Coronary Arteriography in the Intact Dog

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A method is described whereby the coronary arteries of dogs with intact chests can be regularly demonstrated roentgenologically by the use of small amounts of Diodrast injected through a specially devised catheter which is passed to the aortic sinus through a peripheral artery. The artery is preserved by suture. Electrocardiograms taken during the procedure were normal. The aortic valves of two excised hearts previously subjected to forceful trauma by the catheter, showed no abnormality. Characteristic arteriograms are reproduced, showing coronary arteries, separate cusps of the aortic valves, and the proximal aorta.

Until recently, no satisfactory method has been available for the safe and dependable roentgenologic visualization of the proximal aorta and the aortic arch. In an attempt to produce such a method, one of us (F. P.) has devised and reported a special thin-walled, woven nylon, radio-opaque catheter* which may be inserted into a peripheral artery and easily passed to the proximal aorta or the left ventricle under fluoroscopic control. The catheter is so constructed that by manual syringe pressure alone it can deliver 5 cc. per second of radio-opaque liquid against the force of the arterial pressure. The outside diameter of the catheter is small enough so that the artery of insertion can be preserved by suture when the catheter is withdrawn. Details of the use of the catheter will be reported in subsequent communications.

This method of precision retrograde arteriography was utilized in an attempt to demonstrate the coronary arteries of the intact dog. The catheter was passed to the aortic sinus (of Valsalva) through an opening in the carotid or the femoral artery. For the precise placement of the catheter and the actual arteriography, the animal was placed on its left or right side.

The heart when x-rayed from the lateral position was clearly seen without the interference of the shadows cast by the vertebral column. Many experiments were conducted, altering the position of the catheter or the temporal relationship between injection of radio-opaque medium and x-ray exposure. Finally, we were successful in obtaining consistently clear-cut, contrasting coronary arteriograms with an injection of only 4 cc. of 70% Diodrast† solution, of which at least 1.5 cc. was used in filling the catheter itself (figs. 1, 2, and 3). Electrocardiograms taken during the time the catheter was in place, and during and after the injection of Diodrast, showed no abnormality.

The catheter was connected to a special pressure apparatus which kept its lumen clear with a small steady stream of heparinized normal salt solution. It was then inserted into the exposed and stripped peripheral artery so that there was no leakage, and passed proximal. The angulated tip allowed it to follow the curve of the aortic arch and to approach the heart. Precise placement of the catheter was then done under fluoroscopic control. When the catheter contacted the aortic valves, a characteristic sense of resistance was communicated to the hand of the operator; one observed also in the fluoroscope that the catheter buckled slightly and the whipping motion of the tip was restricted. The forward pressure on the catheter then was released and it was withdrawn under fluoroscopy about 0.5 cm. until the operator was certain that the tip of the catheter lay free and mobile in the main aortic current. Blood was aspirated from and injected gently through the catheter in order to make sure that the
openings in the catheter were not blocked by impingement against the aortic valves or wall. The x-ray apparatus was arranged for \( \frac{1}{4} \) second Bucky exposure. The pressure apparatus containing salt solution was disconnected and replaced by a Robb syringe containing 4 cc. of 70 per cent Diodrast. Blood was prevented from regurgitating through the catheter by steady manual pressure upon the plunger. The operator then injected the solution as quickly as possible, beginning \( \frac{1}{2} \) to \( \frac{3}{4} \) second before the first roentgen exposure. Using a tunnel, two exposures were taken about \( \frac{1}{4} \) to \( \frac{1}{2} \) second apart. The syringe was replaced by the pressure apparatus and the films were developed. If necessary, additional films were taken, using variations of the technique indicated by the ones already exposed.

The catheter at times was observed to enter the left ventricle. When this occurred, a forceful systolic impulse was transmitted through the catheter to the operator's hand. If such did occur, the catheter was merely withdrawn under fluoroscopic visualization to a point just above the aortic sinus (Valsalva) and pushed forward toward the aortic valve until the characteristic resistance was felt and the buckling of the catheter was seen. When the catheter did enter the left ventricle, it was often due to excessive force used in passing it against the resistance offered by the aortic valves. In certain positions of the catheter, even considerable pressure fails to overcome this resistance and the catheter chooses to buckle rather than enter the ventricle. One should guard against making undue pressure against the aortic valves since a cusp thus may be injured or ruptured, although no evidence of this was seen in

Fig. 1.—Dog. Intact chest. Right side down. Special arterial catheter inserted to aortic sinus through the carotid artery. Only 4 cc. of 70 per cent Diodrast injected. The right, left anterior descending and left circumflex arteries are well demonstrated.
Fig. 2.—Dog. Intact chest. Right side down. Special arterial catheter inserted to aortic sinus through carotid artery. Only 4 cc. of 70 per cent diodrast injected. The left anterior descending and left circumflex coronary arteries and their finer branches are well outlined. The proximal portion of the right coronary artery is obscured behind the left anterior descending artery, but soon appears as a separate shadow.

Fig. 3.—Dog. Intact chest. Lateral exposure, right side down. Special catheter inserted through left femoral artery to aortic sinus. Four cc. of 70 per cent Diodrast injected. The left circumflex, left anterior descending and right coronary arteries and their smaller branches are well demarcated, and show good contrast. One also sees the aortic sinus (Valsalva), the separate shadows of all three aortic cusps, the ascending aorta, the aortic arch with the carotid arteries arising from it, and the descending thoracic aorta.
two excised hearts previously subjected to this trauma. If one desires to pass the catheter into the left ventricle, gentle manipulation will affect its entry through the aortic valve without injury.

with many of the fine terminal branches clearly visible. Such pictures were obtained only by lateral exposures. In antero-posterior exposures, the individual coronary arteries were obscured partially by the shadows of the vertebral column.

The coronary arteriograms obtained by this method showed the course of the right, left anterior descending, and left circumflex coronary arteries. Each one was outlined individually against the background of the cardiac shadow, column, and the projection of one coronary vessel upon another (fig. 4). Good coronary arteriograms have been obtained, also, with the animal on its right side, but those taken with the animal on the left side appeared better.

Fig. 4.—Dog. Antero-posterior projection. Four cc. of 70 per cent Diodrast injected through the special arterial catheter which had been passed to the aortic sinus through the carotid artery. The left main coronary artery, its circumflex and anterior descending branches, and their smaller ramifications are well demonstrated, but much detail is lost because of the superimposed shadow of the vertebral column, ribs and thoracic aorta. Compare this view with figure 1, taken with the same subject in lateral projection.
We are attempting by means of numerous coronary arteriograms already taken, in normal animals, to establish the basic normal coronary vascular pattern and its normal variations. In a few instances, we have compared the coronary arteriograms taken on the living dog with roentgenograms of the same vessels injected after death by means of the Schlesinger technique. As the number of normal coronary arteriograms increases, the basic normal pattern, even now quite well established, will become better stabilized and defined.

Experiments are now in progress to visualize in the intact animal coronary arteries previously subjected to experimental lesions.

The development of a safe and dependable method for the roentgenological visualization of the coronary arteries has important implications in respect to the diagnosis and possible treatment of disturbances of the coronary circulation in man, and in experimental coronary artery disease in animals.

**Summary**

A dependable and apparently safe method for coronary arteriography is described which uses a specially devised catheter inserted into the aortic sinus through a peripheral artery. Clear-cut images of the coronary circulation of living dogs were regularly obtained by this method. Electrocardiograms taken during the procedure showed no abnormalities.

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