Correlation of Arteriographic and Pathologic Findings in the Coronary Arteries in Man


Surgical Measures designed to improve total myocardial blood flow have been recommended as a form of therapy in established occlusive arteriosclerotic heart disease. A direct approach attempting to improve blood flow in localized areas of myocardial ischemia by means of coronary endarterectomy was reported to have been successful by Murray in 1953, and since then others have published favorable results using this procedure. End-to-side anastomoses of coronary arteries have also resulted in improved flow through existing vessels.

In 1958, Szi1agyi and co-workers concluded from a postmortem injection study of 114 hearts with arteriosclerotic heart disease that surgical intervention could have led to cure in 21 per cent and palliation in another 35 per cent.

Successful direct operative intervention presupposes a safe, valid, and precise means of localizing obstructive vascular disease in the living patient. Attempts at coronary artery visualization in living man began with Radner's transsternal aortic puncture technic in 1945. Since then several procedures have been developed with use of various sites and methods of injection. Coronary artery filling has been improved by means of pharmacologically induced cardiac arrest as well as balloon occlusion of the aortic outflow.

Innovations in roentgenographic technics have occurred concomitantly. In 1958, Sones reported favorably on the use of cinefluorography with an image intensifier enabling selective catheterization and injection of each main coronary artery. With further improvement in methods, coronary arteriography promises to aid in the differential diagnosis of chest pain, identification of occlusive arterial disease, and evaluation of postoperative results.

An essential of any technic of arteriography is that it reproduce accurately underlying structural alteration. Schlesinger, discussing his postmortem injection-dissection technic, said that no final decision as to the patency or occlusion of any vessel can be made from the roentgenogram alone. He further stressed that injections without dissections miss occlusions and vice versa.

From a clinical viewpoint there have appeared in the literature many opinions as to the precision of coronary arteriography. No published study, however, has included critical observations of a point-for-point correlation between pathologic and roentgenologic findings. The present study was designed to compare postmortem coronary arteriographic findings with the anatomic lesions observed at autopsy in order to assess the validity of arteriographic findings.

Methods and Materials

Fifteen adults were studied at autopsy during May and June 1960 at the Institute of Pathology of Western Reserve University. Cases were selected irrespective of cause of death. Eight women and 7 men were included, having an age span from 31 to 99 years, with a median age of 64 years.

Upon removal of the intact anterior chest wall an incision was made at the base of the aorta through which a curved flanged needle was inserted.
CORONARY ARTERIOGRAPHY

and ligated securely within each coronary ostium. The coronary tree was gently flushed with warm saline, after which a barium sulfate-agar solution was perfused at a constant pressure of 150 mm Hg until equilibrium was reached. The resected anterior chest wall was replaced, and anteroposterior and left lateral roentgenograms were taken. The heart was then excised and chilled in an iced-water bath for 1 hour. After the injection mass had hardened, the heart was opened according to the Schlesinger technique, spread flat, and again roentgenographed. The coronary arteries were dissected from the heart, stored in formalin for 24 hours, and decalcified.

A map of each coronary artery was made by tracing its outline on paper (fig. 1). For direct pathologic examination of the arteries, each was sectioned every 2 mm, and numbered. Corresponding numbers were placed on the map to record the order and location of sections. Each major artery and main branch thus mapped was divided into a proximal, middle, and distal segment for convenience of comparison with its corresponding roentgenogram.

The right, left, left circumflex, and left anterior descending coronary arteries and their branches were examined for evidence of occlusive disease. The main trunk of the left coronary artery was included with the proximal portion of the left circumflex. All branches shorter than 3 cm. were treated as one segment. The extent of vascular narrowing was assessed by both radiologist and pathologist as follows:

- $0$ = no narrowing
- $\text{minimal} = \text{questionable narrowing}$
- $++ = \text{lumen reduced by less than one third}$
- $+++ = \text{lumen reduced by one third or more}$

Each arterial segment was graded according to the greatest degree of narrowing found within it.

**Results**

The extent of coronary artery narrowing did not differ, whether interpreted from the in situ roentgenograms or from the planar views (Schlesinger). Accordingly, only in situ roentgenographic results were used for comparison with the anatomic findings. Two of the original 15 cases were excluded: one in extensive narrowing of the coronary ostia prevented insertion of the cannula and injection of the contrast solution; in the other, identification of the respective arterial segments could not be performed with certainty. Representative normal and abnormal anteroposterior and planar angiograms are shown in figures 2 to 5. The radiologic and pathologic findings in 13 individuals or 130 major arterial segments are shown in table 1.

When pathologic examination revealed no narrowing, roentgenologic findings were similar: of 50 segments graded 0 or minimal by the pathologist only six were graded with more involvement by the radiologist. Among 44 showing grade ++ anatomic change, however, the radiologist interpreted 20 as 0 or minimal, 16 as +, and agreed in only 8.

Ninety-three arterial segments were graded 0

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*600 Gm. BaSO₄, 60 Gm. agar gel, 850 ml. water.
†A Picker 60-MA portable unit was employed with use of 100 MAS at 70 KvP with an 8.1 Stationary grid.
‡10 MAS at 40 KvP were used.

Table 1

Comparison of Roentgenologic Appearance and Anatomic Findings in 130 Coronary Arterial Segments

<table>
<thead>
<tr>
<th>Roentgenologic appearance</th>
<th>Anatomic findings</th>
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<tr>
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<tr>
<td>0</td>
<td>26</td>
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<tr>
<td>Minimal</td>
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<td>+</td>
<td>4</td>
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<tr>
<td>++</td>
<td>0</td>
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<tr>
<td>Total</td>
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or minimal by roentgenogram; anatomic findings were similar in only 44 instances; narrowing was present in the remaining 49, 20 of which showed ++ involvement. Every one of the 11 segments judged ++ by arteriogram revealed unquestionable narrowing at autopsy.

Instances of poor correlation were not confined to particular cases or areas within the arterial tree. As noted by previous workers,27-29 the left anterior descending artery was involved by stenosing lesions more often than any other artery and proximal segments more than distal ones.

Discussion

The urgent question concerning the accuracy and usefulness of coronary arteriography was posed by Lehman30 as follows: "With how much precision can clinically applied coronary arteriography reveal areas of luminal narrowing, atherosclerotic plaques, and obstructive lesions in the coronary arteries of the intact adult human? How specifically can it thus be determined whether significant coronary artery disease is or is not present? These are questions which are as yet unanswered." The objective of the present study was a careful segmental comparison of pathologic and roentgenologic arterial findings in cadavers in an attempt to provide an answer to these questions.

Interpretation of these data requires consideration of many technical details. The clinical situation was simulated, but not wholly reproduced by the use of cadavers. The post-mortem arteriographs in the present study revealed finer detail than usually available from in vivo studies. Contrast media in clinical use were not employed, since a gel was necessary to facilitate a subsequent planar view and dissection. Opinions vary widely regarding optimal injection pressure and, arbitrarily, Schlesinger’s method using 150 mm. Hg was followed.26 Examination of both anteroposterior and lateral films precluded misinterpretation caused by foreshortening and overlapping of vessels.31 The arteriogram of the flattened, unrolled heart (Schlesinger preparation) was used to provide an optimal roentgenogram with which to compare the in situ views. Finally, the division of the arteries into thirds provided a larger number of individual segments for accurate comparison.

Several groups of investigators have reported that abnormal arteriograms were veri-
fied by surgical findings. In a retrograde arteriographic study by Littman, abnormal preoperative roentgenograms were confirmed in six of six individuals at the time of surgery. In this same study normal arteriograms were observed in only two of 17 patients with clinical evidence of arteriosclerotic heart disease and in 25 of 30 persons without such evidence.

Sloman and Hare, using a retrograde aortic technic in patients undergoing surgery to correct valvular defects, found that six of seven with normal arteriograms had coronary vessels free of visible and palpable atheromatous lesions at operation. They studied an additional three patients at autopsy and reported agreement between roentgenographic and anatomic lesions.

Other studies have shown that a normal arteriogram does not necessarily exclude pathologic change. Harrison and Wood, in 1949, published a clinicopathologic study of a group of cardiac patients and controls by use of postmortem arteriography. Severe anatomic lesions were noted in three and lesser lesions in two of 12 controls with normal roentgenograms. In 20 normal-appearing arteriograms of hypertensive patients, 16 showed some slight patchy involvement when examined histologically. Miller and co-workers reported that arteriography failed to visualize experimentally induced arterial ligation in three of six dogs. Longmire et al., inspecting the coronary tree of a patient at the time of surgery, found the atherosclerosis to be more extensive than the arteriograms had indicated.

The findings in the present study indicate that the abnormal arteriogram provided reliable evidence of narrowed coronary arteries; however, many affected segments escaped radiologic detection. The discrepancy between morphologic and roentgenologic findings may be due to intravascular pressure distending a weakened sclerotic wall, resulting in a normal lumen radiologically. No attempt has been made here, however, to interpret arteriosclerotic narrowing in pathophysiologic terms.
Summary

The accuracy of clinical coronary arteriography was studied by comparing pathologic and radiologic findings in 130 major coronary arterial segments obtained from 13 individuals at autopsy. Abnormal roentgenographic findings were verified by pathologic examination; however, half of the segments that appeared normal or minimally involved radiologically demonstrated more severe changes at autopsy.

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Figure 5

Abnormal planar arteriogram (Schlesinger preparation). The patient was a 77-year-old white woman with hypertensive and arteriosclerotic heart disease. Coronary arteries were extensively involved at autopsy. Arrows indicate some of the areas of narrowing observed on arteriogram. F.D., filling defect; A., calcified aortic valve.

References


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