Original Article

Ultrasonographic Screening of the Carotid Artery in Coronary Artery Bypass Surgery

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Abstract

Background: *The incidence of stroke after coronary artery bypass grafting (CABG) is between 0.9% and 6.7%, which significantly increases in-hospital and out-hospital costs. This study was designed to evaluate the prevalence of significant carotid stenosis and its risk factors in CABG.*

Methods: *In total, 2044 consecutive patients undergoing elective CABG were investigated through a pre-operative duplex scanning of the carotid arteries. The relation of age, sex, smoking, hypertension, diabetes, dyslipidemia, and coronary disease with carotid stenosis was evaluated.*

Results: *The prevalence of carotid stenosis was 7.6%. The multivariate analysis showed that age over 55 and left main coronary disease were significant independent risk factors for carotid stenosis. Female gender, smoking, hypertension, and diabetes were the risk factors in the univariate logistic regression model.*

Conclusion: *Carotid stenosis is prevalent in CABG candidates. It seems that age ≥55 years and left main coronary disease are the independent risk factors for carotid stenosis in CABG patients.*

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Introduction

Coronary artery bypass grafting (CABG) is the most common operation in the cardiac surgery field. The incidence of post-CABG stroke is between 0.9% and 6.7%.[1] Post-CABG stroke increases mortality, morbidity, and in-hospital costs. Decreasing perfusion pressure (less than 60 mmHg) during surgery, embolization of a left ventricular clot, and shedding debris from carotid or aortic plaques are the etiologies of post-CABG stroke.[2-3] Endarterectomy of significant carotid plaque has proven beneficiary in the prevention of stroke.[3] There are some studies which advocate the necessity of carotid screening before coronary surgery.[4-8]

Therefore, predicting the risk factors of carotid stenosis is important for cardiac surgeons. The aim of this study was to identify the risk factors for significant carotid stenosis based upon pre-operative screening of CABG patients.

Methods

From May 2005 to September 2006, B-mode and duplex ultrasonography of both carotid arteries were performed

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on all non-emergent CABG candidates (n=2,044). Examinations were performed by a radiologist dedicated to Doppler examination for over six years utilizing the Logiq 5 Expert (the horizon release) GE system with linear 10-MHz and curvilinear 3.5-MHz transducers. The Nicolaides criteria (Table 1),[9] based on the North American Symptomatic Carotid Endarterectomy Trial (NASCET), was applied to all the patients. The common carotid arteries, carotid bulbs, and cervical portions of the internal carotid arteries were assessed for stenosis using color and pulse Doppler techniques after localizing any plaque in a gray-scale study.

All the patients had their lipid profile [triglyceride, cholesterol, Low density lipoproteins (LDL), and High density lipoproteins (HDL)] tested pre-operatively, with cholesterol and triglyceride levels being measured by enzymatic methods, HDL by the direct method, and LDL by the Friedewald method. All the measurements were done using Pars Azmon reagents licensed by German Diagnostics. The American Heart Association guidelines were employed for defining and classifying dyslipidemia. Diabetes was defined as blood sugar >6.6 mmol/lit in two separate examinations or a history of antihyperglycemic drug therapy. All the laboratory measurements were done within 24 hours of carotid sonography.

The smoking status of the patients was determined as well. The patients were classified as active smokers, non-smokers (never smokers or quitters five years previously), and ex-smokers (previous smokers having quitted smoking within the previous 5 years). Packs-years were calculated as the number of cigarettes smoked per day multiplied by the duration of smoking (years) divided by 20.

The results of coronary angiography (degree of left main coronary stenosis and number of diseased coronary arteries) were extracted from the hospital surgery data bank.

Written informed consent was obtained from all the patients participating in this study, and the study protocol was approved by the hospital ethics committee. As carotid Doppler ultrasonography is one of the routine examinations before CABG, the patients did not pay extra charges for the study.

Table 1. Duplex ultrasound criteria used to quantify internal carotid artery stenosis according to Nicolaides

NASCET Stenosis Grade (%)	PSV (cm/s)	EDV (cm/s)	PSV ICA/ PSV CCA	PSV ICA/ EDV CCA	EDV ICA/ EDC CCA
1-49	<150	<80	<2	<10	<2.6
50-59	<250	<130	<3.2	<10	<2.6
60-79	<250	<130	>4	<25	<5.5
80-89	<250	>130	>4	>25	>5.5
90-99	Trickle flow	Trickle flow	Trickle flow	Trickle flow	Trickle flow
100	No flow				

NASCET, North American Symptomatic Carotid Endarterectomy Trial; PSV, Peak systolic velocity; EDV, End diastolic velocity; ICA, Internal carotid artery; CCA, Common carotid artery

Results

From the total of 2062 consecutive candidates for non-emergent CABG, 18 were excluded from the study because of previous carotid stenting. The remaining 2,044 patients were comprised of 1429 (69.9%) men and 615 (30.1%) women with an age range between 31 and 84 years (Table 2). From the 2044 patients, who underwent a duplex study, 1376 (67%) were normal or had unilateral stenosis <50%; 511 (25%) had bilateral stenosis <50%; 114 (5.5%) had unilateral stenosis between 50 and 99%; and 28 (1.4%) suffered bilateral stenosis between 50 and 99%.

Patients with the occlusion of the carotid with stenosis on the other side <50% or >50% numbered 9 (0.4%) and 6 (0.3%), respectively. Additionally, 22 (1.1%) patients had unilateral stenosis >80%. There was no patient with bilateral stenosis >80% in our study.

Table 2. Demographic risk factors of the patients

Gender	
Male	1429(69.9%)
Female	615(30.1%)
Age (y) (mean±SD)	
Male	59.97±9.2
Female	61.94±8.05
All	60.9±8.85
Hypertension (%)	32.2
Smoking status (%)	
Current smoker	25.3
Quitted	3.9
Non smoker	70.8
Diabetes (%)	28.9
Dyslipidemia (%)	63
Left main stenosis >50 (%)	12.5
Involved coronary artery* (%)	
3-VD	77.6
2-VD	19
1-VD	3.4
Prior myocardial infarction (%)	38.5
Ejection fraction (%)(mean±SD)	49.73±10.06

*According to coronary angiography report
VD, Vessel disease

In the primary univariate logistic analysis, gender had a significant role in carotid stenosis: 10.1% of the women had stenosis >50%, whereas this degree of stenosis was detected in only 6.7% of the men (P value=0.007).

Age and increased blood pressure were the other risk factors for >50% stenosis. The mean age for the patients having at least one stenosis >50% was 66.1±7.12 years, while it was 60.52±8.85 for patients without any stenosis > 50% (P value <0.001). The patients were divided into the following subgroups based on age: less than 44 years, 45-54 years, 55-64 years, 65-74 years, and 75 or more. The

prevalence of significant stenosis was 0, 2.8, 6.4, 11.8, and18.7%, respectively (P value <0.001). The prevalence of significant stenosis increased from 2.4% in the patients less than 55 years of age to 9.5% in those 55 years old or more. Significant stenosis was found in 10.1% of the patients with increased blood pressure, while it was detected in 6.5% in the normotensive group (P value=0.005). The effect of hypertension existed amongst the patients with critical (>80%) stenosis, too (P value=0.002). Hypertension for more than ten years is known to increase the odds of significant stenosis by 1.43.

Regarding diabetes mellitus, whereas 23 of 192 (12%) patients with a history of at least ten years of this disease had significant stenosis, it was 7.3% in the non-diabetic group or in the group with a history of less than one decade of diabetes (P value=0.021, OR=1.37, CI:1.08-2.77).

Only 31 (5.0%) of the 615 women were smokers; the effects of smoking were, therefore, analyzed only in the men. The duration of smoking (not packs-years) was associated with the increased risk of carotid stenosis. Significant stenosis was found in 11.4% of the current smoking men with a duration of smoking more than 40 years, while it was 6.9% in the non-smoking men (P value=0.044, OR=1.31, CI:1.00-1.73). Also, 19.4% of the ex-smoking men with a history of smoking for more than 40 years had significant stenosis by comparison with the non-smoking men (P value=0.013, OR=1.79, CI:1.12-2.85). We had access to the coronary angiography results of 1731 patients (84% of the patients). In these patients, the incidence of significant carotid stenosis was 9.8% in the group with left main coronary stenosis >50%, while it was 5.6% in those without left main coronary stenosis (P value=0.018). The multivariate logistic regression analysis revealed that age ≥55 (P value=0.001, OR=3.01, CI:1.59-5.71) and left main coronary stenosis ≥50% (P value=0.01, OR=1.92, CI:1.16-3.19) were the independent risk factors for significant carotid stenosis.

The relation between dyslipidemia with the degree of carotid stenosis is demonstrated in Table 3.

Table 3. Serum lipid level and incidence of significant carotid stenosis*

	mmol/lit	carotid stenosis (%)
Cholesterol	<5.18	8.3
	5.18-6.19	6.7
	≥6.22	6.2
HDL	>1.55	5.7
	0.9-1.54	8.2
	<0.9	6.2
LDL	<3.37	8.2
	3.37-4.12	5.9
	≥4.14	6.9
Triglyceride		
Male	<1.81	8.4
	>1.81	7.2
Female	<1.53	8.4
	>1.53	7.2

*Serum lipid level classification as mmol/lit is shown in the first line and incidence of significant carotid stenosis is shown by % in second line of each group
HDL, High density lipoproteins; LDL, Low density lipoproteins

Discussion

Stroke is a major cause of morbidity and mortality after CABG, and extra cranial carotid stenosis is one of the etiologies of post-CABG stroke.[10] Screening of the cervical carotid arteries by Doppler allocates patients with significant stenosis. Given the costliness of the Doppler study, it is important to determine those bypass candidates who would benefit from screening of the carotids. Female gender,[2,11,12] age of more than 65 years,[11] peripheral vascular disease, history of stroke or transient ischemic attack,[1,11,12] left main coronary disease,[12] carotid bruit, hypertension,[11] smoking,[12] atherosclerosis of the aorta,[1] hypercholesterolemia, and diabetes mellitus[2] have been introduced as risk factors for significant carotid stenosis by different studies. However, some other studies have found no association between hypertension, hypercholesterolemia, smoking,[4] and diabetes[4,11] with carotid stenosis.

Another confusing factor in the existing literature is the fact that while some studies have used the multivariate analysis,[1] others[11] have employed the univariate analysis with a less statistical value. Increase in life expectancy and better techniques of carotid endarterectomy have changed the definition of "significant carotid stenosis". In contrast to the use of 80% stenosis as significant in the past,[12] more recent studies have revised the figure to 50%.[1,10]

To overcome these confusing factors and given the fact that environmental factors are believed to change the pattern of atherosclerosis at different times, this study sought to assess the prevalence of carotid stenosis and its pertinent risk factors. Of the 2044 patients in this study with a mean age of 60.9 years, 157 (7.2%) patients had carotid stenosis >50%, which is in accordance with the results of the Naylor review.9 In his review, the prevalence of >50% carotid stenosis was 11% in patients more than 60 years old (in our study 10.6% [P value=0.35]) and 15% in those older than 70 (in our study 16% [P value=0.32]).[9] Our results were similar in that they showed 11.8% significant stenosis in >65 years and 18.7% significant stenosis in >75 years. Although in the Durand study[10] the prevalence of carotid stenosis significantly increased after 65 years, we observed it at 55 years (prevalence of 2.4% in less than 55 versus 9.5% in older than 55 OR=4.28, CI:2.35-7.78). This may be due to the decreasing age of atherosclerosis in the last decade or ethnic reasons. The Fukuda study[1] in a Japanese community

revealed significant stenosis even in patients in their 40s. Age>55 was an independent risk factor for carotid stenosis in our multivariate analysis.

Female gender was a risk factor for carotid stenosis in the multivariate and univariate analyses of the Berens and Durand studies, respectively.[10,11] Female gender was a risk factor in our univariate analysis (not in our surviving multivariate analysis) (P value=0.007 and 0.30, respectively). It is surprising that female gender was not a risk factor for carotid stenosis in either the univariate analysis or the multivariate analysis of the Fukuda study.[1] Our univariate analysis and that of the Durand study[10] revealed hypertension as a risk factor for significant stenosis (P value=0.005 and 0.003, respectively). In the Durand study, stenosis >70% was considered significant.

In our study, hypertension remained a risk factor for stenosis even in 80% (critical) stenosis. Diabetes mellitus has not been introduced as being predictive of carotid stenosis by some other studies.[4,11] In our study, a history of diabetes was not a risk factor by itself. However, a history exceeding a decade proved significant in the univariate regression (P value=0.021). Diabetic vasculopathy is a chronic process; it would, therefore, be logical to assume that diabetes is not a risk factor for atherosclerosis from the beginning.

Smoking is a subject full of conflicting notions with regard to carotid stenosis. While Berens assumes it as a risk factor of >80% stenosis,[12] Fukuda[1] and Faggioli[12] reject it and Durand[11] simply does not include it in his study. We evaluated the effect of smoking only on the male subgroup of the patients. Despite the fact that "packs-years" was not a risk factor for carotid stenosis, duration of more than 40 years of smoking was a risk factor in the univariate study.
Left main stenosis >50% was an independent risk factor for carotid stenosis in our multivariate analysis, as was the case in the Durand and Berens studies.[10,11]

There was no relation between the measured serum levels of cholesterol, HDL, LDL, and triglyceride with carotid stenosis in our patients. The patients suffering from dyslipidemia in our study had been taking medications for it because they had been referred from cardiology clinics. As a result, the results of serum lipids were not reflecting the real status of the patients' serum lipids. The stress of future cardiac surgery increases sympathetic drive in patients, and sympathetic stimulation is a well-known factor for a temporary reduction in blood lipids. Hypercholesterolemia was not a risk factor in the Fukuda study[1] as well, but was so in our previously published related article.[2]

Conclusion

In summary, age ≥55 years and left main coronary disease are known as the independent risk factors for carotid stenosis in patients candidated for CABG. Female gender, chronic diabetes, hypertension, and long-standing smoking can be considered the other risk factors. We believe that the administration of carotid ultrasonography screening can help in identifying patients who are at greater risk of post-operative stroke and should be considered prior to CABG, particularly patients with a history of prior neurological event or peripheral vascular diseases.

Acknowledgments

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