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Transesophageal Echocardiographic Detection of Thoracic Aortic Plaque Could Noninvasively Predict Significant Obstructive Coronary Artery Disease

Hee-Yeol Kim, M.D., Chong-Jin Kim, M.D., Tai-Ho Rho, M.D.
Ho-Jung Youn, M.D., Seong-Won Jin, M.D., Hyou-young Rhim, M.D.
Ji-Won Park M.D., Heu-Kyung Jeon, M.D. Jang-Seong Chae, M.D.
Jae-Hyung Kim, M,D., Soon-Jo Hong M.D., Kyu-Bo Choi, M.D.

Department of Internal Medicine, College of Medicine,
The Catholic University of Korea, Seoul, Korea

Objective : *Previous pathologic and roentgenographic studies have suggested a relation between aortic plaque and coronary artery disease but have lacked clinical utility. The study was undertaken to elucidate whether atherosclerotic aortic plaque detected by transesophageal echocardiography can be a clinically useful marker for significant obstructive coronary artery disease.*

Methods : *Clinical and angiographic features and intraoperative transesophageal echocardiographic findings were prospectively analyzed in 131 consecutive patients (58 women and 73 men, aged 17 to 75 years [mean 54±12]) undergoing open heart surgery. Significant obstructive coronary artery disease was defined as > or = 50% stenosis of > or = 1 major branch.*

Results : *Seventy-six (58%) of 131 patients were found to have obstructive coronary artery disease. In 76 patients with significant coronary artery disease, 71 had thoracic aortic plaque. In contrast, aortic plaque existed in only 10 of the remaining 55 patients with normal or minimally abnormal coronary arteries. The presence of aortic plaque on transesophageal echocardiographic studies had a sensitivity of 93%, a specificity of 82% and positive and negative predictive values of 88% and 90%, respectively, for significant coronary artery disease. There was a significant relationship between the degree of aortic intimal changes and the severity of coronary artery disease (r=0.74, P<0.0001). Multivariate logistic regression analysis of patient age, sex, risk factors of cardiovascular disease and transesophageal echocardiographic findings revealed that atherosclerotic aortic plaque was the most significant independent predictor of coronary artery disease.*

Conclusion : *This study indicates that transesophageal echocardiographic detection of atherosclerotic plaque in the thoracic aorta is useful in the noninvasive prediction of the presence and severity of coronary artery disease.*

Key Words : *Transesophageal echocardiography, Aortic plaque, Coronary artery disease*

INTRODUCTION

The atherosclerotic process that results in coronary artery disease (CAD) is a generalized process that may involve the entire vasculature[1, 2]. The relation between the presence of aortic plaque in the thoracic aorta and the development of cardiovascular disease has been called to attention recently. Previous roentgenographic studies have suggested a relation between aortic plaque and CAD but have lacked clinical utility[3, 4]. With improved noninvasive imaging techniques now available

Address reprint requests to : Hee-Yeol Kim, Department of Internal Medicine, St. Paul's Hospital, Catholic University Medical College, 620-56, Jeonnong-Dong, Dongdaemoon-Gu, Seoul, Korea

it is necessary to determine whether atherosclerotic aortic plaque can be reliably detected and correlated with coronary artery disease in a clinically useful manner.

Transesophageal echocardiography (TEE) offers high resolution imaging for evaluation of thoracic aortic disease. The degree of atherosclerotic alteration in the thoracic aortic intima can be reliably determined using TEE imaging[5, 7]. Previous analyses have shown that the presence of atherosclerotic plaque in the thoracic aorta correlated closely with systemic embolism and vascular disease[8-12] and retrospectively a marker of CAD[13-15].

Many cardiologists still frequently recommend pre-operative coronary angiography for patients requiring valve surgery because of the difficulties in non-invasive visualization of CAD[16]. The value in the prediction of CAD in detecting atherosclerotic aortic plaque by TEE may be attractive and have great influence on routine pre-operative cardiac catheterization[17-19]. In this study, we prospectively assessed the accuracy of TEE detection of thoracic aortic plaque for predicting the absence or presence and severity of CAD in a series of consecutive patients undergoing open heart surgery.

MATERIALS AND METHODS

1. Study population

One hundred thirty-one patients underwent TEE with aortic imaging in the operating room at St. Paul's Hospital between January 1996 and May 1998. All patients included in this study underwent cardiac catheterization with coronary angiography for one of the following indications : angina (n=53), postmyocardial infarction (n=18), valvular heart disease (n=46) and congenital heart disease (n=14).

2. Intraoperative transesophageal echocardiography examination and analysis

Introperative two-dimensional TEE was performed using ultrasound equipment (Acuson 128XP) with 5-MHz biplane transducer. All studies were recorded on super VHS videotape for subsequent review and analysis.

After aortic imaging, the transducer remained in place to assist in cardiac monitoring during surgical procedure.

Aortic intimal changes were graded on a scale of I to IV proposed by Fazio et al[13]. The thoracic aorta was considered normal with respect to atherosclerotic disease and classified as grade I when the intimal surface was smooth and continuous without lumen irregularity or increased echodensity. Grade II changes consisted of increased echodensity of the aortic intimal surface, which was smooth and continuous without lumen irregularity or thickening. Grade III changes consisted of focal or linear increased density of intima associated with lumen irregularity and thickening or ulceration. Grade IV changes consisted of intimal thickening and lumen irregularity associated with protruding thrombus or highly echodense material that induced shadow artifact (consistent with calcification). Atherosclerotic aortic plaque was defined as a lesion with grade III or grade IV changes (Fig. 1). All 131 studies on the recorded tapes were graded by two independent cardiologists with experience in TEE. Any discrepancy was resolved by consensus.

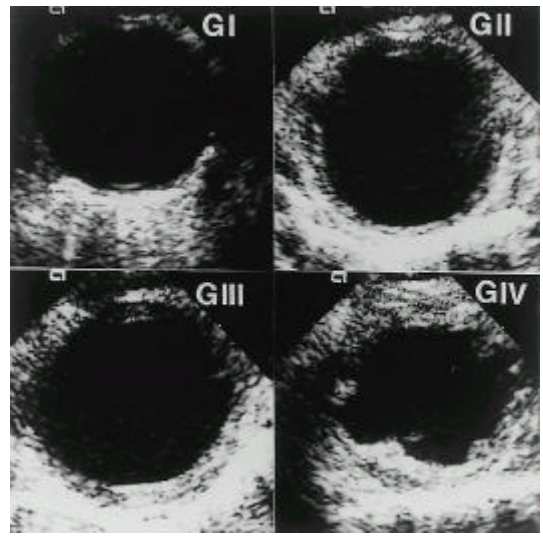

Fig. 1. Grading of echocardiographically detected aortic plaque (see text). G = Grade

3. Coronary angiography

Cardiac catheterization with coronary angiography was perfomed by the Judkins technique. Angiographic films were interpreted by the angiographers, who had

no knowledge of the echocardiographic results.

Coronary artey disease was defined as ≥ 50% reduction of the luminal diameter (75% reduction in luminal area) in the left anterior descending, left circumflex or right coronary arteries. The number of vessels with significant stenosis was recorded. Left main coronary artery disease with ≥ 50% reduction of the luminal diameter was considered to be two-vessel disease involving left anterior descending and left circumflex arteries.

4. Statistical analysis

Angiographic and corresponding echocardiographic data were complied on a 2×2 contingency table to allow calculation of sensitivity and specificity as well as positive and negative predictive values. Discrete variables were analysed by the chi-square test, and a two-tailed *t* test was used to compare continuous variables. For incremental data, the Spearman correlation analysis was applied. Multiple logistic regression analysis was used to determine whether aortic plaque was a statistically significant predictor of significant CAD independent of age, gender and coronary risk factors. A *P* value <0.05 was considered statistically significant.

RESULTS

1. Clinical features

The study group consisted of 73 men and 58 women with an average age of 54±10 years (range 17 to 75 years). 89 (68%) had one or more risk factors. Hypertension was present in 29%, 33% of patients had hypercholesterolemia, 41% smoked cigarettes, 16% had diabetes mellitus and 31% had obesity.

2. Aortic plaque versus CAD

Seventy-six (58%) of 131 patients were found to have obstructive CAD. Of this group, 11 patients had one-vessel disease, 25 had two-vessel disease and 40 had three-vessel disease. Ten patients had left main coronary artery stenosis and seven of them were classified as having three-vessel disease.

TEE detected atherosclerotic plaque in the thoracic aorta in 71 of the 76 patients with obstructive CAD but in only 10 of the 55 patients without obstructive disease. Fifty of our 131 patients did not have aortic plaque on TEE. Forty-five of these 50 patients did not have obstructive CAD; the other 5 had obstructive disease (Table 1).

The discovery of atherosclerotic plaque in the thoracic aorta on TEE had 93% sensitivity for obstructive coronary artery disease. The specificity or "negativity in health" was 82%. The positive predictive value of plaque for obstructive CAD was 88% and negative predictive value was 90%. The accuracy of TEE as a test to predict obstructive CAD was 89% in our study.

Of the 113 patients without previous myocardial infarction, atherosclerotic plaque was detected in the thoracic aorta in 54 of the 59 patients with CAD, and in 10 of the 54 patients without obstructive disease ($p<0.0001$). Thus, it was not present in 49 patients. Forty-four of these 49 patients(90%) did not have significant obstructive coronary disease. Therefore, in patients without previous myocardial infarction, the presence of thoracic atherosclerotic plaque on TEE study identified CAD with a sensitivity of 92%, specificity of 88%, and positive and negative predictive

Table 1. Relation between echocardiographically detected aortic plaque and coronary disease

Group	CAD	No CAD	Total
Aortic plaque	71	10	81
No Aortic plaque	5	45	50
Sensitivity	93%	Positive predictive value	88%
Specificity	82%	Negative predictive value	90%

CAD=obstructive coronary artery disease.

value of 84% and 90%, respectively.

3. Aortic plaque versus severity of CAD

Of the 11 patients with single-vessel CAD, 9 (82%) had aortic plaque as did 24 (96%) of 25 patients with two-vessel disease and 38 (95%) of 40 with three-vessel disease. All 10 with left main obstructive CAD had aortic plaque on TEE (Table 2). There was a significant relation between the different grades of thoracic aortic atherosclerosis and the severity (number of obstructed vessels) of coronary disease (r=0.74, p<0.0001).

Table 2. Relation between echocardiographically detected aortic plaque and severity of coronary disease

Vessel with CAD	Aortic plaque		Total
	Absent	Present	
0	45	10	55
1	2	9	11
2	1	24	25
3	2	38	40
LMCA	0	10	10

CAD=obstructive coronary artery disease; LMCA=left main coronary artery stenosis

4. Risk factors and aortic plaque versus CAD

Aortic plaque was a predictor of obstructive CAD at a statistically significant level (p<0.0001). We also compared age, gender and the coronary risk factors for obstructive CAD. By univariate analysis, age, sex, hypertension, smoking and diabetes mellitus were significant predictors of obstructive CAD (Table 3). Multivariate logistic regression analysis including age, sex, hypertension, smoking, diabetes and aortic plaque revealed two independent predictors of significant CAD: aortic plaque and sex. Aortic plaque was the most significant independent predictor (Table 4).

Table 4. Multiple logistic regression models to predict significant obstructive coronary artery disease

Variable	*P* value	Odds ratio(95% CI)
Age	NS	1.0(0.96-1.06)
Men	0.0266	3.5(1.15-10.65)
Hypertension	NS	1.3(0.33-5.15)
Smoking	NS	0.9(0.17-4.67)
Diabetes Mellitus	NS	3.1(0.52-18.77)
Aortic plaque	<0.0001	53.7(167-173.1)

CI=confidence interval; NS=not statistically significant (p>0.05).

5. Risk factors and CAD versus thoracic aortic plaque

Obstructive CAD was a predictor of thoracic aortic plaque at a statistically significant level (p<0.0001). Age, sex, hypertension and smoking were also significantly associated with aortic plaque (Table 5). By multivariate logistic regression analysis, age (p=0,0004), sex (p=0.0253), smoking (p=0.0024) and CAD (P<0.0001) remained statistically significant predictors of thoracic aortic plaque.

Table 3. Characteristics of patients with and without obstructive coronary artery disease

Risk factor	CAD (n=77)	No CAD (n=54)	*p* value
Age(yr)	59±10	47±13	<0.0001
Men(%)	70	35	<0.0001
Systemic hypertension(%)	40	13	<0.0001
Hypercholesterolemia(%)	31	9	NS
HDL<35mg/dl	25	7	NS
Smoking(%)	60	17	<0.0001
Diabetes mellitus(%)	22	7	<0.05
Aortic plaque	92	19	<0.0001

Data are expressed as mean value±SD. CAD=obstructive coronary artery disease; HDL=high density lipoprotein; NS=not statistically significant (*p*>0.05).

Table 5. Characteristics of patients with and without thoracic aortic plaque on transesophageal echocardiography

Risk factor	Aortic plaque (n=81)	Aortic plaque (n=50)	*p* value
Age(yr)	60±9	44±13	<0.0001
Men(%)	68	36	<0.001
Systemic hypertension(%)	50	8	<0.0001
Hypercholesterolemia(%)	31	9	NS
HDL<35mg/dl	24	8	NS
Smoking(%)	61	12	<0.001
Diabetes mellitus(%)	21	8	NS

Data are expressed as mean value±SD. HDL=high density lipoprotein; NS=not statistically significant(p>0.05).

DISCUSSION

Advances in non-invasive diagnostic techniques over the last decade have enabled accurate assessment of patients with valvular heart disease. Quantitation of hemodynamics, ventricular function and detailed description of valve leaflet thickening, calcification and mobility by Doppler echocardiography have allowed an appropriate selection of patients for valve repair or valve replacement without the need for pre-operative cardiac catheterization and without compromising theirs clinical outcome[17]. However, detection of important coexistent, but asymptomatic CAD has remained the Achilles' heel of non-invasive methods used in the pre-operative evaluation of patients with valvular heart disease. Pre-operative detection of CAD in patients undergoing valve surgery has been regarded as a prerequisite to avoid peri-operative coronary events that might compromise patient outcome[16]. This has been particularly important in elderly patients in whom the prevalence of risk factors for CAD increases the likelihood of adverse cardiovascular events in the peri-operative period and has resulted in the recommendation of routine pre-operative coronary angiography.

The atherosclerotic process that results in CAD is not restricted to the coronary vasculature. In previous roentgenographic studies, the presence of calcified atherosclerotic aortic plaque on chest X-ray film was associated with an increased risk of cardiovascular events and death[3, 4]. However, the low resolution of X-ray limits the possibility of detecting aortic plaque[13]. TEE provides high-resolution imaging of thoracic aorta and is a useful method of evaluating thoracic aortic atherosclerosis, aneurysms and dissections. Many studies have shown that the presence of atherosclerotic plaque in thoracic aorta, detected by TEE, correlated closely with systemic embolism[8-12].

The purpose of our study was to determine whether TEE imaging of noncoronary vascular structures could accurately predict the presence and degree of CAD detected angiographically. Our results show that the thoracic aortic plaque detected on TEE study appeared to be a useful marker for predicting the presence and severity of CAD. These findings are consistent with the observation of Fazio et al[13], and further substantiate the concept that atherosclerosis is a generalized process involving predominantly medium-sized muscular arteries[10, 12]. In this study, although age and some risk factors correlated significantly with the presence of CAD, the predictive values of these variables were lower than those of thoracic aortic plaque detected by TEE examination. Furthermore, multivariate regression analysis revealed thoracic aortic plaque was the most significant independent predictor of CAD.

This study proved that the absence of atherosclerotic plaque in the thoracic aorta, as detected by TEE, is highly specific for angiographically normal coronary arteries and has a high negative predictive value. If coronary risk factors are also taken into account, the positive predictive value of thoracic aorta atherosclerosis improves without an adverse effect on the negative predictive value. The high negative predictive accuracy of obstructive CAD in this study may have important clinical significance. Our results suggest that the decision to perform cardiac

catheterization and coronary angiography should individually take into account risk factors and, particularly, TEE detection of thoracic aortic plaque.

TEE detection of complex aortic plaque may also help to avoid embolic complication when a patient is referred for cardiac catheterization because systemic embolism arising from atherosclerotic debris of the thoracic aorta has been described as following invasive procedures involving the aorta[20-22]. Thus, in a recent study, the risk of systemic embolism caused by a guiding wire during transfemoral catheterization was 0.1% overall but 27% in patients with complex atherosclerotic plaques and debris[23]. The identification and location of plaque on TEE may help decrease the morbidity of catheterization.

In conclusion, our results indicate that TEE detection of atherosclerotic plaque in the thoracic aorta is useful in the noninvasive prediction of the presence and severity of coronary artery disease.

Clinical implications: In patients with valvular heart disease, the absence of thoracic aortic plaque on TEE studies may predict normal or minimal atherosclerotic coronary arteries. In selected patients, TEE examination may avoid the need to perform cardiac catheterization and coronary angiography. This can be extremely important for patients with unstable hemodynamic conditions in whom invasive assessment requires risky procedures. Selective use of cardiac catheterization and coronary angiography will also lower the cost of management and preoperative evaluation of patients with valvular heart disease. A large prospective study using a multiplane transducer is recommended before coming to definitive decision-making conclusions.

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