Preoperative transcranial and carotid Doppler study in coronary artery bypass graft patients

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ABSTRACT

Objective: To assess the correlation of postoperative neurologic complications with preoperative transcranial and carotid Doppler study findings of coronary artery bypass graft (CABG) patients.

Methods: In a descriptive, analytic, follow up study we prospectively studied 201 patients undergoing elective and isolated CABG surgery during a 12 month period from October 2003 to September 2004 at Madani Hospital of Tabriz Medical Sciences University, Iran. Neurologic examination, intracranial cerebral arterial study using transcranial Doppler (TCD) and carotid duplex were performed preoperatively. Intraoperative and postoperative complications were followed up for one month.

Results: Two hundred and one patients (158 male, 43 female) with a mean age of 57.29±9.67 were studied. Out of these, 131 patients had 3 coronary vessels disease, 64 had 2 vessels, 5 had one vessel, and one patient had diffuse coronary disease. A TCD was performed in 183 patients and disclosed abnormalities in 22 patients and was normal in 161 cases. The total number of involved arteries was 34. Among 154 carotid duplex studied patients, 102 had plaque, inducing <50% stenosis in 99, 50-74% stenosis in one, and 75-90% stenosis in 2 cases. Postoperative neurologic complication occurred as follows: 4 stroke, 7 delirium, and 3 amnesia. One of the operated patients died. Nine of 161 patients with normal TCD (5.6%) and 5 of 22 (22.7%) with intracranial cerebral arterial disease (ICAD) showed central nervous system (CNS) complications (p=0.015). There were significant correlations between number of involved cerebral arteries and post CABG CNS complications (p=0.0001), including stroke (p=0.007), and between diabetes mellitus history with these complications (p=0.012).

Conclusion: Our results suggest that lCAD is an independent risk factor for CNS complications after CABG surgery. Hence, we recommend pre-CABG evaluation of the cerebral arteries by TCD, for the risk assessment of CABG surgery.

Neurosciences 2007; Vol. 12 (1): 42-45

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Received 28th May 2006. Accepted 14th October 2006.

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Coronary artery bypass graft (CABG) surgery is one of the most commonly performed surgical procedures worldwide, intended to treat ischemic heart disease and alleviate angina pectoris.[1] Central nervous system (CNS) dysfunction is one of the main causes of postoperative morbidity in this surgery. The incidence of cerebral complications after CABG and its risk factors has been studied extensively.[2] Extracranial carotid artery disease (ECAD) is a proven risk factor for post-CABG CNS complications, particularly stroke,[3] and some authors recommend ultrasound evaluation of carotid arteries before CABG, especially if there is a history of previous cerebrovascular accident or peripheral vascular disease.[4] Intracranial cerebral arterial disease (ICAD) can also be considered as an independent risk factor for cerebral stroke in patients undergoing CABG,[1] which is especially true for Asians and Blacks.[5,6] The present study was designed to assess the correlation of postoperative CNS complications with preoperative transcranial Doppler (TCD) and carotid duplex (CD) findings of CABG patients referred to the single university medical center of North-West of Iran.

Methods. In a descriptive, analytic, and prospective follow up study, a consecutive series of 201 patients undergoing CABG surgery were enrolled during a 12-month period from October 2003 to September 2004 at Madani Hospital in Tabriz, Iran. Inclusion criteria were: elective (non-emergent) CABG, lack of concomitant cardiac arrhythmia, and ejection fraction (EF) >30%. Patients undergoing emergency CABG or CABG combined with other surgical procedures

such as valve replacement or carotid endarterectomy were excluded from the study. We selected these criteria to minimize cardiogenic insults such as emboli and to make surgical procedures similar as much as possible. Before operation, all patients were visited by a neurologist and a thorough history and neurologic examination were performed. The known risk factors of atherosclerosis such as, hypertension (systolic blood pressure >140 or diastolic blood pressure >90 mm Hg), diabetes mellitus (fasting total cholesterol >240 mg/dl, or low-density lipoprotein >160 mg/dl), and smoking (either currently or quit within the past 5 years) and body mass index (BMI), previous cerebrovascular disease, family history of cerebral or cardiac vascular disease, carotid and vertebral arterial bruits were considered. Intracranial cerebral arteries examination was carried out by a neurologist using TCD ultrasonography (Multidopp X4 system, DWL, Germany) to detect ICAD. Criteria for ICAD were as follows: in the middle cerebral artery, mean velocity (MV) >100 cm/sec or peak velocity (PV) >160 cm/sec; in the anterior cerebral artery, MV >90 cm/sec or PV >140 cm/sec; in the posterior cerebral artery, MV >55 cm/sec or PV >85 cm/sec; in the intracranial internal carotid artery, MV >90 cm/sec or PV >135 cm/sec; in the vertebral artery, MV >60 cm/sec or PV >90 cm/sec, and in the basilar artery, MV >65 cm/sec or PV >100 cm/sec.[7] Extracranial carotid arteries were evaluated by a radiologist applying color duplex ultrasonography (EUB-525 ultrasound scanner, HITACHI, Japan) to evaluate intima media thickness, plaque, and stenosis. The degree of carotid stenosis was categorized as: <50%, 50-74%, 75-90%, >90%, and complete occlusion. Criteria for carotid stenosis were based on cross-section, peak systolic velocity, end diastolic velocity, and internal carotid artery to common carotid artery velocity ratio.[8] The presence of plaque in the carotid duplex is defined as ECAD. Intraoperative and perioperative variables that may influence the CNS complications were recorded by an anesthesiologist, including the type of surgery (on or off-pump), the number of grafts, intraoperative events such as, cardiac arrest, cardiopulmonary resuscitations, and events occurring in the ICU such as, low cardiac output (inotropic support for more than 24 hours postoperatively), acute myocardial infarction (AMI), atrial fibrillation (AF) rhythm, cardiac or respiratory arrest, and duration of mechanical ventilation and ICU stay. In the postoperative period both in the ICU and the ward, patients were visited by the same neurologist who had carried out the initial examination. The development of any neurologic complications was recorded until the patient was discharged. The CNS complications were classified as stroke, delirium, ischemic–hypoxic encephalopathy, seizure, and amnesia.[1,9] Nearly one month after discharge, the patients were visited again by the same neurologist and a thorough neurologic examination was carried out again and in the case of neurologic problems, appropriate studies such as CT scan or MRI were performed. The neurologist carrying out the TCD, the radiologist performing CD and the anesthesiologist recording perioperative data and the other neurologist carrying out neurologic examination pre and postoperatively were all blind to the findings of each other. Finally, the data were analyzed using the Statistical Package for Social Sciences. The correlation between qualitative variables was analyzed with Chi-square, correlation between qualitative and quantitative variables with T-test and factor analysis and logistic regression. A *p*-value of less than 0.05 was considered significant. This study was approved by the research committee of Tabriz Medical Faculty.

Results. Out of 201 patients, 158 (78.6%) were male and 43 (21.4%) were female. The mean age of patients was 57.29±9.67 ranging from 31-82 years. The risk factors were: hypertension in 90 (46.4%), diabetes in 42 (21%), hyperlipidemia in 130 (65.5%), and smoking in 75 (37.3%) patients. Mean body mass index (BMI) was 18.1±0.17 and mean body surface area (BSA) was 1.86±0.42. A history of cerebral vascular disease was found in 8 (4.5%) patients; 5 had an ischemic stroke, 2 had a transient ischemic attack, and one had cerebral hemorrhage. On physical examination, carotid artery bruit was detected in 11 (5.5%) and vertebral artery bruit in 12 (6%) patients. Eighty-three (41.3%) had a family history of coronary artery disease and 26 (12.9%) patients had a family history of cerebral vascular disease. Coronary angiography showed 1-vessel disease in 5 (2.5%), 2-vessel disease in 65 (32.3%), 3-vessel disease in 130 (64.7%) patients, and diffuse vessel disease in one (0.5%) patient. Mean EF was 50.65±9.41%.

A TCD was performed in 183 cases. Temporal insonation window was poor in 4 patients, then middle, anterior, and posterior cerebral arteries were unobtainable. Based on detected signals, it appeared normal intracranial hemodynamic state in 161 and abnormal findings in 22 (12.6%) patients. They were as follows: 13 (59.1%) had 1-vessel, 5 (22.7%) had 2-vessel, and 4 (18.2%) patients had 3-vessel stenosis. Totally, 34 intracranial vessels were involved. The basilar artery was abnormal in 12 (6.6%) cases and was the most commonly involved vessel. Out of 154 patients who were randomly evaluated by CD, plaque was found in 102 (66.2%). Stenosis caused by the plaque was <50% in 99, 50-74% in one and 75-90% in 2 patients.

Type of surgery was off-pump in 121 (60.2%) and on–pump in 80 (39.8%) cases. There was no intraoperative accident. In 51 (24.9%), postoperative events occurred, namely, acute myocardial infarction

(AMI) in 11 (5.5%), atrial fibrillation (AF) in 36 (17.9%), respiratory arrest in 3 (1.5%) and cardiac arrest in one patient. Out of 201 patients, 14 (7%) suffered post–CABG CNS complications including ischemic stroke in 4 (1.9%), delirium in 7 (3.5%), and amnesia in 3 (1.5%).

Out of the 4 stroke patients, 3 were in the anterior circulation and one in the posterior circulation. Only one led to severe disability and the other 3 had mild disabilities. All 7 delirium patients recovered completely. Three amnesic patients did not recover even after one month. In one patient who expired, the cause was severe cardiac disease and postoperative cardiac arrest, and no neurologic complication was found. Out of 4 stroke patients, 2 had ICAD and 3 had ECAD (**Table 1**). There was no clinical correlation with TCD in any of them. Among the 22 patients with ICAD, 5 (22.7%) had CNS complication while this figure was 9 (5.6%) among patients with normal TCD, indicating a significant correlation between ICAD and post CABG CNS complications (p=0.015). Regarding the correlation between the number of cerebral stenotic vessels with post – CABG CNS complications; 5.6% of them with normal TCD, 7.1% of them with 1-vessel abnormality, 40% with 2-vessel abnormality, and 50% with 3-vessel abnormality had a CNS complication, indicating a significant correlation (p=0.0001). The correlation between the number of involved cerebral artery and postoperative stroke was also significant (p=0.007).

Out of 14 patients suffering from CNS complications, CD study was carried out in 10, revealing stenosis <50% in 8, and no stenosis in 2 patients, therefore, no significant correlation was found between ECAD and post–CABG CNS complications in this study. Diabetes, like ICAD, and the number of abnormal vessels on TCD, also showed significant correlations with post–CABG CNS complications (p=0.012). However, there was no such correlation with age, sex, hypertension, smoking, and intra/postoperative events (**Table 2**).

Table 1 - Clinical profiles of patients with stroke.

Patient No	Gender/ Age	ICAD	ECAD	Stroke Region	Relation to known ICAD or ECAD
1	male/65	-	R-ICA	Left Occipital	NO
2	female/62	-	R-ICA	Paraventricular	NO
3	male/67	L-ACA	L-ICA	Right parietal	NO
4	female/44	L-PCA, L-CS, R-CS	-	Left fronto-parietal	Possible to ICAD

ICAD - Intracranial cerebral arterial disease, ECAD - Extracranial carotid artery disease, ICA - Internal carotid artery, ACA - Anterior Cerebral Artery, PCA - Posterior Cerebral Artery, CS - Carotid Siphon, L - Left, R - Right

Table 2 - Preoperative factors and frequency of CNS complications after coronary artery bypass graft surgery.

Factors		Frequency of CNS complications	(%)	*P*-value
Age (years)	<60	6/121	(4.9)	0.169
	≥60	8/80	(10)	
Sex	Male	10/158	(6.3)	0.504
	Female	4 /43	(9.3)	
Hypertension	No	7/104	(6.7)	0.779
	Yes	7/90	(7.7)	
Diabetes mellitus	No	7/158	(4.4)	0.012
	Yes	7/42	(16.6)	
Smoking	No	8/126	(6.3)	0.776
	Yes	6/75	(8)	
ICAD	No	9/161	(5.5)	0.015
	Yes	5/22	(22.7)	
ECAD	No	2/52	(3.8)	0.496
	Yes	8/102	(7.8)	

ICAD - Intracranial cerebral arterial disease, ECAD - Extracranial carotid artery disease

Discussion. As mentioned, one of the major morbidities after CABG is CNS complications, especially stroke.[2] In previous studies, multiple factors have been implicated in causing post–CABG CNS complications including ECAD[10,11] and ICAD[1] and many studies have emphasized the importance of preoperative ultrasound evaluation of cervical and intracranial vessels to identify patients with a significant risk to the above mentioned complications.[12]

In a study by Woo et al[1] in 201 patients, ICAD alone was present in 33 (16.4%), ECAD alone in 48 (23.9%) and both ICAD and ECAD were present concomitantly in 28 (13.9%). In our study, out of 183 patients undergoing TCD, 22 (12%) patients had ICAD. Therefore, the incidence of intracranial vessel abnormality was lower, probably due to our study criteria, excluding patients with significant heart disease (EF ≤30%) who probably have concomitant cerebral vascular involvement.[13]

Regarding ECAD; out of 154 patients undergoing CD, 102 (66.2%) patients had abnormal results with 3 (1.9%) patients had significant stenosis. Eighty (51.9%) patients had only ECAD. In the other studies, the incidence of ECAD among coronary vessel disease patients was reported between 5-22%.[10,13,14,15] Therefore in our study, the incidence of ECAD was higher, but the incidence of severe stenosis was slightly lower, which appears to be the result of the different methods used to study vessels and the criteria defining ECAD. Although ECAD is implicated as a risk factor in several studies, our study failed to show such correlation. In previous studies implicating ECAD as a risk factor, the number of patients in the study group and the number of severe stenosis cases were higher, leading to an increase in preoperative stroke in CABG.[3,4,16] The most likely explanation for the failure of our study to show

such correlation was probably due to the inclusion criteria (elective, isolated CABG surgery, normal sinus rhythm, and EF >30%), therefore, patients with severe carotid stenosis culminating in causing simultaneous endarterectomy were not included in this study.

Our study indicates that ICAD increases the risk of post–CABG CNS complications. It has determined ICAD as an independent risk factor for the prediction of these postoperative complications. Very few studies have focused on this issue and only in one comprehensive study this correlation was emphasized.[1] Although MRA can be used to study intra-and-extracranial vessels, this is an expensive method and not applicable to all patients. The TCD has been shown to have the capability of evaluating major intracranial vessels and their stenosis.[17] Currently, TCD is relatively cheap, widely available, accurate and without side effects, and it is considered as the best method, although it has its own pitfalls, such as being operator dependent and has poor or absent temporal window for TCD in 5-19%.[8,18] Regarding to the loss of correlation between ICAD and territory of stroke, it seems that CABG can provoke a systemic inflammatory response and in this process brain arteries may be randomly involved.[19] The number of involved intracranial arteries indicates the background of the intracranial arterial system, and the more intracranial involvement, the more susceptibility to systemic processes, such as CABG.

Stroke is a major complication and clearly affects the outcome of CABG. In our study, 4 patients suffered stroke and one was severely debilitated. There was a strong correlation between ICAD and post-CABG stroke (p=0.007). Since only 4 stroke patients were included in our study, more detailed research, with a greater number of patients is recommended. Due to the known difference in prevalence and incidence of ICAD and ECAD between the Caucasian and Asian population,[5,6] we also stress multicentre studies in this issue to confirm the present conclusion.

Our results indicate that ICAD as an independent risk factor increases post–CABG complications. The TCD, which is an inexpensive and noninvasive method of evaluating intracranial cerebral vessels can determine high risk patients and it is recommended preoperatively.

Acknowledgment. *This study was supported by the Research Vice Chancellor office of Tabriz University of Medical Sciences. The authors appreciate: Dr. Afrasiabi, Dr. Hashemzadeh, Dr. Khalili, and Dr. Nasiri, for the referral of the CABG patients, and the staff of the cardiosurgery and neurodiagnostic wards of our university hospitals.*

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