Prevalence of Carotid Artery Stenosis in Patients With Coronary Artery Disease in Japanese Population

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Background and Purpose—Prevalence of carotid artery stenosis in patients with coronary artery disease (CAD) is unknown in Japanese population.

Methods—The study populations consisted of 632 consecutive patients who underwent coronary angiography because of suspicion of CAD. All patients underwent carotid ultrasonography to screen carotid artery stenosis before coronary angiography. We defined echographic carotid stenosis as area stenosis of >50% or peak systolic velocity of >200 cm/s.

Results—Echographic carotid stenosis was observed in 124 patients (19.6%). Coronary angiography revealed 433 patients had CAD. Prevalence of echographic carotid artery stenosis was 14 of 199 (7.0%), 18 of 124 (14.5%), 28 of 131 (21.4%), and 64 of 178 (36.0%) in patients with 0-, 1-, 2-, and 3-vessel CAD, respectively (P<0.0001). The prevalence rate with carotid stenosis and CAD was 25.4%. Multivariate stepwise logistic regression analysis showed that age and the extent of CAD were independently related to the presence of carotid stenosis (P=0.0002 and <0.0001, respectively).

Conclusions—Prevalence of carotid stenosis in patients with CAD is high in Japan as well as in Western countries. Screening of carotid artery stenosis is recommended especially in older patients with multivessel CAD. (Stroke. 2005; 36:2094-2098.)

Key Words: carotid stenosis ■ coronary artery disease ■ epidemiology ■ Japan

Atherosclerosis frequently occurs at the carotid bifurcation and the proximal internal carotid artery. Carotid atherosclerosis is an important cause of ischemic brain attack and stroke. In Western countries, extracranial carotid atherosclerosis accounts for ≈30% to 40% of cases of ischemic cerebrovascular disease, depending on the population studied.1 It was reported that there were racial differences in the severity and distribution of carotid atherosclerosis.2 Compared with patients in Western countries, Japanese patients had predominantly intracranial artery lesions, and extracranial carotid stenoses were less frequent.3-5 But recently, the incidence of ischemic cerebrovascular disease attributable to extracranial carotid lesions has steadily increased in the Japanese population because of the change in lifestyle toward Western habit.6

An association between carotid atherosclerosis and coronary artery disease (CAD) has been well established7-9 because atherosclerosis is considered to be a generalized disease. It has been reported that Japanese patients who underwent coronary artery bypass grafting (CABG) because of severe CAD had a high incidence of carotid stenosis.10,11 But there are few reports about the complication rate of carotid artery disease in Japanese patients with CAD other than the candidates for bypass surgery.

The aim of this study was to investigate the prevalence of carotid stenosis in patients with CAD and to determine any factors related to carotid stenosis in Japanese population.

Methods

Study Population

The study populations consisted of 632 consecutive patients who were scheduled to undergo coronary angiography because of suspicion of CAD during the period June 2002 to April 2004. Subjects were administered a questionnaire to assess symptoms, risk factor profile, and previous diagnostic evaluations. All patients gave written informed consent to participate in this study.

Evaluation of Risk Factor Variables

We evaluated the risk factor variables including sex, age, body mass index, hypertension, diabetes mellitus, hyperlipidemia, smoking, familial history of CAD, hemodialysis, past history of myocardial infarction, previous percutaneous coronary intervention and CABG, and previous transient ischemic attack or stroke.

Hypertension was defined as present if a subject took medication for hypertension or if the subject’s blood pressure was >140 mm Hg in systole or >90 mm Hg in diastole for ≥2 repeated measurements. Diabetes mellitus was defined as a serum glycosylated hemoglobin

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concentration of $>5.8\%$, if the repeated fasting plasma glucose exceeded 126 mg/dL, or if the patients took medication for diabetes. Hyperlipidemia was defined as taking lipid-lowering medications, a fasting serum total cholesterol concentration of $>220$ mg/dL, low-density lipoprotein cholesterol concentration of $>140$ mg/dL, high-density lipoprotein cholesterol concentration of $<40$ mg/dL, or triglyceride concentration of $>150$ mg/dL. A familial history of CAD was defined as a history of CAD in any first-degree relatives $<60$ years of age. Hemodialysis was defined as undergoing maintenance hemodialysis regardless of etiology.

Assessment of Coronary Angiography

Coronary angiography was performed to investigate CAD. The diameter stenosis was calculated by quantitative coronary angiography with an automated coronary analysis system (CMS Medis Medical Imaging Systems). CAD was defined as a lumen diameter stenosis of $>50\%$ in $\geq$1 major coronary artery. Each patient was classified into 1 of the following groups according to the number of diseased vessels: 0-vessel disease (ie, patients without diseased vessels [group 0]), 1-vessel disease (ie, patients with disease in 1 vessel [group 1]), 2-vessel disease (ie, patients with disease in 2 vessels or left main trunk disease without right coronary artery stenosis [group 2]), 3-vessel disease (ie, patients with disease in 3 vessels or left main trunk disease with right coronary artery stenosis [group 3]).

Assessment of Carotid Atherosclerosis

Atherosclerosis of carotid artery was analyzed by duplex ultrasound scanning within a month before coronary angiography in the all enrolled patients. A commercially available machine (Vingmed; General Electric) with a 10-MHz linear array transducer was used. Imaging was performed while subjects were lying in a supine position with the head turned away from the side being scanned and the neck extended. Transverse and longitudinal scans were obtained on the common carotid artery, the carotid bifurcation, and the internal and external carotid artery by B-mode and color Doppler ultrasound. Area stenosis (percent) was measured as: $[1-(\text{the area of residual lumen/the area of the normal vessels})] \times 100$ by B-mode ultrasound. Doppler spectral analysis can determine the peak systolic velocity (PSV) by sampling at the area of turbulence. The PSV was measured only when the turbulence was found. To measure blood flow velocity on longitudinal scans, a 5- to 7-mm sample was set in the carotid artery and displayed as linearly as possible. Special care was taken to maintain the incident angle between the carotid artery and the beam at 30° to 60°. We defined echographic carotid artery stenosis as the carotid atherosclerosis with area stenosis of $>50\%$ or PSV of $>200$ cm/s on the common carotid artery, the carotid bifurcation, and the internal carotid artery.

Coronary angiography and carotid angiography were performed when echographic carotid artery stenosis was identified. Selective carotid angiography was performed in lateral and frontal views. The view showing the maximum stenosis was selected for quantitative angiographic analysis. The lumen diameter at the point of maximum stenosis and the diameter of the normal distal internal carotid artery were measured; percent stenosis was then calculated using the method described in the North American Symptomatic Carotid Endarterectomy Trial (NASCET) study. We defined angiographic carotid stenosis, according to the NASCET criteria, as a diameter stenosis of $>70\%$ on the common carotid artery, the carotid bifurcation, and the internal carotid artery.

Statistical Analysis

Data analysis was performed using the SAS version 8.02 (SAS Institute Inc). Continuous variables were expressed as mean$\pm$SD. Two-sided unpaired $t$ test was performed for continuous variables and $\chi^2$ test (or Fisher’s exact test when appropriate) for discrete variables. Multivariate stepwise logistic regression analysis was performed to detect independent predictors of carotid artery stenosis using factors that had significant relation in univariate analysis. A value of $P<0.05$ was considered statistically significant.

### Results

We studied 632 consecutive patients (476 men; mean age 65.3$\pm$7.7; range 35 to 89 years). The demographic and clinical characteristics of the entire study population are presented in Table 1.

Among all the enrolled patients, echographic carotid stenosis was found in 124 patients (19.6%). In coronary angiography, CAD was present in 433 patients (68.5%). A total of 124 patients (19.6%) had 1-vessel disease, 131 patients (20.7%) had 2-vessel disease, and 178 patients (28.2%) had 3-vessel disease.

Univariate analysis revealed that the following factors were associated with echographic carotid stenosis: age, hypertension, diabetes mellitus, past history of myocardial infarction, previous CABG, and the extent of CAD (Table 2). From these factors, multivariate stepwise logistic regression analysis selected age ($P=0.0002$) and the extent of CAD ($P<0.0001$) as the independent predictors of the presence of echographic carotid stenosis (Table 3).

We also analyzed angiographic carotid stenosis based on the NASCET criteria. Of the 124 patients with echographic carotid stenosis, 46 had no available carotid angiography because of severe renal dysfunction ($n=6$), the difficulty of selective cannulation to carotid artery ($n=7$), onset of acute coronary syndrome before coronary angiography ($n=20$), and no patient’s consent ($n=13$). These 46 patients were excluded from the postanalysis because of unavailable carotid angiography. Carotid angiography was performed in the residual 78 patients. We found angiographic carotid stenosis in 47 patients.

Univariate analysis revealed that the following factors were associated with angiographic carotid stenosis: age, hypertension, diabetes mellitus, past history of myocardial infarction, previous CABG, and the extent of CAD (Table 4).
TABLE 2. Univariate Analysis of Echographic Carotid Stenosis

<table>
<thead>
<tr>
<th>Variables</th>
<th>Echographic Carotid Stenosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes, n=124</td>
</tr>
<tr>
<td>Male (%)</td>
<td>96 (77.4)</td>
</tr>
<tr>
<td>Age</td>
<td>68.3±9.3</td>
</tr>
<tr>
<td>Body mass index (%)</td>
<td>23.4±3.8</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>91 (73.4)</td>
</tr>
<tr>
<td>Diabetes mellitus (%)</td>
<td>48 (38.7)</td>
</tr>
<tr>
<td>Hyperlipidemia (%)</td>
<td>88 (71.0)</td>
</tr>
<tr>
<td>Current smoking (%)</td>
<td>32 (25.8)</td>
</tr>
<tr>
<td>Familial history of CAD (%)</td>
<td>31 (25.0)</td>
</tr>
<tr>
<td>Hemodialysis (%)</td>
<td>16 (12.9)</td>
</tr>
<tr>
<td>Past history of MI (%)</td>
<td>40 (32.3)</td>
</tr>
<tr>
<td>Prior PCI (%)</td>
<td>39 (31.5)</td>
</tr>
<tr>
<td>Prior CABG (%)</td>
<td>26 (21.0)</td>
</tr>
<tr>
<td>0-vessel disease (%)</td>
<td>14 (11.3)</td>
</tr>
<tr>
<td>CAD (%)</td>
<td>110 (88.7)</td>
</tr>
<tr>
<td>1-vessel disease (%)</td>
<td>18</td>
</tr>
<tr>
<td>2-vessel disease (%)</td>
<td>28</td>
</tr>
<tr>
<td>3-vessel disease (%)</td>
<td>64</td>
</tr>
<tr>
<td>Multivessel disease (%)</td>
<td>92 (74.2)</td>
</tr>
</tbody>
</table>

MI indicates myocardial infarction; PCI, percutaneous coronary intervention.

From these factors, multivariate stepwise logistic regression analysis selected age (P=0.0392) and the extent of CAD (P<0.0001) as the independent predictors of the presence of severe carotid stenosis (Table 3).

The extent of CAD had a strong association with echographic and angiographic carotid stenosis in univariate as well as multivariate analysis. We performed further analysis on the distribution of carotid stenoses according to the extent of CAD (Figure). The distribution of echographic carotid stenosis in the groups with degrees of CAD was 7.0%, 14.5%, and 36.0% of patients with 0-, 1-, 2-, and 3-vessel disease, respectively (P<0.0001). The distribution of angiographic carotid artery stenosis in the groups with degrees of CAD was 21.4%, and 36.0% of patients with 0-, 1-, 2-, and 3-vessel disease, respectively (P<0.0001). There was a stepwise increase in the number of patients with echographic or angiographic carotid stenosis among the patients with increasing severity of CAD. In patients with CAD, 25.4% had echographic stenosis, and 11.0% had angiographic carotid stenosis. The prevalence of echographic or angiographic carotid stenoses were 14.5% or 3.4%, respectively, in 1-vessel disease, whereas it was 29.8% or 14.2%, respectively, in multivessel disease (P<0.0001).

**Discussion**

In this study, our main findings were: (1) the prevalence of carotid stenosis in patients with CAD was unexpectedly high in the sample Japanese population, and (2) age and the extent of CAD were independently related to the presence of carotid stenosis.

In the 1960s, there were few people in Japan with atherosclerosis in the extracranial carotid artery. But the incidence of extracranial carotid atherosclerosis has increased in the past few decades with the change in lifestyle toward Western habits. It is well known that carotid atherosclerosis strongly correlated with CAD. In the severe CAD patients who were scheduled to undergo CABG, the complication rate of carotid...
stenosis was 2% to 18% in Western countries,\textsuperscript{17–24} whereas for the Japanese population, it was 13.7%\textsuperscript{25} But the prevalence of carotid stenosis in patients with CAD other than the candidates for bypass surgery has not been well evaluated. In our study, the prevalence of echographic carotid stenosis with multivessel CAD was 29.8%. We also analyzed angiographic carotid stenosis in this study. Angiographic carotid stenosis is important for prognosis and to decide on surgical or interventional treatment. However, there have been few reports about the relationship between angiographic carotid stenosis and CAD. Our study showed that 19.4% of patients with 3- vessel disease had angiographic carotid stenosis and may require both coronary and carotid intervention. Histological relationship between carotid and coronary atherosclerosis has been seen in an autopsy study.\textsuperscript{26} The histological relationship may explain the high complication rate.

Open-heart surgery in patients without carotid atherosclerosis carries a risk of stroke of $\approx$1% to 2%, but in the presence of unoperated major carotid stenosis, it is associated with a 14% risk of perioperative stroke.\textsuperscript{23,27–29} Prognosis of CAD has improved in the past few years because of improvement in coronary revascularization. But neurologic complication represents the most frequent cause of mortality in patients undergoing myocardial revascularization.\textsuperscript{30} Therefore, it should be recommended that the patients with CAD, especially those with multivessel CAD, undergo carotid ultrasonography for screening of carotid atherosclerosis before treatment for CAD.

Screening of carotid stenosis in patients with CAD seems insufficient in Japan at present, probably because the complication rate of carotid stenosis has been considered to be low in Japanese population. Previous studies\textsuperscript{10,11} reported high complication rates between carotid artery stenosis and severe CAD in patients undergoing coronary bypass surgery. Our study, including less severe CAD as well as severe CAD, supported these previous studies. The patients with CAD, especially those with multivessel CAD, should undergo carotid ultrasonography in Japan, as in Western countries.

There may be limitations in this study. First, we only studied a group of consecutive patients who were referred for coronary angiography because of suspected CAD. Second, a mean age of patients in this study was high. The prevalence of multivessel CAD was higher in advanced age, and the extent of CAD was affected with the integration of coronary risk factors including age. These selection biases could mean that our findings regarding the relationship between carotid stenosis and CAD are relevant only to this specific group and may not be applicable to the general population.

In conclusion, prevalence of carotid stenosis in patients with CAD is high in Japan as well as in Western countries, and screening of carotid artery stenosis should be recommended in patients with CAD, especially in older patients with multivessel CAD.

\section*{References}


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