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Staged carotid and coronary surgery for concomitant carotid and coronary artery disease

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Abstract

Objective: To demonstrate that staged, consecutive, carotid endarterectomy (CEA) and coronary artery bypass grafting (CABG) are safe, perhaps preferable, alternative for the treatment of patients with severe carotid and coronary artery disease. **Methods**: During an 8-year period ending December 1999, 77 (2.1%) of 3633 consecutive patients who were referred for isolated coronary surgery were found to have significant carotid disease and underwent CEA, and subsequently, CABG. The mean age was 65.2 ± 5.9 years and 66 (85.7%) were males. The majority (84.4%) had triple vessel and 19.4% had left main disease. Carotid disease was unilateral in 71 patients (92.2%) and bilateral in six (7.8%), and 57 (74.0%) were neurologically asymptomatic. Only obstructions >70% were considered for endarterectomy. **Results**: Eighty-three isolated CEAs were performed with direct clamping of the artery (mean 20.1 ± 5.9 min) in all but one. There were no deaths. There were two strokes (2.4%) and three (3.6%) myocardial infarctions (MI). The mean admission time was 6.0 ± 3.5 days. The staging interval was 32.4 days. During coronary surgery, a mean of 2.9 coronary grafts/patient was performed and all but one patient received at least one IMA graft. One patient (1.3%) died. There were two cases (2.6%) of MI and three patients (3.9%) had a stroke. Hence, the overall rates of perioperative mortality, MI and stroke were 1.3, 6.3 and 6.3%, respectively. The mean admission time was 8.3 ± 6.0 days. **Conclusions**: Staging of carotid and coronary operations resulted in low global perioperative mortality and morbidity rates in these high-risk patients and is a good alternative therapeutic option.

Keywords: Carotid artery stenosis; Coronary artery disease; Carotid endarterectomy; Coronary artery bypass; Staged approach

1. Introduction

Although a significant amount of information is currently available with regard to the dilemma of myocardial revascularisation in the presence of carotid arterial disease, the choice of treatment for patients who present with severe carotid artery stenosis that is incidentally found during preparation for coronary artery bypass grafting (CABG) is still a matter of debate. The options vary from a simultaneous (same anaesthetic) to a staged procedure, whereby carotid endarterectomy (CEA) is performed several days prior to (staged approach) or after (reversed staged approach) coronary revascularisation. To date, no well-designed prospective randomised trial has clarified this problem. Each of these methods has its advantages and disadvantages, which can be measured, essentially, by the global mortality and incidence of MI and of stroke.

Since 1992, it has been our philosophy to manage these patients by the staged approach. This decision resulted, essentially, from the fact that in our country cardiac surgery and vascular surgery are two different specialties, making it more difficult to coordinate two surgical teams to perform both procedures during the same anaesthetic session. The purpose of this work was to evaluate our early results in 77 consecutive patients who underwent such surgery.

2. Materials and methods

During an 8-year period ending December 1999, 77 (2.1%) of 3633 consecutive patients who had isolated coronary artery bypass grafting (CABG) underwent carotid, and subsequently, coronary surgery for severe concomitant arterial disease. To avoid the introduction of potentially conflicting factors, patients who had associated procedures, such as valvular surgery, and those who had undergone unrelated carotid surgery in the past, were not included in this series.

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2.1. Diagnosis and general management protocol

All patients were originally admitted to our hospital for CABG and the diagnosis of internal carotid artery disease was made during the preoperative clinical workup. They underwent carotid artery evaluation on a selective basis, mainly dependent on the auscultation of a bruit in the neck and/or a history of neurological symptoms consistent with cerebrovascular disease. Although most of these patients had duplex studies, the diagnosis and severity of the carotid disease was finally established in all cases by carotid angiography.

Selection criteria for carotid surgery were constant throughout and well defined, i.e. patients underwent CEA if they had a haemodynamically significant lesion (luminal diameter >70%, using the diameter of the distal internal carotid artery as a reference) of either or both carotid arteries, independent of the symptomatic neurological status. During the period covered by this study, all patients were treated using the staged approach, i.e. CEA was performed first, followed by CABG at a second operation. In patients with bilateral disease, surgery to each of the two carotid arteries was performed in different anaesthetic times.

In the majority of cases (66 patients; 85.7%) CEA was performed in our Department of Vascular Surgery. Immediately after surgery, they were admitted to the Coronary Care Unit, where they usually stayed until the next morning and then returned to the Vascular Department ward.

During the period mediating between hospital discharge from CEA and re-admission for CABG, a cardiologist of our own Department closely monitored these patients. As a rule, the CABG was performed within a minimum time interval of 2 weeks from the carotid surgery, during a different period of hospitalisation, unless the cardiac condition dictated earlier surgery (two cases). This interval was dictated by the protocol in use in the Department of Vascular Surgery, which calls for a minimum period of 1 week of anti-platelet aggregation followed by 1 week of suspension prior to CABG.

2.2. Preoperative patients data

The clinical data of the 77 patients is detailed in Table 1. The mean age was 65.2 ± 5.9 years (range 49–81 years) and 66 (85.7%) were males. Nineteen (24.7%) patients were diabetic, and 51 (66.2%) had dislipidemia. Thirty-four (44.2%) and 43 (55.8%) patients were, respectively, in class I/II and III/IV of the Canadian Cardiovascular Society. A history of previous MI was recorded in 43 patients (55.8%). Five (6.5%) patients, otherwise stable on the day of carotid artery surgery, had been on intravenous anti-anginal medication in the previous 2 days. Twenty-three patients (29.9%) had peripheral vascular disease. Sixty-five patients

Table 1
Preoperative clinical, angiographic and operative cardiac data of patients who had the staged procedure versus patients who had isolated CABG during the same period[a]

Variable	Staged operation (%)	Isolated CABG (%)	*P* value
Patients (*n*)	77	3556	
Mean age (years)	65.2 ± 5.9	60.1 ± 9.3	< 0.001
Female sex	(14.2)	(11.4)	NS
Family history of CAD	(22.1)	(22.4)	NS
Smoking	(51.9)	(55.5)	NS
Diabetes mellitus	(24.7)	(21.5)	NS
Dislipidemia	(66.2)	(54.5)	NS
Hypertension	(72.7)	(56.8)	0.005
History of MI	(55.8)	(59.1)	NS
Peripheral vascular disease	(29.9)	(9.5)	< 0.0001
History of stroke or TIA	(26.0)	(4.5)	< 0.0001
One vessel disease	(2.6)	(5.1)	NS
Two vessels disease	(13.0)	(18.3)	NS
Three vessels disease	(84.4)	(76.6)	NS
Left main disease	(19.4)	(15.8)	NS
Left ventricular function			
Normal	(49.3)	(51.6)	NS
Mild dysfunction	(39.0)	(32.5)	NS
Moderate dysfunction	(9.1)	(11.1)	NS
Severe dysfunction	(2.6)	(3.4)	NS
Mean no. of coronary grafts	2.9	2.9	NS
Arterial conduit			
Left IMA	(98.7)	(99.1)	NS
Bilateral IMA	(9.1)	(25.2)	< 0.0001
Coronary endarterectomy	(19.5)	(7.1)	< 0.0001

[a] TIA, transient ischaemic attack; MI, myocardial infarction; CAD, coronary artery disease; NS, not significant.

(84.4%) had triple vessel coronary disease and 15 (19.4%) had left main disease. Moderate or severe left ventricular dysfunction (ejection fraction <40%) was present in nine cases (11.7%). There were no cases of redo-CABG among these patients.

For comparison, data on 3556 patients without known carotid disease subjected to isolated CABG during the same period of time is also presented in Table 1. The staged operation group was significantly older (65.2 years versus 60.1 years, $P < 0.001$), had more patients with cerebral (26.0 versus 4.5%, $P < 0.0001$) and peripheral vascular (29.9 versus 9.5%, $P < 0.0001$) disease, and with hypertension (72.2 versus 56.8%, $P = 0.005$). This group also presented a significantly higher incidence of patients who had coronary endarterectomy and a lower incidence of use of bilateral IMA.

The preoperative neurological symptoms and anatomy of the carotid disease are shown in Table 2. Twenty patients (26.0%) had neurological symptoms, including 11 patients with permanent stroke and nine with transient symptoms (five with transient ischaemic attacks and four with amaurosis fugax). Carotid disease was unilateral in 71 patients (92.2 %) and bilateral in six (7.8%), with no cases of contralateral occlusion.

2.3. Operative techniques — carotid and coronary surgery

In all but two cases (2.4%) the CEA was performed under general anaesthesia. Invasive arterial blood pressure and cardiac rhythm were continuously monitored. Direct clamping of the artery (mean 20 ± 6 min) was used in all patients but one who had a temporary shunt inserted.

The technique for coronary revascularisation involved aortic and right atrial cannulation and mild systemic hypothermic cardiopulmonary bypass (30–32°C). A left ventricular vent was routinely introduced through the right superior pulmonary vein. We have adopted the method of ventricular fibrillation for construction of the distal anastomosis. Proximal anastomosis of vein grafts were constructed during a single period of aortic side-clamping. Internal mammary artery (AMI) grafts were used in all but one patient (98.7%), including seven (9.1%) in whom both AMIs were used. An average of 2.9 coronary artery branches were bypassed per patient. Coronary endarterectomies, mostly of the right, were performed in 15 patients (19.4%). Cardiopulmonary bypass time was 64 ± 18 min.

Table 2
Neurological and carotid angiographic data in patients submitted to the staged operation[a]

	N	%
Neurological symptoms		
Asymptomatic	57	74.0
Symptomatic		
Stroke	11	14.3
TIA	5	6.5
Amaurosis fugax	4	5.2
Carotid angiography		
Stenosis		
70–90%	68	88.3
> 90%	9	11.7
Bilateral disease	6	7.8

[a] TIA, transient ischaemic attack.

2.4. Data analysis

Perioperative events included those occurring within 30 days of surgery or during the same hospitalisation. Standard statistical tests (Student *t* and χ^2) were used for comparison of data, and statistical significance was inferred for $P < 0.05$.

3. Results

3.1. Carotid surgery and staging interval

There were 83 isolated CEAs performed in the 77 patients, with no mortality. There were two cases (2.4%) of permanent ipsilateral stroke. Cerebral computed tomography (CT) showed an area of infarct in both cases and non-invasive carotid artery evaluation revealed patency of the CEA site. These two patients underwent CABG subsequently with a staging interval of 55 and 40 days, respectively. Additionally, two patients (2.4%) had transient ischaemic attacks (TIA), with negative CT scans and permeable carotids. There were no cases of contralateral central neurological accidents. Four patients developed minor peripheral neurological deficits, of which two did not resolve during the postoperative follow-up: one had a left vocal chordal palsy and the other had isolated hypoglossal nerve palsy.

There were three (3.6%) cases of MI, all occurring in the early (hospital) period and evolving with haemodynamic stability. Four patients developed unstable angina and two of them, who did not respond to intravenous medication, required urgent CABG. One patient had an episode of ventricular fibrillation during the carotid surgery, without clinical consequences. Three patients were re-explored for revision of haemostasis and one had a wound infection treated by debridement and antibiotics.

All patients returned home in a stable cardiac situation. The time of hospital stay was 6.2 ± 3.4 days. After hospital discharge and through to the time of coronary surgery, there was no mortality or new cases of neurological complications or MI. Nevertheless, two patients (2.4%) developed unstable angina and required hospitalisation with successful medical control. The mean staging interval was 32.4 days.

3.2. Coronary surgery

There was one death (1.3 %) due to stroke. Seven patients (9.1%) required inotropic support in the immediate postoperative period. There were electrocardiogram (ECG) criteria of perioperative MI in two patients (2.6%). Twenty-three patients (29.9%) developed atrial arrhythmias (fibrillation and/or flutter) that required treatment and two patients (2.6%) had an episode of ventricular fibrillation without clinical consequences. Two patients (2.6%) were re-operated for bleeding and one for sternal dehiscence. Five patients (6.5%) developed transient acute renal insufficiency (creatinine ≥2.5 mg/dl), not requiring dialysis.

There were three cases (3.9%) of stroke, all ipsilateral to the CEA. The one, which was the cause of the single in-hospital death in this study, occurred in a patient with a history of permanent stroke in the past and who was submitted to bilateral CEA (the last performed 28 days before CABG). This patient did not wake up from anaesthesia and died on postoperative day 10. The necropsy study showed a major infarction of the right cerebral hemisphere and extensive right carotid thrombosis. The second patient, who also had a history of permanent stroke in the past, was submitted to urgent CABG 6 days after left CEA, because of untreatable unstable angina. In the immediate postoperative period, he developed a severe and prolonged period of hypotension as a result of major bleeding from the aortic cannulation site, and a right hemiplegia was noted when he woke up. The third patient sustained an ipsilateral stroke on postoperative day 2, probably embolic from the CEA left site (performed 27 days before), which was patent as assessed by non-invasive means. Both patients were ambulatory, albeit with sequelae, at discharge. There were no cases of transient ischaemic attacks or reversible ischaemic neurological deficit. The hospital stay was 8.3 ± 6.0 days.

4. Discussion

The incidence of major neurological complications occurring during the performance of coronary artery surgery varies widely, depending on the definition and accuracy of diagnosis, and has been reported between 1 and 6% [1].

Although the role of carotid disease in the genesis of perioperative stroke in patients undergoing isolated myocardial revascularisation remains incompletely defined, because of the multifactorial aetiology, several reports indicate that significant carotid artery stenosis is an important, and for some the strongest, incremental risk factor [2–4]. Nevertheless, D'Agostino et al., estimated perioperative risk at <2% in patients with carotid stenosis <50%, 10% with stenosis 50–80%, and 11–19% with stenosis >80% [5].

Routine carotid evaluation before CABG has yielded significant internal carotid stenosis (>70%) in 3–12% of patients [1,6]. In our experience, the diagnosis of severe carotid disease was secondarily made in 2.1% of the patients who had been admitted for isolated CABG. However, this could obviously be an underestimation of the real incidence of carotid disease because routine preoperative evaluation of all CABG patients, other than auscultation of bruits, was not carried out. Many surgical groups perform carotid duplex studies routinely in patients who are to undergo CABG, but this has not proven to lead to a better outcome.

On the other hand, a controversy still exists in the literature as to whether or not CEA is protective against stroke. However, some randomised trials have now unequivocally demonstrated a significant benefit of CEA over continued medical treatment for patients with symptomatic, and more recently, with asymptomatic severe carotid artery stenosis. The North American Symptomatic Carotid Endarterectomy Trial (NASCET) study [7] showed that in symptomatic patients with 70–99% carotid stenosis, CEA decreased the 2-year rate of ipsilateral stroke from 26% (in medically treated patients) to 9%. The Asymptomatic Carotid Atherosclerosis Study (ACAS) study [8] demonstrated a reduction in total ipsilateral neurological events in patients with >60% carotid stenosis from 18 to 7%, over 5 years. These data may, perhaps, be extrapolated to patients requiring CABG and argue for an aggressive surgical approach in this population.

We believe that the rational approach for virtually all patients who present with severe combined arterial disease is to submit them to carotid surgery before myocardial revascularisation. In this context, the surgical options are then either a simultaneous procedure (same anaesthetic) or a staged approach with CEA performed several days prior to CABG. Proponents of both types of approaches have published series proclaiming the safety of each technique. However, no well-designed prospective randomised trial has, until now, clarified this problem. Consequently, the optimal strategy for management remains undefined and each centre must select and analyse its own treatment policy and compare the results with those described in other published reports. In 1992, we adopted the staged approach

Table 3
Studies reporting results with the staged approach

Series	No. of patients	MI	Stroke	Death	Stroke + death
Bernhard et al. [12]	16	3 (18.8%)	2 (12.5%)	5 (31.3%)	7 (43.5%)
Reul et al. [13]	164	?	4 (2.4%)	8 (4.9%)	12 (7.3%)
Hertzer et al. [14]	24	1 (4.2%)	1 (4.2%)	1 (4.2%)	2 (8.4%)
Fagioly et al. [15]	17	?	0	0	0
Carrel et al. [16]	45	4 (8.8%)	0	2 (2.2%)	2 (4.4%)
Coyle et al. [17]	45	?	2 (4.4%)	1 (2.2%)	3 (6.6%)
Takach et al. [18]	257	12 (4.7%)	5 (1.9%)	4 (1.6%)	9 (3.5%)
Total	568	20 (5.8%)	14 (3.7%)	21 (3.7%)	35 (6.2%)

Table 4
Parcel and global results: mortality, MI and stroke[a]

Variable	CEA+SI $N = 83$[b]	CABG $N = 77$	CEA+CABG
Mortality	0	1 (1.3%)	1 (1.3%)[c]
MI	3 (3.6%)	2 (2.6%)	5 (6.3%)
Stroke	2 (2.4%)	3 (3.9%)	5 (6.3%)
Total stroke and mortality			5 (6.3%)

[a] SI indicates staging interval.
[b] Total number of carotid endarterectomies performed on the 77 patients.
[c] The patient who died is one of five who had stroke.

to treat all patients who present with concomitant arterial carotid and coronary disease. Our decision was made mainly because two different surgical teams (cardiac and vascular) are involved, making a simultaneous procedure difficult to coordinate. Most unstable patients can now be stabilised medically in the coronary care unit. This was successfully done in all (five) of our patients. If stabilisation cannot be achieved or the coronary lesions are of extreme severity, CABG should be performed first. As far as we can recall, this was necessary in three of our cases.

Although the results with the simultaneous approach have been well documented, fewer studies report results with the staged approach (Table 3). The overall risk of mortality was 3.7%, that for MI was 5.8% and that for stroke was 2.5%, with a composite rate of death and stroke of 6.2%. In general, these studies also reported increased composite rates of death and stroke in the simultaneous compared with the staged group, although there was often a bias in assigning higher risk patients to the simultaneous approach. The same conclusion, suggesting that combined CABG and CEA may be associated with a higher risk of stroke or death than in staged procedures, was recently reported in a metaanalysis by Borger et al. [11].

To the best of our knowledge, this is the first report of the results of the staged operation used as the routine method to treat all patients with identified concomitant carotid and coronary arterial disease, and this may be one of its weaknesses, as we do not have a control group with which to compare our results. In fact, all series dealing with the results of the staged operation (Table 3) came from institutions that also use other treatment options, including the combined approach. In the beginning of this experience, we were naturally concerned about the eventual consequences of this method of treatment, with regards to the eventual occurrence of MI during CEA and in the staging interval. In the past, some influential studies had associated CEA in patients with severe uncorrected coronary artery disease with prohibitive rates of perioperative mortality and of MI [9,10]. We agree that this group of patients may be at higher risk of perioperative coronary ischaemic events, but our results, reported herein, with no mortality and an incidence of MI of 3.6%, appear to demonstrate the relative safety of this approach.

Because patient selection is one critical factor in this clinical evaluation, we intended to compare our series (Table 4) only with others, which analyse the simultaneous approach as a method to treat all patients. Even considering that our series is relatively small by comparison with some included, our global mortality (1.3%) and composite death and stroke (6.3%) rates compare favourably with those reported in the literature since 1992 for patients managed using a simultaneous approach (Table 5). However, as it probably might have been expected, our incidence of MI was higher. On the other hand, we did not expect the relatively high incidence of stroke after CABG (three patients; 3.9%), and also the fact that all were ipsilateral to the CEA site. This result underscores the multifactorial aetiology of stroke after CABG, particularly in these high-risk patients, but is insufficient to question the value of prophylactic CEA in reducing the incidence of stroke. We believe that the rate of cerebrovascular accidents in our patients would have been even higher if they had not undergone the CEA before the CABG. However, the occurrence of three strokes, resulting from cerebral damage ipsilateral to the CEA, raises the question of residual carotid disease. Perhaps routine duplex scanning or angiography, which we have not used until now, should be considered in these cases.

In conclusion, stroke after CABG is a dreadful complication. Carotid disease is significantly associated with this neurological outcome. Hence, we believe that the rational approach for the treatment of patients with severe combined

Table 5
Series reporting results of concomitant carotid and coronary operations since 1992

Series	No. of patients	MI	Stroke[a]	Death	Stroke + death
Vermeulen et al. [19]	230	4 (1.8%)	7 (3.0%)	8 (3.5%)	15 (6.5%)
Akins et al. [21]	200	5 (2.5%)	6 (3.0%)	7 (3.5%)	13 (6.5%)
Daily et al. [23]	100	1 (1.0%)	0	4 (4.0%)	4 (4.0%)
Trachiotis et al. [24]	88	0	4 (4.5%)	3 (3.4%)	7 (7.9%)
Darling et al. [20]	420	?	5 (1%)	10 (2.4%)	15 (3.4%)
Plestis et al. [25]	213	5 (2.3%)	11 (5.1%)	12 (5.6%)	23 (10.7%)
Evagelopoulos et al. [22]	313	10 (2.2%)	7 (2.2%)	28 (8.9%)	35 (11.1%)
Khaitan et al. [26]	121	?	7 (5.8%)	7 (5.8%)	14 (11.6%)
Total	1685	25 (2.2%)	47 (2.8%)	79 (4.7%)	126 (7.5%)

[a] Reversible or permanent stroke.

arterial disease is to submit them to carotid surgery before myocardial revascularisation. The results reported in this study showed that good results are possible with the staged approach even in high-risk patients.

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