Surgical Closure of an Aortic Septal Defect

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Occurring just above the aortic and pulmonic valves, an aortic-pulmonary artery communication gives a left-right shunt which may be indistinguishable by clinical findings from a patent ductus arteriosus. Under some circumstances it is possible to identify the lesion by retrograde aortography. Because of increase in cardiac work, the shunt can produce cardiac strain. Whether or not the communication can be closed surgically depends upon the size of the opening and its distance above the coronary arteries. A case is here reported in which an aortic-pulmonary artery communication has been closed surgically.

CONGENITAL communication between the first parts of the ascending aorta and the pulmonary artery, just above the semilunar valves, is an uncommon lesion but deserves some consideration because it can mimic the clinical picture of a patent ductus arteriosus and because it may be possible in some instances to treat the anomaly successfully by surgical means.

In the formation of an embryo, the primitive truncus arteriosus normally becomes divided by a septum into aorta and pulmonary artery. If there is an incomplete development of this septum, an opening of variable size persists between these two great contiguous vessels and gives rise to a shunt between them. The openings have been described as generally ranging from 5 to 10 mm. in diameter, but some have been as large as 20, 30 or more mm. in maximum cross dimensions. The openings have been round, oval, triangular, or slit-like. Some have been situated very close to the orifices of the coronary arteries; others have been a centimeter or two above these vessels. Pathologic descriptions of these anomalies have been all too vague. In view of the probability that surgical correction of the anomaly can be offered some of these patients it would be helpful if pathologists who have the opportunity of studying specimens would give a more complete description of the local pathologic anatomy; in this way the surgical problems could be better understood and the best means could be devised for closing the fistulas.

An opening between the first part of the aorta and the pulmonary artery will obviously give clinical findings quite similar to—and usually indistinguishable from—those of a persistent ductus arteriosus, which is a communication between the two systems situated somewhat further along between the vascular channels. Because of the pressure differentials, the shunt is almost invariably left to right; therefore cyanosis is seldom observed, except in terminal stages of cardiac failure. Some degree of dyspnea or diminution of exercise tolerance is often noted. Some retardation in physical development may be found. A murmur is always present; it is usually continuous, with systolic accentuation. It has been described as systolic alone, or as systolic with only a short diastolic phase. These murmurs are most intense in the second and third intercostal spaces, to the left of the sternum; they can duplicate those which originate from an open ductus. In some cases the murmur has been accompanied by a thrill. The diastolic blood pressure is somewhat reduced, and in some instances gives a pulse pressure wide enough to produce a water-hammer pulse in the arms and legs. By film and fluoroscopic studies there is evidence of a left to right shunt, giving some cardiac enlargement, fullness of the pulmonary conus, enlargement of the pulmonary artery, increased vascularity in the pulmonary bed, and a hilar dance; all of these findings are exactly those produced by an open ductus. The various clinical and roentgenologic findings probably vary in intensity from case to case, depending upon the size of the aortic leak. By electrocardiography the electrical axis may be normal, is apt to be

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shifted to the left, but has been described as rotated to the right. By cardiac catheterization there is evidence of a left to right shunt into the pulmonary circuit, and the finding may be entirely those suggesting an open ductus unless the catheter can by good fortune be made to pass through the communication which lies just above the pulmonary valve; such an observation, proving the existence of an aortic septal defect, has been reported by Dexter.\textsuperscript{3} Angiocardiology is of practically no help in differentiation from an open ductus, for both show the continued recirculation through the pulmonary circuit. Retrograde aortography has demonstrated clearly the presence of an aortic septal defect, as reported by Gasul, Fell, and Casas.\textsuperscript{5}

At the operating table it is possible to differentiate quickly between an open ductus and an aortopulmonary window. In the former a thrill can be felt in the pulmonary artery, opposite the distal end of the aortic arch; digital pressure over the ductus abolishes the thrill. Conversely, an aortopulmonary defect gives a thrill which is most intense in the first part of the pulmonary artery, just above the pulmonary valve and within the pericardial envelope. Digital pressure in this region is necessary to shut off the thrill; compression in the area of the ligamentum arteriosum has no effect on the pulmonary artery turbulence.

Hektoen\textsuperscript{7} gave pathologic descriptions of a case of aortopulmonary septal defect and reviewed nine others from the literature. Subsequently individual reports have been made by Fisher,\textsuperscript{1} Oberwinter,\textsuperscript{9} Bain and Parkinson,\textsuperscript{1} Dadds and Hoyle,\textsuperscript{2} Perelman and Putschar,\textsuperscript{10} Dexter,\textsuperscript{3} Spencer and Dworken,\textsuperscript{11} and Gasul, Fell, and Casas.\textsuperscript{6} An intriguing report of four cases, each found at the operating table but without attack on the lesion, was made by Gibson, Potts, and Langewisch.\textsuperscript{6} To these is added herewith a case in which the lesion was treated surgically with success.

The patient was a 4 year old girl who was examined and treated in 1948. A cardiac murmur had been heard shortly after birth and had persisted thereafter. The cardiac impulse had always been described as being forceful. Since infancy the youngster had sweated profusely, particularly after mild exercise. There was slight exertional dyspnea, but no cyanosis. On physical examination, the child appeared to be normally developed and nourished. The blood pressure was 105/45. The heart sounds were obscured by a very loud, continuous murmur, which had marked systolic accentuation. The murmur was widely transmitted over the precordium but was most intense over the third and fourth intercostal space, just inside the nipple line. Electrocardiographic tracings showed a mild left ventricular hypertrophy. Fluoroscopic and x-ray film studies showed the heart to be enlarged in transverse diameter, predominantly downward and to the left, apparently due mainly to left ventricular enlargement. There appeared to be moderate enlargement of the left auricle posteriorly. There was bilateral pulmonary vascular engorgement with prominent hilar shadows. The left ventricular beat and the pulmonary artery beat were hyperactive. These roentgenologic findings were felt to be indicative of a patent ductus arteriosus (and indeed the murmur was thought to be typical of this condition).

Operation was advised, and exploration was carried out on May 22, 1948. A submammary exposure was made on the left, entering the chest anterolaterally in the third intercostal space, dividing the third and second costal cartilages. The pulmonary artery had a very intense and coarse thrill within it. No open ductus was found, but a fibrous ligamentum arteriosum was encountered. Digital pressure in this region did not change the thrill in the pulmonary artery. To make absolutely certain that a tiny lumen did not exist in the ligamentum, this structure was completely divided and was found to be obliterated. This in no way changed
SURGICAL CLOSURE OF AORTIC SEPTAL DEFECT

Fig. 2. Operative drawings from case here reported. A. Exposure through left, anterolateral transpleural approach in the third intercostal space. L. A., ligamentum arteriosum. P., pulmonary artery. X shows the point where thrill was maximal in pulmonary artery. B. By digital pressure in this area, the pulmonary artery thrill could be completely abolished. C. Pericardium opened and held up by clamp. Epicardium opened over aortopulmonary groove and held back by sutures. A, aorta. F, fenestrum between aorta and pulmonary artery. P, pulmonary artery. D. Fenestrum ligated with a heavy tape. T. F. is the tied fenestrum. Epicardial stitches being started. E. Epicardium closed. F. Closure of pericardium.
the thrill in the pulmonary artery. On further examination the thrill was obviously most intense in the first portion of the pulmonary artery, just above the valve. The pericardium was now opened so that the first portions of the aorta and the pulmonary artery could be examined. The thrill was most intense at a point about 1.5 cm. above the pulmonary valve. The tip of a finger pressed into the groove between the aorta and the pulmonary artery at this level could completely shut off the thrill in the pulmonary artery. It was decided to attack surgically the fenestrum which was now known to exist between the first parts of these two vessels. The epicardium was very carefully opened and peeled back off the aorta and the pulmonary artery, to expose the underlying vessels. The great vessels lay immediately contiguous to one another and there was fear of dissecting between them because of the possibility of plunging into the thin walled communication between them and setting up bleeding which would be uncontrollable. However, it was possible to dissect down between the aorta and pulmonary artery, passing below the shunt and above the coronary arteries. After carrying this dissection toward the posterior aspect of the vessels a similar plane was opened up between the vessels above the shunt. Finally, with considerable apprehension, an aneurysm needle was passed completely around the shunt, though there was very little room between and behind the vessels to permit this. A piece of linen tape, 1.0 cm. wide, was now drawn around between the vessels, so that it encircled the shunt. At this point arterial blood began to escape from the depths of the wound so that it was evident the thin posterior wall of the shunt had been slightly torn. Believing that the one hope of controlling this situation might be to tie quickly the tape which had previously been placed, this was now rapidly and tightly drawn down. Fortunately, all of the bleeding stopped. All of the thrill in the pulmonary artery disappeared. The epicardium was closed over the ligature. The pericardium was repaired with interrupted silk sutures, making the latter closure incomplete so that any excess fluid which might accumulate in the pericardial sac could escape into the pleural cavity. The chest was closed in a routine manner. Following operation the child made a very satisfactory convalescence. She was discharged from the hospital on June 18, 1948. Frequent auscultation now showed that the prominent murmur which existed prior to operation had disappeared. To several observers no murmur existed, but one thought that a grade II systolic murmur could be heard in the pulmonary region.

Since discharge from the hospital the child has had an exceedingly satisfactory and an asymptomatic course. She has had no limitation of her physical activity. There have been no cardiac symptoms. When last examined on June 26, 1951 she was in excellent physical condition, was very vivacious, and was without complaints. Careful auscultation revealed the cardiac sounds to be entirely normal. No murmur could be heard anywhere in the thorax. At this time film and fluoroscopic examination showed only barely detectable structural abnormality of the heart; it was no longer enlarged, but there appeared to be slight left ventricular predominance. No auricular enlargement could be detected. The pulmonary artery and intrapulmonary vessels were normal in size and had normal pulsations.

**COMMENTS**

The surgical exposure employed in this case was a left anterolateral approach; it certainly was not ideal, because the first portions of the aorta and pulmonary artery were retrogressed underneath the sternum, which hung over them like a shelf and interfered with the manipulations in the region. Without
doubt, a better exposure could be attained by 
a transverse, anterior chest incision, trans-
versely dividing the sternum between the third 
and fourth costal spaces. (Indeed, we now 
make it a practice in all patent ductus opera-
tions to make sure that the skin of the entire 
anterior chest wall is prepared well toward the 
right anterior axillary line. Since we commonly 
use a left anterolateral approach, this pre-
caution in draping would allow us to extend 
the incision directly across the sternum if an 
aortopulmonary artery fenestration is en-
countered when the chest is opened).

In the surgical closure of one of these aorto-
pulmonary artery openings, simple ligation 
such as was employed in the above case would 
march certainly not meet with uniform suc-
cess. Such a ligature would in some instances 
incompletely close the shunt or in others 
might very well cut through and allow re-
establishment of the fistula. It would seem 
that to more nearly ideal to carry out a complete 
section and a separation of the aorta and 
pulmonary artery, making a separate closure of 
each vessel wall. To accomplish this would 
require the manufacture of some appropriate 
clamps, one of which could conceivably be 
placed on the aorta to isolate the involved part 
of the aortic wall, while not obstructing the 
main aortic flow. Another similar clamp could 
be placed on the pulmonary vessel. It would 
seem that an instrument such as that in-
geniously devised by Potts for performance of 
aortopulmonary artery anastomosis in pa-
tients with tetralogy of Fallot could be re-
vamped to accomplish the task at hand. How-
ever, examination of the region quickly in-
dicates that these vessels are very large, very 
tense, have little room between them, and are 
difficult to circumvent in their entirety; be-
cause of these various factors it might be 
nearly impossible to devise instruments which 
would suitably isolate appropriate portions 
of the aorta and pulmonary artery.

After successfully treating the above child it 
is felt that the fortunate outcome has been 
attended by a high degree of luck and that 
simple ligature might lead to disaster if at-
tempted in all cases of aortopulmonary artery 
fenestration. In spite of its shortcomings as a 
universal method of treatment, the fact re-
 mains that tape ligation was successful in this 
patient and the method might well be em-
ployed in other suitable, selected cases.

SUMMARY
During fetal life incomplete development 
of the septum between aorta and pulmonary 
artery can lead to persistence of an opening 
between the first portions of these vessels, just 
above the semilunar valves. Such a communica-
tion permits a left to right shunt, producing 
the clinical picture, roentgenologic changes, 
and physiologic disturbances which closely 
simulate those accompanying a patent ductus 
arteriosus. By cardiac catheterization the two 
conditions can be differentiated if the operator 
is fortunate enough to pass the catheter directly 
through the opening which exists between the 
first portions of these two major vessels. 
Retrograde aortography can visualize the 
defect. If a patient is explored, believing there 
is a patent ductus arteriosus, and none is 
found, an aortopulmonary communication can 
be identified by observing the point of max-
um intensity of the thrill within the pulmo-

ary artery. Digital pressure in the region 
normally occupied by a patent ductus will not 
abolish the thrill, whereas digital pressure 
over the groove between the first portions of 
the aorta and pulmonary artery will shut off 
the thrill.

A case is reported in which surgical attack 
has been made on a defect between the first 
portions of the aorta and pulmonary artery, 
this patient having been followed for three 
years since surgical closure. As far as is known, 
this is the first instance of successful surgical 
correction of this congenital abnormality.

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