Carotid-carotid crossover bypass: Is it a durable procedure?

Kathleen J. Ozsvath, MD, Sean P. Roddy, MD, R. Clement Darling III, MD, John Byrne, MD, Paul B. Kreienberg, MD, Daniel Choi, MD, Philip S. K. Paty, MD, Benjamin B. Chang, MD, Manish Mehta, MD, MPH, and **Dhiraj M. Shah, MD,** *Albany, NY*

Purpose: **Reconstruction of a diseased common carotid artery may necessitate direct repair via aortic artery–based revascularization. However, carotid–carotid artery crossover grafting is an alternative extra-anatomic option that obviates the need for median sternotomy. We analyzed our results with carotid–carotid artery crossover bypass surgery.**
Methods: **Data were analyzed for all patients undergoing carotid–carotid crossover bypass surgery from 1995 to 2000. Data on patient demographics, indications for surgery, perioperative morbidity and mortality, and graft patency were retrieved from a vascular surgery data base and hospital records. Stroke-free survival and graft patency were determined with life table methods.**
Results: **Over 5 years, 24 carotid–carotid artery crossover bypass procedures were performed to treat both symptomatic (n = 19, 79%) and asymptomatic (n = 5, 17%) disease. Nine procedures (38%) were performed in men, 3 (13%) in patients with diabetes, 12 (50%) in active smokers, and 2 in patients with a history of Takayasu arteritis. Patient mean age was 63 years (range, 38-79 years). Twenty-three patients (96%) received polytetrafluoroethylene conduit grafts, and the remaining patients received vein grafts. Ten (42%) patients underwent concomitant endarterectomy. There were no perioperative deaths. One patient (4%) had asymptomatic early occlusion, one had transient neurologic deficit (4%), one (4%) required additional surgery because of bleeding, and one (4%) had a perioperative cerebrovascular accident (stroke). Three (17%) asymptomatic late occlusions were identified at 11, 57, and 64 months, respectively. Mean follow-up was 30 months (range, 1-70 months). Primary patency was 88%, and secondary patency was 92% at 3 years. Stroke-free survival was 94% at 4 years.**
Conclusion: **Carotid–carotid artery crossover bypass surgery is a safe and durable procedure. Its use precludes the need for median sternotomy and provides acceptable stroke-free survival. (J Vasc Surg 2003;37:582-5.)**

Atherosclerotic occlusive disease of the great vessels can lead to hemodynamic or embolic complications. Common carotid, vertebrobasilar, and less frequently innominate artery disease can lead to cerebrovascular insufficiency. Both patients with symptomatic and asymptomatic carotid bifurcation disease can benefit from carotid endarterectomy.[1-5] However, only 1.5% to 2% of patients with symptoms have proximal carotid disease not amenable to standard carotid endarterectomy.[6,7] The natural history of common carotid artery lesions is not completely understood because they are relatively rare, and in the literature patients tend to be grouped with patients with other great vessel disease.[8] In addition to cerebrovascular insufficiency, patients with atherosclerotic occlusive disease involving the proximal subclavian arteries or the innominate artery may experience microembolic events or upper extremity exercise-induced ischemia. Initially, treatment of proximal great vessel disease was performed with a direct approach to the aortic arch.[9,10] Endarterectomy and bypass grafting were chosen as treatment options.[11,12] In a review of 10 years of experience with transthoracic treatment of proximal great vessel disease, Crawford et al[13] found high morbidity and high mortality. Extra anatomic bypass procedures have become more widely accepted because of technical ease, decreased morbidity, and similar patency rates. Axillary-axillary bypass grafts, subclavian-subclavian bypass grafts, carotid-subclavian bypass grafts, carotid-carotid bypass grafts, and subclavian-carotid transposition have been used to treat proximal great vessel disease, with variable results.[14-24] We reviewed our experience with carotid-carotid bypass procedures, specifically analyzing complications, patency, operative mortality, and stroke-free survival associated with this approach.

METHODS

From 1995 to 2000, 24 patients underwent carotid-carotid bypass surgery. Patient demographics, indications for intervention, perioperative morbidity and mortality, and patency rates were retrieved from a vascular registry data base and analyzed. All patients underwent preoperative testing that included either duplex ultrasonographic scanning or magnetic resonance imaging and four-vessel angiography. All patients had documented either common carotid or innominate artery stenosis or occlusions. There were an equal number of occlusions and stenosis in these patients.

From the Institute for Vascular Health and Disease, Albany Medical College, Albany, NY
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Reprint requests: R. Clement Darling III, MD, Vascular Institute (MC157), Albany Medical College, 47 New Scotland Ave, Albany, NY 12208 (e-mail: DarlinC@mail.amc.edu).

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Table I. Patient demographics

Carotid-carotid artery bypass procedures	24
Patients	
Men	9
Women	9
Patient age (y)	
Mean	63
Range	38-79
Takayasu arteritis	2
Diabetes	3
Smokers	12
Follow-up (mo)	
Mean	34
Range	1-70

All procedures were carried out after induction of general anesthesia. In patients with carotid artery bifurcation disease, eversion endarterectomy was performed in conjunction with carotid-carotid bypass. Bypass grafts were preferentially placed in the retroesophageal position. The tunnel was made with careful blunt and sharp dissection on both sides of the neck, following the plane between the buccopharyngeal fascia and the prevertebral fascia. Once the tunnel was made, the graft was placed, ensuring placement without kinks. Polytetrafluoroethylene (PTFE) was preferred as conduit. The bypass grafts were taken from the donor carotid artery at the base of the neck, and the distal anastomosis on the contralateral carotid artery was either sewn into the common carotid artery or at the bifurcation in patients undergoing concurrent endarterectomy. This provided a more obliquely lying graft. No intraoperative arterial monitoring was performed. No intraluminal shunts were used. Although no on-table angiography was performed, all bypass grafts were assessed with intraoperative Doppler scanning.

During the postoperative period all patients were monitored, specifically for blood pressure fluctuation and change in neurologic status. After observation in the postanesthesia care unit, patients were transferred to the vascular surgery floor. All patients were followed up 2 weeks after surgery. Carotid artery duplex scans were obtained at 3, 6, and 12 months and yearly thereafter.

Classification, analysis, and reporting were performed in accord with the criteria published by The Society for Vascular Surgery and the International Society for Cardiovascular Surgry.[25] Stroke-free survival and patency rates were presented with life table methods.

RESULTS

During the 5-year study, 24 carotid–carotid artery bypass procedures were performed in 9 men (38%) and 15 women (62%), with mean age 63 years (range, 38-79 years). Three patients (13%) had diabetes, and 12 (50%) were active smokers. Two patients (8%) had a history of Takayasu arteritis. Mean follow-up was 34 months (range, 1 to 70 months) (Table I).

Indications for surgery included one or a combination of the following conditions: amaurosis fugax (n = 9, 38%), transient ischemia (n = 9, 38%), asymptomatic carotid stenosis (n = 4, 17%), stroke (n = 2, 8%), and subclavian steal syndrome (n = 1, 4%) (Table II). Four patients with either transient ischemia or amaurosis fugax had a history of concurrent upper extremity exercise-induced ischemia. Those patients with asymptomatic carotid bifurcation stenosis had concurrent inflow disease. It was believed that decreased flow in a freshly endarterectomized artery could possibly lead to stasis and possible thrombosis. One patient had a neck mass, which was determined to be a pseudoaneurysm, after subclavian–subclavian artery bypass performed at an outside institution. Two patients had undergone aortic artery–based reconstruction, and one patient had undergone brachiocephalic reconstruction (Table III). Two patients had a history of Takayasu arteritis; one had stroke. This patient had had two previously failed aortic artery–based reconstructions. Inflow was taken from the left common femoral artery to the left common carotid artery, after which left-to-right carotid artery bypass was performed. The other patient also had a previously failed bypass graft and new symptoms (transient ischemia) requiring intervention.

Table II. Indications for surgery

Stroke	2
Asymptomatic carotid stenosis	4
Transient ischemic attack	9
Amaurosis fugax	9
Concurrent arm claudication	4
Subclavian steal syndrome	
With symptoms	1
Without symptoms (incidental finding at angiography)	5
Neck mass (pseudoaneurysm)	1

Table III. Previous surgery performed at outside institutions

Aortic arch–based bypass graft	2
Subclavian-subclavian bypass graft (pseudoaneurysm)	1
Brachiocephalic bypass graft	1
Carotid subclavian bypass graft	1

Ten patients (42%) underwent carotid endarterectomy because of concurrent carotid bifurcation disease. All of these 10 patients had high-grade internal carotid artery stenosis. Seven patients had symptoms referable to the side with the carotid stenosis, but they also had a concurrent proximal occlusion. Of the three patients with no symptoms who underwent carotid endarterectomy, high-grade internal carotid artery stenosis existed at the bifurcation, with concurrent proximal occlusions. Since the endarterectomy was performed in these patients because of asymptomatic carotid stenosis, it was believed that in the presence of a proximal occlusion it would be safest to perform an inflow procedure as well. In 23 patients (96%) 8 mm PTFE grafts were placed, and in one patient (4%) an excised reversed vein bypass procedure was performed (surgeon preference).

Table IV. Complications

Death	0
Early occlusion (thrombectomy, postoperative day 1)	1
Late occlusion (one each at 11, 57, and 64 mo)	3
Transient neurologic deficit	1
Bleeding (anastomosis repair, evacuation of hematoma)	1
Stroke (postoperative)	1

No patients died in the perioperative period. One patient who received a PTFE graft with concurrent carotid endarterectomy experienced a transient neurologic event, which completely resolved before discharge from the hospital. One patient required a repeat operation for evacuation of a hematoma and repair of the suture line at the distal anastomosis. In one patient occlusion of the PTFE bypass perioperatively required thrombectomy. The bypass graft remained open in follow-up. One patient, who received a PTFE graft only, had a neurologic deficit that required rehabilitation. One patient had asymptomatic occlusion of the PTFE graft at 11 months. Two patients had late asymptomatic occlusions at 57 and 64 months, respectively (Table IV). None of these patients experienced new symptoms, and none underwent repeat operation. The primary patency rate at 3 years was 88%, the same as the primary assisted patency rate (Fig 1). The secondary patency rate was 92%. Stroke-free survival was 94% at 4 years (Fig 2).

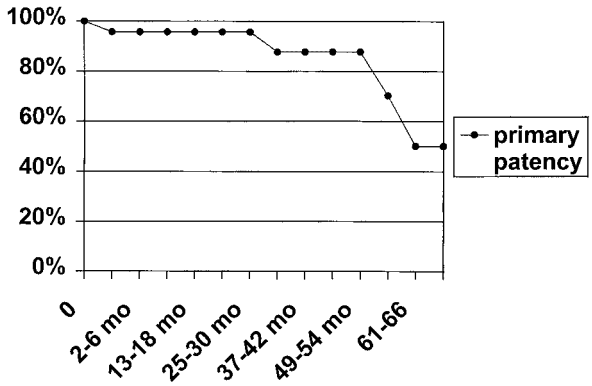

Fig 1. Primary patency (SE > 10% at 37-72 mo).

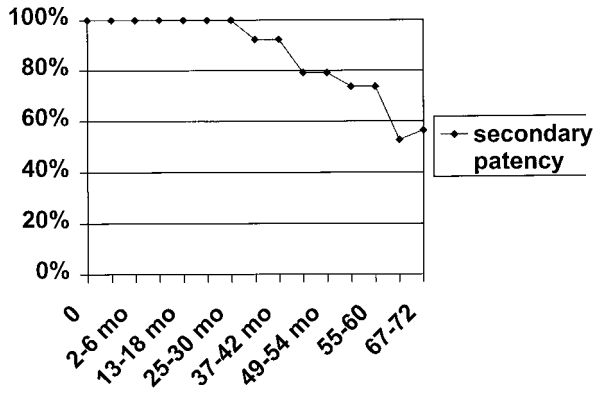

Fig 2. Secondary patency (SE > 10% at 43-72 mo).

DISCUSSION

Most patients with cerebrovascular insufficiency have typical carotid artery bifurcation disease. A small subset of patients have more extensive proximal disease. Treatment of this group must result in similar morbidity and mortality as standard endarterectomy to gain benefit from surgery. Indications for intervention in patients with symptoms of proximal carotid artery disease are probably more clear than in patients without symptoms. Although most proximal innominate and subclavian lesions are likely to be asymptomatic, a small number of patients have vertebrobasilar insufficiency, embolism, or upper extremity exertional ischemia requiring intervention. Results of studies in which extra-anatomic bypass procedures were performed because of aortic branch disease have acceptable patency rates and comparable stroke and mortality rates.

Also of concern is that patients with aortic branch occlusive disease may represent a population at high risk.[21] As reported by Moore et al,[21] 85% of their patients undergoing extrathoracic bypass procedures because of great vessel disease had coronary artery occlusive disease and hypertensive cardiovascular disease. More than 50% of their patients died within 5 years of surgery. The combined stroke and death rate in patients undergoing transthoracic repair appears to be in the range of 14% to 16%.[23,26,27] On the other hand, extra-anatomic bypass of the great vessels can be performed with combined perioperative stroke and death rates under 5%.[23,28,29] A less invasive procedure can clearly increase the possibility of a successful outcome with less morbidity. Abou-Zamzam et al[23] reported patency rates as high as 90% over 5 years for extrathoracic grafts performed specifically because of carotid artery occlusive disease.

A theoretic concern with use of an artery as a donor is the possibility of diminished flow to its own distal vascular bed. However, aortic arch branches without significant proximal disease have also been used as donor arteries without the threat of steal, with greatly increased blood flow supplying more than one distal vascular bed.[19,20,30,31] Specifically, as suggested by Manart et al,[20] carotid-carotid bypass grafts have high flow rates, and the bypass grafts are relatively short and are well protected from injury because of the position of the graft deep in the neck.[20] Some authors believe that externally supported grafts may be a better choice for cervical bypass because of fear of kinking.[23] Although the choice of conduit has been discussed in the literature, there appears to be no significant difference between prosthetic and good quality vein.[23-28]

Recently there has been interest in the use of endovascular techniques, specifically, angioplasty and stenting, in patients at high risk with aortic arch branch disease.[32,33]

The long-term outcome of these procedures remains to be seen. Recently, in a study by Arko et al,[34] proximal carotid artery angioplasty and stenting was performed with concurrent carotid endarterectomy. Six patients underwent combined endovascular and surgical interventions, with follow-up ranging from 6 to 43 months. In very early follow-up no patients had restenosis; however, long-term results have yet to be reported. Recently all patients at our institution have been evaluated for possible endovascular intervention. However, some patients have unfavorable anatomy and require surgical intervention. In addition, if an endovascular procedure has already been undertaken and has failed, extra-anatomic bypass grafting certainly could be considered as a safe and effective secondary procedure. There has been a recent case report by Kumins et al[35] in which restenosis of a carotid lesion occurred after angioplasty and stenting, requiring an internal carotid-carotid transposition.

In patients with aortic branch disease, extra-anatomic bypass procedures are safe and durable. In this series, patients both with and without symptoms with bifurcation disease and concurrent inflow disease, patients with proximal disease with symptoms, patients with Takayasu arteritis with cerebrovascular insufficiency, and a patient with a graft infection underwent carotid–carotid artery bypass procedures, with favorable outcome and acceptable risk.

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