International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2017): 7.296

Atherosclerotic Carotid Artery Disease in Patients Undergoing Coronary Artery Bypass Graft Surgery

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Abstract: ***The prevalence of atherosclerosis has increased steadily due to aging population. The aim of the study was to estimate the prevalence of carotid artery disease in patients undergoing coronary artery bypass surgery. We included 405 consecutive patients with coronary artery disease (CAD) scheduled to undergo coronary artery bypass graft surgery (CABG) at the University Hospital Centre "Mother Theresa". Of 405 patients constituting our population during the period of the study, there were 341 males (76%) and 64 females (15.8%). The mean age of patients was 62.4 (±7.8) years, with a range 42-83 years. Overall 86 (21.2%) patients had a carotid artery stenosis ≥50%. A significant increasing trend of the prevalence of stenosis with increasing age was found (p=0.04). Preoperative diagnosis of carotid disease is very important in reducing the risk of perioperative stroke after cardiac surgery.***

Keywords: carotid arteries; atherosclerosis; coronary artery disease; coronary artery bypass grafting

1. Introduction

The prevalence of atherosclerosis has increased steadily due to aging population. Economic development and urbanization have promoted habits of diet rich in saturated fat and diminished physical activity, which favors atherosclerosis (1). Traditionally two types of atherosclerosis were described, spontaneous and accelerated (2). Accelerated atherosclerosis mainly occurs in patients after heart transplant, coronary artery bypass graft (CABG), and percutaneous transluminal coronary angioplasty (PTCA) (3). Although atherosclerosis is believed to progress over many years, it has been increasingly noted to progress over few months to 2-3 years in few patients without traditional factors for accelerated atherosclerosis. Hence the term rapid progression of atherosclerosis has been used in recent years. Vascular injury in the form of endothelial injury is a critical initiating event in pathogenesis of both spontaneous and accelerated atherosclerosis (4). In spontaneous atherosclerosis, there is chronic damage to arterial endothelium by turbulence of blood flow or other injuries, which leads to non-denuding functional alterations of endothelial cells (type 1 injury). This leads to lipid accumulation, the initial predominant feature in this type. Adhesion of monocytes and platelets either simultaneously or at a later time occurs. Along with altered endothelium, these cells release various growth factors, leading to migration and proliferation of smooth muscle cells. This ultimately forms a typical atherosclerotic plaque (5). In contrast to spontaneous atherosclerosis, accelerated atherosclerosis is initiated by significant denuding endothelial injury (type 2 or 3 injury). Once endothelium is denuded, immediate platelet aggregation and thrombus formation occur on subendothelium. Intact endothelium is a potent inhibitor of growth of smooth muscle cells. Hence endothelial denudation leads to early smooth muscle cell proliferation and fibrosis mediated by various factors released by platelets, leucocytes, and smooth muscle themselves. Accumulation of lipids occurs late in accelerated atherosclerosis (6) Significant carotid artery stenosis (CAS) is an important incremental risk factor for the development of perioperative neurologic injury following coronary artery bypass grafting (CABG) (7). Association of carotid disease with coronary artery disease has been confirmed in previous studies, but the true incidence in different patients population, especially in patients with high incidence of risk factors was not addressed in details. Carotid sonographic screening (duplex and color Doppler sonography) is readily performed before elective bypass surgery at many institutions to identify such patients, although the clinical approach taken after their identification remains in contention (initial endarterectomy, combined endarterectomy and bypass, close post bypass monitoring with later endarterectomy) (8). The aim of the study was to estimate the prevalence of carotid artery disease in patients undergoing coronary artery bypass surgery.

2. Material and Methods

This is a cross-sectional study. We included 405 consecutive patients with coronary artery disease (CAD) scheduled to undergo coronary artery bypass graft surgery (CABG) at the University Hospital Centre "Mother Theresa". Coronary angiographic findings, carotid artery findings, and other patient parameters like age, sex, diabetes mellitus, dyslipidemia, family history, history of smoking, hypertension, history of stroke and left ventricular ejection fractions were all noted from case files. All these factors are known to be associated with carotid artery stenosis. All patients underwent ultrasonic examination of the neck to determine the presence of atheromas and hemodynamic stenoses involving carotid arteries bilaterally. Thereafter they were divided in four groups according to carotid artery stenosis: 1 - normal, 2- <50% carotid stenosis, 3 - 50-69% carotid stenosis and 4 - ≥70% carotid stenosis.

3. Results and Discussion

Of 405 patients constituting our population during the period of the study, there were 341 males (76%) and 64 females (15.8%). The mean age of patients was 62.4 (±7.8) years,

with a range 42-83 years. Table 1 shows the frequency of patients by age and associated stenosis. The majority of patients (64.9%) were below age of 65. Overall 86 (21.2%) patients had a stenosis ≥50%. A significant increasing trend of the prevalence of stenosis with increasing age was found (p=0.04).

Risk factors in association with carotid artery disease are listed in table 2.

Dyslipidemia, carotid bruit and left main artery disease are significantly associated with carotid artery stenosis ($p < 0.01$).

Phenomenon of arteriosclerosis, as a pathophysiology of the coronary and carotid arteries, is expected to accompany these diseases. In Western countries, the incidence of carotid stenosis in patients with severe coronary artery disease is 2-18% (10). In Japan, the incidence of carotid stenosis in patients with severe coronary artery disease is 13.7%. In Tamimoto's study the prevalence of carotid stenosis in patients with multivessel coronary disease was 29.8% (11). In other studies stenosis of carotid arteries in patients undergoing CABG surgery was very low 2.9% (12). In our study, the prevalence of carotid stenosis in patients with coronary artery disease was 21.2%, which is consistent with reports from western countries, therefore, race and environmental facilities seem to be involved. In the study of Evagelopoulos, the mean age of patients with coronary artery disease with involvement of carotid arteries was 66.4 years (13) and the mean age of patients in Fukud's study was 65.3 years (14). In our study, patients with carotid stenosis were in the 6th decade of life consistent with many other countries. In several studies it is determined that the disease of carotid stenosis is associated with age, hypertension, diabetes, history of MI, history of prior CABG, and severity of coronary artery disease. Besides, the age and severity of coronary artery disease are independent risk factors on carotid stenosis. Age was reported as an important factor in patients undergoing CABG surgery with carotid artery disease (15). In our study, dyslipidemia ($p<0.01$), carotid bruit ($p<0.01$) and left main artery disease ($p<0.01$) were significantly associated with carotid stenosis. Open heart surgery and coronary artery bypass can have such complications as bleeding, infection, heart attack and stroke. Contrary to other complications, stroke is an irreversible and debilitating disorder. Thus, it may neutralize the benefits of bypass surgery in the coronary artery stenosis. Despite several studies that have investigated carotid artery diseases as a risk factor for stroke after CABG (16), the possibility that carotid artery disease can be a factor of stroke following heart surgery is still controversial. Some studies have statistically suggested that carotid disease has not been the only factor of stroke in CABG operations (17). In another study, carotid disease has been reported as a risk factor of stroke after coronary artery bypass surgery (20). Considering the differences, it seems necessary to prepare a protocol for screening candidates for surgery of coronary artery bypass. Yet, such a protocol for screening this kind of patients for carotid artery disease is not available. Some researchers mentioned some criteria such as age, audible bruit, history of stroke, carotid surgery, peripheral vascular disease, diabetes, and hypertension (18).

Association of carotid disease with coronary artery disease has been confirmed in previous studies (19), but the true incidence in different patient population, especially in patients with high incidence of risk factors was not addressed in details. To date, no selection criteria have been definitively proposed to identify patients for carotid sonographic screening before elective CABG. Recently, based on the results of many studies, there is a change in the approach from use of routine screening to use of selective screening for carotid stenosis in CABG patients. We now screen only those patients who have a history of stroke or of transient ischemic attack, carotid bruit, left main disease, previous carotid endarterectomy (CEA) or stenting, amaurosis fugax, or new-onset extremity weakness. Studies have shown that selective screening in certain high-risk patients can detect 50% carotid stenosis with 100% sensitivity (20). These high-risk patients include women and those with a history of diabetes, hypertension, peripheral arterial disease, carotid disease, stroke, left main artery disease, and smoking. Durand and colleagues (16) conducted a study to determine which of 2 approaches—selective or nonselective preoperative carotid screening—is most clinically efficacious. They found that selective screening using a risk-profiling algorithm based on patients being aged >65 years, having carotid bruit on exam, and having a history of stroke would have reduced the screening load by 40%, with a negligible effect on either surgical management or stroke. Given these findings and the findings of our study, a more targeted approach for preoperative carotid artery evaluation seems reasonable. Additionally, guidelines recommend screening in selected patients only (21).

In patients undergoing CABG, the risk factors for coronary artery disease are the risk factors for cerebrovascular disease and stroke as well. It has been well established that CABG patients with significant carotid stenosis are at increased risk of stroke. According to The Society of Thoracic Surgeons database, the risk of stroke during CABG is 2% when the patient has severe stenosis, defined as greater than 75% carotid artery disease, compared to a 1% risk of stroke in patients without significant carotid disease (22). These may seem like small numbers, but another way to look at it is that, with severe carotid stenosis, the risk of stroke is doubled in our CABG patients. Logically, it would follow that, by casting a broad net with a liberal use of carotid ultrasound screening, we may catch severe carotid stenosis, allowing us to change our operative plan, and subsequently, the outcome. Unfortunately, multiple reports have demonstrated that unilateral carotid stenosis is not only a risk of stroke, but also a marker that the risk of stroke is increased, not only in the ipsilateral side, but also, in the contralateral sides as well. In addition, there continues to be debate as to whether carotid intervention with CABG improves neurologic outcomes. The report from the Cleveland Clinic experience with nonselective carotid artery ultrasound screening in patients undergoing coronary artery bypass shows that, in a period of 2-1/2 years, almost 90% of their isolated CABG patients had carotid duplex studies. Even though they identified severe carotid artery disease in 6.2% of those patients, their conclusions were that routine carotid evaluation altered the management in only a minority of these patients, and that did not seem to translate into a

decreased risk in the perioperative stroke rate (23). On that basis, they are advocating for a more targeted approach for the use of preoperative carotid screening, which is certainly a positive movement toward being good stewards of health care resources.

4. Conclusion

There is a significant incidence of carotid artery disease in patients undergoing CABG. Routine Doppler ultrasound screening of these patients on list for cardiac surgery will identify patients with carotid artery disease and may help in reducing the risk of perioperative stroke and neurological complications. Preoperative diagnosis of carotid disease is very important in reducing the risk of perioperative stroke after cardiac surgery. Carotid duplex screening is a non-invasive cost-effective method for preoperative screening.

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Table 1: Distribution of patients by age group and type of stenosis

Age group	No stenosis	Stenosis <50%	Stenosis ≥50%	Total
≤45	2 (28.6)	4 (57.1)	1 (14.3)	7 (1.7%)
46-55	12 (19.0)	43 (68.3)	8 (12.7)	63 (15.6%)
56-65	22 (11.4)	134 (69.4)	37 (19.2)	193 (47.7%)
>65	11 (7.7)	91 (64.1)	40 (28.2)	142 (35.1%)
Totali	47 (11.6)	272 (67.2)	86 (21.2)	405

Table 2: Risk factors in association with carotid artery disease

Variables	No stenosis	Stenosis <50%	Stenosis ≥50%	P
Dyslipidemia	23 (7.6)	206 (67.8)	75 (24.7)	**<0.01**
Diabetes mellitus	17 (10.4)	109 (66.9)	37 (22.7)	0.7
Smoking	27 (15.7)	113 (65.7)	32 (18.6)	0.09
Hypertension	34 (9.7)	240 (68.2)	78 (22.2)	0.3
1-vessel CAD	3 (13.6)	17 (77.3)	2 (91.1)	0.3
2 -vessel CAD	14 (14.1)	67 (67.7)	18 (18.2)	0.4
3-vessel CAD	30 (10.6)	188 (66.2)	66 (23.2)	0.5
CAD (total)	47 (11.6)	272 (67.2)	86 (21.2)	1
Left main artery disease	13 (10.0)	84 (64.6)	33 (25.4)	**<0.01**
Carotid bruit	0	39 (34.8)	73 (65.2)	**<0.01**