18

PATENT DUCTUS ARTERIOSUS WITH ACUTE INFECTIVE PULMONARY ENDARTERITIS

BY

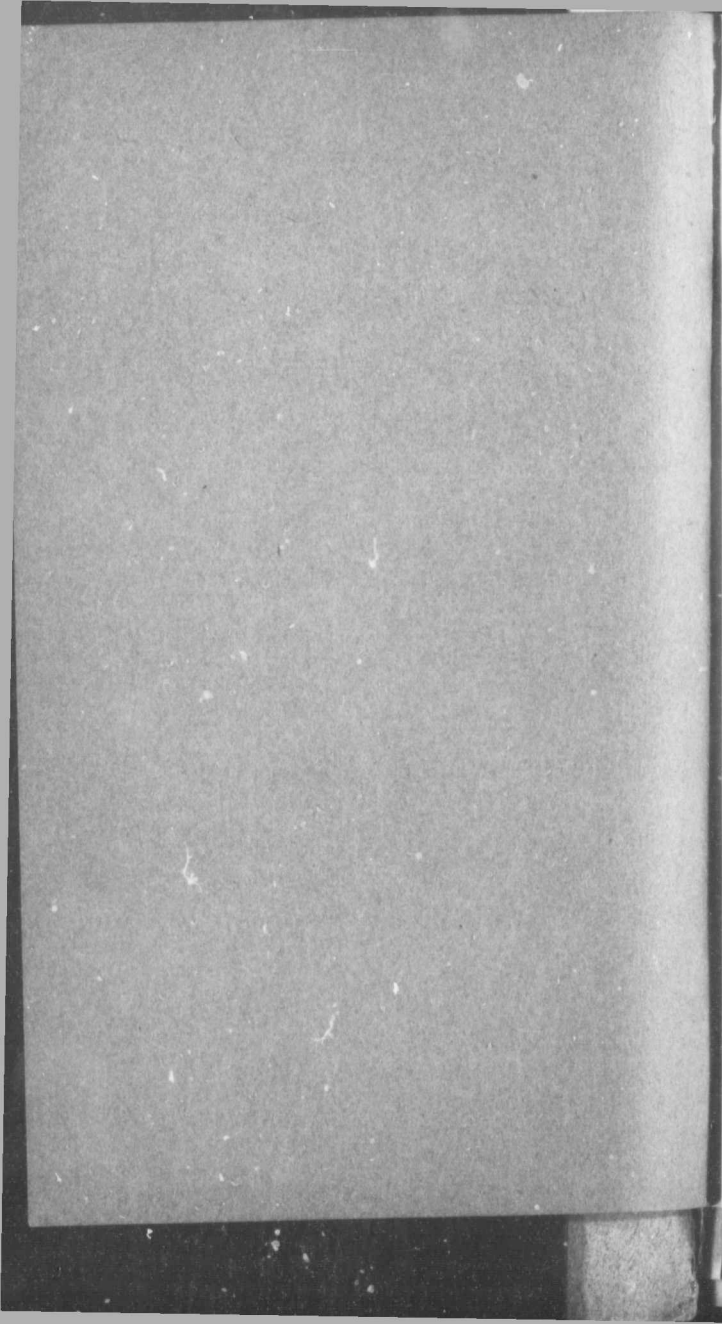
W. F. HAMILTON, M.D.

AND

MAUDE E. ABBOTT, M.D.

MC GILL UNIVERSITY, MONTREAL

From the
Transactions of the Association of American Physicians
1914



Reprinted from the Transactions of the Association of American Physicians, 1914

PATENT DUCTUS ARTERIOSUS WITH ACUTE INFECTIVE PULMONARY ENDARTERITIS

By W. F. HAMILTON, M.D.
AND
MAUDE E. ABBOTT, M.D.
MCGILL UNIVERSITY, MONTREAL

Cases presenting the signs of persistent ductus Botalli are comparatively rare. The clinical diagnosis of this case, confirmed at autopsy, and the very interesting, if not altogether unique, pathological condition found, justify placing it on record.

The patient was a fairly well developed girl, aged nineteen years, who, while never very strong, had never suffered any serious illness save that of scarlet fever in childhood. In the middle of August, 1913, chills, lassitude, weakness and diarrhea set in, symptoms of a general infection resembling that of typhoid fever. A few signs attracted one's attention to the base of the right lung where the percussion note was slightly impaired, and where moist rales were occasionally heard. The course of the case, the temperature, the absence of typical spots and of the Widal reaction, the white cell count of 17,000 with Gram-positive diplococci in the blood culture, proved the case one of septicemia other than that of typhoid fever.

The great vessels at the base of the heart were thought to contain a focus of infection about which so much interest centres. The heart itself was enlarged to the left, and the dulness noted was wider than usual on the left, even in the second and third interspaces (Fig. 1, Radiograph). A faint systolic thrill was occasionally felt over the pulmonary area, where the second sound could be felt sharply accentuated. Here, too, the harsh rumbling continuous murmur, occupying the whole of the cardiac cycle, was best heard. The murmur increased in intensity with systole and diminished in diastole. It was transmitted upward, and to the left, but was not heard behind (Franck's sign). The cardiac signs gave no indication of mitral or other valvular disease.

After an illness of two months, quite characteristic of septicemia, the patient died.

The autopsy, which was performed by Dr. O. C. Gruner, showed the following remarkable combination: *Patent ductus arteriosus*

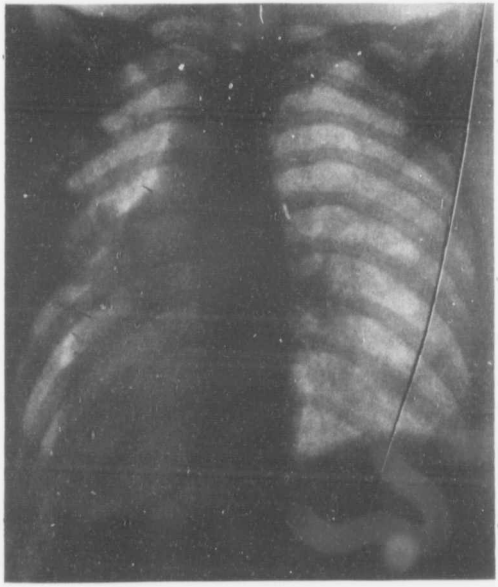


FIG. 1.—Radiogram from a case of patent ductus arteriosus. The second space marked along the left border of the heart is noted here as unusually prominent—the dilated pulmonary artery.

with acute infective endarteritis of its pulmonary end, and of the pulmonary artery adjacent, of pneumococcus origin, with formation of mycotic aneurysm of the main pulmonary trunk, and blocking of its left branch by a thrombotic mass. Dilatation of the pulmonary artery,

hypoplasia, and coarctation of the aorta. Slight hypertrophy and marked dilatation of the right ventricle of the heart, the endocardium healthy, no cardiac anomaly. Multiple septic embolism of both lungs, with infarction and abscess formation, bilateral acute fibrinous pleurisy. Calcification of mediastinal glands about pulmonary end of ductus, with acute lymphadenitis of peribronchial and periaortic glands. Cloudy swelling of kidneys, fatty degeneration of liver, infarct of spleen. Pneumococci in vegetations on pulmonary artery and in embolic abscesses in lungs.

The interest of the case centres in the condition of the great arterial trunks and lungs. The main trunk of the right pulmonary artery was clear, but several of its branches were occluded by white septic thrombi, and the right lung was riddled with septic infarcts and embolic abscesses of old and recent date. The peribronchial lymph glands about the hilum of the lungs were enlarged and succulent, markedly inflamed. In the left lung the thrombotic process extended along the main branches of the pulmonary artery for some distance, completely occluding these. The apex of the upper lobe was occupied by a single small gray septic infarct, and the vessel leading to this area was blocked by the grayish white thrombotic mass.

The aorta was healthy throughout, but it diminished from a circumference of 6 cm. at its origin to 5 cm. beyond the left subclavian, narrowing still further to a circumference of 4 cm. in its descending portion. It presented, at a point 5.5 cm. above the aortic cusps, a little beyond the origin of the left subclavian artery, and on the opposite wall, a round orifice admitting a penholder with sharply defined lower border which led into a canal 0.75 cm. long (patent ductus arteriosus), communicating with the pulmonary artery about 2.5 cm. above the pulmonary valves.

The pulmonary artery was dilated, and was laid open from behind (Fig. 2). Its lumen was occupied by a large moist reddish gray thrombus of smooth lobulated contour, which lay across the pulmonary orifice of the ductus, covering but not occluding this. The clot was roughly pyramidal in shape, its broad base lying vertically in the main lumen of the artery, and its apex projecting into and blocking the branch supplying the left lung, the right pulmonary, and the right half of the main lumen of the artery remaining free;

a ragged fibrinous prolongation of the thrombus was sent downward also to within 1 cm. of the pulmonary valves. The main portion of the thrombus was attached to the subjacent arterial wall by a broad base 2 x 4 cm. in diameter, the lower border of which lay 2 cm. above the pulmonary valves. On raising the mass it was found to spring from an ovoid area of vegetations lying on the right anterior wall of the artery. The pulmonary orifice of the ductus

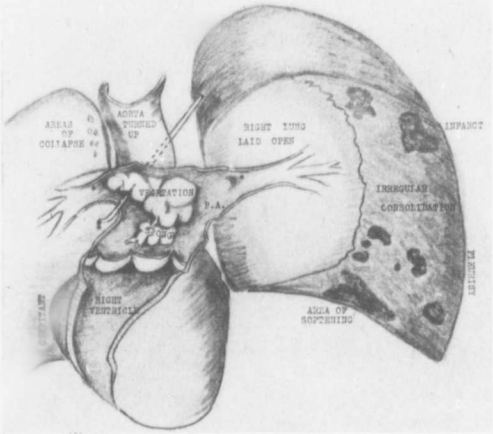


FIG. 2.—Looking from behind. * Orifices of pulmonary arteries. ‡ Probe introduced through small patent ductus arteriosus into aorta.

occupied the centre of this area and was evidently the starting-point of the process, for its edges were surmounted by a ring of firm fibrinous vegetations (one over 1 cm. long), which invaded its lumen for a short distance. The remaining four-fifths of the canal on the side of the aorta appeared smooth and healthy, to the naked eye, but proved on microscopic examination, to be also diseased. Just to the right of the pulmonary orifice of the ductus, the inflammatory process had been most intense, and had resulted in a complete

necrosis of the arterial wall, a mycotic aneurysm resulting. Section through the margin of this necrosed area showed the destructive inflammatory process spreading both without the vessel wall and within its lumen, the tissue of the relatively intact arterial coat showing up sharply between two necrotic zones. This appearance was further confirmed by microscopic investigation. At the outer margin of the diseased area in the pulmonary artery the thrombotic material could be lifted away, leaving an apparently intact intima, while in the neighborhood of the ductus it was densely adherent and incorporated with the necrosed arterial wall. Closely embracing the outer surface of the upper wall of the pulmonary end of the ductus and incorporated with its coats was a calcified mass of glandular tissue, which must have formed an unyielding structure at this point, thus narrowing the lumen and possibly furnishing a seat of maximum strain, which may have given origin to the disease within. A second still larger calcareous mass, the size of an almond, lay in the angle formed by the lower wall of the ductus and the pulmonary artery.

Remarks. The diagnosis of patent ductus arteriosus was made during life from the characteristic physical signs:

(*a*) Dulness in the upper spaces to the left of the sternum.

(*b*) A thrill.

(*c*) The accentuated pulmonic sound.

(*d*) The radiograph showing a shadow over the pulmonary area due to increased volume of the pulmonary artery.

(*e*) A continuous systolic-diastolic murmur at the base of the heart, increasing in systole and transmitted up and to the left.

Of all these signs it would seem from the literature and the writers' experience that the last mentioned is deserving of first place as indicating the anomaly under discussion, although there is at present a tendency to regard the fluoroscopic method as having greater value in the diagnosis. The importance of the radiograph seems indeed to us to lie chiefly in its confirmatory value in the presence of other characteristic physical signs.

The present case is of interest as being one of the very few reported in which the characteristic *x*-ray shadow observed during life has been proved at autopsy to be due to the dilated pulmonary artery in association with patent ductus arteriosus. An autopsy was ob-

tained also in Mead's[1] case, diagnosed by Thayer, in which a "continuous machinery murmur" with systolic accentuation was associated on the fluoroscopic examination with "a localized bulging of the left side of the base of the heart in close juxtaposition with the descending arch of the aorta." Among Goodman's[2] series of 34 cases of patent ductus arteriosus with autopsy findings, in only one had the fluoroscopic examination been made, while in the 37 cases collected by him in which the clinical diagnosis only had been established, the *x*-ray shadow over the dilated pulmonary artery was noted in 17.

The diagnosis of an infective pulmonary endarteritis about the orifice of the patent ductus was also here confidently suggested from a knowlege of the occurrence of such cases as recorded in the literature, and the fact that there was present in this case, septicemia, unassociated with any known focus of infection, or clinical signs of endocardial involvement. Ten such cases, and probably more, have been reported, but in all these the disease of the pulmonary artery was associated with a malignant endocarditis of one or more valves. Our case is, as far as we know, unique in the literature, in that there was here no involvement of the heart, both valvular and mural endocardium being free from any trace of disease.

This fact adds greatly to the pathological interest of the case, which centres about the origin of the infective process in the pulmonary artery, here plainly shown to be due, not to an extension either by contiguity or continuity of an inflammatory focus originating in the heart, but to a primary lesion of the arterial wall itself, adjacent to, or at, the ductus orifice, or within its canal. The causation must, therefore, have been the direct invasion of the wall by an infection carried either through its vasa vasorum or through the blood-stream in the main arterial trunk. We may therefore conclude that we are dealing here with a local process in the pulmonary artery, and the question as to its origin is a threefold one. Was the infection embolic in the vasa vasorum? Or was it carried in the main blood-stream and lodged at the seat of maximum strain and lowered resistance? Or was the process in the first place

[1] Jour. Amer. Med. Assoc., 1910, vol. lv, p. 2205.
[2] Univ. Penna. Med. Bull., 1910, vol. xxiii, p. 509.

a mechanical one, the strain upon the pulmonary end of the ductus resulting in the formation of minute tears in the intima followed by a

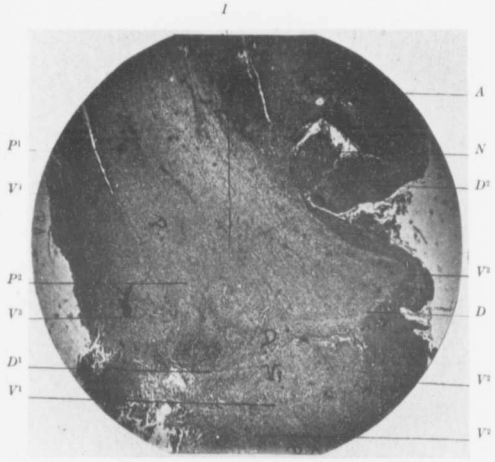


FIG. 3.—Section from rectangular block taken through entire length of ductus and adjacent portions of aorta and pulmonary artery. (Stained H. and E. Leitz obj. No. 2.) *D*, free margin of patent ductus, necrosed and inflamed in all its coats, its elastic tissue in large part destroyed; D^1, angle of junction with pulmonary artery (seat of initial lesion); D^2, angle of junction with aorta (advanced necrosis). *A*, wall of aorta adjacent to ductus, healthy throughout. *P*, wall of pulmonary artery; P^1, wall of pulmonary artery at a distance from ductus, healthy; P^2, wall of pulmonary artery in immediate neighborhood of ductus, intima superficially necrosed, deeper coats healthy. *V*, huge vegetation surmounting necrosed wall of ductus in its entire length and extending over wall of pulmonary artery immediately adjacent; V^1, young, newly vascularized granulation tissue at angle of junction of ductus with pulmonary artery (initial lesion); V^2, unorganized thrombotic mass covering necrosed wall of ductus from angle of junction with aorta (D^2), extending over mass of granulation tissue (V^1) at angle of junction with pulmonary artery and continuous with thrombotic mass here; V^3, unorganized thrombotic mass overlying and incorporated with necrosed pulmonary intima immediately adjacent to ductus; V^4, unorganized thrombotic mass overlying healthy pulmonary artery at a distance from ductus (P^2), not incorporated with it. *N*, area of acute recent extensive necrosis at junction of ductus with healthy aorta (D^2). *I*, area of acute inflammatory cell infiltration in cellular tissue between outer walls of aorta, pulmonary artery and ductus, proceeding from the latter vessel. *Aorta*, lumen of aorta. *P.A.*, lumen of pulmonary artery; *D.A.*, lumen of ductus arteriosus.

simple thrombosis at the seat of injury and secondary infection of this by the circulating organisms?

The reply to these questions is to be found, we think, in the study of the vessel wall in and about the seat of the initial lesion.

For this purpose the following sections were made: (*a*) A large thin slice was cut from the upper wall of the ductus, from end to end of its canal. The rectangular block thus obtained presented a section of the wall of the ductus in its entire length, with the adjacent portions of the aorta and pulmonary artery at either end, and the intervening tissue external to and between the outer surfaces of these vessels (Fig. 3); (*b*) a slice through the opposite margin of the ductus in the pulmonary artery involving the angle of junction of these two structures; (*c*) sections from various parts of the diseased area in the pulmonary artery at some distance from the ductus, including (*d*) the immediate neighborhood of the mycotic aneurysm, where the destructive process was most intense; (*e*) a section from the wall of the apparently healthy pulmonary artery at some distance from the diseased focus. The material was studied with the help of the elastic tissue, Gram-Weigert, and hematoxylin-eosin stains.

(*a*) The large rectangular block containing the ductus and adjacent structures was sectioned *in toto* (Fig. 3), and revealed the *earliest seat of disease to be at the pulmonary end of the ductus*, which was the only point at which organization was manifest, the process everywhere else both in the ductus and pulmonary artery being of a rapidly progressive and highly destructive character. At this point *the angle formed by the walls of the ductus and pulmonary artery was surmounted by a large mass of vegetations which consisted of well organized young granulation tissue very cellular in character, and containing many newly formed bloodvessels* (Fig. 3, V. 1), evidencing a considerable duration. These vegetations were surmounted by a layer of recent thrombotic material which extended also along the wall of the pulmonary artery for a short distance, being at first merged with this, and further out simply superimposed upon it. In the immediate neighborhood of the ductus the pulmonary intima showed superficial inflammation and its endothelium was necrosed, but its deeper structures including its entire media were even here intact, and beyond the thrombotic exudate the wall of this artery was healthy and free from any evidence of disease.

Following the ductus inward toward its aortic end (Fig. 3, D^2) its entire wall was found to be extensively diseased by a recent highly destructive process, its inner coat necrosed, replaced, and covered by thrombotic exudate, and the elastic tissue of its deeper layers lying in broken shreds and islands in the midst of inflammatory exudate and debris. An acutely destructive and very recent process (Fig. 3, N) involved the extreme end of the canal immediately before its junction with the aorta, where it was hollowed into a deep bay in the depths of which lay masses of fibrin and beds of leukocytes and other inflammatory cells. The process was here sharply delimited by the aorta, whose endothelium, intima and media showed no evidence of acute inflammation, the only change noted being a thickening of the walls of its vasa vasorum as from raised peripheral pressure. In the tissue external to the ductus wall, however, and lying between aorta and pulmonary artery (Fig. 3, I) the same acute process had spread, a recent intense inflammation, suppurative and destructive in character, existing.

No pneumococci were present in this section either in the vessel wall or vegetations, or in the recent thrombotic material. The remarkable feature of this whole section is the localization of all organization to the pulmonary end of the ductus, and the limitation of the recent destructive process to this canal and its environs, and the absolute freedom of the deeper layers of the pulmonary artery or aorta from any local foci of disease that could suggest an embolic orgin through the vasa vasorum. *The infective process is here undoubtedly and distinctively superficial in its origin* in relation to the inner surface of the arterial wall.

(*b*) The section through the orifice of the ductus and the adjacent pulmonary artery, on the side opposite to the rectangular block removed, showed an identical process to that occurring here. The ductus wall was extensively destroyed, and the adjacent pulmonary artery relatively intact, but with an inflamed intima, while superimposed on the angle formed by the two structures was a large vegetation, which consisted of organizing tissue at its base, and superficially of a thrombotic mass, in which lay embedded numerous pneumococci.

(*c*) The sections from the diseased area in the pulmonary artery at a distance from the ductus showed everywhere an extremely destructive, thrombotic process, rapidly advancing and of recent date, which (*d*) at the site of the myocotic aneurysm had entirely destroyed the arterial wall, including the elastic tissue of the media, but elsewhere had shown itself superficial to this structure extending both over the inner surface of the artery and burrowing outside of its coats, leaving the wall itself practically intact between two necrotic thrombotic zones. Here also the *media* showed little change, there were no embolic foci, while the *intima* was superficially necrosed and inflamed. Pneumococci in masses were present in the thrombotic material immediately adjacent to the diseased intima, but were nowhere present in the vessel wall, nor in its vasa vasorum.

(*e*) A section from the apparently healthy pulmonary artery at a point about 1 cm. from the vegetations, but where it lay over and against the main thrombus, presented an interesting finding in that it showed one of the most recent foci of invasion of the acute disease. The adventitia and deeper layers of the media were perfectly healthy, but the intima was the seat of extensive leukocytic infiltration, its endothelium was destroyed and at one point the internal elastic lamina was elevated (endothelial lifting) in a characteristic manner above an area of acute inflammation. The intima was covered here and for a short distance by a narrow zone of recent thrombus in which numerous pneumococci were entangled.

Conclusions. 1. This case illustrates in a remarkable manner the hitherto not fully emphasized fact that a vegetative process is commonly associated with congenital cardiac defects.

2. These vegetations, in the present case, and probably in the majority of such processes occurring in conjunction with cardiac defects, are not a simple thrombosis of mechanical orgin, with secondary infection supervening, but from their onset are inflammatory in character, the result of an invasion of the vessel wall at the seat of maximum strain.

3. The inflammatory process present in this case manifestly did not arise as a result of an embolic infection through the vasa vasorum of the arterial wall, but began by the invasion of the intima at a single point, the pulmonary end of the ductus, which was prob-

ably the seat of maximum strain from the two combined causes, the eddying blood stream within its lumen, and the rigid calcareous gland which lay in close juxtaposition without.

4. The present is, so far as we know, the only recorded case in which the ductus and pulmonary artery in the neighborhood are the sole seat of the disease, and in which the pulmonary orifice of the ductus has been demonstrated microscopically to be the oldest, and therefore the initial, seat of the lesion.

5. From observation both of these and other cases we believe that the murmur, continuous throughout the cardiac cycle, but accentuated during systole, and with its point of maximum intensity over the pulmonary area, is the most important diagnostic sign of a patent ductus in adults, and when present, may be considered pathognomonic. The increased cardiac shadow to the left, the so-called *x*-ray cap, caused by the dilated pulmonary artery, furnishes valuable confirmatory evidence of patency, but is not in itself an absolute proof of its presence.

The sincere thanks of the authors are due to Dr. L. Rhea for his advice and assistance in the study of the microscopic appearances in this case and to Dr. Atkinson for the drawing, and Dr. F. Tooke for taking the photomicrograph.

SUMMARY OF LITERATURE. A comparative study of eleven cases, including our own, recorded of infective pulmonary endarteritis about the orifice of a patent ductus reveals the following points of interest:

Localization of Vegetations. The wall of the pulmonary artery adjacent to the opening was involved in all the cases of the series, that of the ductus itself in nine, that of the aorta in seven. In three cases the vegetations involved the wall of the aorta opposite the defect (Foulis[2] Hochhaus,[3] Rickards[4]), indicating that the current through the ductus had impinged here, and that the primary seat of disease was in the pulmonary artery. The heart valves were also the seat of an infective endocarditis in the ten cases published previously to our own, and of these in three (Foulis, Buchwald,[5] Hochhaus), the lesion was multiple; in four (Kidd,[6] Schlagenhaufer,[7] Hart's two cases[8]), the aortic valve only was involved; in two (Gauchery,[9] Rickards), the pulmonary valve only, and in one

(Murray[16]), the tricuspid only was the seat of disease. *The present case was the only one of the series in which the endocardium was free.*

Infection. In Schlagenhaufer's case influenza bacilli were present in the vegetations, in Rickards' "micrococci" and in our own the Gram-positive diplococci believed to be pneumococci. In Hochhaus' case the blood culture yielded *staphylococcus albus.*

Multiple infarcts in both systemic and venous circulation occurred in the cases of Rickards, Hochhaus, Gauchery, Schlagenhaufer, Hart, and probably in our own. The clinical diagnosis of the infective endarteritis present was correctly made by Hochhaus on the basis of this feature.

The accompanying notes show the above points in detail and also the character and localization of murmur and thrill:

No. 1. (Buchwald: Deut. med Woch., 1878.) Female, aged twenty-one years. *Ductus arteriosus*—crater-like opening, with worm-eaten edges. *Vegetations: seat*—aortic valve, mitral valve, aorta, pulmonary artery, ductus arteriosus; *character*—Polypoid granulations surrounding opening of ductus arteriosus in aorta. In pulmonary artery, conglomeration of vegetations reaching from neighborhood of opening of ductus arteriosus, to just above pulmonary valves; *infection*—not determined. *Embolism*—Forked, in lung.

No. 2. (Foulis: Edinburgh Med. Jour., 1884, p. 17.) Female, aged twenty-two years. *Clinical findings*—scarlet fever at sixteen; ill eight months with anemia, increasing weakness, dyspnea, palpitation, epistaxis, and finally anasarca and hemoptysis; heaving systolic pulsation in second left interspace; loud-blowing systolic and fainter diastolic murmurs, separated by a sharp click at second left interspace. *Ductus arteriosus*—canal one-fifth inch long; funnel-shaped toward aorta, blocked by clot at pulmonary end. *Vegetations: seat*—mitral and aortic valves, pulmonary valves, ductus arteriosus, aorta pulmonary artery; *character*—large soft vegetations on ulcerated pulmonary valves, smaller on aortic valve; bean-shaped on one mitral valve; coagulum in pulmonary artery from pulmonary valves to bifurcation, extending into ductus arteriosus and right pulmonary artery, and filling saccular aneurysm on left anterior wall of pulmonary artery; lens-shaped aneurysmal bulging of aorta opposite ductus arteriosus filled with coagulum. *Embolism*—multiple infarcts in lungs. *Remarks*—pulmonary artery dilated; marked hypertrophy and dilatation of right auricle, right ventricle, and left ventricle.

No. 3. (Murray: Trans. Path. Soc., London, 1888, xxxix, p. 67.) Female, aged thirty-six years. *Clinical findings*—Always delicate, never

cyanosed; rheumatism ten years previously; thrill over pulmonary cartilage; faint murmurs; loud grating systolic murmur over whole cardia, + at pulmonary cartilage; died with symptoms of malignant endocarditis. *Ductus arteriosus*—canal, two-third inches long, admitting quill; wall of aortic opening calcified; cone-shaped. *Vegetations: seat*—tricuspid valve, pulmonary artery; *character*—large ovoid mass 1½ x 1 inch in diameter, on upper aspect of pulmonary artery, just before orifice of ductus arteriosus, beginning beyond pulmonary valves; vegetation also on tricuspid valve; *infection*—not determined. *Embolism*—infarcts in spleen and kidneys. *Remarks*—dilatation of pulmonary artery.

No. 4. (Rickards: Brit. Med. Jour., March 23, 1889.) Male, aged seventeen years. *Clinical findings*—Always thin and pale. Precordial pain dyspnea, and night-sweats ten weeks; systolic murmur at apex, + at pulmonary cartilage; loud vibrating double murmur at second left interspace, not transmitted over sternum nor into neck; strong thrill over second left interspace. *Ductus arteriosus*—patent. *Vegetations: seat*—pulmonary valves, aorta, pulmonary artery; *character*—soft polypoid vegetations on pulmonary valves; large mass on anterior wall of pulmonary artery; round orifice of ductus arteriosus, partly occluding lumen. Small portions carried through ductus arteriosus into aorta, impinging on opposite wall of transverse arch; *infection*—micrococci in vegetations. *Embolism*—mycotic aneurysm of branch of right pulmonary artery; infarcts of lung, spleen, and kidney. *Remarks*—left ventricle slightly hypertrophied.

No. 5. (Kidd: Trans. Path. Soc., London, 1893, xliv, 47.) Female, aged twenty-two years. *Clinical findings*—dyspnea and wasting twelve months; double murmurs at aortic and pulmonary areas, and systolic murmur at mitral area. *Ductus arteriosus*—small oval opening size of goose-quill in left branch of pulmonary artery. *Vegetations: seat*—aortic valve, pulmonary artery, aorta, ductus arteriosus; *character*—Soft fibrinous vegetations on thickened, slightly incompetent aortic valve; warty vegetations on wall of pulmonary artery, just beyond thoracic valves; *infection*—not determined. *Embolism*—aneurysm of branch of left pulmonary artery; infarcts of spleen and kidney. *Remarks*—great hypertrophy and dilatation of heart, especially of left ventricle; pulmonary tuberculosis.

No. 6. (Hochhaus: Deut. Arch. f. klin. Med., 1893, Bd. 51, p. 1.) Male, aged twenty-four years. *Clinical findings*—rheumatism and endocarditis at twelve. Precordial pain, dyspnea, and symptoms of general infection two months; systolic murmur at apex; long drawn-out humming, buzzing diastolic murmur, + over pulmonary cartilage localized anteriorly, distinct in back in left interscapular region; pulmonary second loud. *Ductus arteriosus*—short canal 6 mm. wide, aortic opening funnel-shaped. *Vegetations: seat*—pulmonary valves, mitral valve, left auricle, aorta,

ductus arteriosus, pulmonary artery; *character*—vegetations on one pulmonary valve; numerous cauliflower-like yellowish-green excrescences with narrow base on anterior wall of pulmonary artery from 1.5 cm. above valves, to opening of ductus arteriosus; fresh, flat vegetations along wall of ductus arteriosus and long vegetations projecting from aortic opening of ductus arteriosus; *infection*—staphylococcus albus in blood culture during life. *Embolism*—multiple infarcts of lung and spleen. *Remarks*—heart much hypertrophied, especially in right conus; coarctation of aorta.

No. 7. (Gauchery: Centrabl. f. Path., 1900, Bd. 11, p. 70.) Female, aged twenty-seven years. *Ductus arteriosus*—hole between aorta and pulmonary artery. *Vegetations: seat*—pulmonary valves, ductus arteriosus, pulmonary artery; *character*—endocarditic excrescences on pulmonary valves extending up in pulmonary artery to opening of ductus arteriosus, forming a fringe around this similar excrescences on wall of ductus arteriosus; *infection*—not determined. *Embolism*—multiple septic emboli. *Remarks*—pulmonary artery dilated.

No. 8. (Schlagenhaufer, 1901. Quoted by Hart.) Male, aged thirteen years. *Ductus arteriosus*—patent. *Vegetations: seat*—aortic valve, ductus arteriosus, pulmonary artery; *character*—vegetations in aorta about opening of ductus arteriosus, also on aortic valves and in pulmonary artery; *infection*—influenza bacilli.

No. 9. (Hart: Case I, 1904, Virchow's Arch., Bd. 177, p. 218.) Male, aged twenty-three years. *Clinical findings*—marked anemia with intermittent fever; murmurs suggesting aortic insufficiency. *Ductus arteriosus*—large, admitting medium-sized probe; funnel-shaped towards aorta. *Vegetations: seat*—aortic valve, aorta, ductus arteriosus, pulmonary artery; *character*—grayish-red vegetations on aortic valve; wall of funnel-shaped opening of ductus arteriosus in aorta covered with pin-head grayish efflorescences which extend into ductus arteriosus; vegetations abundant in pulmonary artery extending from about opening of ductus arteriosus both to lung and heart; *infection*—not determined. *Embolism*—multiple of kidney, spleen, stomach, intestine, and heart. *Remarks*—left ventricle slightly hypertrophied; hemorrhagic nephritis.

No. 10. (Hart: Case II, 1904, Virchow's Arch., Bd. 177, p. 218.) Female, aged twenty-four years. *Clinical findings*—marked anemia, with intermittent fever. Murmurs suggesting aortic insufficiency, also long-blowing systolic murmur replacing first sound in second left interspace. *Ductus arteriosus*—patent; funnel-shaped toward aorta. *Vegetations: seat*—aortic valve, left ventricle, aorta, ductus arteriosus, pulmonary artery; *character*—cauliflower-like vegetations on aortic valve, adjacent endocardium, sinus of Valsalva and aorta near ductus arteriosus, which is plugged by a mass of vegetations extending through to pulmonary artery; intima of pulmonary

artery covered with small vegetations to medium-sized branches; *infection*—not determined. *Embolism*—multiple of kidney, spleen, heart, and lungs.

No. 11. (Hamilton and Abbott, 1914.) Female, aged nineteen years. *Clinical findings*—pale, slender; symptoms of general infection two months; leukocytes, 17,000; pneumococci in blood-culture; cardiac dulness increased in second and third left interspace (Gerhardt's sign); faint systolic thrill over pulmonary area; harsh, rumbling continuous murmur, + in systole, diminished in diastole, not transmitted upward or to back; pulmonary second, +. *Ductus arteriosus*—large canal 75 mm. long, admitting pen-holder, lined with vegetations. *Vegetations: seat*—ductus arteriosus pulmonary artery; *character*—large pyramidal thrombotic mass in pulmonary artery beginning above pulmonary valves and extending into left branch, blocking it; attached by moderately narrow base to mass of vegetations on anterior wall of pulmonary artery surrounding orifice of ductus arteriosus and invading its lumen; initial lesion at margin of ductus arteriosus in pulmonary artery; aorta and endocardium of all valves in heart healthy; *infection*—pneumococci in thrombus and blood. *Embolism*—embolic abscesses in both lungs. *Remarks*—coarctation of aorta.