Short vein grafts for cerebral revascularization

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Experience with the use of a short saphenous vein bypass graft for cerebral revascularization is reviewed. Twenty patients with symptomatic atherosclerotic occlusive disease underwent a total of 21 bypass procedures. Cerebral revascularization was performed using a short (5 to 10 cm) saphenous vein graft (SVG) extending from the superficial temporal artery (STA) trunk anterior to the ear in 19 bypasses, or from the occipital artery (OA) immediately behind the mastoid process to the posterior temporal or angular branch of the middle cerebral artery (MCA) in two bypasses. The early patency rate for the SVG bypasses was 90%. Two of the four patients with SVG occlusion were found to have substantial resolution of a severe inaccessible internal carotid artery stenosis that was present preoperatively. Filling of multiple major branches of the MCA through the SVG was seen in 90% of patients on late postoperative conventional angiography. The STA trunk or proximal OA was consistently found to be enlarged on the late studies. None of the patients had recurrence of cerebral transient ischemic attacks. The procedure may be useful as a primary means of cerebral revascularization or as an alternative approach when a scalp artery cannot be used because of its small size, severity of arteriosclerotic changes (a common occurrence), or damage during its dissection. Cerebral blood flow studies suggest that the use of a short SVG has a more favorable effect upon the cerebral circulation than the conventional bypass procedure.

KEY WORDS • atherosclerosis • angiography • cerebral blood flow • anastomosis • cerebral ischemia • saphenous vein graft • revascularization

A branch of the superficial temporal artery (STA) or the occipital artery (OA) is usually used as the donor artery for cerebral revascularization. These arteries are relatively long and usually have a luminal diameter of 1 to 2 mm at the site of anastomosis. Recent reports indicate that these arteries frequently have substantial arteriosclerotic changes in the older age group, when cerebral revascularization is usually indicated. These pathological changes could potentially reduce the efficacy of the procedure. In some instances, the scalp artery cannot be used as the donor artery because of its small size (that is, less than 1 mm in diameter), the severity of arteriosclerotic changes, or damage incurred during its dissection. Under these circumstances, a long vein graft from a cervical carotid artery or subclavian artery has been used. An alternative approach is to use a short vein graft from the proximal STA trunk or OA to the cortical receptor artery. In this report we describe our experience with the use of short vein grafts for cerebral revascularization.

Clinical Material and Methods

Angiography

All patients had conventional angiographic studies before surgery, using the femoral artery catheter technique. Angiography included an evaluation of both carotid arteries and at least one vertebral artery. Anteroposterior and lateral views of the head were obtained on the carotid study on the symptomatic side. The luminal diameter of the donor scalp artery at the site of the proximal anastomosis was measured on the lateral projection and corrected for magnification. The percentage of luminal stenosis was calculated in patients with an inaccessible internal carotid artery (ICA) or middle cerebral artery (MCA) stenotic lesion.

The ipsilateral carotid artery system was reevaluated within 2 weeks after surgery and again at 1 to 6 months after surgery with either conventional angiography or intravenous digital subtraction angiography (IV DSA). The technique of IV DSA has been described in detail previously.
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Fig. 1. Left carotid angiogram 6 months after a left superficial temporal artery (STA)-saphenous vein graft (SVG)-middle cerebral artery (MCA) bypass for internal carotid artery occlusion. Rapid filling of multiple major branches of the MCA is seen. The STA trunk has enlarged substantially and its luminal diameter approaches that of the SVG.

Surgical Techniques

Cerebral revascularization was performed using a short saphenous vein graft (SVG), 5 to 10 cm in length, extending from the STA trunk anterior to the ear or from the OA immediately behind the mastoid process to the posterior temporal or angular branch of the MCA. A segment of the greater saphenous vein proximal to the ankle was removed through a linear incision by an assistant during the performance of the craniotomy. After its removal, the SVG was irrigated with heparinized saline. The graft was aligned so that subsequent flow occurred in the direction of the valves. The proximal and distal ends of the SVG were prepared by removing all the adventitia over a 1-mm segment at each end in order to facilitate passage of the suture needle. An end-to-side anastomosis of the vein to the cortical artery was carried out using a continuous suture (9-0 nylon) for the back wall and interrupted sutures (10-0 nylon) for the front wall. Following completion of the anastomosis at the cortical end, a temporary occluding clip was placed across the vein graft adjacent to the anastomosis prior to removing the temporary clips from the cortical receptor artery. The patients were then heparinized in order to prevent clot formation at the cortical anastomotic site while the proximal anastomosis was performed. An end-to-side anastomosis of the vein to the STA trunk immediately above the zygoma or the OA posterior to the mastoid bone was carried out in a similar fashion to the cortical anastomosis. Upon completion of both anastomoses and reopening of the arteries, the heparin was reversed with protamine sulfate.

Operative Results

Twenty patients (15 males and five females, with a mean age of 58 years) underwent 21 cerebral revascularization procedures using a short SVG for symptomatic atherosclerotic occlusive disease. Eighteen patients had an STA-SVG-MCA bypass including one patient with bilateral revascularization procedures. Two patients had an OA-SVG-MCA bypass.

Angiography

Preoperative Findings. Preoperative angiography demonstrated unilateral ICA occlusion in 10 patients, bilateral ICA occlusion in four patients, inaccessible severe ICA stenosis in five patients (90% ± 5%), and severe MCA stenosis in one patient (80%). The STA trunk diameter was 2.0 ± 0.5 mm, and the OA diameter in two patients was 2.0 ± 0.0 mm.

Early Postoperative Findings. Seven patients had early postoperative conventional angiography and 16 patients had early postoperative IV DSA. Eighteen bypasses (90%) were found to be patent. On conventional angiography, multiple major branches of the MCA filled through the SVG in five patients, and the receptor cortical artery only filled in one patient. In one patient with an occluded STA-SVG-MCA bypass, a 50% inaccessible ICA siphon stenosis persisted, but there was rapid MCA filling through the ICA; this patient had had a preoperative 90% ICA stenosis, and the MCA filling was slow. One patient with a patent SVG also had apparent improvement in the severity of ICA stenosis (85% preoperatively, 60% postoperatively). In a third patient, a severely stenotic ICA demonstrated preoperatively was occluded postoperatively.

Late Postoperative Findings. Eleven patients had late postoperative conventional angiography and six patients had postoperative IV DSA. Three patients have yet to undergo late postoperative studies. The diameter of the STA trunk in the conventional studies was 3.5 ± 0.5 mm. Mean SVG diameter was 4.0 ± 0.5 mm. In 10 patients undergoing conventional angiography, the SVG was patent. In this group, filling of the cortical receptor artery only was found in one patient, and filling of multiple major branches of the MCA was found in nine patients (Fig. 1). Improvement of preoperative ICA or MCA stenosis was seen in two additional patients (that is, two others were found to have improvement on the early postoperative studies). One of these patients had 80% stenosis of the petrous segment of the ICA.
before surgery. His SVG was patent on the early postoperative IV DSA. On the late postoperative conventional study, the SVG was occluded but the petrous segment of the ICA had a normal caliber without evidence of stenosis (Fig. 2). The SVG was patent in all other patients who were shown to have a patent SVG on early postoperative conventional angiography and IV DSA.

Clinical Results

One patient died 7 months after surgery from chronic renal failure; autopsy showed the SVG to be widely patent. Microscopic sections revealed mild fibrosis in the wall of the SVG. One patient with inaccessible severe ICA stenosis suffered a small ipsilateral cerebral infarct 3 days following surgery. Early postoperative angiography showed a widely patent SVG but the ipsilateral ICA was now occluded. This patient eventually made a complete neurological recovery. None of the patients had recurrence of transient cerebral ischemic attacks, including the four patients with SVG occlusion.

Discussion

Recent reports have raised concern about the use of scalp arteries for cerebral revascularization. These arteries have been shown to be particularly prone to the development of arteriosclerosis. Lie, et al., evaluated 150 cadaver temporal arteries from infancy to senescence. This investigation revealed progressive intimal thickening and alteration of the internal elastic lamina. Clear-cut atheromatous changes were a rare finding. Diaz, et al., evaluated histologically the STA resected at the time of STA-MCA bypass surgery in 64 consecutive cases. Intimal proliferation was observed in 62 specimens, intimal fibrosis in 56, fragmentation of the internal elastic lamina in 45, splitting of the internal elastic lamina in 41, fragmentation of the media in 38, and fragmentation of the minimal external elastic lamina in 17. Stenosis of the STA, a common finding, was most often the result of intimal fibrosis and hyperplasia.

A short SVG has been used extensively for revascularizing the heart and kidney. Long-term patency rates of the vein grafts in these situations have consistently been greater than 80%. Late occlusion appears to be more common with aorto-coronary grafts, and is usually the result of subintimal fibrous hyperplasia. In contrast, aorto-renal grafts are prone to uniform dilation or aneurysm formation and seldom develop occlusive subintimal hyperplasia.

Comparisons between different organ revascularization procedures using a short SVG are difficult because of the major differences in flow and resistance patterns. In heart and kidney revascularization, the SVG comes directly off the aorta, whereas in cerebral revascularization the SVG comes off a relatively small muscular artery. Because stress on the wall of the SVG in cerebral revascularization is probably less, these grafts may not
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undergo pathological changes as rapidly as grafts used in heart and kidney revascularization, but the lower input pressure may increase the risk of postoperative thrombosis.

Although limited information is available regarding pathological changes in the STA after bypass, some reports have described the angiographic findings. Latchaw, et al., compared the preoperative and postoperative angiograms in 40 patients undergoing STA-MCA bypass. In patients studied during the early postoperative period, 81% with a patent bypass were found to have a mean increase in STA diameter of 58%. Further enlargement was seen in 12 of 18 patients studied at a later date (at a median postoperative time of 5 months). However, despite the enlargement the STA luminal diameter remains relatively small since the STA diameter is initially only 1 to 2 mm. Increased tortuosity of the STA was also a common finding of the late postoperative angiograms.

In the present study, there was a 90% initial patency rate. This compares with a patency rate of 89% for North American centers in the ongoing extracranial-intracranial bypass study. Ninety percent of those patients with a patent SVG bypass had filling of multiple major branches of the MCA through the SVG. The SVG luminal diameter was 4.0 ± 0.5 mm and the STA trunk diameter 3.5 ± 0.5 mm on the late postoperative studies, both consistently larger than STA diameter in patients undergoing conventional bypass surgery. Increase in the length or tortuosity of the SVG was not observed on the late postoperative angiograms.

We have studied 19 patients undergoing conventional bypass surgery and 10 patients undergoing short SVG revascularization with the xenon-133 inhalation regional cerebral blood flow (rCBF) measurement technique. Patients with a patent conventional bypass had a 5% improvement of mean hemispheric rCBF (not statistically significant) after surgery, whereas patients with a patent SVG bypass had an average 24% improvement in rCBF (p < 0.01). These findings suggest that the short SVG has a more favorable effect in improving rCBF compared to the conventional bypass.

A potential advantage of using an SVG for cerebral revascularization is the immediate establishment of a relatively large-caliber bypass. The STA trunk also consistently enlarged and eventually approached the size of the SVG on the late postoperative angiograms. The disadvantages include: 1) harvesting of the SVG; and 2) performance of two anastomoses. Harvesting of the SVG is a relatively easy procedure which can be performed while the craniotomy is being carried out. Time is saved since the STA or OA is exposed only in its proximal segment. The performance of a proximal SVG to STA or OA anastomosis is easier and less time-consuming than with the distal anastomosis. The proximal STA or OA have larger luminal diameters than their distal segments and the wall has a thickness comparable to the SVG.

Improvement in the degree of preoperative ICA or MCA stenosis after surgery was found in four patients. Similar improvement of an inaccessible stenotic lesion has been demonstrated by Fox and by Day, et al. Improvement in the severity of stenosis is most likely the result of resolution of a thrombus or dissection as opposed to regression of an atherosclerotic plaque. The findings of the present and previous studies suggest that a course of anticoagulation with repeat angiography 2 to 3 weeks later might be an appropriate approach in this group of patients before a final decision is made regarding revascularization. Of four patients with SVG occlusion, two had substantial resolution of a previously demonstrated ICA stenosis. Improvement of flow through the ICA probably played an important role in the subsequent occlusion in these two cases. Three of the four patients with SVG occlusion also had a relatively small STA trunk diameter (less than 1.5 mm). A recent report of SVG bypass patency for coronary revascularization suggests that the use of perioperative aspirin and dipyridamole may improve SVG patency.

References


Manuscript received March 3, 1983.

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