Perforation of the Heart during Cardiac Catheterization and Selective Angiocardiography

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Perforation of the myocardium is rare during cardiac catheterization. The precautions to be exercised, particularly in regard to clinical management, are delineated in this communication.

PERFORATION of the heart during the course of cardiac catheterization or selective angiocardiography is a rarity.1 This case is reported as a reminder of its possible occurrence and to describe the roentgen findings that established the correct diagnosis.

Case Report

The patient, a 24-year-old woman, was admitted to Montefiore Hospital on January 10, 1958, for evaluation of suspected congenital heart disease. She gave a history of uncomplicated scarlet fever at the age of 2 years. Childhood activity was unlimited but undue fatigability was present. A heart murmur had been present since 1951. In the past 2 years there was an increase in weakness and the onset of exertional dyspnea. In the past year there were also several episodes, apparently syncopal in nature, of transient loss of consciousness and spontaneous recovery.

Physical examination showed a normal, symmetrical, clear chest. The blood pressure was 125/60, the pulse was 100, and the respirations were 20. The point of maximal cardiac impulse was in the fifth intercostal space in the anterior axillary line. The rhythm was regular. There was a long, rough systolic murmur and thrill along the left sternal border. Both were maximal at the third intercostal space. The pulmonic second sound was equal to or slightly louder than the aortic second sound. The arterial pulsations in the neck were active but not suggestive of aortic insufficiency. There was no venous distention. Peripheral arterial pulses were normal. On January 11, 1958, an electrocardiogram was interpreted as showing combined ventricular hypertrophy. Chest roentgenograms with barium swallow demonstrated mild prominence of the pulmonary artery segment with slight enlargement of the left atrium (fig. 1). The admission diagnosis was interventricular septal defect.

On January 15, 1958, commencing at 1.30 p.m. the patient underwent a standard diagnostic cardiac catheterization. She was postprandial, sedated by 100 mg. of sodium barbital, and breathing room air. A no. 8, 125-cm. Courand catheter was passed without difficulty via the left brachial vein into the right heart and out to the pulmonary arteries. Sequential sampling of blood for oxygen saturation and pressure tracings was done during the advance and withdrawal of the catheter.

The data failed to confirm the clinical impression of an intracardiac shunt but ap-
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The cardiac catheterization was completed by 3 p.m. A selective intracardiac biplane angiocardiogram was then performed. The Cournand catheter was withdrawn and replaced by a no. 7 National Institutes of Health (NIH) catheter. The tip was positioned near the apex of the right ventricle and the position was confirmed by fluoroscopy, right ventricular blood oxygen, and pressure determinations. The patient’s arms were then placed in full extension above the head to clear the chest for the lateral projection of the angiocardiogram. To minimize the effect of the catheter tip retraction, which commonly occurs with the repositioning (due to the lengthening of the venous channel with the conversion of partial extension of the arm to full extension) and to avoid displacement back into the right atrium, the catheter was advanced slightly as the left arm was moved. The patient was then moved along the fluoroscopic table to a biplane Schonander serial-film changer. The catheter was again secured by a slight forward thrust. Scout roentgenograms at 3:30 p.m., though showing the catheter to be slightly deeper in the apex than earlier, gave no cause for concern. Throughout this period the electrocardiogram, heart rate, and right ventricular pressure curve showed no irregularities or variations. The rather low arterial blood pressure (85 mm. Hg systolic) was thought to be due to needle damping and not to physiologic depression. At 3:45 p.m. intravenous sodium pentobarbital sedation 0.2 per cent in 5 per cent glucose was started. During a 1-hour technical delay that followed, the patient’s condition seemed to be stable, though it was noted that she seemed to be quite pale. At 4:15 p.m., with the patient still sedated and breathing 100 per cent oxygen by mask, 50 ml. of 70 per cent Urokon was injected into the right ventricle by a Gidlund pressure syringe at a pressure of 7 Kg. per cm.² The sequence of roentgen exposures

Fig. 2. Selective angiocardiography. Anteroposterior and left lateral projections obtained 2 seconds after injection of opaque medium. Tip of catheter is located at apex of right ventricle directed toward left, caudally and anteriorly. A small quantity of opaque material is in pericardial cavity along the diaphragmatic surface. Lateral projection, in addition, shows opaque medium in pericardial cavity extending upward, anterior, and posterior to heart. Intracardiac opacification delineates mild infundibular stenosis.
FIG. 3. Selective angiocardiography. Anteroposterior and left lateral projections obtained 8 seconds after injection of opaque medium. There is increase in quantity of opaque material, which now completely outlines the extent of the pericardial cavity. At base of heart, opaque material outlines aorta and pulmonary artery. Radiolucent defect in diaphragmatic portion of pericardial cavity indicates presence of blood. Several globules of opaque medium in apex of right ventricle may mark site of perforation.

was 6 per second for 2½ seconds followed by 3 films every 2 seconds for an additional 12 seconds. Sodium pentobarbital was then discontinued and by 4:45 p.m. the patient returned to the recovery room, still asleep. The pulse was 95 to 105, unchanged since the start of the procedure. The systolic blood pressure was 130 mm. Hg.

The roentgenograms were immediately processed and studied. Coincident with the anticipated appearance of contrast medium within the right ventricle, some was seen in the pericardial cavity, the amount gradually increasing to the end of the examination (figs. 2 and 3). Several globules of opaque medium were seen in the right ventricular apical myocardium distal to the tip of the cardiac catheter, suggesting that perforation of the heart had occurred at this point. With the implied potential of cardiac tamponade, a constant check of pulse and blood pressure was begun, the surgical service was notified, blood was ordered and protamine sulfate was given to counteract any residual heparin activity from the cardiac catheterization. At 5:10 p.m. a portable chest x-ray in the sitting position showed the cardiovascular silhouette to be somewhat enlarged with opaque medium collected along the diaphragmatic surface of the pericardial cavity (fig. 4). An electrocardiogram showed no change when compared with the admission study.

Following this, though the patient awakened, the heart rate rose to 139, the blood pressure dropped to 70/40 mm. Hg and the development of cardiac tamponade seemed certain.

At 6:30 p.m. the patient was transferred to the operating room, where, under general endotracheal anesthesia, the right chest was opened and the heart was exposed. The pericardium was seen to be tense and contended and deep blue in color, and the cardiac pulsations were extremely feeble. A vertical pericardial incision was made anterior to the right phrenic nerve and blood stained fluid, estimated to be
200 ml. in volume, gushed forth under tremendous pressure. The heart beat immediately became strong and full and the peripheral pulses returned.

At surgery the right atrium was quite large. The heart was rotated so that the apex, which consisted mainly of right ventricle, was positioned anteriorly and far to the left. At the apex of the right ventricle, there was a soft cleft, the point where the perforation must have occurred. There was no further bleeding. The pericardium was irrigated with large amounts of saline solution. No thrills were felt anywhere over the heart. However, direct pressure tracings confirmed the presence of a ventricular-pulmonary gradient. The condition of the patient at the end of the operation was good.

The postoperative course was not eventful and the patient was discharged from the hospital on January 25, 1958.

**Discussion**

Selective angiocardiography is now a preferred technic for evaluation of many forms of heart disease. A Courand-type catheter with a single opening at the tip is used for the physiologic exploration during cardiac catheterization. With pressure injection of contrast medium through this catheter, there is a recoil effect that displaces the catheter tip. Its relatively thick wall and narrow bore slow the speed of injection. The NIH catheter, designed for selective angiocardiography, has a thinner wall than the Courand catheter of the same external gage, has a greater luminal diameter, a closed tip, and discharges through 4 spirally placed side holes 1 to 2 centimeters proximal to the tip. It permits injection of a larger volume of opaque medium per second without increase of injection pressure, discharges the opaque medium over a wider area more rapidly, and eliminates the recoil effect. However, with the NIH catheter, it is possible for the tip to penetrate the myocardium for as much as 1 cm. with normal blood pressure and blood sampling still obtained through nonoccluded proximal side orifices. It is similarly possible, for the same reason, that test doses of opaque medium, normally injected at relatively low pressures, may fail to demonstrate the occurrence of such accidents when the opaque medium exits from the same proximal nonoccluded openings. If some of the side-wall openings have also penetrated the myocardium, an accentuation of a perforation may result with a pressure injection. This type of accident is less probable with a Courand catheter, as damping of the pressure-tracing occlusion of its single-tip orifice against the endocardium signals its malposition. The very real roentgen advantages of the NIH catheter over the Courand catheter in selective angiocardiography, however, justify the risk of its use.

In this case, there is reason to suspect that perforation probably did not occur with the Courand catheter, which is relatively flexible and which was not inserted in the area of the apex of the right ventricle. The perforation occurred more likely during the insertion of the relatively sharp tipped, more rigid, NIH catheter, most probably when the catheter was additionally advanced after its initial positioning. If this is true, then myocardial penetration must have occurred without the patient's cardiac pulse, respirations, blood pressure, electrocardiogram, or general status showing any evidence thereof. It is not clear,
either, whether the side orifices of the catheter participated in widening the perforation or whether the opaque medium was forced out during the brief period of increased right ventricular pressure that accompanied the sudden augmentation of volume by rapid injection. True clinical tamponade was not seen until 2½ hours after the catheterization, 1½ hours after the catheter replacement, and 1 hour after the angiocardiogram. There is also reason to wonder, in view of past experience, whether this perforation could occur in a normal myocardium. Indeed, while most perforations of the normal heart may be expected to seal spontaneously, in this case it was the unpredictability of a congenitally abnormal heart, with a myocardium soft enough to be ruptured by a catheter, that encouraged surgery as the treatment of choice. Consideration was also given to the possibility of irritation of the pericardial surface by the mixture of Urokon and blood, although there is no available evidence that Urokon will act as an irritant to serosal surfaces. Needle aspiration of the pericardium, transfusion, and a trial of waiting are the considered alternate therapeutic approach.

The diagnosis of perforation of the heart on the plain roentgenograms of the chest is based upon the accumulation of blood within the pericardial cavity. As the volume of fluid within the pericardial cavity needed to increase the area of the cardiac silhouette roentgenographically is almost equal to the amount of fluid found in cases of acute cardiac tamponade, this method of diagnosis is fraught with delay and limitations. It is generally thought that at least 200 ml. of fluid must be present in the pericardial cavity before the diagnosis of pericardial fluid is roentgenographically feasible. Davis reports that 300 ml. or more are usually found in patients with acute fatal tamponade.

This case is a direct angiographic demonstration of a perforation of the right ventricle as indicated by the presence of a small amount of opaque medium dispersed within the pericardial cavity. The opaque medium was observed in the beginning of the angiogram opposite the tip of the catheter in the pericardial cavity outlining the diaphragmatic surface of the heart and later outlining the extent of the pericardial cavity including its limits at the base of the heart. The radiolucent defects noted in the pericardial cavity indicate the presence of blood. The preponderant volume of opaque medium within the cavity of the right ventricle suggests that the perforation was quite small and that most or all of the holes near the tip of the catheter were lying within the cavity of the right ventricle. If the perforation had not been demonstrated directly by angiography, its existence in the presence of clinical symptoms might have been suspected by an increase in the thickness of the lateral cardiac walls due to the hemopericardium.

**Summary**

The occurrence of this case of perforation of the myocardium during cardiac catheterization with selective angiography serves to emphasize some of the risks taken in the application of several of the newer, specialized methods now available for the evaluation of congenital heart disease. With careful technic and good teamwork, however, the danger to the patient can be held to a minimal level and is far outweighed by the positive values of the procedures.

**Summario in Interlingua**

Le facto del occurrentia de iste caso de perforation del myocardio durante catheterisation cardiacon angiografiadoposselectiva servì a relevar certes del risicos che es inerente in le uso de plures del nove e specialisate methodos nun disponebile pro le evaluatión de congenite morbo cardiacone. Tamen, le plus meticulose attention technic e alte grados de cooperativitate del participantè reduc le risco pro le patiente a un mesura minimal e es plus que compensate per le valor del manovra.

**REFERENCES**

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