Contralateral external carotid-to-middle cerebral artery graft using the saphenous vein

Case report

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A variation of the extracranial-intracranial arterial bypass, using a long saphenous vein graft, is presented. The saphenous vein graft was inserted from the contralateral external carotid artery to the distal middle cerebral artery to replace the common and internal carotid arteries in a patient with a large neck tumor that invaded the common and internal carotid arteries, the esophagus, and the trachea. The patient had a positive balloon Matas' test. The saphenous vein was covered with an artificial vascular graft so that turning of the head or movement of the mandible did not displace or compress the graft. A large volume of flow began immediately after anastomosis. A description of the case and the operative technique is presented herein.

KEY WORDS: venous graft • saphenous vein • arterial anastomosis • extracranial-intracranial bypass

The extracranial-intracranial arterial bypass procedure has been used increasingly to treat patients with occlusive cerebrovascular disease, skull-base tumors, and aneurysms.1,2,4 Sundt and coworkers5,6 used interpositioned saphenous vein grafts between the external carotid artery (ECA) and the proximal posterior cerebral artery or the middle cerebral artery (MCA) to treat advanced occlusive disease and giant aneurysms. Reconstruction has also been performed using saphenous vein grafts from the petrous to the supraclinoid portion of the internal carotid artery (ICA) to replace the cavernous ICA in patients during direct intracavernous surgery.7

We describe an alternative means of revascularization using a long saphenous vein graft. The graft extended from the contralateral cervical ECA to the horizontal segment of the MCA, directly bypassing the cervical, petrous, and cavernous ICA proximal to the ophthalmic artery. The graft itself was protected with ringed vascular graft made of Gore-Tex.

Case Report

This 65-year-old woman was referred to our clinic for evaluation of a large mass in the right side of her neck, which had been growing gradually for 2 years. She complained of dyspnea and swallowing disturbances because of the mass.

Examination. A firm, 12 × 12-cm tumor was found on the right side of the neck with evidence of involvement of the ICA, the esophagus, and the trachea. The patient’s neurological examination was normal. Magnetic resonance (MR) images showed that the tumor invaded the esophagus and trachea and encased the right common carotid artery. An MR angiogram showed that the right common carotid and subclavian arteries were encased and narrowed by the tumor.

There was no evidence of collateral flow reserve and the patient could not tolerate a balloon occlusion test of the ICA for 5 minutes. Therefore, barbiturate therapy was used to prevent ischemic brain damage during temporary occlusion of the MCA for grafting.

Operation. The patient was placed supine, with a heavy roll under her left shoulder. The head was turned 20° to the left side. A bifrontal coronal skin incision was made behind the hairline, and the intracranial procedure was carried out through a small pterional craniotomy on the right side. The distal horizontal segment of the MCA in the sylvian fissure was isolated for anastomosis. The anterior clinoid process was removed, and the optic canal was unroofed with a high-speed drill. The distal intracavernous ICA and the ophthalmic artery were exposed after division of the dural ring at its exit from the cavernous sinus. The head was turned to the right and the neck was extended. The left
Contralateral ECA to MCA vein graft

![Diagram](image)

**Fig. 1.** Schematic illustrations of the contralateral cervical carotid-to-middle cerebral artery bypass using the long saphenous vein. The vein is protected with an artificial vascular graft.

The common carotid artery and its bifurcation were prepared for anastomosis.

A segment of the greater saphenous vein (about 38 cm) was removed from the thigh and rinsed with heparinized saline to remove blood and clots. Leaks in the isolated vein were closed with monofilament nylon sutures. The vein was handled meticulously to avoid intimal damage and prevent subsequent thromboemboli. The valves of the vein were not removed. The entire graft was passed through an artificial vascular graft, 5 mm in diameter and 36 cm in length, which had many small holes. Torsion was prevented by filling the vein with saline solution under high pressure, allowing gentle, accurate placement of the vein within the artificial vascular graft.

In order to place the vein with its artificial graft subcutaneously above the mandible and under the zygomatic arch, a chest trocar tube was passed from the cervical carotid artery bifurcation to the superior temporal line through the pterygoid zygomatic fossa. This tube was then replaced with a plastic sleeve 1 cm in diameter. The proximal end of the saphenous vein graft and its protective vascular graft were brought from the cervical to the superior temporal area through this subcutaneous plastic sleeve. A bone conduit, 12 cm long and 5 mm deep, was created transversely on the surface of the bifrontal bone from the left superior temporal line to the medial margin of the right cranialotomy using a high-speed air drill with a diamond burr. The vein graft was passed through the bone conduit to the right intracranial space to be anastomosed. The proximal end of the artificial vascular graft at the cervical carotid artery bifurcation was incised longitudinally with leaf-like cuts, 4 mm long and 3 mm wide, to cover the suture line (Fig. 1).

The proximal anastomosis between the ECA and the distal end of the saphenous vein was performed first. Two temporary vascular clips were placed 2 cm apart at the origin of the left ECA. A linear arteriotomy measuring 5 mm was made on the lateral wall of the ECA. The distal end of the graft, which had a smaller luminal diameter than the proximal end, was adapted to the ECA. The end-to-side anastomosis was completed with interrupted 7–0 nylon sutures. A temporary clip was placed on the vein graft just distal to the suture line to prevent the accumulation of blood or clots or thrombosis during the anastomosis. The two temporary clips were released to restore blood flow through the ECA.

Thiopental sodium and mannitol were administered intravenously, beginning with a bolus injection of thiopental sodium (6 mg/kg). This was maintained with a continuous intravenous infusion of about 4 mg/kg/hr. The intracranial anastomosis was then performed end-to-side at the distal horizontal segment of the MCA using 10–0 interrupted nylon sutures. This procedure lasted about 20 minutes. When the anastomosis was completed, the temporary clip placed on the vein graft at the cervical area was released. Blood flow through the graft was established; inspection and palpation of the grafted vein indicated that it was functioning well. Because forceful blood flow through the graft could form an aneurysm or tear the opposite wall at the anastomotic site, we fastened a T-shaped artificial vas-
cular graft around the site of anastomosis, fixing it with a clip. Finally, a permanent clip was placed on the cavernous ICA proximal to the ophthalmic artery (Fig. 2). Systemic anticoagulation was not used during any stage of the procedure.

Postoperative Course. After surgery, the patient experienced motor weakness on the left side, which later resolved. Because the patient could not tolerate a balloon occlusion test of the ICA, temporary neurological deficits occurred despite intraoperative barbiturate therapy. A postoperative angiogram showed the long vein graft to be patent and, 10 days later, the tumor was totally removed with the involved cervical ICA segment. Histological examination showed that the mass was a malignant schwannoma. The graft was patent on angiograms and transcutaneous Doppler ultrasound studies obtained at the patient's 6-month follow-up examination (Fig. 3).

Discussion

Lougheed, et al.\textsuperscript{6}, were the first to report using a bypass from the common carotid artery to the intracranial ICA incorporating a saphenous vein graft. Spetzler, et al.\textsuperscript{10}, modified this procedure, using the subclavian artery as a donor vessel. In our patient, the ipsilateral common carotid and subclavian arteries had been invaded by the tumor. Consequently, we used the contralateral ECA as the donor and the distal M\textsubscript{1} segment of the MCA as the recipient artery. We chose end-to-side anastomosis instead of end-to-end anastomosis because we did not want to sacrifice the ECA on both sides. The distal MCA was designated the recipient vessel because there were fewer lenticulostriate arteries in the distal MCA on the preoperative angiogram. An anastomosis at this site avoided ischemic damage to the lenticulostriate arteries originating from the proximal MCA during temporary occlusion. Furthermore, the intraluminal diameter at this site was adequate for anastomosis with the relatively larger end of the saphenous vein graft. Therefore, the long saphenous vein graft was necessary for this patient.

Occlusion of the graft in the first few days or weeks after reconstruction most often results from thrombosis.\textsuperscript{1,16} The factors contributing to thrombosis include: intimal desquamation, slow flow through the graft, and the coagulability of the patient’s blood.\textsuperscript{15} After vascular implantation, the graft becomes coated with fibrin. Because of this, high flow rates are required to prevent the rapid accumulation of fibrin and subsequent graft thrombosis.\textsuperscript{7} Subendothelial basement membranes and collagen are thrombogenic; therefore, it seems likely...
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that venous grafts with low flow rates could fail early if the endothelium has been damaged. Consequently, the technical aspects of removing and preparing the vein are crucial to the long-term success of a saphenous vein bypass graft, and careful medical management is necessary to prevent thrombosis.

Because the balloon Matsas’ test was positive in our patient, it was essential that blood flow through the graft provide sufficient supply to the territory of the anterior cerebral artery, the MCA, and the ICA, including the ophthalmic artery. Compared to the conventional superficial temporal artery (STA)-MCA bypass, the saphenous vein graft immediately establishes a large-caliber bypass with high flow rates, compensating for the abrupt occlusion of the ICA and preserving regional cerebral blood flow.

Other technical problems causing graft occlusion include: torsion of the graft in the subcutaneous tunnel, kinking after expansion of the graft under arterial pressure, external compression by fascia or the margin of the craniotomy, and damage resulting from the vascular clamp. We believe that these risk factors can be avoided by protecting the saphenous vein graft with the ringed artificial vascular graft. Small holes were made in the wall of the artificial vascular graft to maintain communication with the outside connective tissue, fascia, or muscles. Other researchers have found angiographic evidence of aneurysmal dilation associated with some grafts at the anastomotic site. To prevent this, the distal anastomotic site in our patient was covered with a T-shaped non-ringed artificial vascular graft, and the suture line at the proximal anastomotic site in the cervical portion was covered with leaf-like cuts at the proximal end of the artificial vessel.

Although Spetzler, et al., reported the “bonnet bypass” technique (a saphenous vein bypass graft from the contralateral STA to the ipsilateral MCA), our technique is different from theirs on the following points: we used the ECA for the donor artery instead of the STA; we made a bone conduit; and the saphenous vein bypass was covered with an artificial vascular graft to secure the patency of the graft.

The long saphenous vein bypass from the contralateral ECA is useful in preventing cerebral ischemia when the ipsilateral common carotid artery must be sacrificed at its cervical portion. This procedure can be anticipated when an extracranial artery is unavailable and large-volume flow is desired.

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References