

Transcranial and carotid Doppler study in coronary artery bypass graft patients

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ABSTRACT

Objectives: Atherosclerosis is a pathogenesis which is common in both coronary and intracranial arterial diseases. Therefore, we designed a group of coronary artery bypass graft (CABG) surgery patients for transcranial Doppler (TCD) to assess intracranial artery diseases and carotid duplex studies to assess carotid artery diseases.

Methods: In a prospective randomized study, 129 elective CABG patients with proven coronary artery disease by angiography, were examined by TCD and 45 patients by carotid duplex preoperatively. Neurologic examination was carried out pre- and post-operatively. This study was carried out from April 2001 to August 2002 at Imam Hospital of Tabriz Medical Science University, Iran.

Results: Out of the 129 CABG patients, there were 105 males and 24 females, with an average age of 57 ± 9.9 years. Risk factors were as follows: smoking in 44.8%, hypertension in 38%, hypercholesterolemia in 29%, and diabetes mellitus in 18.6%. The TCD findings of 30 patients (23.2%, 11 female and 19 male) revealed the following abnormalities: stenosis of basilar artery in 7 patients (5.4%), carotid siphon in 3 (2.3%), intracranial

internal carotid in 5 (3.9%), middle cerebral artery in 3 (2.3%) and vertebral artery in one patient (0.8%). Multiple vessel abnormality was detected in 11 patients (8.5%). There was a significant correlation between severity of coronary artery disease in angiography and abnormality in TCD ($p=0.008$). The TCD abnormality was detected more in females ($p=0.008$) or hypertensive patients ($p=0.004$). In the carotid duplex study of the randomized 45 patients, 23 (51.1%) had abnormal results as follows: stenosis $<50\%$ in 17 (38%) cases, stenosis between 50-70% in 5 (11%), and hemodynamically significant stenosis ($>70\%$) only in one (2%) patient. There was also significant correlation between severity of coronary involvement and carotid involvement ($p<0.01$). No stroke occurred in the first postoperative week following CABG surgery.

Conclusion: Stenosis of intracranial and carotid arteries was more common in CABG patients with more than 2-coronary vessel involvement or hypertensive or female patients. We recommend TCD and carotid duplex studies in these patients for prevention of probable cerebrovascular accidents.

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Atherosclerosis is a systemic vascular disorder that may lead to symptomatic atherosclerotic diseases of heart, brain, kidney, lower limbs and small intestine.¹ There is a vast variety in the etiology of stroke but, like in coronary artery disease (CAD), the major etiology is atherosclerotic arterial changes. Atherosclerosis is the main pathologic process that acts as the common

mechanism of CAD or cerebrovascular disease evolution. Age, sex, smoking, hypertension, hypercholesterolemia, and diabetes are major risk factors for atherosclerosis, and modifiable risk factors are challenging subjects for the prevention of atherosclerosis complications.^{2,3} Coronary artery bypass graft (CABG) surgery is one of the most common operative procedures performed around the

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world and is becoming a more frequent procedure among Asians.⁴ Extracranial carotid artery disease (ECAD) increases the risk of stroke after CABG surgery.^{5,6} Some authors recommend carotid Doppler ultrasonography before CABG, particularly in patients with a history of neurologic deficit or peripheral vascular disease.⁷ Intracranial cerebral artery disease (ICAD) may also be an independent risk factor for stroke after CABG surgery.⁴ Intracranial cerebral artery disease is known to be more common in blacks and Asians than in whites.⁸⁻¹¹ Transcranial Doppler (TCD) sonography is a safe, non-invasive method for studying major intracranial arteries.¹² Alexandrov et al showed TCD sensitivity of 83% and specificity of 96-98% for detecting intracranial arterial stenosis.¹³ They also showed that in 26% of their patients, TCD provided additional information to angiography, including flow velocities, and microembolic signals.¹⁴ The American Academy of Neurology Technology Assessment stated that TCD has an established value in the assessment of patients with intracranial artery stenosis, collaterals, subarachnoid hemorrhage (SAH) and brain death.¹⁵ Our objectives in this study were to evaluate cerebrovascular disease by TCD and carotid duplex in CABG patients, and to reveal any correlation between severity of CAD determined by angiography and severity of cerebrovascular disease by the Doppler studies.

Methods. In a prospective randomized study, 129 cases of elective CABG candidates were evaluated from April 2001 to August 2002 at Imam Hospital of Tabriz Medical Science University, Iran. Patients undergoing emergency CABG were excluded. Coronary angiography showed 3-vessel disease in 93 patients (72.1%), 2-vessel disease in 34 patients (26.4%) and 1-vessel disease in 2 patients (1.6%). By utilizing TCD, we tried to evaluate the disease process in another arterial system not examined by the coronary angiographic method. Before operation, neurologic and neurovascular examinations were carried out and then TCD (Multidopp P system, DWL, Germany) was applied by one neurologist to all cases to evaluate the main intracranial arteries. Criteria for intracranial arteries stenosis was as below: in middle cerebral artery, mean velocity (MV)>100 cm/sec or peak velocity (PV)>160 cm/sec; in anterior cerebral artery, MV>90cm/sec or PV>140 cm/sec; in posterior cerebral artery, MV>55cm/sec or PV>85cm/sec; in intracranial internal carotid artery, MV>90cm/sec or PV>135cm/sec; in vertebral artery, MV>60cm/sec or PV>90cm/sec; and in basilar artery, MV>65cm/sec or PV>100cm/sec diagnosed as stenosis.¹⁶ The severity of stenosis of intracranial arteries could not be determined exactly by TCD. In order to evaluate extracranial carotids,

color duplex ultrasonography (EUB-525 Ultrasound scanner, HITACHI, Japan) also applied randomly in 45 cases by one radiologist, as well as TCD. Criteria for carotid duplex study were based on cross-section, peak systolic velocity, end diastolic velocity and internal carotid artery to common carotid artery velocity ratio.¹² The risk factors for atherosclerosis, such as hypertension (systolic pressure > 140 mm Hg or diastolic pressure >90 mm Hg), diabetes, hypercholesterolemia (fasting total serum cholesterol >240 mg/dL), and smoking (current smoker or ex-smoker who quit within 5 years) were noted, and past cerebrovascular accident (CVA) were considered in the study. The patients were followed for a 7-10 day postoperative period for the occurrence of cerebrovascular accidents. Finally, the data were analyzed using statistical software EPI6. The comparison between various variables was analyzed with chi-square test and relative risk (RR) with confidence interval (CI) of 95%. In all measurements mean value \pm standard deviation (SD) of the mean is considered. A *p* value of less than 0.05 was considered significant.

Results. Out of 129 CABG patients 81.4% were male (105 cases) and 18.6% were female, the mean age of patients was 57 ± 9.9 years. The risk factors were: hypertension in 49 cases (38%), diabetes mellitus in 24 patients (18.6%), hypercholesterolemia in 38 cases (29%) and smoking in 56 patients (44.8%). There was no history of previous transient ischemic attack. On physical examination carotid bruit was detected in 5 patients (3.9%) and vertebral artery bruit in 2 patients (1.6%). The TCD study showed normal intracranial hemodynamics in 99 patients (76.8%) and abnormal findings in 30 patients (23.2%). The abnormal TCD findings were as follows: stenosis of basilar artery in 7 patients (5.4%), carotid siphon in 3 patients (2.3%), intracranial internal carotid in 5 patients (3.9%), middle cerebral artery in 3 patients (2.3%) and vertebral artery in one patient (0.8%). Multiple vessel abnormality was detected in 11 patients (8.5%). In correlating coronary angiographic findings to TCD results, in 30 patients with abnormal TCD, 2 patients had 1-vessel disease in coronary angiography, 4 had 2-vessel disease and 24 had 3-vessel disease. In 99 patients with normal TCD, 30 patients had 2-vessel disease and 69 patients had 3-vessel disease. The TCD abnormality was 25.8% in 3-CAD patients and 16.67% in one and 2-CAD patients. This shows significant correlation between severity of CAD and evidence of cerebrovascular disease in TCD ($p=0.008$). In patients with abnormal TCD findings, 11 were female and 19 were male while 13 female and 86 male patients had normal TCD study. We conclude hemodynamic changes in TCD are more common in females than males (relative risk (RR) = 2.53, 95%

Table 1 - Preoperative factors and TCD ultrasonography results.

Factor	Normal TCD 99 (76.8%) patients	Abnormal TCD 30 (23.2%) patients	p value
Age	55.83 ± 9	61.43 ± 10	NS
Sex: M/F	86/13	19/11*	0.008
Hypertension	31 (63.3%)	18 (36.7%)*	0.004
Smoker	45 (80.4%)	11 (19.7%)	NS
Cholesterol >240 mg/dl	30 (77.8%)	8 (22.2%)	NS
Diabetes	15 (62.5%)	9 (37.5%)	NS
>2 coronary vessel disease	69 (74.2%)	24 (25.8%)*	0.008

TCD - Transcranial Doppler, *Statistically significant difference, NS - non significant, M - male, F - female

confidence interval (CI), $1.40 < RR < 4.60$, $p=0.008$). In 49 patients with a history of hypertension, TCD findings showed abnormality in 18 cases but in 80 patients without history of hypertension, TCD was abnormal in 12 cases (37% versus 15%). This difference is statistically significant ($RR=2.45$, 95% CI, $1.29 < RR < 4.64$, $p=0.004$). Total serum cholesterol level of the patients with abnormal TCD was less than 240 mg/dl in 22 and more than 240mg/dl in 8 patients. In 99 patients with normal TCD, only 30 patients had a higher level of serum total cholesterol. There was no significant correlation between the cholesterol levels and TCD abnormality. ($\chi^2 = 1.18$, degrees of freedom (df) = 2, $p < 0.55$). **Table 1** summarizes all preoperative factors and their differences in the 2 groups of patients with and without abnormal TCD findings. Duplex ultrasound was randomly applied to extracranial carotid arteries in 45 cases. Twenty-three patients (51.1%) had abnormal duplex ultrasonography results. In 17 cases, internal carotid artery stenosis was less than 50%. In 5 patients the degree of severity of stenosis was moderate (50-70%). In one patient there was significant stenosis in one of the extracranial carotid arteries. Out of these 45 cases, in 33 patients with 3 coronary artery diseases, 18 (54.5%) had abnormal duplex study but in the remaining 12 patients with less than 3 coronary vessel disease only 5 patients (41.6%) had abnormal duplex results. There was significant correlation between carotid duplex findings and severity of coronary artery involvement ($\chi^2 = 5.32$, df = 1, $p < 0.05$). In 20 smoking patients, carotid duplex study was abnormal in 11 cases, and in 25 non-smokers it was abnormal in 12 patients. This difference is not significant. Follow up of all the patients after CABG did not show any stroke in a period of 7-10 postoperative days.

Discussion. The correlation between ICAD and CAD has previously been suggested by a few earlier autopsy-based studies,^{17,18} and ECAD is also associated with coronary heart disease.^{19,20} There was ICAD with or without ECAD in 23.2% of our patients. Byung-Woo, et al found out that 30.3% of patients concomitantly had CAD and ICAD.⁴ Uehara et al reported ICAD in 16.4% of Japanese patients with ischemic heart disease, severe in 4.5% of the patients.²¹ Our results intervene between the 2 mentioned studies and show that TCD could have enough efficacy for evaluation of intracranial cerebral arteries. There is significant correlation between TCD findings and hypertension history. As mentioned above, hypertension is a major risk factor in atherosclerosis and according to Holme et al, hypertension is the most important risk factor for raising of cerebral artery lesions.²² There is a significant correlation between abnormal TCD findings and sex factor which could be due to menopausal changes in this period of female patients. We know that young women tend to have lower incidences of coronary artery disease, stroke and myocardial infarctions than men, but this situation changes dramatically at menopause, after which women are at greater risk than men.²³ Estrogen deficiency leads to the rapid progression of cardiovascular risk in women after menopause. Hypertension is one of the most powerful and prevalent contributors to atherosclerotic cardiovascular disease. Hypertension affects more men than women until 55 years of age, but after 55 the percentage of women with hypertension is higher.²⁴ Gender differences in components of the renin-angiotensin system have been shown to exist, and may play a central role in blood pressure control. In normotensive populations, plasma renin activity is significantly higher in men than in women, and is higher in postmenopausal versus premenopausal women.²⁵ More recent studies, however, suggest that the increased cardiovascular morbidity and mortality after menopause cannot be fully explained by changes in plasma lipoproteins, and supports the concept that ovarian hormone deprivation has a widespread impact on the cardiovascular system, with a direct harmful effect on vessel-wall physiology.²⁶

Out of the 45 patients studied by carotid duplex ultrasound, approximately 50% had abnormal duplex findings, but significant and clinically important stenosis (>70% stenosis) was found only in one (2%) patient. Although Faggioli et al⁵ showed the overall prevalence of extracranial carotid stenosis greater than 75% was 8.7%, Young et al reported a lower rate of patients with severe carotid stenosis, in their study severe ECAD was found in 3%,¹⁷ which is lower than the rates previously reported in other studies (3.8-12%).^{7,27-30} Chen and colleague showed that in Chinese patients, 50%

stenosis of one or more of the extracranial cerebral arteries was 21% and internal carotid arteries were involved in 17 (11%) of 153 patients.²⁸ Our study suggests that significant ECAD seems to be lower in Iranian patients than other nationalities, but as previously mentioned, ICAD is relatively common.⁸⁻¹¹ Uehara et al found that the incidence of extracranial carotid artery stenosis and the severity of coronary atherosclerosis had a significant correlation,²¹ this is in agreement with the results of this study.

We recommend TCD and carotid duplex studies for those CABG cases with more than 2 coronary vessel involvement, hypertensive patients, or female patients. Regarding the small number of cases included in our study, and lack of any clinical cerebrovascular event perioperatively, we could not define any predictable risk for perioperative cerebrovascular complications, and this requires further study with more cases with consideration of all postoperative central nervous system complications.

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