Use of Transesophageal Echocardiography to Predict Significant Coronary Artery Disease in Aortic Stenosis*

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Study objectives: This study was conducted to examine if the use of multiplane transesophageal echocardiography (TEE) could predict the absence or the presence of significant coronary artery disease (CAD) in patients with aortic stenosis.

Design: Prospective study.

Setting: University hospital.

Patients: Clinical, angiographic features and TEE findings were prospectively analyzed in 132 consecutive patients with aortic stenosis.

Measurements and results: In 63 patients with significant CAD, 57 had thoracic aortic plaque on TEE studies. In contrast, aortic plaque existed in only 19 of the remaining 69 patients with normal or mildly abnormal coronary arteries. Therefore, the presence of aortic plaque on the TEE identified significant CAD with a sensitivity of 90.5%, a specificity of 72.5%, and with positive and negative predictive values of 75.0% and 89.3%, respectively. There was a significant relation between the severity of thoracic aortic atherosclerosis and the severity of CAD (p<0.0001). Multivariate logistic regression analysis revealed that aortic plaque, angina, and age were independent predictors of CAD. Aortic plaque was the most significant independent predictor. Conclusion: This prospective study indicates that TEE examination of thoracic atherosclerotic plaque is a powerful predictor of absence of significant CAD in patients with aortic stenosis.

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Key words: aortic stenosis; atherosclerotic aortic plaque; coronary artery disease; transesophageal echocardiography

Abbreviations: CAD=coronary artery disease; TEE=transesophageal echocardiography

With the advent of transthoracic and transesophageal echocardiography (TEE), an improved noninvasive assessment of aortic stenosis has come within our reach. Numerous studies have shown that this technique is accurate for determining left ventricular function, and ascertaining the cause and the severity of aortic stenosis.1-6 In most patients with aortic stenosis, additional hemodynamic and angiographic investigations, although providing confirmation of diagnosis and severity of aortic stenosis assessed by Doppler echocardiography,1,3 rarely alter management strategy. Many cardiologists, however, frequently recommend preoperative coronary angiography for patients with aortic stenosis requiring valve surgery.7 The degree of atherosclerotic alterations of the thoracic aortic intima can be reliably determined using TEE imaging.8-13 Previous analyses have shown that the presence of thoracic aortic atherosclerotic plaque correlated closely with vascular disease8-13 and was retrospectively a marker for coronary artery disease (CAD), but no detailed data are available in patients with aortic stenosis.14,15 In this study, we prospectively assessed the accuracy of multiplane TEE detection of thoracic aortic plaque for predicting the absence or presence and the severity of CAD in 132 consecutive patients with aortic stenosis.

Materials and Methods

Study Patients

Between September 1993 and November 1996, 132 consecutive patients with aortic stenosis considered for surgery (111 degenerative, 10 congenital, 11 rheumatic stenosis) by clinical
and transthoracic echocardiography underwent prospectively a cardiac catheterization and a multiplane TEE examination. For each patient, age, sex, standard risk factors for CAD (systemic hypertension, cigarette smoking, serum cholesterol level ≥200 mg/dL, diabetes mellitus, and family history of CAD), and symptoms of typical anginal pectoris were recorded.

**TEE Examination**

TEE was performed within 2 days of cardiac catheterization using an ultrasonograph (Sonos 1000 or 2000; Hewlett-Packard; Palo Alto, Calif) and a multiplane probe. For each patient, informed consent was obtained prior to the procedure. There were no complications in any patient. A well-standardized protocol described previously was applied to cardiac examinations in all patients, especially for the study of the thoracic aorta. All studies were recorded on a videotape for display and evaluation in real-time, slow-motion, or single-frame format. The TEE recordings of all patients were interpreted independently by two experienced observers who had no knowledge of clinical and catheterization results. The thoracic aorta was considered normal when the intimal surface was smooth and continuous without lumen irregularities or increased echodensity. If the intimal surface increased in echodensity but remained smooth and continuous without lumen irregularities, it was defined as grade 1. Intimal thickening ≥5 mm with highly echogenic areas disrupting the normal smooth surface of the vessel wall and causing luminal irregularities was classified as grade 2. Grade 3 changes consisted of intimal thickening ≥5 mm and/or obvious lumen irregularities associated with localized highly echogenic mobile lesions protruding into the vessel lumen. Grade 2 or 3 lesions were considered as atherosclerotic aortic plaques. The two observers had an excellent agreement on the presence or absence of atherosclerotic aortic plaques (100%). In addition, the sum of the maximal plaque thickness in millimeters of the ascending aorta (segment 1), of the horizontal aorta (segment 2), and of the lower, mid, and upper third of the descending aorta (segments 3, 4, and 5) was considered as a measure of the extent and severity of aortic atherosclerosis and was used as a score of thoracic aortic atherosclerosis.

**Coronary Angiography**

Selective coronary arteriography was performed by the Judkins technique for patients with normal or moderately atherosclerotic aortic intima (grade 1 or 2) and by the Sones method for those with severe aortic plaques (grade 3). There were no complications of procedure in any subject. Patients with normal coronary and mild atherosclerotic coronary arteries (no significant lesion) angiographically evaluated were considered as patients without significant CAD. Lesions were described as significant when ≥70% of the luminal diameter of the left anterior descending, left circumflex, or right coronary artery was stenosed or when a ≥50% stenosis was present in the left main coronary artery. The number of vessels with significant stenosis was recorded. Left main coronary artery disease was considered to be two-vessel disease involving left anterior descending and circumflex coronary arteries. The severity and extent of coronary atherosclerosis was assessed in terms of coronary score. The coronary angiography of all patients was interpreted independently by two experienced observers who had no knowledge of clinical and TEE findings. With regard to the interobserver variability, an excellent correlation was found between two independent observers for the coronary score (r=0.97; y=0.97x+0.006; p<0.0001).

**Statistical Analysis**

Discrete variables were analyzed by the χ² test. A p<0.05 was considered statistically significant. Simple linear regression was used to test the association between continuous variables. For incremental data, the Spearman correlation analysis was applied. Sensitivity, specificity, and predictive accuracy values were calculated using a standard method. All variables with potential influence on CAD were examined by multivariate logistic regression analysis.

**Results**

**Clinical Features**

The study group consisted of 89 men and 43 women with an average age of 68±10 years (range, 33 to 86 years). A total of 52 patients (39%) had angina pectoris, and 100 patients (76%) had one or more risk factors. Hypertension was present in 47%, 31% of patients had hypercholesterolemia, 32% smoked cigarettes, 14% had diabetes mellitus, and 16% had a family history of cardiovascular disease. The mean number of risk factors was 1.7 per patient.

**Angiographic Findings**

Coronary arteriography revealed significant CAD in 63 patients: one-vessel disease in 29, two-vessel disease in 18, and three-vessel disease in 16. Three patients had left main coronary artery stenosis and one of them was classified as having three-vessel disease. The remaining 69 patients were found to have normal coronary arteries (n=58) or mild atherosclerotic coronary lesions (n=11).

**TEE Detection of Aortic Plaque**

TEE examinations detected thoracic aortic plaque in 57 of the 63 patients with CAD but in only 13 of 58 patients with normal coronary arteries and 6 of 11 patients with mild atherosclerotic coronary lesions. The six patients with significant CAD without thoracic aortic plaque (five men and one woman; mean age, 68±9 years) all had at least two risk factors except one patient and angina pectoris in four patients. By univariate analysis, aortic plaque (p<0.0001), age (p=0.001), sex (p=0.0002), angina (p<0.0001), hypercholesterolemia (p=0.009), and smoking (p<0.0001) were significant predictors of CAD (Table 1). Therefore, the presence of thoracic aortic plaque detected on TEE study in 132 patients identified significant CAD with a sensitivity of 90.5%, a specificity of 72.5%, and positive and negative predictive values of 75.0% and 89.3%, respectively. There was a significant relation between the different grades of thoracic aortic atherosclerosis and the extent of CAD (number of vessels).
(p<0.0001) or the coronary score (p<0.0001). Similarly, there was a significant relation between the score of aortic atherosclerosis and the coronary score (p<0.0001). Multivariate logistic regression analysis including patient age, sex, risk factors, angina, and TEE parameters revealed three independent predictors of significant CAD: aortic plaque, angina, and age. Aortic plaque was the most significant independent predictor (Table 2).

**DISCUSSION**

Aortic stenosis is one of the most frequent valvular heart diseases in industrialized countries with an increase in the last decade in operative indications in the elderly and for degenerative aortic stenosis. This tendency will probably still increase in the future due to a progressive increase in life expectancy within the general population. Transthoracic Doppler echocardiography, in experienced hands, improved noninvasive assessment in patients with aortic stenosis and can be used for clinical decision-making, that is, cardiac surgery, valvuloplasty, or conservative treatment. Multiplane TEE is also a reliable method of quantitating aortic valve area in most patients with aortic stenosis and provides useful information, particularly in patients with unsatisfactory imaging during transthoracic examination. Therefore, noninvasive evaluation provides most of the needed clinical data for the decision-making with the notable exception of coronary anatomy, given that significant coronary disease is present in 20 to 45% of patients with aortic stenosis. It remains in our practice to perform in a large majority of patients a coronary arteriography only if there is a clinical suspicion that coronary disease might be present, especially in older patients with significant risk factors. It should be underlined that limiting the invasive procedure to coronary arteriography will result in lowering morbidity by not subjecting patients to a longer procedure and protracted attempts to cross the aortic valve, as well as lowering the management cost.

This prospective study using a transesophageal multiplane probe in 132 consecutive patients with aortic stenosis has shown that thoracic aortic plaques detected on TEE studies appeared to be a marker for absence or presence and severity of significant CAD, and further substantiates the concept that atherosclerosis is a generalized process involving predominantly medium-sized muscular arteries. In a group selected to have a high prevalence of CAD (67%), Fazio et al retrospectively reported that the presence of aortic plaques on transesophageal studies had a sensitivity of 90%, a specificity of 90%, a positive predictive value of 95%, and a negative predictive value of 82% for angiographically proved significant obstructive CAD. These findings are consistent with our previous observations but to our knowledge, no detailed data are available in patients with aortic stenosis. The most important clinical finding of the present prospective study is the high negative predictive value of thoracic aortic plaque detected on TEE for identification of significant CAD. This indicates that the absence of thoracic aortic atherosclerosis is a powerful predictor of normal or mildly abnormal angiographic coronary arteries in patients with aortic stenosis who often are elderly. The absence of thoracic aortic plaque on TEE studies was noted in 42% of our patients. False-negative TEEs did not occur in the group with more severe CAD: five of the six patients with significant CAD without thoracic aortic plaque had single-vessel disease and one had two-vessel disease. All patients with left main coronary stenosis or three-vessel disease had atherosclerotic plaques on TEE studies. The prevalence of significant CAD in our patients with aortic stenosis is relatively high (47%). It is possible, even with a

**Table 1—Comparison of Patients With Aortic Stenosis, With and Without CAD**

<table>
<thead>
<tr>
<th>Patients</th>
<th>With CAD</th>
<th>Without CAD</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=63)</td>
<td>(n=69)</td>
<td></td>
</tr>
<tr>
<td>Age, yr</td>
<td>71 ±6</td>
<td>66 ±12</td>
<td>0.001</td>
</tr>
<tr>
<td>Sex, men, women</td>
<td>53 /10</td>
<td>36 /33</td>
<td>0.0002</td>
</tr>
<tr>
<td>Thoracic aortic plaque</td>
<td>57</td>
<td>19</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Angina</td>
<td>43</td>
<td>9</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>27</td>
<td>14</td>
<td>0.009</td>
</tr>
<tr>
<td>Smoking</td>
<td>31</td>
<td>11</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Diabetes</td>
<td>12</td>
<td>6</td>
<td>NS*</td>
</tr>
<tr>
<td>Family history of CAD</td>
<td>11</td>
<td>10</td>
<td>NS</td>
</tr>
<tr>
<td>Hypertension</td>
<td>33</td>
<td>29</td>
<td>NS</td>
</tr>
</tbody>
</table>

*NS=not statistically significant.

**Table 2—Multivariate Analysis of Clinical and Echocardiographic Factors Related to Subsequent CAD in 132 Patients With Aortic Stenosis**

<table>
<thead>
<tr>
<th></th>
<th>Odds Ratio</th>
<th>95% CI*</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic plaque</td>
<td>7.26</td>
<td>2.14–24.61</td>
<td>0.001</td>
</tr>
<tr>
<td>Angina</td>
<td>5.94</td>
<td>1.88–18.79</td>
<td>0.002</td>
</tr>
<tr>
<td>Age</td>
<td>1.08</td>
<td>1.00–1.16</td>
<td>0.04</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>3.36</td>
<td>0.98–11.58</td>
<td>NS</td>
</tr>
<tr>
<td>Smoking</td>
<td>3.03</td>
<td>0.91–10.08</td>
<td>NS</td>
</tr>
<tr>
<td>Diabetes</td>
<td>2.42</td>
<td>0.50–11.70</td>
<td>NS</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1.01</td>
<td>0.35–2.87</td>
<td>NS</td>
</tr>
<tr>
<td>Family history of CAD</td>
<td>0.76</td>
<td>0.16–3.48</td>
<td>NS</td>
</tr>
<tr>
<td>Sex</td>
<td>0.33</td>
<td>0.09–1.12</td>
<td>NS</td>
</tr>
</tbody>
</table>

*CI=confidence interval.
multiplane probe, that we have slightly underestimated the incidence of atherosclerotic plaques in the thoracic aorta, especially in the upper ascending aorta, due to the interposition of the trachea. In this study, although patient age, sex, and risk factors except for diabetes, hypertension, and family history of CAD were significantly related to the presence of CAD, the predictive values of these variables were lower than those of thoracic aortic plaques detected by TEE examination. Furthermore, multivariate logistic regression analysis revealed that thoracic aortic plaque was clearly the most significant independent predictor of significant CAD. TEE detection of complex aortic plaque may also help to avoid embolic complications when a patient is referred for catheterization because systemic embolism arising from atherosclerotic debris of the thoracic aorta has been described as following invasive procedures involving the aorta. Thus, in a recent study, the incidence of systemic embolism during transfemoral catheterization was 27% in patients with complex atherosclerotic plaques and debris.

**CONCLUSION**

TEE is frequently used to assess valvular heart disease. In patients with aortic stenosis, absence of aortic atherosclerotic plaque on TEE examination appears to be a predictor of absence of significant CAD. Nevertheless, about 10% of patients without aortic plaque have significant CAD and the presence of aortic plaque has a positive predictive value only of 75% to identify the presence of significant CAD. Thus, TEE may not be considered as a substitute for coronary arteriography. In practice, the decision to forgo preoperative coronary arteriography in patients with valvular disease is usually based on age and absence of cardiac risk factors. The absence of aortic atherosclerotic plaque on TEE examination might be added to these criteria to support more judiciously the decision not to perform coronary arteriography in patients with aortic stenosis.

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