysm

hemorrhage is not often instantly fatal, but during several days recurs again and again in larger and larger amounts. The pressure of an aneurysm causes atrophy of tissues, hard and soft, bones and cartilages being as easily destroyed as muscles and fat. Sometimes the perivascular tissues inflame and suppurate, and the sac is opened rapidly by sloughing. An aneurysm usually progresses toward rupture, the slowest in this progression being the fusiform dilatation, which may exist for many years, but which finally is converted into the sacculated variety.

In some rare instances there takes place spontaneous cure, which may result from laminated fibrin being deposited upon the walls of the sac as the blood circulates through it. This laminated fibrin is known as an “active clot,” and eventually fills the sac. The weaker and slower the blood-stream, the greater is the tendency to the formation of an active clot; hence any agent impeding, but not abolishing, the circulation aids in the deposition. This weakening and slowing of circulation may be brought about by great activity of the collateral circulation diverting most of the blood from the area of disease. Sometimes a clot breaks off from the sac-wall and plugs the artery beyond the aneurysm, and the anastomotic vessels, enlarging, divert the blood-stream. A large aneurysm, falling over by its own weight upon the vessel above the mouth of the sac, may, in very unusual cases, diminish the blood-stream. The development of another aneurysm upon the same vessel nearer to the heart weakens the circulation in and may cure the older one. Inflammation occasionally forms a clot. The tissues about an aneurysm tend to contract when arterial force is lessened; hence tissue-pressure may more than counteract blood-pressure when the circulation is feeble. Clotting of the blood contained within a sac, circulation through the aneurysm having ceased, causes a “passive clot.” A passive clot, which occasionally induces cure, may arise from a twist of the neck of the sac preventing the passage of blood; from the lodgment of a clot in the mouth of the sac; and from inflammation. Spontaneous cure is, unfortunately, very rare.

Causes of Aneurysm.—Gradual distention of arterial coats which are in a condition of arterial sclerosis, or of coats whose resisting power is lowered because of atheroma, may cause aneurysm. Hence the causes of sclerosis and atheroma are also causes of aneurysm. The principal cause of aneurysm is increased blood-pressure. This increase may be brought about by severe labor; by sudden strains, as in lifting; by violent efforts, as in rowing in a boat-race; by chronic interstitial nephritis; by hypertrophy of the heart; by alcoholic excess; and by syphilis. Arterial disease is commonest in the larger vessels, and in the aged, but it may occur in youth. When an aneurysm follows a strain, it may be due to laceration of the media and loss of resistance at a narrow point. The intima may lacerate, permitting the blood to come in contact with the media or causing blood to diffuse between the coats (dissecting aneurysm). When an embolus lodges in an artery the vessels may become aneurysmal on the proximal side of the clot. The embolus, if infective, causes softening, and if calcareous causes laceration (Osler). Colonies of micrococci may cause aneurysm.* The parasite *strongylus armatus* causes aneurysm of the mesenteric arteries in horses. Suppuration around a vessel weakens its coats and tends to aneurysm by inducing acute arteritis

* See Osler on “Malignant Endocarditis.”
and softening. Sometimes an individual develops multiple aneurysms the origins of which are absolutely unknown. A cut or puncture of a healthy artery may lead, after the surface wound heals, to the development of an aneurysm. Such an aneurysm does not differ in symptoms or treatment from the other form.

*The constituent parts of an aneurysm* are (1) the wall of the sac; (2) the cavity; (3) the mouth; and (4) the contents.

**Symptoms of Aneurysm.**—The formation of an aneurysm, when sudden, is occasionally, though rarely, appreciated by the patient, and is described by him as a feeling of something having given way. In most instances the feeling of beating and the discovery of the lump are the first intimations that anything is wrong. An oval or globular, soft, elastic, and pulsatile protrusion develops in the line of an artery. It is usually quite evident to the touch that the sac contains fluid, but sometimes in old aneurysms the sac feels firm or even hard, because of the deposit of fibrin upon its inner surface. In a partially consolidated aneurysm pulsation may be slight or even inappreciable. The protrusion instantly ceases to pulsate and almost disappears on making firm pressure on the artery above. On relaxing the pressure the pulsatile

![Fig. 94.—Radial pulse-tracings in aneurysm of right brachial artery: 1, Left radial pulse; 2, right radial pulse (after Mahomed).](image)

enlargement at once reappears. Direct pressure upon the tumor may cause it to almost disappear. Pressure upon the artery below causes the tumor to enlarge. The pulsation is expansile—that is, the sac expands in all directions during every cardiac contraction—and if an index-finger be laid on each side of the tumor so that the points nearly touch, each pulsation not only lifts the fingers, but it also separates them. On placing a stethoscope over the aneurysm or over the vessel below the aneurysm there is imparted to the ear a distinct bruit which travels in the direction of the blood-stream, is systolic in time, and is usually blowing in character. In some cases bruit is absent (when a sacculated aneurysm has a very small mouth, when the circulation is tranquil, or when the sac is full of blood and clot). When bruit is absent it may sometimes be developed by muscular exercise or raising the affected limb (Holloway). In rare cases there may be a double bruit. Occasionally in fusiform aortic aneurysm linked with aortic regurgitation a diastolic bruit exists. A bruit is arrested by pressing upon the artery between the aneurysm and the heart.* A patient who has an aneurysm of an extremity complains of a sensation of beating, of weakness or stiffness of the limb, frequently of pain in a nerve, a feeling of fatigue in the muscles, and edema and dilated veins are apt to develop because of pressure upon large veins and loss of *vis a

* Holloway on “Aneurysm,” in Park’s “Surgery by American Authors.”
Treatment of Aneurysm

Aneurysm in the circulation. The skin over an aneurysm may be normal, may be discolored, may ulcerate, or even slough. The pulse below an aneurysm is weaker than the pulse of a corresponding part of the opposite limb. This is well shown by sphygmographic tracings (Fig. 94). The tracings taken below an aneurysm are rounded without a sudden rise or an abrupt fall. In internal aneurysms pressure-symptoms are marked. Thoracic aneurysm causes intercostal pain; iliac aneurysm causes pain in the thigh. Aneurysm of the thoracic aorta pressing upon the pneumogastric nerve causes spasmodic dyspnea, and upon the recurrent laryngeal, causes hoarseness, which may be associated with loss of voice, cough, and laryngeal spasm, and is due to unilateral abductor paralysis. Pressure upon a bronchus or the trachea causes dyspnea from obstruction, dysphagia, and cough from laryngeal spasm. Pressure upon the cervical sympathetic first causes dilatation and later contraction of the pupil of the same side. An aneurysm in the neck may interfere with the cerebral circulation and produce vertigo and even attacks of unconsciousness. The evidences of rupture of an aneurysm of an extremity into the tissues are loss of distinctness of outline and increase in area of the tumor, weakening or disappearance of both bruit and pulsation, absence of pulse below the aneurysm, severe pain, edema and coldness of the surface, shock, and possibly syncope. External hemorrhage may arise; the tissues may become extensively infiltrated with blood; sloughing or gangrene may ensue. Death is frequent, and only in very rare cases does spontaneous cure take place. Rupture of a large aneurysm into a cavity causes intense pallor, advancing weakness, syncope, and death.

Diagnosis.—A cyst or abscess over a vessel may show transmitted pulsation which is not expansile, and the tumor does not disappear when pressure is made upon the vessel above it. The pulsation ceases when the growth is lifted off the vessel, or when the position is changed so as to permit it to fall away from the vessel. There is no true bruit, and the history is widely different. A growth under a vessel may lift the vessel and simulate an aneurysm, but the pulsation is not noted in the entire growth, the growth does not disappear on proximal pressure, and there is only a false, and never a true, bruit. The larger the growth under a vessel, the less is the pulsation, because of pressure narrowing the caliber of the vessel. A sarcoma, especially a soft sarcoma attached to the bone, and also a nevoid mass, pulsate and often have a bruit; the tumor never disappears from proximal pressure, though it may slowly diminish in size, to gradually enlarge again when pressure is withdrawn. These growths do not feel fluid, and are rarely circumscribed. An aneurysm may cease to pulsate from consolidation leading to cure, or from rupture. Rupture of a large aneurysm into a cavity induces deadly pallor, syncope, and rapid death. Rupture of an aneurysm of an extremity into the tissues is made manifest by a sensation of something breaking, by pain, by sudden increase in size, by diminution or absence of bruit and pulsation, by absence of pulse below the aneurysm, by swelling and coldness of the limb, and by shock.

Treatment.—In inoperable aneurysms general, medical, and dietetic treatment must be tried. A chief element in treatment is rest in bed to diminish the rapidity and force of the circulation and favor fibrinous deposit. Valsalva long ago suggested rest, occasional bleeding, and a diet just above
the point of starvation. Tuffnell's plan is to reduce the heart-beats by rest and mental quiet, and to rigidly restrict the diet so as to diminish the total amount of blood and render it more fibrinous. Liquids are restricted in amount, and the patient lives through each twenty-four hours upon four ounces of bread, a very little butter, eight ounces of milk, and three ounces of meat. This plan is pursued for several months if possible, or it is employed for several weeks, intermitted for a short period, the rigid diet again returned to, and so on, over and over again. There can be no doubt that Tuffnell's treatment sometimes cures aneurysm by decidedly lowering the blood-pressure. Many who suffer from aneurysm may be permitted to go about, taking their time about everything and avoiding work, worry, and excitement. The diet should be low and non-stimulating, and the bowels must be maintained in a loose condition.

Even in an operable case diet and rest are of importance. The patient should remain in bed for a number of days before operation, the daily diet consisting of ten or twelve ounces of solid food with a pint of milk. If the circulation is very active, use aconite and allay pain by morphin.

Iodid of potassium in doses of 20 grains undoubtedly does good in aneurysm and not only in syphilitic cases. It seems to lower the blood-pressure. Balfour taught that it thickened the walls of the sac. Osler says it relieves the pain. Iron, acetate of lead, and ergotin are prescribed by some. Digitalis is contraindicated, as it raises the blood-pressure. S. Solis Cohen has used with some success the hydrated chlorid of calcium. Morphin and bromid of potassium are occasionally useful to tranquilize the circulation, allay pain, or secure sleep. Aconite and veratrum viride have long been employed.

Lancereaux and others claim that hypodermatic injections of gelatin at some indifferent point may cure aortic and subclavian aneurysm. In 1896 Dastres and Floresco proved that gelatin injected in the blood increases coagulability. Later Lancereaux and Paulesco showed that injections into the subcutaneous tissue act similarly. Carnot pointed out that gelatin applied to a wound may arrest bleeding. How gelatin acts is uncertain, but that it does increase blood-coagulability seems proved. The value of injections of gelatin for aneurysm is in dispute. Lancereaux warmly advocates its use for sacculated aneurysm and says that after the first dose the aneurysm is seen to shrink and the pulsation is observed to lessen. He injects it slowly and with aseptic care into the subcutaneous tissue of the thigh, using normal salt solution containing from 5 to 10 per cent. gelatin. He never injects less than 5 gm. He gives an injection every tenth to fifteenth day and administers from ten to twenty injections. But the treatment is not free from danger; several deaths have taken place, and several persons have died from tetanus. Care must be taken not to inject gelatin into a vessel, and it must never be thrown about the aneurysmal sac. It irritates the kidneys and its use is contraindicated in renal disease. The injections cause much pain, and it is very doubtful if they do any real good in aneurysm. If used, it should be given at the temperature of the body, and not over 3 gm. should be administered at one dose. A 10 per cent. solution is the proper strength and from 10 to 20 c.c. the correct dose. Gelatin can be given by the mouth. When thus given it is not so powerful, but its coagulating property is not destroyed by digestion. Gelatin in normal salt solution is known as Car-
not's solution. Carnot's solution is best prepared by Sailer's formula, as follows (Joseph Sailer, in "Therapeutic Gazette," August, 1901): Take 5 gm. of common salt, 1 liter of distilled water, and 100 gm. of gelatin. Bring the water to a temperature of 80° C. and slowly stir in the gelatin until it is all in solution. Remove the solution from the stove, cool it to 40° C., add to it the white of one egg, and stir for several minutes, and then put the flask on the stove and boil the fluid. The white of egg coagulates and clears the solution. Filter through gauze and then through paper. Place the fluid in test-tubes, each of which will contain 10 c.c., and insert a cotton plug in the mouth of each tube. Sterilize by putting the tubes in a steam sterilizer for fifteen minutes on three successive days. When we wish to use a tube, place it in a cup of hot water until the gelatin liquefies, pour the gelatin into a sterile glass, and draw it up into a sterile syringe. When kept several weeks the tubes dry out.

Other expedients sometimes used in the treatment of aneurysm are: the kneading of the sac to release a clot, in the hope that it will plug the mouth of the sac or the artery beyond it—this is dangerous; electricity; electrolysis; the injection of an astringent liquid; the insertion of a fine aspirating needle and the pushing through it into the sac of a large quantity of silver wire, in the hope that it will aid in whipping out fibrin. Some physicians have inserted needles and horsehair.

Treatment by Pressure.—Instrumental pressure is made by applying two Signorini tourniquets or some specially devised apparatus to limit the flow of blood through an aneurysm without entirely stopping it, the aneurysmal sac being felt to still slightly pulsate. In some situations Lister's abdominal tourniquet is applied; in other regions we may use Tuffnell's compress, which is like a spring truss and is strapped in place. A heavy body suspended over the artery and resting part of its weight upon the vessel has occasionally brought about cure. Compressing instruments can be worn for from twelve to sixteen hours at a time; usually they are removed to permit sleep and are reapplied the next day, and so on for several days. Before applying the compress be sure the sac is full of blood, and render this certain by applying for a few minutes distal compression. This method may cure, but it is very painful. It cannot be used successfully in treating aneurysm of the axillary, subclavian, or carotid artery. It aids in the formation of an active clot.

Digital pressure, made with the thumb aided by a weight, and maintained for many hours by a relay of assistants, has cured many cases. This method may be used alone or may be used as an accessory to instrumental pressure. Its chief field is in the treatment of aneurysm for which other methods are inapplicable (orbit and root of neck). It entirely cuts off the blood and promotes the formation of a passive clot. If cure does not take place in three days, abandon pressure. It must often be abandoned far earlier because of pain.

Direct pressure upon the sac has been used in aneurysm of the popliteal artery, the pressure being obtained by flexing the leg; and in aneurysm of the brachial artery pressure has been applied at the bend of the elbow by flexing the elbow. The pressure of a hollow rubber ball has been used in aneurysm of the subclavian.

Rapid pressure completely arrests the passage of blood through the sac.
for a limited time, and is applied while the patient is under the influence of an anesthetic. Take, for example, a case of popliteal aneurysm: the patient is placed under the influence of ether; two Esmarch bandages are used, one being applied to the limb from the toes up to the lower limit of the aneurysm, and the other from the groin down to the upper limit of the sac, and the Esmarch band is fastened above the upper bandage. This procedure stagnates the blood both in the veins and in the arteries, and the sac remains full of blood. Pressure is thus maintained for three or four hours, and on removing the Esmarch apparatus a tourniquet is put on the artery above the aneurysm and partly tightened in order to limit the amount of blood passing through and thus prevent the washing away of clot. This method of rapid pressure sometimes cures by forming a passive clot, but it sometimes results in gangrene. It was devised by John Reid.

Operative Treatment: By the Ligature.—Ligation of the main artery is, as a rule, the best procedure. The methods of ligation are—(1) the method of Antyllus; (2) extirpation of the sac; (3) the method of Anel; (4) the method of Hunter; (5) the method of Wardrop; and (6) the method of Brasdor.

In the method of Antyllus (Fig. 95), as usually described, the sac itself is attacked. The artery is ligated immediately above and below the sac, the sac is opened and its contents turned out, or the sac is extirpated. As a matter of fact, Antyllus advocated applying a ligature on each side of the sac and opening the tumor in order to evacuate its contents, but he distinctly opposed extirpation because of its danger. All we know of Antyllus is found in the writings of Oribasius, who lived in the fourth century (B. G. A. Moynihan, in "Annals of Surgery," July, 1898). Syme maintained many years ago that incision of the sac is the proper operation for aneurysm of the gluteal, iliac, carotid, and axillary arteries, but Syme’s method is productive of fearful hemorrhage and the plan of Antyllus is vastly better. Syme opened the sac, inserted his finger, and plugged the artery until a ligature was applied and tied, and packed the sac with lint.

Extirpation of the sac, if practised, should be carried out after applying a ligature on each side after the method of Antyllus. It was originally practised by Philagrius and was reintroduced by Purmann in 1699 (Moynihan).

Extirpation finds warm advocates in Delbet, Littlewood, and Moynihan. Moynihan claims that, as compared with distal ligature, there is a greater chance of recovery, no chance of recurrence, less risk of gangrene, and complete recovery from troubles due to nerve interference ("Annals of Surgery," July, 1898). Extirpation is the best operation for traumatic aneurysm, but if the vessel is seriously diseased near the sac some other method should be employed. The operation is growing in favor and will probably in most instances become the operation of choice ("Annals of Surgery," July, 1898).

The Method of Anel.—In Anel’s method the artery is ligated above the sac, and so close to it that there are no anastomotic branches between the sac and the ligature (Fig. 96). It is used only for traumatic aneurysms, and is never employed when the vessel is diseased beyond the aneurysm. Extirpation is preferable to Anel’s operation.
The Method of Hunter.—This operation, which is the modern method of ligation, was devised by the illustrious John Hunter. He is said by Sir Everard Hume to have recognized the fact that the vessel adjacent to an aneurysm was apt to be diseased, and he discovered the anastomotic circulation. Putting together these two facts, he devised the operation which goes by his name. It consists in applying a ligature between the heart and the aneurysm, but so far above the sac that collateral branches are given off between it and the point of ligation (Fig. 97). This operation, which is done upon a healthy area, does not permanently cut off all blood, but so diminishes the force and frequency of the circulation that an active clot forms within the sac. Thus is lessened the danger of secondary hemorrhage and of gangrene. According to Stimson ("New York Med. Jour.," July, 1884), Hunter really builded better than he knew, for he sought only to tie the artery without opening the sac and at a healthy point, but said not a word about the necessity of having branches between the sac and the ligature or about the desirability of diminishing the flow of blood instead of cutting it off completely (Moynihan, in "Annals of Surgery," July, 1898). Hunter tied the artery in the region now known as Hunter's canal. Scarpa introduced the custom, which we still follow, of tying it in Scarpa's triangle. The Hunterian method is, in the majority of cases, the proper operation for aneurysm. In some cases, pulsation does not return after tightening the ligature; in most cases, however, it reappears for a time after about thirty-six hours, but is weak from the start, constantly diminishes, and finally disappears permanently. Previous prolonged compression by enlarging the collateral branches permits strong pulsation to recur soon after ligation, and thus militates against cure; hence it is a bad plan to use pressure in cases admitting of ligation, and in which the success of pressure is very doubtful. Occasionally after Hunter's operation the sac suppurates, producing symptoms like those of abscess. Sup-
puration may occur between the first and the thirty-second week after ligation.* When pus forms, open freely as we would open an abscess, and, if no blood flows, treat as an abscess, but have a tourniquet loosely applied for several days ready to screw up at the first sign of danger. If hemorrhage occurs, tie the vessel above and below the aneurysm, open the sac, and pack with iodoform gauze. If bleeding recurs, there is no use reapplying the ligature and there is little use tying higher up. If dealing with an arm, try the application of a ligature higher up; if dealing with a leg, amputate at once.

**Distal Ligation.**—When an aneurysm is so near the trunk that Hunter's operation is impracticable, or when the artery on the cardiac side of the tumor is greatly diseased, distal ligation may be employed. Distal ligation forms a barrier to the onflow of blood, collateral branches above the aneurysm enlarge, the blood-current is gradually diverted, and a clot may form within the aneurysm. Distal ligation is used in some aneurysms of the aorta, iliacs, innominate carotids, and subclavians. It occasionally causes rupture of the sac of the aneurysm. I have obtained one notably successful result in an aneurysm of the innominate artery by ligation of the carotid and subclavian of the right side.

*See the case described by Sir Astley Cooper.

**The operation of Brasdor** consists in tying the main trunk some little distance below the aneurysm (Fig. 98). It completely arrests circulation in the sac.

**The operation of Wardrop** consists in tying one of the branches of the artery below the aneurysm. Wardrop originally advocated ligation at a point where there is no intervening branch between the sac and the ligature. Later he advocated ligation at a point where there is an intervening branch. Since then it is the custom to consider Wardrop's operation to be the ligation of one branch below the aneurysm, as shown in Fig. 99. The circulation is but partially arrested by Wardrop's operation. An x-ray picture should be taken in every case of aortic aneurysm. Such a picture may aid us in coming to a conclusion as to which vessel or vessels to tie.

**Matas's Operation (Arteriorrhaphy).**—In a limb the blood is emptied out by elevation and is kept out by an Esmarch band. In a limb near the body or in the neck the main artery is exposed, a traction loop is placed

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**Fig. 98.**—Brasdor's operation (Holmes).

**Fig. 99.**—Wardrop's operation (Holmes).
under the artery between the aneurysm and the heart, and the vessel
is compressed by an assistant. The sac is exposed, opened, and emptied.
The type of sac is studied and the number of openings determined. In a
fusiform aneurysm the continuity of the artery cannot be restored and
sutures are applied in order to close the openings and obliterate the sac. In
a sacciform aneurysm with a single opening it is often possible to close this
opening by sutures without lessening the caliber of the vessel and thus cure
the aneurysm without destroying arterial continuity (see Rudolph Matas in
"Annals of Surgery," Feb., 1903). If a branch opens from the sac, the
opening must be sutured. Matas has operated upon four cases by this
method.

After ligating for aneurysm of an extremity by any of these methods,
elevate the limb, keep it warm, and subdue arterial excitement. When
gangrene of a limb follows ligation, await a line of demarcation, and when
it forms, amputate. Rupture of the sac after ligation may produce gangrene
or be associated with suppuration, the first condition demanding amputation,
and the second incision for drainage.

Injection of coagulating agents into the sac (ergot, perchlorid of iron, etc.)
is very dangerous and is to be utterly condemned. It may lead to suppuration,
gangrene, rupture, or embolism.

Manipulation to break up the clot was suggested by Sir Wm. Fergusson,
and has been practised. The object aimed at is to have a fragment of clot
block up the vessel upon the peripheral side of the artery and act like a distal
ligature. The method is dangerous, especially in carotid aneurysm, and
should never be employed.

Amputation, instead of distal ligation, is performed in some perilous cases
of subclavian aneurysm.

Electrolysis.—An attempt may be made to coagulate the blood at once,
or from time to time an endeavor may be made to produce fibrinous deposits,
but the first method is the better. It is, however, rarely possible to at once
occlude a sac, and pulsation, which is for a time abolished, recurs as the gas
present is absorbed. Use the constant current. Take from three to six
cells which stand in point of size between those used for the cautery and those
used for ordinary medical purposes. A platinum needle is attached to the
positive pole and a steel needle to the negative pole, each needle being insulated
by vulcanite at the spot where the tissues will touch it. The asepticized
needles are plunged into the sac where it is thick, and they are kept near
together. The current is passed for a variable period (from half an hour to
an hour and a half). This operation is not dangerous. Pressure stops the
bleeding. Electrolysis often ameliorates, and sometimes, though very rarely,
cures, aortic aneurysms.*

Acupressure consists of the partial introduction of a number of ordinary
sewing needles into an aneurysmal sac and leaving them in it for five or six
days or more. Prof. Macewen introduces a needle, and with it irritates the
interior of the sac of an aneurysm, hoping thus to cause deposition of leuko-
cytes and clot-formation.

Introduction of Wire.—Insert into the sac a hypodermatic or small aspirat-
ing needle, and push through the needle or cannula a considerable quantity

* See John Duncan, in Heath's Dictionary.
of aseptic gold wire, which is allowed to remain permanently. Electrolysis should be combined with the introduction of wire. This operation was first proposed by Corradi. Loreta and Barwell both inserted wire into an aneurysm before Corradi, but Corradi inserted wire and also used electricity. Corradi's operation can be used when distal ligation cannot be carried out, and can be used even when the vessel is extremely atheromatous. It finds its chief use in aneurysms of the thoracic aorta and innominate. In some cases of abdominal aneurysm the belly has been opened and the operation carried out. Some cases have been notably improved, and one of Stewart's cases was apparently cured.* The operation is performed with aseptic care. If the thoracic aorta is to be operated upon, an anesthetic is not required. If the abdominal aorta is to be wired, the patient must be anesthetized. The wire used must have been previously drawn, so that it will easily pass through a hypodermic needle and will coil up spirally within the sac (Stewart). The best wire is of silver or gold. It is a great mistake, Stewart says, to introduce a large quantity. He considers that a globular sac three inches in diameter requires from three to five feet, and a sac five inches in diameter requires from eight to ten feet. A hypodermic needle, insulated up to one-quarter inch of the point, is carried into the interior of the aneurysm through a fairly thick portion of the sac. The required amount of wire is introduced. The wire is attached to the positive pole of the battery. The negative pole is fastened to a large flat piece of clay or a pad of moistened absorbent cotton, and the negative electrode is placed upon the back or abdomen. The current is turned on gradually until the necessary strength is obtained (40 to 80 ma.). When ready to terminate the operation the current is lowered gradually to zero, the needle is withdrawn, the wire is cut off close to the skin, the end is pushed under the skin and the puncture is covered with iodoform collodion. The entire operation requires from three-quarters of an hour to one and a half hours.† A clot forms with considerable rapidity and expansive pulsation may lessen or cease. The operation can be repeated if necessary.

**Treatment of Aneurysm following Wound of a Healthy Artery.**—The prognosis in such a case is usually extremely good. The treatment is as for the other forms. Extirpation is particularly adapted to such direct traumatic aneurysms.

**Diffuse Traumatic Aneurysm.**—When an artery ruptures or an aneurysm ruptures and a large mass of blood is extravasated into the tissues, no sac exists, and the condition is usually called diffuse traumatic aneurysm. In diffuse traumatic aneurysm, a large, oblong, fluctuating swelling is found. If the rent is large, there are bruit and pulsation. There is no pulsation in the artery below the aneurysm, and the limb is cold and swollen. The skin is at first of a natural color, but becomes thin and purple.

**Treatment.**—Cut down upon the seat of rupture and tie on each side of the tear. For a ruptured aneurysm perform the operation of Antyllus. If the main vein is also ruptured, amputate.

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Arteriovenous aneurysm was first described by Wm. Hunter in 1757. By the term we mean an unnatural passageway between a vein and an artery, through which passage blood circulates. There are two forms: (a) aneurysmal varix, or Pott’s aneurysm, a vein and an artery directly communicating; and (b) varicose aneurysm, a vein and an artery communicating through an intervening sac. These conditions arise usually from punctured wounds, the instrument passing through one vessel and into the other, blood flowing into the vein, the subsequent inflammation gluing the two vessels together, and the aperture failing to close (aneurysmal varix, Fig. 100). After the infliction of the wound the two vessels may separate; the blood continuing to flow from artery into vein, and the blood-pressure, by consolidating tissue, forming a sac of junction (varicose aneurysm, Fig. 101). Wounds produced by small bullets may result in arteriovenous aneurysm. Aneurysmal varix is a less grave disorder than varicose aneurysm. Arteriovenous aneurysm used to be most frequent at the bend of the elbow, the vessels being injured during venesection. The condition may occur in the neck, the axilla, the extremities, or the groin. I assisted Prof. Keen in an operation upon an aneurysmal varix of the common carotid and internal jugular vein, and assisted Dr. Hearn in operating on a varicose aneurysm involving the external iliac vessels. Treves operated on a case involving the internal maxillary vessels. Very rarely an arteriovenous aneurysm forms spontaneously. Spontaneous arteriovenous aneurysm is most frequent between the aorta and vena cava. There is no tendency to spontaneous cure in arteriovenous aneurysm. Edema is the rule, muscular atrophy is common, and ulceration or even gangrene may occur.

Symptoms of Aneurysmal Varix.—The arterial blood is cast forcibly into the vein and as a consequence the vein becomes enlarged, tortuous, and thickened. The scar of a wound is almost invariably apparent. At the point of trouble the most marked dilatation exists and it is of bluish color. The tumor pulsates markedly, imparts a sensation to the finger like that felt when the hand is laid upon the back of a purring cat. This thrill or vibration is very characteristic. A sound of a hissing or buzzing nature can be easily heard. The tumor at once disappears on pressure being made upon it or on the artery between it and the heart. It is diminished in size by raising the limb, is increased in size by a dependent position of the limb and by compressing the vein between the heart and the tumor. The adjacent veins are dilated and often the dilatation is manifested over a wide area above and below, and the thrill and bruit are transmitted a considerable distance. If an extremity is involved it is usually edematous. The parts as a rule are painful. The condition progresses, but very slowly, and sometimes years may elapse without any notable aggravation.
Symptoms of Varicose Aneurysm.—In this condition we find many of the symptoms of aneurysmal varix, but in varicose aneurysm pressure over the artery of supply between the heart and the lesion does not cause the entire disappearance of the tumor; the veins collapse, it is true, but a distinct tumor remains which may be emptied by direct pressure.

Treatment.—The prognosis after operation is better than in ordinary aneurysm (Treves), but nevertheless it is wisest to refrain from operating on aneurysmal varix so long as the condition is not progressing obviously, is borne without inconvenience, and is not leading to complications. Varicose aneurysm should be operated upon. If we refrain from operating upon aneurysmal varix the patient should wear a support; but if the part becomes painful or if there seems to be danger of rupture of the vein, each vessel should be tied above and below the opening and a portion of each vessel should be excised, the excised area including the opening. In varicose aneurysm each vessel above and below the sac must be ligated, and the sac and a portion of each vessel should be excised.

Cirsoid aneurysm, or aneurysm by anastomosis, consists in great dilatation with pouching and lengthening of one or several arteries. The disease progresses and after a time involves the veins and capillaries. The walls of the arteries become thin and the vessels tend to rupture. Cirsoid aneurysm is most commonly met with upon the forehead and scalp of young people, where it sometimes takes origin from a nevus. It is sometimes seen upon the back or upper extremity. The cause is unknown. Usually there is no assignable cause, but occasionally the condition follows an injury. Pregnancy causes a cirsoid aneurysm to grow rapidly, and so usually does the onset of puberty. Occasionally some of the enlarged vessels fuse and form a great cavity. If rupture occurs, desperate hemorrhage inevitably ensues.

Symptoms.—There is a pulsating mass, irregular in outline, composed of dilated, elongated, and tortuous vessels that empty into one another. The mass is soft, can be much reduced by direct pressure, and is diminished by compression of the main artery of supply. A thrill and a bruit exist.

Treatment.—In treating a cirsoid aneurysm the ligation of the larger arteries of supply is a wretched failure. Subcutaneous ligation at many points of the diseased area has effected cure in some cases, but it has failed in more. Direct pressure is also entirely useless. Ligation in mass has been successful. Destruction by caustic has its advocates. Electropuncture with circular compression of the arteries of supply has once or twice effected a cure. Injection of astringents has been recommended. Verneuil ligated the afferent arteries, incised the tissues around the tumor, and sank a constricting ligature into the cut. The proper method of treatment is excision after exposure and ligation of every accessible tributary of supply. In a very extensive mass extirpation is impossible; hence one of the other methods suggested must be employed. A very considerable mass can be excised, and the resulting wound should be covered with Thiersch skin-grafts.

Wounds of arteries are divided into contused, incised, lacerated, punctured, and gunshot-wounds, and vascular ruptures.

Contused and Incised Wounds.—A contusion may destroy vitality and be followed by sloughing and hemorrhage. A contusion may rupture a
blood-vessel, and is especially apt to do so if the vessel is diseased. Blood is at once effused at the seat of rupture. If an artery is ruptured, there may or may not be a bruit and pulsation over the seat of rupture, pulse is absent below, and the leg below the injury swells and becomes cold. If a large vein ruptures, a blood tumor forms, which does not pulsate and has no bruit, and the limb below becomes intensely edematous. Gangrene is apt to follow the rupture of a main blood-vessel of an extremity. A contusion may rupture the internal and middle coats of an artery, the external coat remaining intact. When this happens the internal coat curls up and the middle coat contracts and retracts, the blood-stream is arrested, and a large clot forms within the artery. If the clot blocks up many collaterals, gangrene will follow, and, as has been pointed out, the gangrene will not be preceded by swelling at the seat of injury, which always occurs if a vessel is ruptured. A contused wound may do little damage, or it may produce gangrene from thrombosis, or it may cause secondary hemorrhage. In an incised wound of an artery there is profuse hemorrhage. The artery after a time is apt to contract and retract, bleeding being thus arrested. A transverse wound causes profuse bleeding, but there is a better chance for natural arrest than in an oblique

![Fig. 102.—Clots formed after division of an artery: 1, 2, 3, Outer, middle, and inner coats; c. c., branches; d, d, internal clot; e, e, external clot.](image)

or in a longitudinal wound. The clot which forms within a cut artery is known as the "internal clot." It used to be taught that the internal clot always reaches as high as the first collateral branch, and subsequently is replaced by fibrous tissue, which permanently obliterates the vessel, and converts it into a shrunken fibrous cord. As a matter of fact, when the parts are aseptic after a ligation the clot is rarely bulky and is often very scanty, repair being quickly effected by proliferation of endothelial cells. Between the vessel and its sheath, over the end of the vessel, and in the surrounding peri-vascular tissues is the "external clot." (Fig. 102).

A lacerated wound of an artery causes little primary hemorrhage. The internal coat curls up, the circular muscular fibers of the media contract upon it, the longitudinal fibers retract and draw the vessel within the sheath, and the external coat becomes a cap over the orifice of the vessel. All of these conditions favor clotting. The vessel-wall is so damaged that secondary hemorrhage is usual.

**Punctured Wounds.**—In punctured wounds primary hemorrhage is slight unless a large vessel is punctured. Secondary hemorrhage is not
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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