INDICATIONS FOR THORACIC AORTOGRAPHY

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The recent advances in thoracic surgery have necessitated a considerable development of diagnostic methods in cardiovascular disease. The introduction of cardiac catheterization as a routine method of examination has made it possible to diagnose malformations of the great veins of the thorax, the right side of the heart, and the pulmonary artery with accuracy. Pressure measurements and the deterioration of arterio-venous shunts within the heart give evidence of abnormal communications between the heart chambers or great vessels. However, there are still difficulties in the diagnosis of diseases exclusively localized to the left side of the heart and the aorta and of malformations where the abnormal communication between the arterial and venous side is so small that its presence could not be proved by pressure measurements or blood analyses.

Angiocardiography after injecting dye into an arm vein is generally inconclusive in the diagnosis of these diseases, as the dye after its passage through the lungs is so diluted that the contrast filling of the left side of the heart and the aorta is insufficient.

A more detailed study of the anatomy of the aorta *in vivo* has been made possible by the introduction of thoracic aortography. As early as 1939 Castellanos and Pereiras performed thoracic aortographies by injecting dye retrogradely through the left brachial artery. Gomez Del Campo and Meneses Hoyos (1947) developed a technique of direct puncture of the aorta through the left second intercostal space and have performed aortographies by injecting dye through a cannula. Several authors have made aortographies through the left carotid artery by percutaneous puncture or by direct insertion of a needle or catheter into the artery after exposing the vessel (Burford and Carson, 1948; Jönsson, 1949). In order to obtain sufficiently good filling of the aorta by these methods, it is necessary to use a heavy needle, which involves the risk of thrombosis of the artery or perforation of the aorta and periarterial injection of the dye.

During the last two years we have performed thoracic aortographies by the technique, introduced by Radner (1948) and further developed by Jönsson and his colleagues (Brodén, Hanson, and Karnell, 1948; Brodén, Jönsson, and Karnell, 1949; Jönsson, Brodén, and Karnell, 1951; Falholt, Thomsen, and Davidsen, 1954). By their method a catheter is introduced through the right or left radial artery to the aorta and the dye is injected through the catheter. This technique has proved satisfactory in those cases in which we have found it indicated.

To begin with, the aortographies were performed under nitrous oxide-oxygen-ether anaesthesia. Lately we have used pentothal-curare anaesthesia, and this has been satisfactory.

Aortography is only fully profitable when a cassette changer, able to expose at least one picture in two planes per second, is employed. In single cases it may be of interest to obtain exposures with considerably shorter intervals in order to observe the filling of the aorta and possible malformations in the different phases of the cardiac cycle.

During the two years in which we have been able to perform thoracic aortography we have only found it indicated as a supplementary examination in 20 out of 700 catheterized cases of congenital and acquired heart disease. In no case have serious complications developed. In spite of being ligated, the radial artery was generally palpable immediately after the examination, giving evidence of sufficient collaterals. Frequently respiratory paresis was observed for a few seconds to a few minutes after the injection of the dye (70% diodone, 1 g. per kg., maximal 60 g.). Artificial respiration was given during this period. Frequently the patients complained of a headache the first day after the aortography was performed, but we have never seen oedema of the brain such as has been reported by a few authors. Cases of temporary hemiplegia have been reported after the performance of thoracic aortography (Jönsson and others, 1952; Pierce, 1953). These last complications are, according to Broman and Olsson

(1949), due partly to a toxic, partly an osmotic, effect of the hypertonic diodone solution on the blood-brain barrier.

INDICATIONS

PATENT DUCTUS ARTERIOSUS.—The clinical picture of this disease, in which the continuous murmur maximum in the second left intercostal space is so characteristic that neither cardiac catheterization nor thoracic aortography is indicated when the electrocardiograms or radiographs do not show complicating anomalies of the heart. However, in cases of small patent ducts or very great ducts the murmurs are frequently atypical. In the first instance the continuous murmur is often displaced by separated systolic-diastolic murmurs.

In cases of voluminous patent ducts, possibly with equalization of the pressures in the aorta and pulmonary artery, one may find a pure, rough, systolic murmur, which is louder and of lower frequency than the typical murmur. As we consider cardiac catheterization less risky than aortography, these cases have been catheterized, and in all we have succeeded in proving the presence of the duct by passing the catheter through it into the aorta.

In the case of very small ducts, where the arterio-venous shunt to the pulmonary artery is so small that it cannot be demonstrated by the analyses of blood samples or by pulmonary hypertension, and where it has not been possible to pass the catheter through the duct, we have considered thoracic aortography to be indicated. The duct is then so small that it is not visualized directly, but early filling of the pulmonary artery, possibly displacement of the pulmonary artery towards the aorta, and irregularities in the outline of the aorta are evidence (Fig. 1) of the patent duct (Steinberg, Grishman, and Sussman, 1943).

AORTIC SEPTAL DEFECT.—This disease is a differential diagnostic problem to patent ductus arteriosus. It originates in a defective development of the septum between the aorta and the pulmonary artery. It is of practical importance to establish the differential diagnosis before operation. In aortic septal defect cyanosis is often present from early childhood, but, apart from this, it gives the same symptoms as a patent duct. The murmurs are highly variable, varying from a pure systolic murmur to systolic-diastolic murmurs maximum in the lower precordium. Because pulmonary hypertension develops early these patients seldom survive the age of 20 years.

Radiologically the picture is identical with that of patent ductus arteriosus: uncharacteristic enlargement of the heart, dilatation of the pulmonary

FIG. 1.—Patent ductus arteriosus. The aorta is visualized, and early filling of the pulmonary artery together with irregularities in the outline of the aorta indicate the presence of the patent duct.

artery, hilar dance, and increased vascularization of the lung fields. The physiological conditions may likewise be identical: pulmonary hypertension and an arterio-venous shunt to the pulmonary artery, which is shown by cardiac catheterization. The differential diagnosis between these malformations is thus only possible by direct catheterization of the patent duct, or the aortic septal defect itself, and, if this is not managed, by thoracic aortography.

COARCTATION OF THE AORTA.—The murmurs with projection to the arteries of the neck, the decreased or missing pulsation of the femoral artery, and the notches in the ribs shown on radiographs are generally sufficient to establish the diagnosis of coarctation of the aorta. Thoracic aortography is seldom indicated from a diagnostic point of view.

Certain authors (Jönsson and others, 1952) have maintained that aortography ought to be performed in any case of coarctation of the aorta before operation in order to obtain information of the anatomy of the stenosis, its localization, its grade, and its length. In this hospital 45 cases of coarctation of the aorta have been operated upon. The stenotic part of the aorta is resected and an anastomosis established between the aorta above and below the portion resected (Crafoord and Nylin, 1945). In all of the cases operated upon here it was possible to perform this direct anastomosis. As long strictures are apparently extremely

rare, we do not consider thoracic aortography indicated as a routine method of examination in coarctation of the aorta, the risks of aortography being taken into consideration. We have thus only performed aortography in cases where we had a suspicion that there were complicating anomalies of the heart, such as aortic insufficiency or patent ductus arteriosus. If experiments with homologue transplantation in operations for coarctation of the aorta become fully satisfactory, thoracic aortography may become a routine before operation.

The different congenital malformations of the aorta, double aortic arch, aortic ring, left circumflex arch, etc., are rare. In the even rarer instances, where they are the cause of symptoms by compression of the oesophagus or trachea and operation is contemplated, thoracic aortography may be indicated (Thomsen, Vesterdal, and Husfeldt, 1953).

ACQUIRED DISEASES

Acquired diseases of the aorta or aortic valves can generally be diagnosed by the combination of the clinical and radiological examination. But we have seen cases where the malformation was so slight that it was not possible with sufficient accuracy to establish the diagnosis in this way. In these cases we have performed aortography in order to exclude the possibility of surgical treatment.

Aortography may be considered indicated in the differential diagnosis between aortic aneurysm and some tumours of the mediastinum. During the

FIG. 2.—Demonstration of the coronary arteries by thoracic aortography.

FIG. 3.—Aneurysm of the right sinus of Valsalva. The aneurysm is seen deeply buried in the heart muscle, in contrast to aneurysm of the coronary artery, which would be situated on the surface of the heart.

time in which we have been able to do aortography we have not met this problem, and we would hesitate to perform aortography in cases of aortic aneurysm because of the risk of rupturing the aneurysm during the injection of the dye.

As demonstrated by Fig. 2 the coronary arteries can be visualized by thoracic aortography (Radner, 1945). We consider this a risky procedure and only use it for exceptional reasons.

ANEURYSM OF THE SINUS OF VALSALVA

Aneurysms of the sinuses of Valsalva are extremely rare. The three sinuses of Valsalva form the proximal, partly intracardiac, portion of the aorta, and aneurysms of these can be of congenital, syphilitic, arteriosclerotic, or mycotic origin. Most frequently they develop from the left sinus of Valsalva and rupture into the pericardial sac. The congenital aneurysms generally develop from the right and anterior sinuses and extend into the myocardium, where they can produce conduction disturbances or rupture into the right side of the heart or pulmonary artery, resulting in an arterio-venous fistula, from which the patient usually succumbs within a few months because of cardiac insufficiency.

Before rupture of the aneurysm has taken place the symptoms are not characteristic; they consist of slight dyspnoea on exercise and palpitations. The murmur is generally systolic-diastolic and

maximal in the lower precordium. The differential diagnosis from patent ductus arteriosus and aortic septal defect may be difficult. This problem may be solved by cardiac catheterization, but the final diagnosis (Fig. 3) is first established by thoracic aortography (Falholt and Thomsen, 1953).

SUMMARY

Thoracic aortography is considered to be indicated in the following circumstances: (1) Suspicion of a small patent duct with an atypical murmur, when a duct could not be demonstrated by cardiac catheterization; (2) cases where the differential diagnosis between patent ductus arteriosus and an aortic septal defect could not be established by cardiac catheterization; (3) coarctation of the aorta, where the clinical examination or radiograph was suspicious of a complicating cardiac anomaly; (4) congenital anomalies of the aorta, double arch, aortic ring, etc.,

where surgical treatment is intended; (5) diseases of the heart, where the clinical and radiological examinations do not explain the murmurs found, and where an aortic disease must be suspected.

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