CLINICOPATHOLOGIC CORRELATIONS

Correlation of the Antemortem Coronary Arteriogram and the Postmortem Specimen

By Zeev Vlodaver, M.D., Robert Frech, M.D., Robert A. Van Tassel, M.D., and Jesse E. Edwards, M.D.

SUMMARY

Correlative studies were carried out on the coronary arteriograms made during diagnostic procedures and on the specimens obtained at necropsy in 10 cases of coronary heart disease. Of the 134 segments of coronary arteries available for both studies, 44 (33%) were given false-negative arteriographic diagnosis of obstructive atherosclerosis.

Factors which may underlie this discrepancy include (1) radiographic technic, (2) projection used, (3) a slitlike lumen adjacent to the atheroma, (4) comparison of severely obstructed segments involved but less severely obstructed, and (5) misinterpretation from the specimen of obstruction present in life.

Additional Indexing Words:
Coronary atherosclerosis  Radiographic technic

The current trend toward surgical intervention in certain types of coronary artery disease relies on the coronary arteriogram to delineate the pathologic lesion. The coronary arteriogram, however, even when obtained by postmortem injection, does not always correlate well with the gross and microscopic alterations found by dissection of the coronary arteries. The coronary arteriogram has generally been found to reveal less extensive disease than postmortem examination does. Two reasons have been put forward to explain this discrepancy: (1) the intravascular pressure of postmortem injection may distend a weakened sclerotic wall, and (2) the anatomic configuration of the arterial lumen may appear normal or nearly normal in one projection of the coronary arteriogram but in projections at right angles to this view, the lumen may appear greatly obstructed.

The present study was undertaken to correlate the antemortem coronary arteriogram with the postmortem pathologic specimen, with special attention to areas of disagreement between these two methods of investigation.

Methods

Ten cases of coronary arterial disease from the Cardiovascular Registry of the United Hospitals, Inc.-Miller Division (formerly the Charles T. Miller Hospital) were selected for study. In each case manifestations of coronary heart disease had been present clinically, and coronary arteriography had been performed during life. Death in each case was attributable to coronary disease. The interval between arteriography and death varied from 3 to 13 weeks in nine cases; in the tenth case the interval was 3 years. The arteriograms and fixed pathologic specimens were available for review in each case.

Coronary arteriography had been performed at the University of Minnesota Hospital by the method of Amplatz as part of the evaluation of the patient with clinical coronary disease. Both frontal and lateral projections, for which the biplane Schonander changer with lead cutout shields was used, were available in six cases. In two out of these six cases, the right coronary artery was studied by 35-mm cinearteriography only. In two more of the 10 cases the 0.3-mm focal-spot magnification technic of Randall and Amplatz was...
utilized. In these two cases, serial arteriograms were available in the right anterior oblique and lateral projections for two arteries and in a single projection for the other two arteries. In the last two cases studied, right anterior oblique and lateral projections were available that utilized the 2-mm focal spot without magnification.

The fixed heart was examined by two experienced observers (Z.V. and R.A.V.T.) studying, independently of each other, the extent, location, and type of atheromatous lesions in the coronary arteries. For each heart, 19 segments of the major coronary arteries were designated as shown in figure 1. The right coronary artery was divided into three primary segments as follows: the anterior, the intermediate, and the posterior descending. The anterior segment included the right coronary artery from its ostium in the right aortic sinus to the origin of its marginal branch; the intermediate segment extended from the origin of the marginal branch to the crux of the heart; and the posterior descending artery occupied the posterior interventricular sulcus. The anterior and intermediate segments were each further subdivided into four equal segments, two of which were further subdivided. The left coronary artery from its origin to the site of branching made up one segment. The circumflex and anterior descending branches then were each subdivided into four equal subsegments. This subdividing yielded a total of 19 coronary arterial segments per heart.

**Angiographic Grading of the Coronary Arteries**

Using the same segmental designation as that given for the specimen, two observers (R.F. and R.A.V.T.) reviewed and interpreted the 10 coronary arteriograms. Each segment was graded as exhibiting either <50 or ≥50% narrowing. The widest diameter of the coronary artery adjacent to a lesion was used as the normal in our estimate of the degree of narrowing. In some segments visualization was too poor for any grading; these were classified as having "no or inadequate visualization." Technical problems associated with filming, injection, or failure of the contrast material to fill the coronary artery adjacent to an apparent obstruction were responsible for the poor visualization.

**Pathologic Grading of the Coronary Arteries**

Each segment was graded by the observers according to the most severe lesion in that segment as depicted in figure 2. Grade I refers to the lumen that is reduced up to and including 25% by atheromatous plaques; grade II, to 26-49% reduction of the lumen; grade II+, to 50-74%; grade III, to 75%; grade III+, to 76-99%; and grade IV, occlusion.

Representative histologic sections were taken later from segments of the coronary arteries where there was either agreement or disagreement between coronary arteriogram and the pathologic specimen. Additional sections were taken from segments not visualized by the coronary arteriogram. The total samples taken for histologic examination totaled 55.

**Comparison of Findings**

The interpretation of the coronary arteriogram and the findings of postmortem examination were compared and the results were tabulated as follows.

**Failure to Visualize.** Failure to visualize a segment of a coronary artery on the arteriogram occurred for technical reasons in one case but, in the remainder of the cases, it occurred because the artery could not be visualized adequately.

**False-Negative Result.** The result of the arteriographic study was recorded as false negative when the coronary arteriogram was interpreted as showing less than 50% reduction in the arterial lumen, while the pathologic examination found 50% or more loss of the arterial lumen as seen in cross section.

**False-Positive Result.** A false-positive result was recorded when reduction of the lumen was interpreted from the coronary arteriogram as being 50% or more but was found on postmortem examination to be less than 50%.

![Diagrammatic portrayal of the coronary arteries and the sites of the 19 segments identified in each heart.](image1)

**Figure 1**

Diagrammatic portrayal of the coronary arteries and the sites of the 19 segments identified in each heart. a. Anterior view. b. Posterior view. Anterior R.C. = anterior segment of right coronary artery; Intermediate R.C. = intermediate segment of right coronary artery, that segment between the origin of the marginal branch (M.B.) and the posterior descending artery; (P.D.); L.A.D. = anterior descending coronary artery; Cir. A. = left circumflex coronary artery.

![Diagrammatic portrayal of the grades of obstruction of arterial lumina according to the grades employed in this study.](image2)

**Figure 2**

Diagrammatic portrayal of the grades of obstruction of arterial lumina according to the grades employed in this study.
Agreement. Agreement was recorded when both the coronary arteriographic and pathologic examinations showed the same degree of narrowing of the lumen, that is, less than or greater than 50% loss of arterial lumen.

Results

For various technical reasons, certain segments were not available for pathologic or arteriographic studies or for both. Thus, among the 10 hearts a total of 153 segments were studied pathologically and 152 arteriographically. Segments for which data were available by both methods of study totaled 134.

Among the 152 segments studied arteriographically, 60 exhibited narrowing that was judged to be greater than 50%. Of the 153 segments studied pathologically, 108 showed narrowing of 50% or more.

The 135 segments for which both pathologic and arteriographic data were available represent the material to be covered in the main body of this report. The subject of failure to visualize arteriographically will be covered independently in a section below.

Of the 135 comparisons, 86 (64%) were in agreement, 44 (32.5%) were categorized as false negative, and five (3.5%) as false positive. Figure 3 summarizes the correlation between the interpretation of the coronary arteriogram and the pathologic findings in the 10 cases reviewed.

In the left coronary artery, the main segment was visualized in all 10 cases and agreement was present in five (50%). For 33 of the 40 subsegments from the left anterior descending coronary artery, comparison could be made, and in 26 of these 33 (70%) agreement was present. For 10 (48%) of the 21 subsegments of the circumflex branch that were compared, agreement was recorded.

In 35 of the 40 subsegments of the anterior segment of the right coronary artery, the coronary arteriogram and pathologic findings could be compared. Agreement was present in 22 of these 35 subsegments (63%). Comparison could be made between the findings from the coronary arteriogram and the specimen in 22 of the 40 subsegments from the intermediate segment of the right coronary artery. Agreement was present in nine (41%). Comparison between the coronary arteriogram and the specimen was possible in 14 of the 20 segments of the posterior descending coronary artery. Agreement was recorded in each comparison (100%). The posterior descending coronary artery was devoid of obstructive lesions.

Among segments showing a false-negative correlation, there were several cases in which the patient's widest coronary artery as seen arteriographically was found severely diseased during pathologic examination.

In some instances, arterial lumens measuring between 2 and 3 mm in diameter in the arteriogram were graded pathologically as III or III+.

Histologic Studies

The primary purpose of the histologic examination of 55 segments was to determine whether the shape of lumen of the diseased coronary artery and the angiographic interpretation were related. Three types of lumen were envisioned, based on a previous study and designated as follows: (1) central, (2) eccentric polymorphous, and (3) eccentric slitlike.

The designation "central" type of lumen was given when the walls of the artery were symmetrically involved by atherosclerosis, so that the remaining lumen was central in location, usually circular in outline, but occasionally slitlike. The other two types of lumen were eccentric as the...
The result of an eccentric deposit of atheromatous material. When the eccentric lumen was a narrow slit, the length of which approached the basic diameter of the artery, the lumen was classified as slitlike. When an eccentric lumen was other than slitlike, the lumen was designated "eccentric polymorphous" in type. In some of the latter instances, the lumen was circular in outline.

Figure 4 shows the relationship of the type of lumen to the agreement or disagreement of the coronary arteriogram with the pathologic observations. No central lumens were found; this may perhaps be explained by the fact that the lesions in the sections studied were all of significant proportion.

It is evident from figure 4 that, when the lumen of the artery was slitlike, agreement between the coronary arteriogram and the postmortem specimen was less frequent than when the lumen was eccentric polymorphous in type (figs. 5, 6). The lumen was slitlike in 15 (68%) of the 22 segments taken from areas of false-negative readings and in 11 (33.3%) of the 33 sections taken from areas of agreement. These numbers are significant if one compares them with a previous study6 at this institution in which histologic examination of coronary arteries in unselected cases of severe coronary atherosclerosis revealed a slitlike lumen in only 29% of cases, while an eccentric polymorphous lumen was present in 40%. A central lumen was present in 31% of the cases of the earlier study.

Comment

The results of this study are in general agreement with previous investigations. These show that the coronary arteriogram underestimates the degree of narrowing found at postmortem examination.1-4

In our study the segments particularly prone to arteriographic underestimation of the degree of obstruction were the intermediate segment of the right coronary artery, the main left coronary artery, and the proximal half of the left circumflex artery. The intermediate segment of the right coronary artery as visualized in the coronary arteriogram is the area most frequently poorly correlated with the postmortem specimen. In this study, pathologic examination of the right coronary artery revealed that the anterior segment and the intermediate segment were equally involved with atherosclerosis. The arteriogram, however, tended to reveal the involvement of the anterior segment well but showed less involvement of the intermediate segment. As a result, the degree of involvement in the intermediate segment was underestimated, arteriographically.

One possible explanation for vulnerability of the intermediate segment of the right and the proximal segment of the left circumflex arteries is that arteriographic projections ideal for visualizing the anterior segment of the right and the anterior descending coronary arteries are not ideal for the two problem segments named.

Also, the roentgenologist's anticipation of the normal caliber of the intermediate segment of the right coronary artery may be an underestimation. Some false-negative readings were recorded for segments that showed only a uniform but relatively small vessel arteriographically, while pathologically diffuse disease was demonstrated.

Still another factor is that of comparing different degrees of stenosis. Thus, the main left and proximal segment of the left circumflex coronary arteries were subject to false-negative interpretation when adjacent segments were more severely
diseased. This suggests that an important consideration for the physician interpreting the coronary arteriogram is to be aware that he may be grading the degree of narrowing in the lumen of the artery as a percentage of the image of the lumen in the immediate vicinity of the lesion. The roentgenologist is thus frequently grading the degree of stenosis against an already diseased and compromised lumen of the coronary artery which he interprets as normal. There is need for a comprehensive experience with arteriography of nondiseased coronary arteries. A series of arteriograms in young adults, ostensibly healthy persons, would be of great help in this problem. After consideration of dominance of coronary arteries, each segment and subsegment could be measured, and a normal range of size assigned to each segment to be used by the roentgenologist as an aid in interpreting arteriograms in cases of suspected coronary disease.

The presence of a slitlike lumen in areas of false-negative recordings suggests that on the arteriogram one may view the slit in its widest diameter and interpret this wide image as that of a normal artery. This error should be corrected by filming in the plane of the slitlike lumen, and this becomes more likely when several projections are made. Even here, there remains a problem. This relates to the orientation of atheromas. We have observed that when one makes a series of sections of a given artery, the several atheromas vary in their orientation with respect to surface of the heart. Considering this from the arteriographic point of view, it is apparent that one projection may be ideal to show a
certain atheroma and poor for others in the same vessel.

Specific roentgenographic technic is an obvious basis for quality of arteriographic results.

Serial magnification technic as described by Randall and Amplatz were superior to technics without magnification. In the two of our cases so studied, agreement was reached on 23 of 25 segments; in the others, on 62 of 109. On pathologic examination of the coronary artery, the degree of narrowing by contraction of the wall during fixation of the specimen may indeed be overestimated. Such a phenomenon is easiest to envision with regard to the slitlike lumen. It is also possible that some atheromatous plaques may sink into or indent the media of the vessel during life and thus appear less conspicuous in the coronary arteriogram than in the specimen. The reverse may also be true. For example, in eight of the nine segments showing apparent complete occlusion in the coronary arteriogram, gross and histologic examinations revealed some lumen.

Acknowledgment

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References

Correlation of arteriography and pathologic findings in a study of the right coronary artery. 
a. Arteriogram of right coronary artery. I identifies a point in the anterior segment considered narrowed 50% or more from its original caliber. This conforms to the pathologic findings shown in b, in which grade II+ atherosclerosis is present with an eccentric polymorphous lumen. At the arrow, the intermediate segment of the artery is considered as showing no stenosis, while the pathologic picture illustrated in c shows grade III+ narrowing of the lumen by atherosclerosis with a slitlike lumen. 
b and c. Photomicrographs. 
b. Anterior segment of right coronary artery from the segment identified by I in a. Elastic tissue stain, × 10. 

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