The Effect of Angiocardiography on the Heart as Measured by Electrocardiographic Alterations

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Six consecutive patients studied by angiocardiography or aortography ranging in age from 1 to 68 years were checked by a direct-writer type of electrocardiograph during the procedure. The clinical entities consisted of pulmonary stenosis, coarctation of the aorta, aneurysm of the ascending aorta, ventricular septal defect (2 cases), and atrial septal defect associated with complete transposition of the great vessels. Following angiocardiography immediate T-wave depression was noted. This was followed within three minutes by the development of short bursts of ventricular tachycardia lasting up to 27 minutes after dye injection. A different and much less spectacular picture followed aortography. None of these cases showed visible distress.

These records are presented to bring to the attention of those doing angiocardiography the need for direct-writer continuous electrocardiographic observations during the procedure. In the field of cardiac catheterization this precaution was emphasized by Courand, Baldwin, and Himmelstein. Certainly the warnings issued in the reports of Dotter and Jackson and Morgan point to a need for additional precautions in performing a diagnostic procedure which has a reported mortality between 0.4 and 1 per cent! Almost half of the 26 catastrophes reported by Dotter and Jackson in their survey could easily have been sudden cardiac accidents. Biorck and co-workers recently reported arrhythmias resulting from contrast media injected through an intracardiac catheter and considered their results to be due to the direct effect of the jet against the endocardium. They felt injection distal to the superior vena cava could be done without electrocardiographic control. More recently Gordon and co-workers have evaluated the effect of contrast media on dogs, and in a study on the effect of angiocardiography on blood pressure by Howarth a brief mention was made of cardiac irregularities following injection of the dye. The incidence of such catastrophes makes it imperative to evaluate the effect of contrast media on the human myocardium.

Method

Continuous tracings made with a direct-writer electrocardiograph were made during angiocardiographic and retrograde aortographic procedures. As normal leads could not be applied because of the apparatus involved in the procedures, the electrodes were so placed as to give a recognizable P, QRS, and T wave pattern. Observation was continued until a stable rhythm was reestablished or for 15 minutes after injection of the dye if no changes occurred.

Results

Six consecutive illustrative cases cited below with accompanying electrocardiograms provide ample demonstration of the effects of this procedure on the heart.

Case 1. W. B., a 7 year old Negro boy, was referred for angiocardiography with the diagnosis of a pulmonary arteriovenous fistula in the presence of associated cardiac anomalies. On Aug. 11, 1950, while under Avertin basal anesthesia, 28 cc. of 75 per cent Neo-iopax was injected into the left median basilic vein within one and one-half seconds using a 12 gage needle and a Robb-Steinberg syringe. Six films were taken at 0.7 second intervals by means of a rapid cassette changer. The angiogram revealed an abnormality of the great vessels and a large atrial septal defect.

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This work was done while one of the authors (W. J. Z.) was a National Heart Institute Trainee.
The electrocardiographic record shown in figure 1 presented immediate inversion of T waves persisting for 30 seconds. Beginning two and one-half minutes after injection premature ventricular beats appeared which soon became bigeminal. Longer and more frequent intervals of normal sinus rhythm appeared after the first 15 minutes, but basic sinus rhythm was not completely restored until 25 minutes after the injection.

The electrocardiogram (fig. 2) showed an initial bradycardia with flattening of T waves which reverted to normal within one minute. During the second minute after injection the Q-T interval was prolonged due to lengthening of the S-T segment. An apparently normal pattern was present two and one-fourth minutes after the injection, but frequent ventricular premature beats appeared within three minutes, as did a short period of sinus arrest. Bi-

Case 2. S. D., a 1½ year old Caucasian boy, was referred for angiocardiography with the diagnosis of an interventricular septal defect. Eighteen cc. of 75 per cent Neo-iopax was injected in one second through the left basilic vein and six films were taken within four and two-tenths seconds by means of the previously described technic. No defect was demonstrated.
Case 3. A. W., a 68 year old Negro man, was referred for angiocardiography because of a mass arising beneath the right clavicle near the sternum which had been increasing in size during the past four months. The patient had an old history of inadequately treated syphilis. Although the mass resembled an aneurysm of the aorta, it could not be ascertained by either radiologic or physical examination whether this was a tumor of vascular or non-vascular origin. Two attempts were made to demonstrate the mass by angiocardiography, but on the first occasion the cassette changer became stuck and on the second study insufficient concentration of dye occurred in the left side of the circulation. On each occasion 50 cc. of 75 per cent Neo-iopax was injected within one second and six films were taken beginning five seconds after the injection at two and one-half second intervals.

The electrocardiogram taken during the first study is shown in part in the upper portion of figure 3. The lower portion shows the tracing obtained at the second examination. Prior to the second examination large doses of quinidine were administered orally at two hour intervals for a total of three doses. The first record shows the appearance of the ventricular premature beats and episodes of ventricular tachycardia as previously noted in other patients. Restoration of the sinus rhythm occurred but within one minute normal rhythm was restored and the T waves were upright. The tracing was entirely normal during the next eight minutes. This patient received 10 mg. per kilogram of body weight of procaine amide orally two hours before the procedure and again just prior to the procedure.

Case 4. B. A. S., a 2 year old Caucasian girl, was admitted for angiocardiography with the diagnosis of an interventricular septal defect. Fifteen cc. of 75 per cent Neo-iopax was injected into the left median basilic vein and six films were taken in four and two-tenths seconds. No evidence of recirculation could be demonstrated.

The electrocardiogram (fig. 4) showed immediate lowering, flattening, and inversion of T waves. A few beats showed aberrant ventricular conduction.
strated an interventricular septal defect with an overriding aorta.

The electrocardiogram (figure 5) showed immediate, marked depression of the S-T segment and inversion of the T wave. This returned to normal shortly, but no ventricular ectopic beats were noted although the electrocardiographic tracing was watched for 15 minutes after injection of the dye.

Case 6. D. G., an 18 year old Caucasian boy, was referred for retrograde aortography with the diagnosis of coarctation of the aorta. Forty cc. of 75 per cent Neo-iopax was injected within four seconds into the left carotid artery through a 16 gage needle. Six films were taken within four and two-tenths seconds. A hypoplastic aorta, large subelavian artery, and sharply constricted adult-type coarctation were demonstrated.

No evidence of S-T segment or T-wave changes appeared on the electrocardiogram. Within forty-five seconds premature beats appeared. These were gone within one and one-half minutes and did not recur.

**DISCUSSION**

The illustrations amply demonstrate the need for direct electrocardiographic control during angiocardiography. The development of irritable ventricular foci could easily initiate sudden ventricular fibrillation. A second dose of dye injected into any of these irritable hearts to obtain a view in a different position, as is frequently practiced, would increase the chance of such a catastrophe. Without direct observation of the electrocardiogram such an event could not readily be differentiated from cardiac or respiratory arrest since the fibrillating ventricle may be inaudible to the stethoscope and all respiratory movement may cease with the onset of syncope. Premedication with quinidine or procaine-amide appears to lessen the hazards of the procedure. It might also be expected that prompt administration of intravenous medication would terminate dangerous arrhythmias before irreversible changes had occurred.

These tracings are of particular interest in interpreting the effects of 75 per cent Neo-iopax on the human myocardium. The con

![Fig. 5. Case 5. Serial electrocardiographic changes during angiocardiography. Premedication with quinidine.](image)
duced ventricular premature contractions within 30 to 45 seconds. It may be that the irritable myocardial foci develop in portions of the myocardium rendered ischemic by dye-induced spasm of smaller branches of the coronary arteries. Retrograde aortography would introduce dye more directly into the coronary ostia, but as most of the dye would pass directly down the descending aorta a far smaller amount would reach the coronary system than would be the case in angiocardiography. Angiocardiography, on the other hand, would entail a delay in reaching the coronary vessels, but the entire bolus must pass the ostia, giving a larger accumulation of dye in the smaller coronary radicles than would be the case in aortography.

An alternative explanation of the observed effects rests on the work of Broman, Forssman, and Olsson in Sweden. Studying the effect of contrast media on cerebral vessels they noted a series of effects. First, increase in permeability of the vessel wall occurred. Next, local edema at the site of injury appeared. Finally they noted punctate hemorrhages in adjacent brain tissues. Of importance to the present problem they further noted that repeated nontoxic doses of dye had a summation effect, damaging the vessels by repeated subtoxic doses.

Aortography appears to affect the coronary vessels as does a single dose of dye; angiocardiography, on the other hand, in passing the whole mass of dye past the coronary ostia over a number of cardiac cycles produces the summation effect noted by Broman and his co-workers. The damage to the smaller vessels, by producing increased permeability and local edema, might produce direct myocardial irritability and thus remove the necessity of postulating vascular spasm. This explanation accounts both for the delayed onset and prolonged duration of the ectopic foci of ventricular irritability.

CONCLUSIONS

1. Immediate ischemic changes as evidenced by T-wave inversion can be induced by rapid injection of 75 per cent Neo-iopax.

2. Irritable ventricular foci are frequently produced with frequent and prolonged bursts of ventricular tachycardia. Both events are delayed in onset and may persist at least for one-half hour after the injection of 75 per cent Neo-iopax.

3. Premedication with adequate amounts of quinidine or procaine-amine may lessen the hazard of the procedure.

4. Retrograde aortography when indicated may not present as great a cardiac risk as angiocardiography, probably because far less of the contrast medium contacts the myocardium.

5. Direct-writer continuous electrocardiographic observation during angiocardiography should be maintained at all times. It must never be forgotten that the procedure is diagnostic, not therapeutic. As angiocardiography is associated with a 0.4 per cent to 1.0 per cent mortality, the procedure should be surrounded by all possible safeguards.

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