Coronary Artery Catheterization in the Intact Dog

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A technique is described for selective catheterization of individual coronary arterial branches in intact dogs by means of special catheters which permit intracoronary injections of pharmacologic agents or radio-opaque materials. All the main coronary arteries (right, left anterior descending, left circumflex) have been successfully catheterized and injected, both alone and in combination.

Studies of the coronary circulation by injections of drugs, embolizing particles or radio-opaque materials into the coronary arteries until recently have necessitated a choice between opening the chest for direct injections, and indirect injection through a catheter into the vicinity of the coronary ostia without opening the chest. The advantages of both approaches could be combined, and their disadvantages circumvented, by a method which permits direct catheterization of individual coronary arterial branches without opening the chest. Such a method was developed in this laboratory during the summer of 1955. Since this time several preliminary reports1-3 have been presented and two papers4-5 have been published upon results obtained with this technique. Similar efforts have recently been reported by others.6-8 We shall describe our procedures and present representative examples of some of the results.

Methods

Normal adult mongrel dogs weighing 15 to 30 Kg., were anesthetized by intravenous injection of sodium pentobarbital (30 mg./Kg.) or chloralose (70 mg./Kg.); or a combination of equal volumes of Dial-Urethane solution (100 and 400 mg./ml., respectively) and pentobarbital sodium veterinary solution (60 mg./ml.), the dosage being 0.25 ml./Kg., after previous subcutaneous injection of morphine (3 mg./Kg.). The selection of the anesthesia depended upon the type of experiment planned.

Special Coronary Artery Catheter. At first we
used stiff polyethylene catheters with a special curved tip and with external diameters varying between 0.042 inch and 0.064 inch. Although these were relatively easy to introduce into the coronary arteries, they had the disadvantages of being relatively large and of losing their rigidity while lying in the arterial blood stream. A catheter of stainless steel hypodermic needle tubing with a special tip overcame these objections (Fig. 1). The tip of the catheter is curved and is covered with a section of soft, flexible polyethylene tubing 2½ inches in length to prevent puncturing the vessel. The opposite end of the catheter is reinforced with additional steel tubing or small sections of polyethylene and rubber tubing and is attached to the hub of a hypodermic needle. Wings are also added at this end of the catheter by wrapping it with adhesive tape, which serves to hold the catheter in position by anchoring it to the neck of the animal once the coronary artery has been catheterized.

 Catheterization of Individual Coronary Arteries. This is done under fluoroscopic visualization. The left lateral position (left side up) is desirable but not essential. The catheter is introduced into a carotid artery and is advanced until its tip lies just above the aortic valves. In most dogs the left coronary ostium is on a level with the edge of the anterior half of the anterior left aortic cusp.* Once the ostium is entered, the catheter may be passed into either the circumflex or the anterior descending branch of the main left coronary by rotating the catheter tip in the appropriate direction. When the catheter is in the circumflex branch it will be seen to follow the ativoventricular sulcus, whereas in the anterior descending it will follow the anterior longitudinal sulcus.

Fig. 2. Effects of right coronary arterial drug injections. Upper record in each case shows the electrocardiogram (lead II); lower record, femoral arterial blood pressure (Statham transducer manometer). Timer, seconds. All records were obtained from the same experiment on a dog under pentobarbital anesthesia. Note the transient sinus arrest followed by nodal escapes after acetylcholine injection into the right coronary artery. Injections of epinephrine and norepinephrine into the same site resulted in a marked sinus tachycardia (from 150 beats/min. to 280 beats/min.) as seen in middle and bottom records.

Fig. 3. Acetylcholine injection into the left circumflex branch. Upper record, femoral artery blood pressure; Lower record, electrocardiogram (lead II). Timer, seconds. Dog under pentobarbital anesthesia. Note the transient period of complete A-V heart block with an escape beat accompanied by a drop in systemic blood pressure following acetylcholine injection into the left circumflex branch. Atrial fibrillation developed later.
The right coronary artery is by far the most difficult of the three main coronary arteries to catheterize. A catheter with a greater bend (longer head) is desirable, since the right ostium lies deeper than the left when the animal is in the left lateral position. The catheter is rotated towards the right (lateral) and downward until the right aortic cusp is engaged and is then brought into the right coronary ostium. Once the catheter is in the ostium it can be felt to enter the artery and seen to advance towards the right side of the heart. The right lateral position (right side up) is often helpful for catheterizing the right coronary artery, since the right aortic cusp then is located on a higher plane and the right coronary ostium is more easily found. However, it is also easy to engage the left anterior descending branch and to confuse it with the right coronary in this position. The catheter positions can be determined by touch, fluoroscopic visualization and injections of appropriate drugs or radio-opaque material. Following insertion of the various catheters, there is no indication of coronary insufficiency in the electrocardiogram or in the behavior of the blood pressure.

We have applied the procedures described to 238 dogs and have been able to enter the left coronary branches in 98 per cent, the right coronary in 80 per cent of our attempts, without opening the chest to resort to digital guidance of the catheter.

RESULTS

Electrocardiographic effects. Acetylcholine injections (0.04-0.4 μg./Kg.) into the right coronary artery resulted in sinus inhibition (atrial arrest or bradycardia) or atrial fibrillation (fig. 2), while injections into the left circumflex branch resulted in complete A-V heart block followed by ventricular or nodal escapes (fig. 3).

Injections of epinephrine and levarterenol (norepinephrine—0.004-0.04 μg./Kg.) into the right coronary (fig. 2) or left circumflex...
produced cardiac acceleration (sinus or nodal tachycardia respectively) accompanied by similar ST-T wave changes (fig. 4) while injections in the left anterior descending resulted only in ST-T wave alteration consisting of S-T segment depression and T wave inversion followed later by peaking of the T wave with no alteration in the cardiac rhythm (fig. 5).

Selective Coronary Angiography. We have injected Hypaque sodium (sodium 3-5 diacetamido 2-4-6 tri-iodobenzoate) into one, two and all three of the main coronary arteries (right, left anterior descending, left circumflex) of 10 dogs under light anesthesia with morphine (2 mg./Kg. subcutaneously) and pentobarbital (30 mg./Kg. intravenously). The quantity of material injected (50 per cent Hypaque) was 2 ml. dose for serial roentgenograms taken at 2 frames per second. These doses were repeated 5 to 10 times without evident harm. Examples of coronary angiograms obtained by this procedure are shown in figures 6 and 7. In two dogs 5 ml. was given rapidly into the left anterior descending and left circumflex arteries respectively, but these were rapidly fatal in both cases.

DISCUSSION

The results obtained by injecting acetylcholine and epinephrine (or norepinephrine) into the right coronary artery indicate that such injections reach the S-A node, injections into the left circumflex reach the A-V node (see Halpern10 on the anatomic studies of the arterial supply to the nodal tissue), while injections into the left anterior descending do not reach either of these two rhythmic centers.

The catheters described above offer obvious advantages for coronary angiography. Earlier studies in animals11-14 were accom-

Fig. 6. Single catheterizations of the left and right coronary arteries accompanied by dye injections (left lateral view). A. Dye injection in left anterior descending branch. B. Dye injection in left circumflex branch. C. Dye injection in right main coronary artery.
CORONARY ARTERY CATHETERIZATION

plished by retrograde injections through catheters introduced into the ascending aorta via the common carotid or femoral artery. Such procedures, even when they are successful, involve the necessity for very rapid injection of large amounts of material under considerable pressure and the wide-spread distribution of the agent detracts from the value of the findings. In addition, this technic can be used in studying the acute and chronic myocardial infarction resulting from coronary embolization in the intact animal, without the previously unavoidable injection of the material into the root of the aorta near the coronary ostia.15-17

SUMMARY

A technic is presented for coronary artery catheterization in dogs with intact chest, utilizing a specially devised coronary artery catheter. It permits the injection of drugs into individual coronary branches in dosage too small to have generalized effects but large enough to produce localized responses as revealed by the electrocardiogram. In addition, selective coronary angiography has been successfully accomplished in all the main coronary arteries (right, left anterior descending, left circumflex) both alone and in combination.

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FIG. 7. Combined catheterization of the left and right coronary arteries (left lateral view). A. Dye injected simultaneously in the anterior descending and circumflex branches of the left coronary artery. B. Dye injected simultaneously into the right coronary and left circumflex branch. C. Dye injected in all the three main coronary branches.
SUMMARY IN INTERLINGUA

Es presentate un technica pro le catheterisation del arteria coronari in canes con thorace intacte. Le technica utilisa un catheter de construction special pro le arteria coronari. Illo permette le injection de drogas a in le brancas coronari individual in dosages troppo micre pro exercer effectos generalisate sed satis grande pro producer responsas localisate que es revelate per le electrocardiogramma. In plus, selective angiographia coronari esseva effectuate eon bon succes in orane le major arterias coronari—dextere, descendente sinistro-anterior, circumflexe sinistre—tanto individualmente como etiam in combination.

REFERENCES


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