Clinical Significance of Coronary Artery Calcification Seen Fluoroscopically with the Image Intensifier

By Johnson McGuire, M.D., Harold J. Schneider, M.D., and Te-Chuan Chou, M.D.

SUMMARY

Five hundred forty-four unscreened patients were examined by a radiologist as to the presence or absence of coronary artery calcification. The overall prevalence of coronary calcification was 20% and there was a definite increase in the prevalence of the finding with increasing age. A comparison of 94 patients with coronary calcification with a matched control group without calcification indicated that the prevalence of symptomatic ischemic heart disease in the group with calcification was approximately twice that of the control group. The correlation was even more significant when the degree of calcification was moderate or severe.

It is concluded that cardiac fluoroscopy with image intensification is a useful supplementary tool in the clinical evaluation of patients suspected of having coronary artery disease. It can be performed easily and imposes no risk to the patient.

Additional Indexing Words: Angina pectoris Myocardial infarction Hypertension Hypercholesterolemia

The purpose of this study is to determine the clinical significance of coronary artery calcification in a mixed group of patients as recognized fluoroscopically with the image intensifier, and its usefulness as a routine procedure in the evaluation of patients suspected of having ischemic heart disease. Recent advance in the visualization of coronary arteries by the injection of radiopaque material has immensely improved the diagnosis of coronary disease. However, use of the technique of coronary arteriography has been limited to major medical centers; the procedure is not without serious hazards and should not be done in the average hospital. Although the fluoroscopic demonstration of calcification of the coronary artery does not necessarily imply that there is impairment of the coronary circulation, it does indicate the presence of a diseased vessel. Patients with ischemic heart disease have been found to have a very high incidence of coronary artery calcification at autopsy.

Methods

Five hundred and forty-four consecutive patients who were referred to the Radiology Department of the Christian Holmes Hospital for fluoroscopic examination other than that of the cardiovascular system were included in the study. The investigation covered a period of 15 months from July 1965 through September 1966. All of the patients were of the Caucasian race; 282 of them were male and 262 were female. Their ages varied from 15 to 90 years. All of the fluoroscopic examinations were done by one of the authors (H.J.S.) who had no knowledge as to the presence or absence of coronary artery disease in any of the patients. During the same period, cardiac fluoroscopy was specifically requested on an additional 45 patients. They were not included in this series since the cardiac diagnosis was known to the examiner and bias might have occurred.

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The image amplifier unit used for the examination consisted of a binocular optical system with a 9-inch diameter visual field. Its intensifier tube produced a $3,000 \times$ intensification gain of the image over the conventional fluoroscopy unit. The examination was done with the patient in anteroposterior and left and right oblique positions. In each position the entire heart was examined; subsequently, the major branches of the coronary arteries were scanned with a smaller field size. The procedure was accomplished in less than 1 minute of fluoroscopy time.

The degree of coronary artery calcification was classified as mild, moderate, or severe. Although the severity of the lesion could be reflected by either its extensiveness or density, our previous experience indicated that they were usually closely related. To avoid rather complicated classification, only the length of the lesion was used as the criterion for the separation, realizing that such a method of division gave only a gross impression of the severity of calcification. The lesion was considered to be mild when its length was between 0 and 2.5 cm; moderate, when between 2.5 and 5.0 cm; severe when 5.0 cm or more.

The clinical records of patients with coronary artery calcification were reviewed. Only those cases in which a complete history and physical examination were available were used for analysis. The clinical information was recorded by members of the house staff before the results of the fluoroscopic examination were known. The presence or absence of the following was determined: typical history of angina pectoris, well-documented myocardial infarction, electrocardiographic abnormalities, hypertension, diabetes mellitus, hypercholesterolemia, and hyperlipemia. All of the electrocardiograms were interpreted by a cardiologist who was not involved in this study and had no knowledge as to the results of the fluoroscopic examinations at the time. Hypertension was considered to be present when the diastolic pressure was 100 mm Hg or higher. The diagnosis of diabetes mellitus was based on the elevation of the fasting blood sugar to 120 mg% or more, or that of the 2-hour postprandial blood sugar to 140 mg% or higher, or repeated glycosuria. The serum cholesterol was considered to be abnormal when it was 250 mg% or higher. When the total fasting serum lipids were above 800 mg%, hyperlipemia was present.

To determine the clinical significance of coronary artery calcification, a matching control group was selected from the patients in whom coronary artery calcification was not detected during fluoroscopy. The object was to have a patient of the same sex and age in the control group for each one in the group with coronary artery calcification. When more than one patient in the group without detectable calcification met the stated requirements, one was chosen at random. If none was found, the patient of the same sex and closest in age was used. An attempt was made to equalize the ages of the patients in the two groups. The age difference of the matching pair was 2 years or less in the great majority (84%) and in no instance was the difference more than 5 years. The selection of the control group was done by an individual who had no knowledge as to the clinical findings of these patients. The same clinical and laboratory data were obtained from the control group and the group with calcification.

Results

Coronary artery calcification was detected in 107 of the 544 patients examined. Fifty-eight of the patients were male, 49 were female. The percentage of males having coronary calcification was 21%, and that of the females, 19% (table 1). The abnormality occurred more frequently in the elderly individuals. The average age of the patients with coronary calcification was 69 years, while that of patients without calcification was 53 years. The average age of the entire group examined was 56 years.

Table 2 illustrates the progressive increase in the incidence of coronary calcification with advancing age. None of the patients under 40 years was found to have demonstrable calcification. The prevalence increased in a linear fashion thereafter with each de-

<table>
<thead>
<tr>
<th></th>
<th>Total group</th>
<th>Patients with calcification</th>
<th>Patients without calcification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Av age (yr)</td>
<td>No.</td>
</tr>
<tr>
<td>Male</td>
<td>282</td>
<td>55</td>
<td>58</td>
</tr>
<tr>
<td>Female</td>
<td>262</td>
<td>57</td>
<td>49</td>
</tr>
<tr>
<td>Total</td>
<td>544</td>
<td>56</td>
<td>107</td>
</tr>
</tbody>
</table>
Table 2

Coronary Artery Calcification in the Various Age Groups

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>10-19</th>
<th>20-29</th>
<th>30-39</th>
<th>40-49</th>
<th>50-59</th>
<th>60-69</th>
<th>70-79</th>
<th>80-89</th>
<th>90-99</th>
<th>Total patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. examined</td>
<td>9</td>
<td>27</td>
<td>53</td>
<td>75</td>
<td>136</td>
<td>135</td>
<td>79</td>
<td>29</td>
<td>1</td>
<td>544</td>
</tr>
<tr>
<td>Calcification</td>
<td>Patients</td>
<td>%</td>
<td>Patients</td>
<td>%</td>
<td>Patients</td>
<td>%</td>
<td>Patients</td>
<td>%</td>
<td>Patients</td>
<td>%</td>
</tr>
<tr>
<td>Control group</td>
<td>94</td>
<td>(avg age, 67)</td>
<td>94</td>
<td>(avg age, 67)</td>
<td>23</td>
<td>25%</td>
<td>11</td>
<td>12%</td>
<td>18</td>
<td>19%</td>
</tr>
</tbody>
</table>

Table 3

Comparative Incidence of Symptomatic Coronary Artery Disease in the Group with Calcification and in the Control Group

<table>
<thead>
<tr>
<th>Group with calcification</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. of patients studied</td>
<td>94 (avg age, 67)</td>
</tr>
<tr>
<td>Angina</td>
<td>23</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>18</td>
</tr>
<tr>
<td>Angina and/or myocardial infarction</td>
<td>33</td>
</tr>
</tbody>
</table>

cad and 55% of the patients in the 80- to 89-year-old group were found to have this abnormal finding.

In 71 patients, the left coronary artery alone was involved; in 33, both the left and the right coronary arteries were calcified. Calcification involving the right coronary artery alone was observed in only three patients.

Adequate clinical information was available in 97 of the 107 patients with coronary calcification. Three additional patients were eliminated because matching patients for the control group could not be found to meet the requirement previously described. Clinical analysis was, therefore, confined to 94 pairs of patients. The average age of both groups was 67 years. In the group with calcification, 23 of the 94 patients (25%) gave a typical history of angina pectoris; 18 (19%) had a well-documented history of myocardial infarction (table 3). The number of patients with either angina or myocardial infarction, or both, was 33 (35%). In the matching control group (without calcification) the percentage of patients with angina or myocardial infarction, or both, was approximately one half that of the group with calcification (12, 11, and 18%, respectively). The difference was also similar when the comparison was made for each of the various age groups (table 4). The difference was, however, more remarkable in the female than in the male. The percentage of female patients with symptomatic coronary artery disease in the group with calcification was almost three times that of the control group (32% versus 11%) (table 5).

Table 4

Comparative Incidence of Angina and/or Myocardial Infarction in the Various Age Groups

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Under 40</th>
<th>40-49</th>
<th>50-59</th>
<th>60-69</th>
<th>70-79</th>
<th>80-89</th>
<th>90-99</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group with calcification of coronary arteries</td>
<td>Total no. of patients</td>
<td>0</td>
<td>2</td>
<td>15</td>
<td>38</td>
<td>28</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Angina and/or myocardial infarction</td>
<td>Patients</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>14</td>
<td>8</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>%</td>
<td>0</td>
<td>50</td>
<td>33</td>
<td>37</td>
<td>29</td>
<td>45</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>Control group</td>
<td>Total no. of patients</td>
<td>0</td>
<td>2</td>
<td>17</td>
<td>33</td>
<td>33</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Angina and/or myocardial infarction</td>
<td>Patients</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>7</td>
<td>5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>% of total</td>
<td>0</td>
<td>0</td>
<td>18</td>
<td>21</td>
<td>15</td>
<td>14</td>
<td>50</td>
<td>18</td>
</tr>
</tbody>
</table>
The electrocardiographic findings which were considered to be compatible with coronary artery disease in the two groups of individuals are listed in Table 7. A recent tracing was available in 83 patients of the group with calcification and 87 patients of the control group. In 49% of the former and 29% of the latter, the diagnosis was that of either myocardial ischemia or infarction. In five of the group with calcification and four of the control group, these abnormalities were present in the absence of any history or symptom suggestive of ischemic heart disease. If they are also included as cases having coronary artery disease, the total number of such patients in the two groups would be 38 (40%) and 21 (22%), respectively.

Comparison of the frequency of hypertension, diabetes, and hypercholesterolemia or hyperlipemia revealed that hypertension with a diastolic blood pressure of 100 mm Hg or higher occurred with similar frequency among the two groups. It was present in 17 of the 94 patients (18%) in the group with calcification and 16 (17%) in the control group. There were more patients (21, or 22%) in the group with calcification having evidence of diabetes.
mellitus than in the control group (15, or 16%) but the difference was not statistically significant. The values of serum cholesterol or total lipids were not available in all of the 94 pairs of patients. They were elevated in 22 of the 54 patients (41%) in the group with calcification but only in 12 of the 52 patients (23%) in the control group.

Discussion

Coronary arterial calcification is encountered frequently in the heart at autopsy. With rare exceptions it is associated with atherosclerosis.5 Pyke and Symons4 radiographed 72 consecutive hearts during necropsy and found that 53% had calcified lesions in the coronary artery. The average age of the patients was 65 years. Blankenhorn and Stern5 examined the hearts of 76 patients mostly over 40 years of age who died of various cardiac and noncardiac diseases. Coronary artery calcification was observed in the roentgenograms of the autopsied heart in 80%. In 1,242 consecutive necropsies on patients between the ages of 30 and 69 years, Eggen and associates2 found calcified plaques in 64.5% of the dissected coronary arteries with roentgenograms. The incidence was especially high in patients who died from the sequelae of coronary atherosclerosis and approached almost 100% when these patients were over 40 years of age.

Roentgenographic demonstration of coronary calcification in the living man was first reported by Lenk6 in 1927. Isolated case reports appeared in the ensuing years. With routine cardiac fluoroscopies supplemented by short exposure spot films and kymograms, Habbe and Wright7 found coronary calcification in 3% of the cardiac patients over 40 years of age. Considerable improvement in the identification of this abnormality has been made with the advent of the more recent roentgenographic techniques. Using cinefluorography, Lieber and Jorgens8 were able to detect coronary calcification in 23.8% of patients with known or suspected heart disease, and Tampas and Soule9 were able to detect it in 15% of unselected patients. Oliver and associates10 have used and evaluated various radiological techniques in the detection of coronary artery calcification. These included conventional fluoroscopy, fluoroscopy with the image intensifier, cinefluorography, spot films, and laminograms. They found calcification in the coronary arteries in 54% of patients with, and 24% without, ischemic heart disease. They believed that fluoroscopy with an image intensifier was the most satisfactory method. In their opinion cinefluorography did not materially improve the result. Using only image intensification we have found an overall lower incidence of coronary calcification (20%). However, since the manner in which the patient material was obtained and the way the investigation was conducted are quite different, the results cannot be readily compared.

Both the autopsy material and examination of the living subjects indicated that the left coronary artery was more often involved than the right. The left anterior descending branch has been found to be the most frequent site.2, 8, 10 The lesions were most often located about 2 cm from the orifice of the artery.2

The difference between the prevalence of symptomatic coronary artery disease in the group with calcification as compared to that of the control group is quite remarkable. Almost twice as many patients in the group with calcification had evidence of symptomatic coronary artery disease as those in the group without calcification. In the female patients, the difference was almost threefold. Since the patients examined in our study consisted of both cardiac and noncardiac cases and the clinical diagnosis was not known to the radiologist during the examination, these findings are highly significant. When the degree of the calcification was severe, the degree of correlation was even higher.

In our series, the prevalence of diastolic hypertension was not significantly higher in the group with calcification than in the control group. This is in contrast with results of other investigators.10 The number of patients with diabetes mellitus was greater in the group with calcification but the difference was not
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statistically significant at the 5% level. However, the occurrence of abnormal elevation of serum cholesterol or total lipids, electrocardiographic findings suggestive of myocardial infarction, or ischemia was definitely more frequent in the group with calcification. This further suggests that the presence of coronary artery calcification is associated with an increased probability of development or existence of symptomatic ischemic heart disease.

It is important to realize that the presence of calcification does not always indicate that the lesion is obstructive. The calcification may be quite extensive without impairment of the coronary circulation to a significant degree. However the association is generally quite strong as indicated from the autopsy studies. Although a stenotic lesion can best be outlined during life by coronary arteriograms, this procedure is still limited to medical centers where personnel and equipment are available to cope with the possible serious complications which may arise with coronary arteriography. Fluoroscopic examination with an image intensifier is a simple procedure which can be performed without risk to the patient. Since it requires little additional time, it can be done as a routine procedure, even when the patient is being examined for other purposes. It may be of particular value in supplying additional useful information in the total evaluation of patients suspected of having ischemic heart disease. It is possible that it is of prognostic significance in patients who are asymptomatic and without other abnormal clinical and laboratory findings at the time of examination. A long-term follow-up of this type of patient is necessary for this purpose and is being carried out in our institution.

References

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