Cerebral Revascularization: Common Carotid to Distal Middle Cerebral Artery Bypass

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A right common carotid to distal middle cerebral artery bypass utilizing a saphenous vein graft was performed in a patient with episodic cerebral ischemia and reversible ischemic neurological deficit. The patient was relieved of his symptoms, and there was improved motor function in the left hand. Postoperative angiography revealed flow through the graft with excellent filling of the middle cerebral circulation, both retrograde and antegrade. This bypass procedure provided an immediate source of high volume blood flow and thereby provided immediate protection to the hemisphere.

Key words: Bypass, Cerebral revascularization, Common carotid artery, Graft, Middle cerebral artery, Vein

INTRODUCTION

The development of cerebral revascularization, beginning with superficial temporal artery-middle cerebral artery anastomosis (STA-MCA anastomosis), as first performed by Donaghy and Yasargil in 1967 (2, 13) and later by many others, offers new hope for the patient with cerebrovascular insufficiency and impending stroke related to occlusion of the major cervical vessels or resulting from inaccessible stenotic or occlusive intracranial vascular lesions. The STA-MCA anastomosis is a safe and effective method of supplementing cerebral blood flow. The procedure may be expected to increase flow in the middle cerebral artery distribution (1, 11). A criticism of the procedure, however, has been the limited increase in flow and, hence, the possibly limited protection provided, especially in the initial postsurgical phase.

Woringer and Kunlin in 1963 performed a common carotid to intracranial internal carotid bypass utilizing a saphenous vein graft in a patient with cervical internal carotid occlusion (12). The graft was patent at autopsy 1 day after operation. Lougheed et al. in 1971 succeeded in providing apparent high volume flow via a common carotid-intracranial internal carotid artery bypass utilizing a saphenous vein graft in another patient with occlusion of the cervical internal carotid artery (9). We have used this procedure and have found it to be effective in providing immediate and continued high volume flow. The saphenous vein-intracranial carotid anastomosis is more difficult and potentially more hazardous, however, than a STA-MCA anastomosis because of several factors: it requires more manipulation of the brain for exposure, it may require temporary occlusion of essential collateral channels, and it is often complicated by the presence of considerable atheromatous degeneration in the recipient vessel, which increases the difficulty of the intracranial anastomosis.

We recently encountered a patient who needed augmentation of his cerebral blood flow. A STA-MCA anastomosis was not feasible. The parietal branch of the superficial temporal artery was too small and the frontal branch, although enlarged, was supplying significant collateral support to the hemisphere by retrograde flow through the ophthalmic artery. A common carotid to intracranial internal carotid bypass was not attractive because this anastomosis would require temporary occlusion of the posterior communicating

artery and the ophthalmic artery; such temporary occlusions would interrupt the principal collateral blood supply to the hemisphere. It was decided that a common carotid artery to distal middle cerebral artery bypass was the only appropriate alternative. The technical feasibility of such a bypass procedure had been demonstrated in dogs by Khodadad in 1972 (6) and by Maroon and Donaghy in 1973 (10).

CASE PRESENTATION

A 65-year-old Latin American male experienced a transient left hemiparesis in April 1977. Angiography at that time revealed total occlusion of the right cervical internal carotid artery. Subsequently, the patient developed multiple episodes of transient right cerebral ischemia.

In August 1977, the patient experienced an episode of cerebral ischemia that resulted in diminished fine motor function in the left hand. Angiography revealed occlusion of the right cervical internal carotid artery (Fig. 1) and occlusion of the right vertebral artery. The left vertebrobasilar injection revealed good filling of all branches and internal collateral filling of the right middle cerebral artery via the right posterior communicating artery. However, the right posterior communicating artery was significantly narrowed by atherosclerotic changes, making this collateral supply to the right hemisphere tenuous. The left carotid injection revealed mild stenosis of the cervical internal carotid artery with good filling of the intracranial vessels. There was no spontaneous crossover to the right hemisphere.

It was our feeling that this patient's clinical manifestations were secondary to intermittent episodes of diminished blood flow to the right cerebral hemisphere in the distribution of the middle cerebral artery, and this constituted the indication for a bypass procedure. On August 29, 1977, a common carotid to distal middle cerebral artery bypass was performed.

The initial step in this procedure was a routine exposure of the common carotid artery; simultaneously, we prepared a saphenous vein graft of appropriate length. Care was taken to mark one end of the vein so that the graft remained oriented properly.

The intracranial procedure was performed through a moderate size frontotemporal scalp incision and a small, free bone flap placed over the sylvian fissue. A cortical branch of the middle cerebral artery arising from the posterior sylvian fissure was isolated between temporary clips. The arachnoid over the vessel was removed, and the vessel was measured. It was 1.75 mm in diameter. After the application of papaverine, the vessel measured 2 mm in diameter. The distal end of the saphenous vein graft was brought into the cranial field through a subcutaneous tunnel. The internal diameter of the vein was 5 mm. An elliptical opening in the cortical vessel was fashioned and matched to the graft. The anastomosis was then performed end to side utilizing 10-0 interrupted nylon sutures.



Fig. 1. Lateral view, right common carotid angiogram, demonstrating occlusion of the internal carotid artery. Note also the relative enlargement of the frontal branch of the superficial temporal artery and retrograde filling of the ophthalmic artery and intracranial internal carotid artery.

Before we sutured the vein to the common carotid artery, we assessed the competency of the cortical anastomosis by filling the vein with saline solution under mild pressure. The proximal end of the saphenous vein graft was then spatulated, and an elliptical incision in the common carotid artery was made. An end-to-side anastomosis was created with running and interrupted 7-0 nylon sutures.

When the anastomoses were completed, flow was re-established; inspection and palpation of the vein indicated excellent function of the graft. Systemic anticoagulation was not employed at any stage of this procedure.

RESULTS

On the second postoperative day, it was noted that fine motor function in the left hand had definitely improved. Although this improvement may have been fortuitous (and might have occurred had the procedure not been performed at all), the immediate postsurgical improvement was striking and suggested to us that it was related to the procedure.

Angiography 1 month postoperatively revealed filling of the vein graft and the proximal and distal middle cerebral vessels (Figs. 2 to 5). Retrograde flow in the middle cerebral artery extended into the internal carotid artery and antegrade into the ophthalmic artery (Figs. 3 and 4). Palpation of the graft in its subcutaneous position, anterior to the tragus of the ear, revealed a bounding pulse.

Three months after operation the patient was neurologically normal. The vein graft, which was easily palpated, continued to exhibit bounding pulsations. A radionuclide dynamic brain scan demonstrated activity along the course of the graft.

Four and one-half months after operation, the patient remained neurologically normal. The graft was readily palpable and was pulsatile. On January 9, 1978, a right retrograde brachial angiogram was performed; it revealed excellent pat-



Fig. 2. Postoperative angiogram, demonstrating the common carotid artery, the origin of the saphenous vein graft (VG), and the occluded internal carotid artery (IC).



FIG. 3. Lateral view, postoperative right common carotid angiogram, demonstrating filling of the saphenous vein graft and antegrade and retrograde filling of the middle cerebral vessels. Note also the antegrade filling of the ophthalmic artery and the diminished size of the frontal branch of the superficial temporal artery. Consideration must be given to the magnification differences between pre- and postoperative studies.

ency of the graft and perfusion in the distribution of the middle cerebral artery.

DISCUSSION

The intent of this procedure was to supply immediate high volume blood flow in the distribution of the middle cerebral artery, thereby providing immediate protection to the cerebral hemisphere. Blood flow studies are not available on this patient, but postoperative angiography suggests that blood flow through the system is substantial. The graft and the middle cerebral artery filled well, as noted. Additionally, there has been a marked decrease in the size of the frontal branch of the superficial temporal artery (Fig. 3). The diminished size of the superficial temporal artery suggests improved flow in the middle cerebral artery circulation. Finally, restoration of normal antegrade flow in the ophthalmic artery further attests to the improved status of flow in the middle cerebral artery.

It is striking that a 2-mm cortical artery can receive a large volume blood flow and provide runoff sufficient to prevent occlusion of such a sizable (5-mm) vein graft. The middle cerebral autoregulatory system seems to have remained intact, because a marked enlargement of the recipient middle cerebral vessels has not occurred, despite the imposition of a high pressure, high volume source.

The question of vein graft patency over a protracted period arises. Extrapolating from the experience of others who have performed coronary bypass procedures utilizing saphenous vein grafts anastomosed to small vessels, one would expect that, with appropriate surgical technique coupled with good distal runoff, the patency rate should approximate 80% in 5 years (3-5, 7, 8).

The common carotid-distal middle cerebral artery bypass procedure may be of particular importance when the superficial temporal artery is occluded or is too small to provide adequate blood flow. It also may be of value when the superficial temporal artery is already supplying important collateral circulation to the brain. Thus far, we are encouraged by this bypass procedure and we plan to evaluate the technique in suitable candidates in the future.

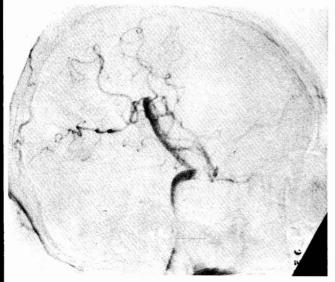


Fig. 4. Lateral postoperative angiogram, later in the series, demonstrating the extent of filling of the middle cerebral circulation.

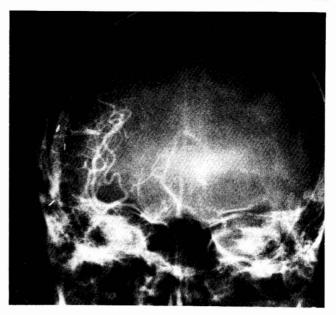


Fig. 5. Anteroposterior view of the postoperative right common carotid artery injection.

CONCLUSIONS

A procedure for providing immediate high volume blood flow to the cerebral hemisphere has been performed. A relatively small (2-mm) recipient vessel provided adequate runoff to maintain patency in the large (5-mm) bypass vein graft. Retrograde flow from the middle cerebral artery into the intracranial carotid artery and then antegrade into the ophthalmic artery was demonstrated angiographically after the bypass procedure. Both subjectively and objectively, fine motor function in the left hand improved in the early postoperative phase.

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COMMENTS

This is an interesting and provocative case report: the authors used a large venous conduit from the common carotid artery to a branch of the middle cerebral artery intracranially. An arteriogram performed at 4½ months revealed good patency and good flow. As the authors point out, the question of vein graft patency with the further passage of time is a serious one. It is imperative, therefore, to obtain arteriograms on this patient at 1 year to ascertain whether changes in this saphenous vein occur, similar to the changes found in cardiac bypass grafts. A good review of these changes may be found in the October 1977 issue of the *American Heart Journal* (1).

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This case report describes a useful variation of the techniques available for cerebral revascularization. We have used this very method of long saphenous bypass grafting between the common carotid artery and a superficial branch of the middle cerebral artery (usually the angular branch) on six occasions. In four instances, this has been used in the

treatment of occlusive vascular disease, where the superficial temporal artery was of insufficient caliber or length to permit superficial temporal to middle cerebral anastomosis, and on two occasions it was used when we planned deliberately to occlude a dominant middle cerebral artery in the treatment of giant middle cerebral artery aneurysm and when we had determined that a high volume flow through an alternate pathway would be necessary. However, when we have measured cerebral blood flow in patients, our highest rates of flow have been obtained in the superficial temporal to middle cerebral bypass procedures rather than in the vein bypass. It would seem that factors such as runoff, resistance at the anastomosis, and pressure drop across the anastomosis are probably more important than is simply the size of the inflow conduit. Of greater concern, however, is the unknown factor of the long term patency of the vein graft. Because of the small experience in cerebral revascularization with an interposed vein graft, this is not known at this time and probably the figures from the shorter segments used in coronary bypass surgery will not apply to the much longer grafts used in neurosurgery.

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In this report of a patient who suffered cerebral ischemia due to unilateral carotid occlusion, the authors have identified one of the most cogent problems in selecting patients for superficial temporal artery bypass surgery; namely, the absence of a suitable donor artery or the suggestion that the external carotid branch is serving as a dynamic source of collateral supply to the ischemic hemisphere. A number of alternative approaches have been suggested for application in this circumstance. These include arterial grafts, such as the radial artery (4), and autogenous vein grafts (1, 3). More recently, interest has been kindled by the success of umbilical vein and arterial grafts in peripheral vascular procedures (2).

One of the principal problems with long vein grafts, delayed thrombosis, has been mentioned by the authors. Another factor of perhaps greater importance than the length of the graft relates to the size discrepancy. If the internal diameter of the donor vessel exceeds that of the recipient vessel by a factor of 2, the turbulance at the anastomosis is great and the risk of thrombosis is enhanced (5). An additional troublesome feature common in the saphenous vein is wall thickness, frequently seen in leg veins, which causes a great variance between this donor vessel and the delicate wall of the cortical artery.

These problems notwithstanding, the procedure successfully performed by the authors should be considered as an alternative to temporal artery grafting. Another valuable technique reported by this reviewer consists of using the more delicate and smaller cephalic vein of the forearm and creating a graft from the proximal external carotid to the middle cerebral artery (6). Continued investigation, such as that reported by the authors, is necessary in the continuing search for a better array of options for a difficult clinical problem.

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