Clinical Investigation

Simultaneous Coronary Artery Bypass and Carotid Endarterectomy

Determinants of Outcome

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From January of 1988 to May of 1993, simultaneous single-stage coronary revascularization and carotid endarterectomy was performed in 33 patients (mean age, 69 years). Thirty-one patients (94%) were in New York Heart Association class III or IV, 15 (46%) had unstable angina, and 7 (21%) were operated on because of evolving myocardial infarction. One or more previous myocardial infarctions were present in 18 patients (54%). Nineteen patients (58%) presented with neurologic symptoms, and 22 (67%) had severe bilateral carotid stenosis. Thirty (91%) had triple-vessel or left main coronary artery disease. Sequential reconstruction of the carotid artery followed by coronary artery bypass grafting was performed in all patients. In 4 cases, additional cardiac procedures were performed. Operative mortality (6%) was cardiac related. Perioperative morbidity included myocardial infarction in 1 patient (3%) and neurologic deficit in 6 (18%), with permanent functional impairment in 2 patients (6%). The stroke rate was higher in the bilateral than in the unilateral carotid stenosis group (22.7% vs 9.1%, p=0.047). Previously completed stroke influenced the operative outcome (55.6% vs 4.2%, p=0.003). Low ejection fraction (33.5% ± 7.5% vs 52.8% ± 3.5%, p=0.03) and left main coronary artery disease (36% vs 5%, p=0.03) also predicted postoperative neurologic complications. During a mean follow-up of 24.6 ± 3.5 months, 3 patients died. The 5-year life-table survival rate was 85%. Eighty-nine percent of long-term survivors were free of cardiovascular disease symptoms. Our results show that the outcome of simultaneous carotid endarterectomy/coronary artery bypass grafting in this high-risk population depends upon the preoperative absence or presence of completed stroke or bilateral carotid stenosis, upon the preoperative ejection fraction, and upon the extent of the left main coronary artery disease. ***(Texas Heart Institute Journal 1994;21:119-24)***

Key words: *Carotid stenosis; coronary artery bypass; coronary artery disease; endarterectomy, carotid; myocardial infarction; myocardial revascularization; risk factors*

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Patients presenting with the combination of ischemic heart disease and cerebrovascular insufficiency due to multisystem atherosclerosis may be at a higher risk for cardiovascular morbidity.[1,2] The high incidence of myocardial infarction after carotid endarterectomy (CEA) and cerebral infarction after coronary artery bypass grafting (CABG) has motivated interest in a combined surgical approach.[3-5] Since 1972, when combined carotid and coronary artery surgery in patients with associated ischemic heart disease and cerebrovascular pathology was proposed by Bernhard and colleagues,[3] more than 50 articles have been published about this issue. Various surgical approaches and strategies have been described for treatment of this group of patients.[6-10] However, despite growing experience, the performance of simultaneous CEA/CABG remains controversial.[11-16] There is a lack of consensus concerning the indications for combined procedures, intraoperative techniques for brain protection, the sequence of operation, and the outcome of the surgical treatment.

This report presents an analysis of our recent experience with 33 patients who underwent combined CEA/CABG operations for significant coexisting carotid and coronary artery disease. The article emphasizes prognostic factors that determined the outcome.

Patients and Methods

From January of 1988 to May of 1993, 33 patients underwent combined unilateral carotid endarterectomy and CABG for severe cerebrovascular and ischemic heart

disease. Patients' ages ranged from 37 to 82 (mean, 68.9 ± 1.7 years). Twenty-seven patients were men and 6 were women. Preoperatively, 11 patients (33%) had stable angina pectoris, 15 patients (46%) had unstable angina, and 7 patients (21%) were operated on because of evolving myocardial infarction. Clinical signs of mild or moderate congestive heart failure were present in 5 patients. Preoperatively, 2 patients (6%) were in New York Heart Association (NYHA) functional class II, 6 patients (18%) were in class III, and the remaining 25 patients (76%) were in class IV. Eighteen patients (54%) had a history of myocardial infarction (Table I). Seventy-six percent had a history of hypertension, 54% smoked cigarettes, 36% had hypercholesterolemia, and 21% had diabetes mellitus (Table II).

Asymptomatic cervical bruit was present in 14 patients (42%). Nineteen patients (58%) were symptomatic, including 10 patients with transient ischemic attacks (with or without amaurosis fugax), and 9 patients with histories of cerebrovascular accidents. Three patients had histories of stroke without neurologic symptoms, and 6 patients had residual neurologic symptomatology secondary to stroke.

TABLE I. Preoperative Cardiac Findings in 33 Patients Undergoing Combined Carotid Endarterectomy and CABG

Preoperative Findings	No. of Patients (%)
New York Heart Association Class	
II	2 (6)
III	6 (18)
IV	25 (76)
Congestive heart failure and angina	5 (15)
Stable angina	6 (18)
Unstable angina	15 (46)
Evolving myocardial infarction	7 (21)
Associated aortic valve disease	3 (9)
Previous myocardial infarction	18 (54)
Previous coronary artery bypass grafts	1 (3)
Left main coronary artery disease	14 (42)
Single-vessel disease	3 (9)
Double-vessel disease	5 (15)
Triple-vessel disease	25 (76)

CABG = coronary artery bypass grafting

TABLE II. Risk Factors Observed in Patients before Surgery

Risk Factors	No. of Patients (%)
Hypertension	25 (76)
Cigarette smoking	18 (54)
Hypercholesterolemia	12 (36)
Diabetes mellitus	7 (21)

The extent of concomitant disease of other organs and systems found on admission is presented in Table III.

Carotid pathology was diagnosed by noninvasive ultrasound testing, angiography, or both (Table IV). Carotid disease was unilateral in 11 patients (33%) and bilateral in 22 (67%), including 3 patients with concomitant lesions of the vertebral artery, the subclavian artery, or both. Indications for operation in 14 patients with asymptomatic carotid stenosis were severe bilateral lesions (in 5 patients) and unilateral lesions (in 9 patients), with ulcerative plaque in 5 of the 14. In a group of 19 patients with symptoms of cerebrovascular insufficiency, 6 had carotid occlusion with severe contralateral stenosis, 11 had severe bilateral stenosis, and 2 had unilateral stenosis.

In patients with bilateral carotid disease, eversion CEA was performed on the symptomatic side or on the side flowing to the dominant hemisphere. Intraoperative temporary shunting was performed in 2 cases. Indications for shunting were hypoplasia or stenosis of intracranial cerebral arteries.

Coronary angiography was performed in all patients. Three patients (9%) had single-vessel disease, 5 patients (15%) had double-vessel disease, and 25

TABLE III. Preoperative Associated Pathology* Found at the Time of Admission

Concomitant Pathology	No. of Patients (%)
Abdominal aortic aneurysm	2 (6)
Peripheral vascular pathology	6 (18)
Visceral vascular pathology	1 (3)
Chronic obstructive pulmonary disease	5 (15)
Tumor	4 (12)
Chronic renal failure	5 (15)

*Some patients presented with multisystem disease.

TABLE IV. Severity of Extracranial Cerebrovascular Disease

Carotid Stenosis Type and Percentage	No. of Patients (%)
Occlusion with contralateral stenosis >70%	6 (18)
Bilateral stenosis >70%	16 (48)
Unilateral stenosis >70% with contralateral stenosis ≤50%	10 (30)
Unilateral ulcerative plaque with <50% stenosis	1 (3)

patients (76%) had triple-vessel disease. Fourteen patients (42%) had left main lesions. The mean preoperative left ventricular end-diastolic (LVED) pressure and ejection fraction (EF) were 16.9 ± 1.0 mmHg and 48.8% ± 2.9%, respectively. The mean cardiac index was 2.5 ± 0.1 L/min/m^2.

Surgical Technique

The operative procedure was performed during a single general anesthesia. Carotid and cardiac surgical procedures were performed by 2 surgical teams. The CEA was completed first. For patients in stable hemodynamic condition, carotid exposure and endarterectomy were performed while the saphenous vein was dissected from the leg before sternotomy. In 1 patient with unstable hemodynamics, CEA was performed under cold extracorporeal circulation. Anticoagulation with 5,000 IU of heparin was used for the CEA. An indwelling carotid shunt was used in 2 cases. In those without shunts, the aortic cross-clamp time ranged from 5 to 14 minutes (mean, 9.0 ± 2.2 min). The neck wound was packed with iodoform-soaked gauze, and cardiopulmonary bypass (CPB) was instituted. Myocardial protection was achieved with moderate (28 °C) systemic hypothermia and standardized cold hyperkalemic or blood cardioplegia. One patient underwent redo CABG. All distal coronary anastomoses were accomplished 1st, during a single ischemic period of aortic cross-clamping. The mean aortic cross-clamp time was 53.6 ± 2.6 min (range, 28 to 89 min). The proximal anastomoses were performed after release of the cross-clamp. The average number of grafts was 3.2 ± 0.2 (range, 1 to 5). In 19 patients, the left anterior descending coronary artery was revascularized using the left internal thoracic artery. The mean CPB time was 90.7 ± 3.9 min (range, 49 to 144 min). Additionally, 3 patients underwent concomitant aortic valve replacement for aortic stenosis, and another had an automatic implantable cardioverter defibrillator implanted. Three patients required intraaortic balloon pump assistance immediately after surgery, for correction of hemodynamic instability. After completion of the cardiac stage of operation, heparin was reversed and all wounds were closed simultaneously. Coronary revascularization was elective in 20 patients, urgent in 11, and emergent in 2.

The mean postoperative hospital stay was 21.5 ± 2.1 days (range, 7 to 60 days). Operative mortality was defined as death occurring within 30 days of operation, or during the same hospital stay. All diagnoses of stroke were confirmed by computed tomographic (CT) scan. A neurologist was consulted in all cases, both in the establishment of the diagnosis and in the course of the patient's care. All patients discharged from the hospital were interviewed by telephone or were seen in the clinic to determine their postoperative cardiovascular and neurologic status. Probability of survival and freedom from complications were determined by actuarial method. Differences in outcomes were analyzed using Fisher's exact test. The Statistical Products Services and Solutions (SPSS) PC Plus (Version 3.0) was used for descriptive analysis. Data are presented as mean ± standard error of the mean where appropriate.

Results

The overall operative mortality was 6%. Two patients died 12 and 14 days postoperatively, from rhythm disturbances and low cardiac output, respectively. No deaths occurred due to neurologic causes. Six patients (18%) developed postoperative neurologic symptoms. All but 1 of these patients had presented with previously completed stroke. In the group of patients without history of cerebrovascular accident, the stroke rate was 4%, as opposed to 56% in those who had prior completed strokes ($p=0.003$). One patient had an ipsilateral stroke to the operated carotid artery. Four had a stroke contralateral to the operated side, and 1 patient developed brain stem infarction 7 days after the operation. Functional impairment was permanent in 2 patients (6%) and included hemiparesis with dysarthria in 1 patient and hemiparesis with facial asymmetry in another. Four other patients had resolution of neurologic symptoms from 14 to 30 days postoperatively. In the group of patients with bilateral carotid lesions, the stroke rate was 23%, versus 9% in the group with unilateral carotid pathology ($p=0.047$). Five of 14 patients with bilateral symptomatic stenosis (36%) developed ischemic neurologic deficit. Patients with asymptomatic carotid stenosis presented with no cerebrovascular complications. One of 5 patients with symptomatic unilateral carotid stenosis developed reversible ischemic neurologic deficit. Patients with low EF and left main coronary artery stenosis

had an increased risk for neurologic complications. Thirty-six percent of the patients with left main coronary disease had postoperative stroke, versus 5% of patients without such anatomic lesions (p=0.03). The mean ejection fraction was 33.5% ± 7.5% in the group of patients with neurologic complications, versus 52.8% ± 3.5% (p=0.03) in patients with an uncomplicated postoperative course. Other clinical, hemodynamic, and angiographic variables were not statistically different among the groups. The presence of postoperative neurologic complications necessitated longer postoperative hospital stays (39.2 ± 5.7 days versus 17.3 ± 1.4 days, p <0.001).

Other major complications included perioperative myocardial infarction, paroxysmal ventricular tachycardia, supraventricular tachycardia, respiratory failure, renal insufficiency, and enterocutaneous fistula (Table V).

Thirty-one operative survivors were followed up for 1 to 58 months (mean, 24.6 ± 3.5 months). One patient underwent resection of an abdominal aneurysm 2 months after CEA/CABG, and 2 patients underwent contralateral CEA 4 months and 6 months after the initial CEA/CABG because of recurrent transient ischemic attacks. The actuarial probability of survival at 5 years was 85%. Most long-term survivors (89%) were in NYHA functional class I or II postoperatively, or were doing well on medications.

Discussion

The positive relationship between carotid and coronary artery disease is well known. As coronary atherosclerosis progresses, the rate of complicating carotid atherosclerosis and silent cerebral infarction becomes higher in patients with ischemic heart disease, and the brain CT score increases.[17] Reduced flow through stenotic extracranial or intracranial cerebral vessels, dislodging of ulcerative plaque from the carotid artery, and embolization of atherosclerotic material or platelet-fibrin debris from the ascending aorta are possible causes of postoperative stroke following CABG operations.[5,18,19] The incidence of significant carotid stenosis in candidates for myocardial revascularization has been reported to be between 6% and 16%.[20-23]

TABLE V. Perioperative Complications in Patients Undergoing Combined Carotid Endarterectomy and CABG

Complication	No. of Patients (%)
Cardiac	
Ventricular tachycardia	3 (9)
Supraventricular tachycardia	2 (6)
Myocardial infarction	1 (3)
Renal failure	2 (6)
Adult respiratory distress syndrome	2 (6)
Enterocutaneous fistula	1 (3)

CABG = coronary artery bypass grafting

The treatment of asymptomatic carotid stenosis (especially at the time of coronary artery bypass surgery) is controversial. Furlan and coworkers[24] reported that asymptomatic unilateral carotid artery stenosis or occlusion does not increase the risk of ipsilateral brain infarction in patients undergoing CABG. Successful CPB was reported even in patients with bilateral carotid occlusion.[18] In an analysis of risk factors for stroke after CABG, Jones and colleagues[5] reported a 0.9% overall incidence, which increased to 3.3% in patients with asymptomatic bruit and to 8.6% in a group of patients with previous neurologic events. Similar results have been reported by others.[14,25] Therefore, the risk of perioperative stroke associated with asymptomatic carotid stenosis is still uncertain.

In our series, there was no occurrence of perioperative stroke in patients with asymptomatic unilateral or bilateral carotid stenosis. When we considered the stroke risk in preoperatively symptomatic patients, we found an increased risk for complications in bilateral disease. A high incidence of left main coronary disease and low ejection fraction in a group of patients with postoperative ischemic neurologic deficit reflects the presence of severe atherosclerotic disease with possible decrease of hemispheric collateral compensation. It has been suggested that neurologic complications in this category of patients can be decreased by performing simultaneous bilateral carotid endarterectomy and coronary artery bypass grafting under hypothermic extracorporeal circulation.[9]

Our previous analysis[26] of septuagenarians and octogenarians with extracranial carotid and coronary artery disease demonstrated that combined operations could be performed safely and with low hospital mortality. Older patients had increased morbidity due to the concomitant noncardiac diseases. Patients who undergo simultaneous CEA/CABG due to concomitant unstable angina and cerebrovascular insufficiency have an increased rate of postoperative neurologic complications. The age of the patient and the performance of the operation under emergency conditions did not influence the risk of perioperative stroke.

Some investigators presented satisfactory results of simultaneous management of combined carotid

and coronary artery disease. However, there were higher morbidity and mortality rates compared with staged operations, perhaps due to more advanced atherosclerotic disease in these patients.[27,28] Our experience demonstrates that asymptomatic patients with carotid stenosis may undergo prophylactic CEA combined with CABG at low risk. We used a 2-team technique and repaired severe carotid lesions before the institution of CPB cerebral protection. Several reports have documented an increased risk of perioperative stroke in a group of patients with bilateral carotid disease.[15,24] Our data confirm these results. Four of 6 cases of ischemic neurologic deficit were contralateral to the side of carotid repair; however, no death occurred as a result of a neurologic event. Our 5-year survival rate of 85% and our observations from long-term follow-up of simultaneous CEA/CABG are similar to reports from other series.[12,29-32]

These data further emphasize that simultaneous CEA/CABG, in this high-risk population, is an alternative procedure that provides long-term protection from neurologic and cardiac complications.

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