Original Article

Combining carotid endarterectomy with off-pump coronary artery bypass graft surgery is safe and effective

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Abstract

Background: We, as neurologists, are frequently consulted to give neurological clearance for surgery in patients who are undergoing coronary artery bypass graft (CABG) surgery and have suffered from stroke or transient ischemic attack (TIA) in past. Similarly clearance is also sought in another group of patients who, though have not suffered from stroke or TIA, but found to have significant carotid stenosis on routine screening prior to surgery. Cardiac surgeons and anesthetists want to know the risk of perioperative stroke in such patients and should carotid endarterectomy (CEA) be done along with CABG. In absence of any clear-cut guideline, neurologists often fail to give any specific recommendation. **Aim:** To find out safety and efficacy of synchronous CEA in patients undergoing CABG. **Design:** Retrospective study. **Materials and Methods:** Out of 3,700 patients who underwent CABG, 150 were found to have severe carotid stenosis of >70%. Out of this, 46 patients with >80% stenosis (three symptomatic and 43 asymptomatic) and one patient with >70% symptomatic carotid stenosis (TIA within last 2 weeks) were taken for simultaneous CEA along with CABG. These three symptomatic carotid patients had suffered from stroke within last 6 months. **Results:** One patient with asymptomatic near total occlusion of carotid artery suffered from hyperperfusion syndrome. None suffered from ischemic stroke, myocardial infarction (MI), or death during perioperative period. **Conclusion:** Combining CEA along with CABG is a safe and effective procedure.

Key Words

Carotid endarterectomy, coronary artery bypass graft surgery, off-pump CABG, peri-operative stroke

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Introduction

In patients undergoing coronary artery bypass graft (CABG) surgery, significant but asymptomatic internal carotid artery (ICA) stenosis is found in 8-10%. Stroke is a devastating complication after CABG surgery, occurring in up to 3% of patients, and those patients who have considerable carotid disease represent a particularly high-risk category of patients.[1] After the North American Symptomatic Carotid Endarterectomy Trial (NASCET)[2] and Asymptomatic Carotid Atherosclerosis Study (ACAS)[3] demonstrated that carotid endarterectomy (CEA) reduced the risk of stroke in patients with ICA stenosis, CEA is increasingly being performed alongside of CABG surgery for stroke prophylaxis. The goal of cardiothoracic surgeons is to minimize the risk either by revascularizing the stenotic carotid artery followed by CABG or in the reversed fashion. However, studies have found that the patients who undergo CABG prior to CEA will have increased risk of stroke. On the other hand in patients where CEA is done prior to CABG, there is risk of myocardial infarction (MI).[4]In order to decrease the rate of mortality and risk of MI and stroke, performing a CEA and CABG simultaneously (CEA/CABG) has been proposed, provided that the combined operation can be performed safely. Present study was a retrospective analysis of safety and efficacy of CEA combined with CABG in patients with severe carotid stenosis requiring CABG surgery.

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Materials and Methods

Data of all patients who underwent CABG in our hospital from January 2010 to December 2011 was analyzed. To assess the degree of stenosis of ICAs, carotid Doppler was done preoperatively in all patients. Computed tomography angiogram (CTA) or magnetic resonance angiogram (MRA) was done to confirm the degree of stenosis in patients who had 50% or more stenosis of carotid artery oncarotid Doppler. Carotid stenosis was defined as severe if stenosis was >70% and symptomatic if there was any history of stroke or transient ischemic attack (TIA) within last 6 months involving same side. Near total occlusion was defined as severe stenosis

of >95% with distal collapse of vessel. Initially all patients with symptomatic carotid stenosis of >70% were considered for simultaneous CEA, but after release of American Heart Association (AHA) guidelines in February 2011, patients only with >80% symptomatic stenosis were considered for combined procedure. Similarly patients with asymptomatic >80% carotid stenosis were also subjected to CEA along with CABG, if there was no contraindication. The eligibility for CEA along with CABG or isolated CABG was determined based on the joint decision of the cardiologist, cardiac surgeon, and neurologist. Patient with intracranial stenosis that exceeded the severity of the extracranial stenosis were excluded. Patients with total occlusion of internal carotid were also excluded.

The CEA was done after a median sternotomy and after harvesting the conduits; off-pump CABG was followed thereafter. CEA was performed by a vertical incision anterior to the sternocleidomastoid, thus exposing the common carotid artery, ICA, and the external carotid artery. The patient was heparinized by giving 2 mg/kg heparin. The artery was opened through a longitudinal incision followed by an endarterectomy. The arteriotomy was closed either directly or by a saphenous vein patch or polytetrafluoroethylene patch. Care was taken to keep the systolic blood pressure above 120 mmHg and, if need be, inotropic agents were started to maintain adequate blood pressure and cerebral flow. The Octopus tissue stabilization systems (Medtronic, Minneapolis, MN) or the Cardiothoracic Systems (CTS, Cupertino, CA) were used for mechanical stabilization of the heart while performing all distal anastomosis. Intracoronary shunts (Baxter Anasta FLO intravascular shunt; Baxter, Irvine, CA) were used in most of the patients. The neck wound was closed with or without a drain, only after complete reversal of heparin by protamine after CABG and after achieving good hemostasis.

In our center, all postoperative CABG patients undergo continuous cardiac monitoring for the first 3postoperative days. All patients have a pulmonary artery catheter inserted after induction of anesthesia, which is removed on day 3 of surgery. A 12-lead electrocardiogram is also done daily for first 3 days after surgery in all patients. Review echocardiogram and cardiac enzymes are performed in patients who show fresh electrocardiogram (ECG) changes, raised pulmonary artery pressures, or hemodynamic instability or atrial/ ventricular arrhythmias in the post-operative period.

Results

A total of 3,700 patients underwent off-pump CABG during this period of 24 months. Carotid stenosis of >50% was found in 254 patients on carotid Doppler. All these patients were subjected to CTA (MRA was done in five patients in whom CTA was not possible because of deranged kidney functions). On CTA (or MRA), total 150 patients (4%) had severe carotid stenosis (>70%). Tables 1 and 2 depicts the characteristic of carotid stenosis in symptomatic (n = 12) and asymptomatic (n = 138) groups. Of this, 47 patients (four symptomatic and 43 asymptomatic) were subjected to combined surgery. All these 47 patients were suffering from symptomatic coronary artery disease (CAD) with history of either acute coronary syndrome (two patients), prior MI (nine patients), and angina or dyspnea on exertion. On echocardiography, ejection fraction was found to be 25-40% in 12 patients, while it was 50-60% in remaining 35 patients. Forty-two patients had triple vessel disease, while five patients were suffering from double vessel disease. Left main coronary artery was diseased in 11 patients. Their CAD was not amenable to percutaneous transluminal coronary angioplasty (PTCA) or stenting, and they had viable endocardium as confirmed by dobutamine stress echo (DSE) or positron emission tomography (PET).

Symptomatic group of four patients comprised of one patient who had suffered from TIA within last 2 weeks and had carotid stenosis of >70%, but less than 80% on CTA; and three patients who had suffered from stroke within last 6 months, but not within last 2 weeks and had >80% stenosis on CTA. Post-stroke treatment record of these three patients could not be traced. In asymptomatic group of 43 patients, all had carotid stenosis of >80% as confirmed on CTA. None suffered from perioperative ischemic stroke, but one patient with near total occlusion (asymptomatic group) suffered from hemorrhagic stroke on ipsilateral side following CEA. All the patients were followed-up till discharge from the hospital. None had any cardiovascular or cerebrovascular complication during this period. Though MRI with diffusion-weighted images (DWIs) might pick up silent infarcts in these patients, it is not feasible in post CABG patients because of pacing wires and sternal wires in immediate postoperative period. CT was done in three patients, who had delirium in the early postoperative period, and it did not reveal any fresh ischemic infarction. Their delirium was attributable to perioperative encephalopathy (pain, intensive care unit (ICU) setting, sepsis, metabolic encephalopathy, etc.). However, possibility of tiny silent infarction cannot be ruled out in these patients. All the patients were discharged from the hospital in stable condition without any fresh neurological deficits. Patient with perioperative hemorrhagic stroke following CEA also recovered well (mRS 0-1) at the end of 1 month.

Discussion

While discussing role of carotid revascularization in patients undergoing CABG, we should first discuss reasonableness or rationale of doing so and then should discuss feasibility, that is, safety and efficacy of such procedures. As per a systematic review, the risk of stroke after CABG was <2% in patients with no significant carotid disease, 3% in asymptomatic patients with 50-99% stenosis, increasing to 5% in those with bilateral 50-99% stenosis and 7-11% in patients with carotid occlusion.[5] Moreover, the risk of perioperative stroke in CABG

Table 1: Symptomatic patients (n = 12)

Unilateral ICA stenosis > 70% but <80%(no significant intracranial stenosis)	Unilateral ICA stenosis>80%(no significant intracranial stenosis)*	Unilateralcarotid stenosis >70% (intracranial >extracranial stenosis)	Unilateral ICA occlusion	Bilateral ICA occlusion	Unilateral ICA occluded (contralateral near total occlusion)
1 (8.3)	3 (25.0)	3 (25.0)	0	4 (33.3)	1 (8.3)

ICA = Internal carotid artery

Table 2: Asymptomatic patients (n = 138)

Unilateral stenosis >80% (normal contralateral ICA with no significant intracranial stenosis)*	Severe unilateral intracranial stenosis >extracranial stenosis >80%)	Unilateral near total occlusion**	Unilateral ICA occlusion	One ICA occlusion and>80% stenosis of contralateral ICA with severe intracranial stenosis	One ICA occlusion and>80% stenosis of contralateral ICA (normal intracranial ICA)*	Bilateral severe Stenosis (one ICA >70% other 80% but no occlusion)		Unilateral ICA stenosis >70% but <80%
						No significant intracranial disease*	Intracranial stenosis >extracranial stenosis	
37 (26.8)	33 (23.9)	3 (2.2)	10 (7.2)	3 (2.2)	2 (1.4)	3 (2.2)	8 (5.8)	39 (28.3)

*Patients taken for combined CEA and CABG, **one patient was taken for combined CEA and CABG, suffered from hyperperfusion syndrome. CEA = Carotid endarterectomy, CABG = Coronary artery bypass graft, ICA = Internal carotid artery

patients who report a prior TIA or stroke has been associated with a fourfold increased risk as compared to the risk for asymptomatic patients.[6] Therefore, it seems appropriate to offer prophylactic CEA to symptomatic severe carotid artery stenosis (CAS) patients who are undergoing CABG.[7] However, it is not determined whether overall cardiovascular risk of death, stroke, and MI was significantly increased in patients with severe carotid and coronary disease undergoing isolated CABG, especially in patients with asymptomatic ICA stenosis of >80%. There are papers that have reported low risk of ipsilateral stroke in patients with significant carotid stenosis who underwent isolated CABG.[8] In a retrospective analysis of 878 consecutive patients who underwent isolated CABG, patients with severe CAS were compared with those without severe CAS to assess the rates of stroke during hospitalization for CABG. Patients with severe CAS had similar rates of in-hospital stroke compared with patients without severe CAS.[9] Similarly in another study which compared the outcomes of patients who underwent carotid artery stenting followed by CABG with the outcomes of those who underwent isolated CABG without carotid intervention, the risk of ipsilateral stroke in the isolated CABG approach in patients with concomitant coronary and carotid stenosis was found to be small, and there was no evidence that this risk is lessened by prophylactic carotid stenting.[10] In a recently published systematic review also, favorable clinical outcome without any stroke in patients with carotid and CAD undergoing isolated CABG have been described.[11]

However, these data represent a fraction of data compared to the vast amount of previous information demonstrating a high stroke incidence (9.2-11.5%) in isolated CABG.[12] A recent meta-analysis estimated that prophylactic carotid revascularization would prevent 40-50% of perioperative stroke in these patients.[13] Since previous cohort studies showed mixed results, necessity of a randomized controlled trial (RCT) has been advocated. A recent RCT showed that patients undergoing prophylactic or simultaneous CEA + CABG had lower stroke rates (0%) compared with delayed CEA 1-3 months after CABG (7.7%), without significant perioperative mortality difference. This study included patients with unilateral asymptomatic carotid stenosis of >70% requiring CABG.[14] An earlier partly randomized trial also showed better outcomes for patients undergoing simultaneous procedures.[15] An explanation for why many systematic reviews previously failed to show compelling evidence supporting prophylactic CEA may be because they did not analyze different cohort qualities (symptomatic/asymptomatic carotid disease, degree of carotid stenosis, severity of coronaries, and on-pump/off-pump surgery).

Besides two RCTs discussed earlier, safety and efficacy of combined CEA, especially with off-pump CABG in patients with significant concomitant carotid and CAD was also found superior when compared with other techniques and was reported by us long back and by others recently.[16,17] In one meta-analysis of 56 studies and another systematic review of 94 studies, reverse staged procedures (CABG-CEA) were found to be associated with the highest risk of ipsilateral stroke and lowest risk of MI. The risk of stroke was lowest and of MI was highest in patients undergoing staged CEA-CABG. Overall risk of all types of cerebrovascular complications (stroke,

MI, and death) was lowest in combined CEA + CABG group. Hence RCTs, systematic review, meta-analysis, and our own experience; all favor combined surgery as a safe option in cases of severe CAS undergoing CABG.[18,19] As per a recently published best evidence topic also, current evidence leans towards simultaneous CEA-CABG.[17]

Can carotid artery stenting be a better modality in such patients? The results of large studies such as the SAPPHIRE trial have led to the consideration of coronary artery stenting as a preferred revascularization modality for CABG candidates with significant carotid stenosis on account of the fact that majority of them have high operative risk factors for CEA.[20] A meta-analysis of 30-day outcome following staged carotid artery stenting before coronary bypass surgery showed that carotid artery stenting plus CABG is an attractive and less invasive alternative to CEA+ CABG.[11] Although the number of reported studies and included patients are so far very small. Besides this, need for aggressive antiplatelet therapy, and the hemodynamic changes during the procedure makes this strategy unsuitable for the patients with unstable coronary disease.[21] Periprocedural treatment with antiplatelet therapy increases the risk of life-threatening bleeding associated with CABG, and if this therapy is delayed, risk of stent thrombosis and subsequent stroke is very high.

AHA recommends that for patients with a TIA or ischemic stroke within the past 6 months and ipsilateral severe (70-99%) CAS as documented by noninvasive imaging (CD, CTA, and MRA), CEA should be done, if the perioperative morbidity and mortality risk is estimated to be less than 6%.[22] All our patients were admitted primarily for symptomatic CAD and were planned for CABG based on joint decision of cardiologists and cardiothoracic surgeon. Carotid Doppler was done as a part of routine screening in all these patients, which revealed carotid stenosis in 254 patients. Stenosis of >70% was confirmed by doing CTA (or MRA in five who had derangement of renal functions) in 150 patients. Decision to do CEA along with CABG was done in all 47 eligible patients on the basis of CTA findings. The combination of carotid Doppler and CTA is an acceptable method for the quantification of severe CAS in a substantial number of patients, thus avoiding digital subtraction angiography (DSA) as an invasive and potentially harmful procedure.[23] DSA was not done in any of our patients.

AHA guidelines further recommends that CEA preferably be performed within 2 weeks of nondisabling stroke or TIA, if there is no contraindication (Class IIa; level of evidence B).[22] One of our patient had TIA within last 2 weeks of admission for CABG and he was subjected to combined approach. However, it should be noted that the risk for perioperative intracranial hemorrhage (ICH) may be increased with early surgery in patients with major cerebral infarction or stroke in evolution. When carotid revascularization is considered concurrent with myocardial revascularization surgery, recent AHA guidelines recommend CEA in patients with >80% stenosis who has suffered from ipsilateral stroke or TIA within last 6 months (level of evidence: C).[24] Three of our patients presented with symptomatic CAD and symptomatic carotid disease was diagnosed during process of preoperative screening. Since these patients had symptomatic stenosis of >80% and stroke had occurred within last 6 months, they were taken for combined surgery. Only one patient with history of TIA within last 2 weeks and carotid stenosis of <80% (>70%) was operated for simultaneous procedures. But this case was done prior to release of recent AHA guidelines in February 2011. After these guidelines, we changed our policy and now only patients with >80% stenosis are subjected to combined surgery.

For asymptomatic severe carotid stenosis patients, it is reasonable to perform CEA if stenosis is more than 70% and risk of perioperative stroke, MI, and death is low (Class IIa, level of evidence: A).[22] On the other hand with availability of best medical therapy including statins, better antiplatelets and antihypertensive medications, natural history of asymptomatic carotid stenosis has become more benign than what transpired from Asymptomatic Carotid Atherosclerosis Study (ACAS)[3] and European Asymptomatic Carotid Surgery Trial (ACST),[25] which were done long back before the availability of these agents. Recent studies have suggested that the annual risk of ipsilateral stroke in asymptomatic patients with ICA stenosis treated with modern medical therapy is less than 2% per year.[26] Hence, CEA is now recommended in asymptomatic CAS patients only when stenosis is hemodynamically significant (i.e.,>80%) and patient is having life expectancy, which exceeds 5 years. But when it comes to safety and efficacy of concurrent CEA and CABG, recent AHA guidelines state that same is not well-established in asymptomatic stenosis of >80% (level of evidence: C). However, it also states that clinical practice must follow a patient-specific approach and stresses the need to conduct a properly designed prospective study to answer these issues.[24]

Doing CEA along with CABG is a routine practice in our institute if severe carotid stenosis is found in patients undergoing CABG and patients fulfill the criteria for the same. It is also important to note that most of our patients are operated with off-pump technique unless there is any specific indication for the use of on-pump surgery. Out of 47 patients opted for combined approach, none suffered from ischemic stroke after surgery. Only one patient with near total occlusion had ipsilateral ICH because of hyperperfusion syndrome. A rapid restoration of normal perfusion pressure following CEA may result in hyperperfusion in regions of the brain that have impaired autoregulatory capacity.[27] Risk factors for this syndrome include long-standing hypertension and high-grade stenosis. This patient suffered from faciobrachial paresis, and made almost complete recovery within 1 month. After this initial setback, all patients (three in number) with near total occlusion were not taken for CEA.

Absence of any significant complications (stroke, MI, or death) reflects competence and expertise of our surgeons, same team of surgeons is doing this type of surgery for many years in our high volume center.[16] While the European Society of Vascular Surgery (ESVS) Guidelines recommend as appropriate management of patients with concomitant severe coronary and carotid artery disease an individualized surgical approach,[28] we strongly feel that combined approach is the best option, if done in a high volume center, if surgical team has good experience and off-pump CABG is a better technique as compared to on-pump. AHA guidelines also suggest that combined CEA + CABG is acceptable in patients with severe CAS, provided CEA can be performed in asymptomatic patients

in the surgeon's routine practice with a death/stroke rate of <3%. At the same time it downgrades the recommendation to uncertain if procedural risk is more than that.[29]

Because carotid revascularization has proven its value in preventing risk of future ischemic stroke in patients with severe carotid disease, it seems appropriate to correct it in conjunction with CABG to achieve any additional protection from perioperative stroke that this approach may provide. Synchronous CEA/CABG also offers the economic benefit of avoiding two separate procedures/hospitalizations and advantage of patients being exposed to only one anesthesia. Limitations of this study are those inherent to retrospective studies.

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