Suprasternal Transaortic Coronary Arteriography

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Opacification of the coronary arteries has been accomplished by direct needle puncture of the ascending portion of the thoracic aorta via a suprasternal approach and injection of highly-concentrated radiopaque medium. Experience with 35 attempts in 31 patients at such coronary opacification is described. The electrocardiographic observations, the reactions, and the complications incident to the study are discussed. Thirteen of the 31 patients had some type of intrapericardial cardiac surgery subsequent to this procedure, and the surgical observations regarding the status of the coronary arteries are compared with the coronary arteriographic findings.

The development of a satisfactory method of radiologic visualization of the coronary arteries in man has become of increasing importance with the advent of direct surgical approach to disease of these vessels. Previous efforts to opacify the coronary arteries in man include angiocardiography, catheter aortography, cardiac ventriculography, and direct transthoracic needle puncture of the aorta.

Angiocardiography only occasionally demonstrates the coronary arteries, basically because the injected opaque medium is too greatly diluted by the time it reaches the ascending aorta. The opaque medium in the cardiac chambers in considerable measure also obscures the coronary vessels.

Injection of opaque medium through a catheter introduced into the ascending aorta by way of a carotid, radial, or brachial artery, to effect entry of the opaque material into the coronary arterial system, has produced opacification of the coronary arterial vessels. Catheter aortography necessitates a cut-down exposure of the vessel through which the catheter is passed and thus introduces possible undesirable sequelae incident to repair of the vessel opening.

Cardiac ventriculography can effect opacification of the coronary arteries, as reported by Lehman, Musser, and Lykens. Since in left-sided cardiac ventriculography the opaque medium is injected directly into the left ventricle, the left ventricular opacification obscures to a certain extent visualization of the coronary arterial supply.

In 1945 Radner reported rather unsuccessful attempts at coronary opacification by direct needle puncture of the aorta through the sternum. Hoyos and Del Campo, in 1948, reported opacification of the coronary arteries by a left parasternal needle puncture of the ascending aorta. Wickbom, in 1952, introduced a technic of "thoracic aortography after direct puncture of the aorta from the jugulum," but he did not mention coronary artery opacification, except in his report of 1 fatality resulting from his procedure.

The suprasternal approach to direct puncture of the left atrium and of the ascending aorta to obtain left atrial and aortic pressure recordings, as reported by Radner, suggested to us the possibility of coronary artery opacification by injecting a highly concentrated radiopaque medium through a needle introduced into the ascending aorta via a suprasternal approach, and advancing the needle until its tip was near the coronary ostia.

Our experience with 35 attempts at suprasternal transaortic coronary arteriography in 31 patients forms the basis of this communication.

Methods and Materials

In our procedure we have adopted, in large measure, the materials and methods utilized for cardiac ventriculography. We use a 17 gage, thin wall, 7 inch beveled needle, with a single side hole opening adjacent to its tip. This needle is connected by plastic tubing through a 3 way stop-
cock to an electromanometer and to a pressure injection apparatus. Electrocardiographic and pressure tracings are recorded on a direct-writing oscillograph. Serial filming is performed at the rate of 2 films per second for 4 to 5 seconds. In this series we employed 90 per cent sodium diatrizoate methylglueamine (Hypaque) in doses of 35 to 40 ml. per injection.

The patient is placed in supine position, with head and chin in complete extension and rotated to the right, the head actually being suspended over the filming device. From films obtained with the patient in this position, and from conventional preliminary chest films, the position of the ascending aorta, the approximate level of the aortic valve, and the most suitable roentgenographic factors are determined.

The patient is given 100 mg. of pentobarbital by mouth 1 hour prior to the procedure, followed 1/2 hour later by 50 mg. of meperidine, hypodermically.

At the site of needle insertion, we apply cutaneous procaine anesthesia and extend it subcutaneously below the level of the suprasternal notch. With a continuous dribble of saline solution flowing through the needle, the needle is introduced through a cutaneous stab wound approximately 3.0 cm. above the suprasternal notch. The saline dribble is then shut off and the electromanometer is adjusted to record pressure waves. The needle is passed in the midline behind the manubrium toward the ascending aorta (fig. 1). With continuous electrocardiographic recording, the needle is advanced until pressure tracings indicate aortic penetration. If there is no damping of pressure tracings, the needle is advanced a predetermined distance to place its tip slightly above the level of the aortic sinuses. If damping of pressure waves occurs, the needle is readjusted, retracted, or completely withdrawn.

With the needle in satisfactory position, and with no damping of pressure recordings, the stopcock is then adjusted to connect the needle to the injection apparatus, the patient is told to stop breathing, and the radiopaque medium is injected in approximately 2 seconds. On completion of injection, the needle is immediately withdrawn. The first of the filming series is started immediately before injection.

**Analysis of Cases**

Of the 31 patients 23 were males and 8 females; their ages varied from 31 to 58 years. Of the total of 35 attempts at coronary visualization, opaque medium was injected in all but 3. In these 3 instances no opaque medium was injected because of failure to obtain satisfactory needle puncture of the ascending aorta. In 1 additional case, the needle was believed to be in the ascending aorta; however, film study revealed it to be actually in the main pulmonary artery and this latter vessel was unintentionally opacified.

Of the 31 injections of opaque substance into the aorta, satisfactory needle puncture of the ascending aorta was accomplished with 1 needle pass in 20; in 5 instances satisfactory placement of the needle required 2 passes; in 3, 3 passes were required; in 2, 4 were necessary; and in 1 examination, satis-
factory placement of the needle necessitated 7 passes. Of the 11 examinations requiring more than 1 needle insertion, the pulmonary artery (as judged by the pressure wave recordings) was entered on 2 occasions.

Of the total of 31 patients, 4 had repeat examinations. One repetition was because of failure to puncture the aorta satisfactorily the first time. In another patient, the second study was performed after surgical implantation of the internal mammary artery into the myocardium (Vineberg procedure), in order to evaluate the patency of the implanted internal mammary artery. In a third patient, the second examination was performed because marked dilatation of the ascending aorta resulted in such dilution of the opaque solution that the coronary arterial system was poorly opacified; the procedure was repeated with a larger amount of opaque solution. In the fourth patient the injecting syringe collapsed at the first examination with delivery of insufficient opaque solution.

The primary purpose of the procedure was the visualization of the coronary arterial system in 23 of the 35 examinations. In 11 examinations the principal objective was the quantitation of aortic insufficiency; in 1 study, the main objective was to demonstrate a suspected patent ductus arteriosus. In the patients who had clinical features suggestive of coronary artery disease, the examination was performed to demonstrate whether the proximal portions of the coronary arteries were involved by atheromatous narrowing or occlusion.

Our procedure does not permit simultaneous multiple electrocardiographic leads; so lead II was routinely used. Of the 31 injections of radiopaque medium into the aorta, 14 showed no change in the electrocardiogram throughout the procedure. At the time of needle insertion into the aorta, there were 7 instances of electrocardiographic changes: 1 instance of sinus tachycardia, 1 of a single ventricular premature contraction; in 1, 3 ventricular premature beats; 2 instances of several atrial premature beats; 1 occasion of short runs of both atrial and ventricular tachycardia; and 1 occasion of RS-T segment elevation. Immediately at the injection of opaque medium, there were 3 occasions of minimal T-wave inversion; 1 instance of a single ventricular premature beat, and 1 occasion of sinoatrial block which persisted for 10 minutes. In the period after injection, we observed 9 occasions of sinus tachycardia, all of short duration. Several seconds of sinus bradycardia frequently preceded the tachycardia. There were also 1 occasion of a single ventricular premature contraction in the post-injection period, 1 instance of RS-T segment depression for 3 minutes, and 3 instances of T-wave inversion, lasting 1 to 5 minutes.

The most common subjective reaction was a sensation of heat and flushing. Occasionally, nausea and, less frequently, vomiting occurred. Such reactions were temporary, rarely lasting more than 60 seconds, and in no instance were they alarming. Mild headache, lasting no more than a half hour, occurred 4 times. There has been 1 episode of slight hypotension following injection of the radiopaque medium.

No clinical manifestations occurred suggestive of cerebral dysfunction or damage. In no case, to our knowledge, did the procedure precipitate a myocardial infarction or an anginal episode. The majority of patients complained of slight to moderate substernal discomfort, usually lasting less than 24 hours. In a few patients, this was present for several days and 1 patient complained of discomfort for 1 week. We have encountered 1 instance of pneumothorax. In this patient, we attempted 3 needle passes to the aorta, without success. No opaque medium was injected. The patient developed hypotension, and x-ray revealed a small pneumothorax on the right. There was no known instance of needle laceration of the aortic sinuses, the aortic valve, or the coronary artery.

In 2 patients the films revealed that a very small amount of the radiopaque medium, estimated as no more than 1.0 ml., entered the right lateral aortic wall at a point about 3.0 to 5.0 cm. above the aortic valve. The needle tip was very close to the intima of the aorta, and it is believed that this amount of opaque material was injected into the aortic wall.
Additional films taken approximately 10 and 12 minutes after the injection revealed no residuum of opaque substance in the aortic wall and we presume that it had been absorbed. No complications developed as a result of these minimal intramural injections.

Of the 31 patients in the series cardiac surgery was performed at some time following the procedure in 18. In these patients the surgical exposure afforded an opportunity to determine whether there was gross hemorrhage, hematoma, or ecchymosis of the anterior mediastinum. The time lapse between coronary arteriography and surgery ranged from 4 to 15 days. Ecchymosis of the anterior mediastinal tissues was observed in 3 instances.

In analyzing the final radiologic observations, we have graded the degree of opacification of the ascending aorta and the aortic sinuses, and of the right and left coronary arteries on a basis of excellent, good, fair, or poor opacification, or failure of opacification. In the grading we have evaluated the adequacy of visualization of the main coronary arteries and the major branches arising from each of the coronary arteries. While we are concerned with the tertiary or smaller branches of the coronary arterial system, it is well established that these branches are subject to considerable normal variation in origin, number, size, and distribution. We have therefore confined our evaluation largely to the degree of visualization of the main coronary arteries and their major branches.

Seven of the 35 procedures are excluded from analysis of coronary opacification because of unsatisfactory puncture of the aorta in 3, inadvertent injection into the main pulmonary artery in 1, failure of radiographic apparatus in 2, and breaking of the injecting syringe in 1.

Thus 28 examinations remain for analysis. Opacification of the ascending aorta and aortic sinuses was considered excellent in 20, fair in 4, and poor in 4 examinations, and there were no failures. Opacification of coronary arteries was graded for the left coronary artery as excellent in 3, good in 7, fair in 8, poor in 5, and no visualization in 5. There were 6 instances of opacification of the left but no opacification of the right coronary artery and 5 occasions in which neither coronary artery was opacified.

The findings of coronary arteriographic study were compared with surgical observations of the coronary arteries in 13 patients in our series. Seven of these patients were subjected to internal mammary artery implantation into the myocardium (Vineberg procedure), 5 had aortic valvular surgery, and 1 had a coronary endarterectomy. While digital and visual examination of the coronary arteries at surgery has definite limitations, it can reveal instances of atheromatous calcific change in the epicardial coronary vessels. There was essential agreement and good correlation in 8, and partial agreement in 4 cases. In 1 case there was poor arteriographic visualization of both coronary arteries, but apparently normal coronary arteries were reported at surgery. This case had marked aortic regurgitation, which probably accounted for the poor coronary opacification.

A brief description of the arteriographic and surgical findings in each of these 13 patients follows.

**Case 1**

Male, age 58 years. Clinical diagnosis: Aortic stenosis and coronary insufficiency.

**Coronary Arteriograms.** Moderate aortic regurgitation. Right coronary artery: Fair visualization, no evident lesion. Left coronary artery: Fair visualization; irregular narrowing, main trunk and anterior descending and circumflex branches, with terminal poor filling.

**Surgery.** Transventricular aortic commissurotomy. Severe atherosclerosis of left coronary artery and major branches.

**Comment.** Good correlation of coronary arteriography with surgical and subsequent autopsy findings.

**Case 2**

Male, age 37 years. Clinical diagnosis: Myocardial infarction, 3 years prior to admission. Progressive angina, 14 months.

Surgery. Attempted coronary endarterectomy, left circumflex artery, technically difficult and incomplete. Vineberg procedure: Localized sclerotic calcific lesion, proximal portion of circumflex branch of left coronary artery; anterior descending branch fibrotic and stringlike, with numerous arteriosclerotic plaques.

Comment. Good correlation of coronary arteriography with surgical findings.

Case 3

Male, age 41 years. Clinical diagnosis: Angina, 3 years, myocardial infarction, 6 months prior to admission.


Surgery. Vineberg procedure. Palpable sclerotic and calcific plaques, right and left coronary arteries.

Comment. Good correlation of coronary arteriography with surgical findings.

Case 4

Female, age 37 years. Clinical diagnosis: Aortic insufficiency.

Coronary Arteriograms (Fig. 2). Marked aortic regurgitation. Right coronary artery: Poor visualization, no evident lesion. Left coronary artery: Good visualization, no evident lesion.


Comment. Partial correlation of coronary arteriography with surgical findings. Poor visualization of right coronary artery is unexplained, except on the possible basis of aortic regurgitation.

Case 5

Female, age 40 years. Clinical diagnosis: Aortic stenosis, major; aortic insufficiency, minor; cardiac failure for 14 years.


Comment. Good correlation of coronary arteriography with surgical findings.

Case 6
Male, age 31 years. Clinical diagnosis: Aortic stenosis.

Coronary Arteriograms (Fig. 3). Marked aortic regurgitation. Right coronary artery: Poor visualization, no evident lesion. Left coronary artery: Poor visualization, no evident lesion.


Comment. Poor correlation of coronary arteriography with surgical findings. Failure of satisfactory coronary opacification presumably due to marked aortic insufficiency.

Case 7
Male, age 40 years. History of myocardial infarction 1 year prior to admission; angina for 5 months.


Comment. Partial correlation of coronary arteriography with surgical findings. Arteriographic studies did not demonstrate sclerosis of right coronary artery.

Case 8
Male, age 56 years. Clinical diagnosis: Coronary insufficiency.

Coronary Arteriograms. Right coronary artery: No visualization. Left coronary artery: Good visualization. Irregular defects, main trunk and proximal portions of circumflex and anterior descending branches, with poor filling of distal portions of both branches.

Comment. Good correlation of coronary arteriography with surgical findings. Nonvisualization of right coronary artery presumably due to sclerotic changes.

Case 9
Male, age 48 years. History of angina for 11 years.
Coronary Arteriograms. Right and left coronary arteries: No visualization.

Comment. Good correlation of coronary arteriography with surgical findings. Nonvisualization of coronary arteries at arteriography presumably due to extensive disease of both vessels.

Case 10
Male, age 40 years. History of angina for 16 months. Myocardial infarction 1 year prior to admission.
Coronary Arteriograms (Fig. 4). Right coronary artery: Poor visualization. Incomplete filling. Questionable constrictive narrowing. Left coronary artery: Good visualization. Constrictive defects, proximal 1.5 cm. anterior descending branch. Good visualization circumflex branch.

Surgery. Vineberg procedure. Thickened proximal 2.0 cm. of right coronary artery. Thickened left main trunk and proximal 1.0 cm. of left circumflex branch. Bifurcated left anterior descending, with occlusion of mesial branch.

Comment. Partial correlation of coronary arteriography with surgical findings. Coronary arteriography did not disclose any abnormality of the circumflex branch of the left coronary artery.

Case 11
Female, age 42 years. Clinical diagnosis: Aortic stenosis, major; aortic insufficiency, minor.
Coronary Arteriograms (Fig. 5). Moderate aortic regurgitation. Right and left coronary arteries: Excellent visualization, no evident lesion.

Fig. 6. Case 12. Right coronary artery: fair visualization; irregular narrowing, proximal 3.0 cm. Left coronary artery: good visualization; constrictive defects, main trunk and anterior descending branch; poor filling circumflex branch.

Comment. Good correlation of coronary arteriography with surgical findings.

Case 12
Male, age 54 years. History of angina for 8 years. Two episodes of myocardial infarction: one 8 years, and one 5 months prior to admission.
Coronary Arteriograms (Fig. 6). Right coronary artery: Fair visualization. Irregular narrowing, proximal 3.0 cm. Left coronary artery: Good visualization. Constrictive defects, main trunk and anterior descending branch. Poor filling circumflex branch.


Comment. Good correlation of coronary arteriography with surgical findings.

Case 13
Male, age 46 years. History of angina for 2 years. Electrocardiogram showed old myocardial infarction.

Surgery. Coronary endarterectomy, anterior descending branch of left coronary artery. No palpable disease of right coronary artery. Sclerotic plaques in left main trunk and in circumflex and left anterior descending branches.

Comment. Partial correlation of coronary arteriography with surgical findings. The incomplete filling of the right coronary artery is unexplained.

The correlation of digital and visual surgical observations of the exposed epicardial portions of the coronary arterial system with coronary arteriographic findings raises the question of the value of each procedure in assessing pathologic states that interfere with coronary flow. The reliability of suprasternal transaortic coronary arteriography as we employ it cannot be fully determined until such time as an adequate series of cases, exhibiting no evidence of coronary artery disease by clinical history, careful clinical examination, and subsequent anatomic studies of the coronary arteries has been examined by this procedure of coronary visualization.

Summary

A procedure of coronary arteriography for needle-puncture opacification of the ascending aorta by a suprasternal approach is presented. The coronary visualizations obtained by this procedure are analyzed, and the reactions and complications encountered in 35 studies in 31 patients is recorded. The correlation of coronary arteriographic with surgical findings is discussed.

Summario in Interlingua

Es describite un technica de arteriographia coronari, con opacification acupunctural del aorta ascendente per un approche supraster-

nal. Le visualization coronari obtenite per iste technica es analysete, e le reactiones e complications incontrate in 35 studios in 31 patientes es presentate. Le correlation inter le constatationes de arteriographia coronari e le constatationes chirurgic es discutite.

REFERENCES
