The role of combined carotid endarterectomy and coronary artery bypass grafting in the era of carotid stenting in view of long-term results

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Abstract

OBJECTIVES: The management of concomitant coronary and carotid artery disease is still in evolution. The surgical options are staged approach—carotid endarterectomy (CEA), followed by coronary artery bypass grafting (CABG) or a reversed-staged approach, or combined approach—CEA and CABG under the same anaesthesia. In view of the percutaneous carotid artery stenting option, we have reviewed our short- and long-term experience with combined CEA and CABG to define the role of this procedure.

METHODS: From January 1992 to December 2006, we operated on 80 patients performing combined carotid endarterectomy and myocardial revascularization. Short- and long-term results were reviewed.

RESULTS: Operative mortality was 3.7%. Perioperative cerebrovascular accident (CVA) occurred in 2 patients (2.5%). Perioperative myocardial infarction (MI) occurred in 3 patients (3.7%). Combined complications of death + MI + CVA = 10%. During the mean follow-up of 10 ± 3.2 years (1–14 years), 6 patients (7.6%) had neurological events. Freedom from neurological events for 10 years was 92 ± 4%. Nearly 17 (21.5%) had cardiac events. The 5-year and 10-year survival rates were 74 ± 5 and 62 ± 6%, respectively.

CONCLUSIONS: Although the short-term results of the non-surgical carotid therapeutic alternative is similar to our surgical results, there are limitations to carotid artery stenting: the need for aggressive antiplatelet therapy, and the haemodynamic changes during the procedure that may be unacceptable for patients with unstable coronary artery disease. Therefore, there is still a role for concomitant surgical CEA and CABG to the results of which the other options should be compared.

Keywords: CABG • Carotid endarterectomy • Combined

INTRODUCTION

The treatment of patients with concomitant coronary and carotid artery disease is still evolving. Although carotid stenting is increasingly performed in this setting, the haemodynamic changes that may accompany this procedure [1, 2] may be harmful to some of the patients. Patients with life-threatening coronary pathology such as left main coronary artery stenosis, proximal left anterior descending (LAD) coronary artery stenosis or severe three-vessel disease may not tolerate hypotension or bradycardia well during the stenting procedure [1, 2]. Surgical approach to both conditions may still be valuable in such patients. Patients with coronary disease whose carotid lesions are not suitable for carotid stenting may also need the combined surgical procedure.

The surgical options for coronary and carotid artery disease are either staged approach, with carotid endarterectomy (CEA) performed first, followed by coronary artery bypass grafting (CABG) or simultaneous (combined) approach, with both procedures performed under single anaesthesia. The reversed approach, in which CABG operation is performed first, yielded inferior results with cerebrovascular accident (CVA) rate >6% [3]. CEA in the presence of untreated coronary artery disease carries a 17% risk of perioperative myocardial infarction (MI) and a 20% risk of perioperative death [4]. Nevertheless, studies published in the 1980’s suggested an increased risk for combined procedures [5, 6] and recommended staged surgeries. Later studies reported favourable operative outcomes with combined CEA and CABG [7, 8]. Two meta-analyses that reviewed the data of the two methods have reached conflicting conclusions about the benefits of the two [9, 10]. Brener found 6% MI with the staged compared with 4% with the combined approach [9], but Peric reported about 8.3% of major adverse complications with the combined compared with 7% with the staged approach [10]. Studies
Peripheral arterial occlusive disease in addition to their combined surgery in his follow-up [12] and Zacharias reported the results of 5-year follow-up as well [13]. Akins et al. published the results of 500 patients who had combined surgery, with the mean follow-up of 5.9 years. By actuarial methods, they have calculated what should be the results after 10 years, including survival and event-free survival from cardiac and neurological events [14].

In recent years carotid artery stenting has replaced surgical endarterectomy in many patients. It is unclear whether prospective randomized studies comparing carotid artery stenting and CABG with the combined surgical approach will be performed. The long-term results of approaches involving percutaneous carotid intervention in addition to myocardial revascularization are not yet published. We want to present our experience with combined CEA and CABG, to document the results of 5-year follow-up as well [13]. Akins et al. published the results of the combined surgery including the CEA using cardiopulmonary bypass, and their follow-up is up to 5 years only [11]. Peric included only 41 patients with combined surgery in his follow-up [12] and Zacharias reported the results of 5-year follow-up as well [13].

### PATIENTS AND METHODS

The study was approved by the institutional review board (IRB) of our medical centre. From January 1992 to December 2006, 80 patients were treated with combined CEA and CABG. The demographic and clinical profiles are presented in Table 1. Majority (79%) of patients were males, 88% were hypertensive, 58% had hyperlipidaemia, 42% were diabetics and 27% had peripheral arterial occlusive disease in addition to their combined carotid and coronary artery disease. Twelve (15%) of our patients had left main disease. The extent of the coronary disease among the patients is presented in Table 2.

The criteria for performing carotid duplex were (i) age > 70 years; (ii) patients with PVD; (iii) patients with carotid murmur; (iv) patients with any neurological event; (v) patients with left main disease.

Indications for surgery were (i) internal carotid artery stenosis of 60% or more in symptomatic disease; (ii) 80% stenosis or more in asymptomatic carotid artery disease; (iii) bilateral asymptomatic carotid artery stenosis of ≥70%. Until 2003, stenosis was first determined by carotid duplex, and, if surgery was planned, by catheter angiography. Later, surgery was planned according to carotid duplex and CT angiography.

During the study period, all patients that had carotid duplex according to the indications stated earlier, and met the criteria for CABG and carotid surgery, were operated upon using the combined approach.

The combined surgical procedure was performed under single general anaesthesia, and the patients were monitored using continuous EEG with a real-time spectral analysis (Cerebrotrac®, Shorashim, Israel). CEA and saphenous vein harvesting were done simultaneously so that a segment of the vein could be used as a patch for the operated carotid artery. The neck wound was left open during the CABG procedure to control possible bleeding or the formation of haematoma during the full heparinization period. In case of bilateral carotid stenosis, endarterectomy was done to the higher grade stenosed carotid artery. Nine CABG operations (11%) were performed off-pump due to surgeons’ preferences, and the rest were performed using extracorporeal circulation. The surgical wounds were closed simultaneously after the conclusion of both procedures.

The final analysis of data was performed with SPSS software (version 11.0 for Windows; SPSS, Inc., Chicago, IL). Discrete variables are expressed as percentages, and continuous variables are expressed as means ± standard deviation.

### RESULTS

The immediate postoperative results are presented in Table 3. Perioperative mortality was 3.7%. One patient died due to low cardiac output, one patient was in coma after the operation and died a few days later, and one died because of empyema after chest tube insertion for haemothorax. Two patients had perioperative stroke (2.5%) resulting in hemiparesis, one ipsilateral

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**Table 1:** Baseline characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>n (%)</th>
<th>or mean ± SD</th>
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<tbody>
<tr>
<td>Number of patients</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>69 ± 6</td>
<td></td>
</tr>
<tr>
<td>Sex (male/female)</td>
<td>63/17</td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td>24 (30)</td>
<td></td>
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<tr>
<td>Hypertension</td>
<td>71 (88.7)</td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>34 (42.5)</td>
<td></td>
</tr>
<tr>
<td>Hyperlipidaemia</td>
<td>47 (58.7)</td>
<td></td>
</tr>
<tr>
<td>Peripheral arterial occlusive disease</td>
<td>19 (23.7)</td>
<td></td>
</tr>
<tr>
<td>Chronic renal failure*</td>
<td>14 (17.5)</td>
<td></td>
</tr>
<tr>
<td>Extent of carotid disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asymptomatic unilateral carotid stenosis</td>
<td>52 (60)</td>
<td></td>
</tr>
<tr>
<td>History of stroke</td>
<td>19 (22)</td>
<td></td>
</tr>
<tr>
<td>History of TIA/amaurosis fugax</td>
<td>16 (18.4)</td>
<td></td>
</tr>
<tr>
<td>Bilateral carotid stenosis</td>
<td>33 (38)</td>
<td></td>
</tr>
<tr>
<td>Contralateral carotid occlusion</td>
<td>11 (12.6)</td>
<td></td>
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</tbody>
</table>

TIA: transient ischaemic attack; *neurological deficits persisting <24 h; blood creatinine level >106 μmol/l.

**Table 2:** CABG intervention

<table>
<thead>
<tr>
<th>Parameter</th>
<th>n (%)</th>
<th>or mean ± SD</th>
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<tbody>
<tr>
<td>Off-pump</td>
<td>9 (11)</td>
<td></td>
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<tr>
<td>Duration of extracorporeal circulation</td>
<td>84.3 ± 40.6</td>
<td></td>
</tr>
<tr>
<td>Clamping time</td>
<td>50.5 ± 20.8</td>
<td></td>
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<tr>
<td>Number of grafts</td>
<td>2.7 ± 1.05</td>
<td></td>
</tr>
<tr>
<td>LIMA</td>
<td>74 (89)</td>
<td></td>
</tr>
<tr>
<td>LIMA + RIMA</td>
<td>3 (4)</td>
<td></td>
</tr>
</tbody>
</table>

LIMA: left internal mammary artery; RIMA: right internal mammary artery.
and one contralateral to the operated carotid side. The degree of narrowing in the contralateral carotid artery in both patients was <25%. Three patients had perioperative MI (3.7%). The cumulative incidence of perioperative death, stroke and MI was 10%. There were two chest explorations for bleeding (2.5%) and one deep sternal wound infection (1.25%). The long-term follow-up included 76 patients (99%). One patient left the country and was lost to follow-up. The mean long-term follow-up period was 10 ± 3.2 years (range 1–14 years). The follow-up was obtained by reviewing the medical records of the patients, and by telephone contact with all the survivors and their treating physicians. The actuarial 1, 5 and 10-year survival was 90 ± 3, 74 ± 5 and 62 ± 6%, respectively (Fig. 1). Late cardiac events occurred in 17 patients (21%) during the follow-up period (Table 4) including MI (1%), and myocardial ischaemia (11%). Cardiac actuarial 1, 5 and 10-year survival was 95 ± 3, 85 ± 6 and 73 ± 5%, respectively, depicting only cardiac-related deaths (Fig. 1). Total late neurological events were 7.6% (Table 4). Four patients had CVA (5.1%), three ipsilateral and one contralateral. The stenosis in the contralateral carotid artery was 40%. Two patients had TIA (2.5%). Freedom from neurological events for 10 years was 92 ± 4% (Fig. 2).

**DISCUSSION**

The controversy regarding the optimal way of treating patients with concomitant coronary and carotid disease still exists. Naylor et al. [3], who reviewed publications with 8972 patients who underwent combined, staged or reversed staged operations, found that the reversed staged cohort had 6.3% events of CVA, making this approach significantly inferior. They also found that there was no statistically significant difference in the rate of perioperative death, MI and CVA between the combined and staged approaches. Ziada et al. reported their results with carotid stenting and CABG [15], and found a 3% rate of MI and a 2% rate of CVA. After carotid stenting, there is a need for aggressive antiplatelet therapy including clopidogrel for at least 1 month. There may also be haemodynamic changes such as bradycardia and hypotension, due to pressure on the carotid body [1, 2]. These facts make carotid stenting procedure unfavourable for treating patients with life-threatening coronary anatomy.

Our perioperative results with mortality of 3.7, MI 3.7 and CVA 2.5%, are similar to those published in the medical literature [16]. Naylor et al. [3] found in their analysis an MI rate of 6.2% following staged procedure, emphasizing the advantage of treating both the carotid and cardiac systems synchronously.

Recently, the results of a new therapeutic strategy consisting of sequential hybrid approach with carotid stenting followed immediately by CABG operation were reported [17]. The procedure was performed by highly experienced operators, in a group of
37 patients. The patients had carotid artery stenting and transferred immediately to the operating room for CABG operation. The cumulative incidence of stroke, MI and death was 8.1%, 2 patients died (5.4%) and 1 patient had a stroke after the carotid stenting. The lack of experience in a large number of patients and the lack of long-term results as well as the need of aggressive antiplatelet therapy are expected to limit the widespread acceptance of this approach. In case of bleeding, the postoperative antiplatelet treatment might need to be postponed, endangering the long-term patency of the treated carotid artery.

Also, when considering carotid artery stenting vs CEA, one should be aware that in a report, documenting the results of all carotid revascularization procedures for the year 2005 in the United States (n=135 701), McPhee found that carotid artery stenting had increased the rates of postprocedure stroke, death and resource utilization than does CEA among symptomatic patients with carotid artery stenosis, and there was a 4-fold increased risk of in-hospital mortality (4.6 vs 1.4%, P < 0.05) and a 2-fold increased risk of postoperative stroke in the entire group (1.1 vs 0.57%, P < 0.05) compared with the surgical approach [18].

Van der Vaart reviewed 12 randomized trials of carotid artery stenting vs CEA. His conclusion was that there is no evidence that carotid artery stenting provides better stroke prevention compared with CEA; therefore, CEA remains the ‘gold standard’ for treating carotid artery stenosis [19].

The CREST study [20], published in 2010 examined carotid artery stenting vs endarterectomy for patients with carotid artery stenosis. The results in 2502 patients randomly assigned for the procedures, showed that the 4-year rate for stroke or death was 6.4% with stenting and 4.7% with endarterectomy (P = 0.03). Peri-procedural results showed the 4.1% stroke rate for stenting vs 2.3% for endarterectomy (P = 0.01). On the other hand, the MI rate was 1.1% for stenting vs 2.3% for endarterectomy (P = 0.03). Although there was no significant difference in the risk of composite outcome of stroke, MI and death between the procedures, we think that performing the combined procedure can reduce the risk of MI during CEA and make a difference in favour of this procedure.

Our mean follow-up is 10 ± 3.2 years and is 99% complete. The survival rate at 1 year (90 ± 3%), 5 years (74 ± 5%) and 10 years (62 ± 6%) is lower than the long-term survival rate of patients after CABG alone [21], demonstrating the impact of extensive atherosclerotic disease involving two (or more) systems on survival. Akins [14] found the 10-year survival to be 43%, significantly lower than our findings. The cardiac survival rate (cardiac deaths only) was 95 ± 3% at 1 year, 85 ± 6% at 5 years and 73 ± 5% at 10 years, similar to the survival rate of patients after CABG alone [21]. The late neurological event-free rate shows an excellent actuarial freedom of 92 ± 4% from neurological events at 10 years. Akins [14] had also reported 10-year freedom from stroke to be 85%.

The long-term results demonstrate that cardiawise and neurological-wise the combined CEA and CABG give good results.

In our experience, combined CEA and CABG is a safe procedure with acceptable hospital mortality and morbidity, and the long-term results are good.

Neurological complications are the area were CABG shows inferiority compared with PCI [22, 23]. Every effort should be made to reduce the rate of neurological complications after CABG, and that includes performing carotid duplex to the relevant patient population as defined earlier, and address it properly.

Our recommendation is to approach patients with concomitant carotid and coronary artery disease, with the combined surgical procedure, especially if they have life threatening coronary anatomy consisting of LM disease or proximal LAD stenosis or high-grade stenosis three-vessel disease (high SYNTAX score).

Limitation of the study: The study represents a single-institution experience and includes a relatively small number of patients. The retrospective collection of data may have resulted in overlooking some minor events and complications. The use of both internal thoracic arteries was uncommon at the time of this study primarily because of the prevalence of diabetes mellitus (42%) which is no longer considered a contraindication. Presently, we use bilateral ITA in more than 50% of our patients potentially improving the long-term results.

Conflict of interest: none declared.

REFERENCES


