Combined Carotid Endarterectomy and Coronary Artery Bypass Grafting : Review

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Abstract

Considerable progress has been made over the last 2 decades in diagnosing and treating patient with ischaemic heart and atherosclerotic carotid diseases.

Next to operative mortality, an irreversible perioperative cerebrovacular accident is the most dreaded perioperative complication of myocardial revacularisation; primarily because of the devastating consequences to the patient and because of the significantly increased cost of hospitalization and post hospital care. Perioperative stroke following coronary artery bypass grafting increasingly concerns the cardiac surgeon, because the average age of coronary bypass patients continues to rise and with it the risk of stroke. This article will elaborate the relationship of carotid artery disease to perioperative neurologic complications following myocardial revacularisation, evaluate treatment options and provide guidelines on optimum patient selection and timing for each intervention either isolated or in combination.

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Magnitude of the problem :

To better understand the magnitude of the problem of perioperative cerebrovascular accidents after CABG, one need only to review the literature on the rising incidence of stroke.

John et al[1] reported that the New York State Cardiac Surgical Database recorded a stroke rate of 1.4% in 19,224 patients having coronary artery bypass grafting in 1995. In their review of 10,860 patients having myocardial revacularization between 1986 and 1996, Puskas et al[2] noted that stroke occurred in 2.2%. Multivariable predictors of stroke were age, previous TIA and carotid bruits. They also mentioned that perioperative stroke was associated with significantly more in-hospital morbidity, longer length of stay and almost twice the hospital cost. Patients in that study who suffered a perioperative stroke had a 23% hospital mortality rate. Roach et al[5] noted a 21% mortality rate for patients suffering a perioperative stroke following coronary artery bypass grafting and a mean hospital stay of 25 days among survivors.

In addition to death, the disability following stroke must be considered from the standpoint of the crippling effect on the patients as well as the socioechonomic burden on the patients, his or her family and society. Direct & indirect of the financial impact of stroke for calender year 1999 was estimated to be $45.3 billion cost in USA, where stroke is the 3rd leading cause of death.

Causes of perioperative stroke:

The most common cause of perioperative stroke is atherosclerotic or thrombotic embolic debris from the heart or major vessels. The aorta has been increasingly recognized as a source of embolic debris. Wareing et al have demonstrated that aortic atherosclerosis is an important contributor to perioperative neurologic injury.[4]

Embolism from diseased carotid arteries is a well-defined cause of perioperative neurologic injury. Evidence exists that the carotid plaque morphology has an important impact in the stroke risk for patients with carotid stenosis. It was found that ulcerated carotid plaques were significant incremental risk factor for stroke across all degrees of carotid stenosis[5]. Berner et al studied 4047 cardiac surgical patients and found a 9.2% rate of stroke or TIA in patients with asymptomatic carotid stenosis, which was significantly greater than the 1.3% rate of patients with no carotid stenosis.[6]

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Faggioli et al found the odds ratio for stroke increased 9.9 fold in the presence of a greater than 75% carotid stenosis. For patients over age 60 with a greater that 75% carotid stenosis, the stroke rate was 15% versus 0.6% for patients of the same age with no carotid disease.[7]

Thus adequate evidence exists that significant carotid artery stenosis is an important incremental risk factor for the development of perioperative neurologic injury following CABG.

Carotid stenosis in coronary artery bypass patients:

Faggioli et al found 8.7% of their patients had a carotid stenosis greater that 75%. The incidence rose from 3.8% for patients younger than 60 years to 11.3% for patients of 60.[7]

Berens et al reported results of routine carotid duplex ultrasonography in 1087 candidates for cardiac surgery and found greater that 50% stenosis in 17% and more than 80% stenosis in 5.9% patients.[8]

D'Agostino et al performed noninvasive carotid testing in 1279 coronary bypass candidates and found 20.5% had greater than 50% stenosis in at least one carotid artery and 1.8% had bilateral stenosis greater that 80%.[9]

Multivariable predictors of significant carotid disease in above studies were age, diabetes, female sex, left main coronary disease, history of TIA or stroke, peripheral vascular disease and smoking.

Evaluation of Carotid artery disease :

Physical examination : Palpation of carotid artery provides no useful information and theoretically can dislodge thrombus or embolic debris.

Auscultation of bruit over the neck may provide some evidence of a carotid artery stenosis, but it is neither diagnostic nor capable of revealing the degree of stenosis.[10] Indeed, as the degree of stenosis increases and approaches total occlusion, the bruit may fade and become inaudible.

Non-invasive testing **:** It is the procedure of choice for screening patients. It may be indirect or direct.

Indirect : I) Oculoplethysmography is the method of measurement of pressure in the ophthalmic artery, which in turn reflects the pressure on the distal internal carotid artery.

II) Transcranial Doppler assess ophthalmic and intracranial arterial flow and is useful in elucidating the status of collateral flow above a lesion at the origin or in the siphon of the ICA.

Direct : It consists of either duplex or triplex ultrasound scanning of neck arteries. In duplex study a range gated Doppler probe study the morphology of the vessel, presence and characteristics of plaques along with Doppler flow pattern and wave forms.

Triplex ultrasonsography or colour flow Doppler, combines with B-mode imaging of duplex scanning with a multi-gated pulse Doppler. Both methods are operator dependant and need patient's cooperation. If properly performed by a technically sound operator, interventional and routine follow-up can be done depending only on its findings.

Current indications[11] for performing non-invasive carotid testing include patients with :

1. An audible bruit in the neck
2. History of a prior stroke
3. History of transient ischaemic attacks (TIA)
4. Patients with severe peripheral vascular disease
5. Elderly patients.

MRI / MRA : It came in routine practice in the early 1990s and used to define the degree and location of carotid lesions. A severe stenosis is usually manifested by signal dropout when the stenosis is greater than 70%. This technique cannot distinguish total from near total occlusion and it is costly.

CTA : Computed tomography angiography produces better vascular images than with conventional CT. It has been favourably compared with contrast arteriography, which is technically difficult and probability with a number of complications. With 3-D reconstruction more reliable estimate of stenosis is possible However, calcifications can produce imaging artifacts in CTA. These artifacts may be incorrectly identified as stenosis. More over it can not identify ulcerated plaques like non invasive duplex ultrasound evaluation.

Invasive testing: Before the era of ultrasound evaluation, carotid angiography was the routine procedure of evaluation. This investigation is informative, however, with risk of complications like aortic dissection or embolization of debris from carotid lesion. Moreover the technique is quite expensive and not suitable for screening and follow-up.

Clinical recommendations:

It must be recognized that there is presently no clinical test that can give an absolute value for the degree of stenosis in every carotid artery.

Combination of duplex scanning and MRA has been recommended at several medical centers[12,13]. With this strategy, the tendency of MRA to overestimate the degree of stenosis should be balanced by the ultrasound findings. This combination of tests has been reported to be accurate in selection of patients of surgery.

Effectiveness of carotid endarectectomy as a treatment for carotid stenosis :

Until the 1990s there was considerable debate as to whether or not carotid endarterectomy (CEA) improves survival and yielded a lower incidence of neurologic events in patients with documented carotid stenosis.

In 1991 the results of the randomized North American Carotid Endarterectomy Trial (NASCET) of medical treatment or CEA in 659 patients were reported.[14] All patients had either hemispheric, retinal transient ischaemic attacks or nondisabling strokes within 120 days of entry into the trial in association with a 70% to 99% stenosis in the symptomatic carotid artery. The actuarial cumulative risk of ipsilateral stroke at 2 years was significantly lower at 3% in the 328 surgical patients versus 26% in the 331 medical patients. For major fatal ipsilateral stroked, the risk was 2.5% for surgical patients versus 13.1% for medical patients ($p<.001$). When all deaths and strokes were included in the analysis, carotid endarterectomy was still found to be better than continuous medical treatment.

The European Carotid Surgery trial randomized to medical or surgical treatment 2518 patients with a nondisabling stroke, TIA or retinal infarction in conjunction with stenosis in the ipsilateral carotid artery.[15] For the patients with severe stenosis of 70% to 99% the cumulative risk of stroked at CEA of 7.5%, plus an additional late stroke rate of 3 years of 2.8%, was less than the 16.8% rate for medically treated patients. At 3 years the cummulative risk of operative death and stroke, ipsilateral stroke and any other stroke was 12.3% for the surgical cohort versus 21.9% for the medical group ($p<0.05$). Finally the risk of fatal or disabling ipsilateral stroke at 3 years was 6.0% for the CEA patients versus 11.0% for the medical control patients ($p<0.05$). Thus with these trial reports, the superiority of CEA over continuous medical treatment for patients with symptomatic severe carotid artery stenosis is clearly established.

The results of Veterans Affairs Cooperative Study[16] of randomized medical treatment of CEA in 444 patients with asymptomatic carotid artery stenosis revealed 8% neurologic events in surgical patients versus 20.6% in medical group ($p<.001$). In 1995 the results of Asymptomatic Carotid Arteriosclerosis Study (ACAS) which randomize 1662 patients to either CEA or continued medical treatment, were published.[17] After a mean follow-up of 2.7 years, the aggregate risk for ipsilateral stroke and any perioperative stroke or death for the surgical group was 5.1%, which was significantly lower than the rate of 11.0% for medical group.

These trials have documented a significant advantage of CEA over continued medical management for patients with severe asymptomatic carotid artery stenosis.

Timing of carotid and coronary surgery :

Summerizing previous informations one is to accept that : (1) uncorrected carotid stenosis poses an important risk of neurologic events for patients with severe carotid and coronary artery disease who have only isolated coronary artery bypass grafting, (2) CEA is the indicated treatment for severe symptomatic and asymptomatic carotid stenosis, (3) Coronary artery disease is a significant contributor to the short and long-term risk for CEA patients and (4) Coronary artery bypass grafting is an indicated treatment for severe coronary artery disease. Now the important question is not the indications for but the timing of the 2 operative procedures. By convention performing the CEA before coronary artery bypass grafting is referred to as a “staged procedure”, while performing the coronary grafting followed by the carotid operation is called a “reversed staged “procedure.[11]

Most surgeons advocating a sequential operative approach to patients with severe combined disease usually do the CEA initially if the patient is haemodynamically stable and not ischaemic. However, the risk of a perioperative coronary ischaemic event remain a real threat.

Some cardiac surgeons have opted to perform an initial CABG followed by CEA for patients with unstable angina and asymptomatic carotid lesion. The principal risk with this approach is the potential for neurologic complications either during or shortly after the myocardial revascularization.

Currently concomitant CEA and CABG for virtually all patients with severe combined disease is advocated.[11,17] The strategy of performing both operative procedures during one anesthetic is based upon the premise that only such an approach in patients with severe combined disease can minimize cardiac events that frequently complicate isolated CABG. Moreover, doing the 2 operative procedures together is more cost effective in terms of number of anesthesia and additional hospital stay.[18,19]

Procedure of Choice:

The usual operative technique for concomitant CEA and CABG has been to perform the CEA during harvesting of coronary bypass conduits prior to cardio-pulmonary bypass.

The actual technique of CEA varies among vascular surgeons. Some surgeons use EEG monitoring and place an intravascular shunt if changes are noted on that study. Others routinely employ an intravascular shunt without using EEG monitoring. All these procedures go with or without patch (PTFE/ Vein/Dacron) closure of arteriotomy. A number of surgeons using eversion endarterectomy perform with or without intravascular shunts. After the CEA is completed, the neck incision is loosely approximated over a sponge. Final closure of the neck incision is performed after cardiopulmonary bypass is completed and heparinization is reversed. Some surgeons advocate performing the CEA on bypass with systemic and hypothermia to 20°C and heart protected with retrograde blood cardioplegia. These surgeons feel that hypothermia on cardiopulmonary bypass provides an extra margin of ischaemic protection for the brain during the CEA and avoids the need for intravascular shunting. Whether or not this approach of performing the carotid and coronary operations on cardiopulmonary bypass saves total operative time is not proven, but it does prolong aortic occlusion and cardiopulmonary bypass times, something most cardiac surgeons would preferably avoid. Recent publications have shown CEA and CABG are safe and effective using off- pump coronary artery bypass (OPCAB) even in patients with critical left main stem coronary stenosis.[20,21] It has been shown that the requirement for ionotropic support, prolonged length of stay, incidence of stroke and chest infections were significantly reduced in patients receiving OPCAB coronary surgery.

Postoperative management of patients following concomitant CEA and CABG does not differ importantly from the management of patients having isolated myocardial revacularisation. Maintenance of a good coronary perfusion pressure, and good cerebral perfusion pressure, in the early postoperative period is beneficial. Standard anticoagulation protocol consisting of aspirin within 6 hours of surgery is practiced. Additional heparin is used if prosthetic patch is used, or the patient has considerable residual disease higher in the carotid system that can not be approached, or there is uncorrected contralateral carotid disease. Early heparinization followed by long-tern anticoagulation with warfarin or clopidogrel is preferred in these cases.

Conclusion :

There are few areas in cardio-vascular surgery more controversial than the issue of combined carotid endarterectomy (CEA) and coronary artery bypass grafting (CABG). Although indications for both operations have been elucidated and techniques have been standardized, the results varies between centers.

The risk of perioperative stroke following myocardial revascularization is directly related to the increasing age of coronary artery bypass patients and this increasing age is accompanied by an increased incidence of carotid artery disease. It is well known from the NASCET and ACAS trials that the long-term stroke risk of medical therapy is far higher than the risk of CEA in patients who have high grade carotid stenosis. Excellent randomized trails have established the safety and efficiency of CEA as the most appropriate treatment for both symptomatic and asymptomatic severe carotid stenosis. Other randomized studies have demonstrated the advantage of a concomitant CEA and CABG over reversed staged operations. Therefore, if one is to improve the overall morbidity and mortality of patients and combined cardiac and carotid disease, concomitant CEA and CABG must be done.

References :

1. John R, Choudhuri AF, Wienberg AD,et al : Multicenter review of preoperative risk factors for stroke after coronary artery bypass grafting. *Ann Thorac Srug*, 2000; 69: 30.
2. Puscas JD, Winston D, Wright CE et al : Stroke after coronary artery operation : incidence, correlates, outcome, & cost. *Ann Thorac Srug*, 2000; 69: 1053.
3. Roach GW, Kanchuger M, Mangane CM et al. Adverse cerebral outcomes after coronary bypass surgery. *N Engl J Med.* 1996; 355; 185.
4. Wareing TH, Davila – Roman VG, Barzil IB et al: Management of the severely atherosclerotic ascending aorta during cardiac operations. *J. Thorc Cardiovasc Surg* 1992; 103: 165.
5. Eliasziw M, Streifler JY, Fox AJ, et al : Significance of plaque ulceration in symptomatic patients with high grade carotid stneosis. *Stroke* 1994; 25: 304.
6. Brener BJ, Brief DK, Alpert J, et al : The risk of stroke of patients with asymptomatic carotid stenosis undergoing cardiac surgery : follow up study. *J. Vasc Surg* 1987; 5: 269.
7. Faggioli GL, Curl GR, Ricotta JJ : The role of carotid screening before coronary artery bypass. *J. Vasc Surg* 1990; 12: 724.
8. Berens ES, Kouchoukos NT, Murphy SF, Wareing TH: Preoperative carotid artery screening elderly patients undergoing cardiac surgery. *J. Vasc Surg* 1992; 15: 313.
9. D'Agostino RS, Svensson LG, Neumar DT et al. Screening carotid ultrasonography and risk factors for stroke in coronary artery surgery patients. *Ann Thorac Surg* 1996; 62: 1714
10. Sauve JS, Thorpe KE, Sackett DL et al. Can bruits distinguish high-grade from moderate symptomatic carotid stenosis ? *Ann Intern Med*; 1994; 120: 633
11. Akins CW, Moncure AC. Myocardial revascularization with carotid artery dieseae. In Cohn LH, Edmunds LH Jr. ed. Cardiac surgery in the adults. 2nd edn, 2003, Mcgraw-hill, PP. 627-637.
12. Lustgarten JH, Soloman RA, Quest DO et al: Carotid endarterectomy after noninvasive evaluation by duplex ultrasonography and magnetic resonance angiography. *Neurosurgery*, 1994, 34: 612.
13. Turnipseed WD, Kennell TW, Turski PA et al: Combined use of duplex imaging and MRA for evaluation of patients with symptomatic ipsilateral high grade stenosis. *J Vasc Surg* 1993; 17: 832.
14. North American Symptomatic Carotid Endarterectomy Trial Collaborators : Beneficial effect of carotid endarterectomy in symptomatic patients with high grade carotid stenosis : *N Engl J Med* 1991; 325: 445.
15. European Carotid Surgery Trialist's Collaborative group : MRC European carotid surgery trial : interim results for symptomatic patients with severe (70-99%) or with mild (0-29%) carotid stenosis, *Lancet* 1991; 337: 1235.
16. Hobson RW, Weiss DG, Fields WS et al., Efficacy of carotid endarterectomy for asymptomatic carotid stenosis. *N Engl J Med* 1993; 328: 221.
17. Daily PO, Freeman RK, Dembitsky WP, et al : Cost reduction by combined carotid endarterectomy and coronary artery bypass grafting. *J thorac cardiovasc surg* 1996; 111: 1185.
18. Minami K, Gawaz M, Ohlmeier H, et al : Management of concomitant occlusive disease of coronary and carotid arteries using cardiopulmonary bypass for both procedures. *J Cardiovasc Surg*, 1989; 30: 723.
19. Weiss SJ, Suttar FP, Shanon TO, Goldman SM: Combined Cardiac Operation and Caroid endarterectomy during aortic cross clamping. *Ann Thorac Surg* 1992; 53: 813.
20. John CYL, Antony DG, Pullan DM; On-pump versus off-pump surgical revascularisation for left main stem stenosis : Risk adjusted outcomes. *Ann Thorac Surg.* 2005,80: 136-142.
21. Yugal M, Harpreet W, Vijay K, et al: Concomitant Carotid Endarterectomy and Coronary bypass surgery : outcome of on-pump & off-pump techniques. *Ann Thorac Surg.* 2004,78; 6,2037-42.