Reversed-flow saphenous vein grafts for cerebral revascularization

Technical note

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The authors sought to create a saphenous vein interposition graft to be used in cerebral bypass procedures that would be more physiologically appropriate than standard vein grafts and would provide a better match between the graft and recipient vessels at the anastomotic sites. The saphenous vein graft was prepared by lysing the valves with a valvulotome. The blood flow could then be reversed in the vein, allowing it to be used in either direction as a bypass graft. An illustrative case including angiograms that confirm good patency and blood flow through the reversed-flow bypass graft is presented. It is concluded that the reversed-flow saphenous vein graft provides a more physiologically suitable conduit than standard vein grafts. Lysis of the valves allows the graft to be used in an orientation that takes advantage of the natural tapering of the vein to produce a better match with the recipient vessels at the anastomotic sites. Minimizing diameter changes at the proximal and distal anastomoses helps reduce turbulence, which has been implicated as a cause of early graft failure and thrombosis.

KEY WORDS • venous interposition graft • saphenous vein graft • valvulotome • reversed-flow graft • cerebral revascularization • operative technique

The use of saphenous vein grafts in cerebral revascularization requires that the vein be interposed in its normal anatomical direction to allow blood flow across the intact valves. This standard orientation, however, creates its own problems. First, under physiological conditions the valves close during diastole and must be reopened during systole. Considerable energy is expended to reopen the valves during each cardiac cycle. This problem is compounded in smaller grafts in which the valvular orifices are narrow compared with the diameter of the remaining vein. Restriction produced by the narrowed orifice, combined with the energy required to open and close the valve, has been shown to reduce blood flow significantly.\(^3\) Valvulotomy helps increase blood flow through the graft by eliminating these valves.

The second problem that arises from use of the saphenous vein in its normal flow direction is a significant mismatch in the size of the vein and recipient vessels at the anastomotic sites. Several authors have attributed low patency rates to the disproportionately large diameter of the vein graft compared with the smaller recipient cortical vessels.\(^4,6,10\) In contrast to the arterial branches in which gradual tapering increases blood flow velocity, the vein graft enlarges from its proximal to distal ends, resulting in decreased flow velocities. The mismatch of vessel size at the anastomotic sites further complicates this problem by producing sudden changes in blood flow velocity that create turbulence. At the proximal anastomosis, blood flow velocity and shear stress along the walls suddenly increase as blood enters the narrower end of the graft. Distally, the flow velocity decreases in the widening venous channel before entering the smaller recipient vessel and again being accelerated. These conditions produce local turbulence, which has been linked to early graft failure as well as to the later development of intimal hyperplasia and thrombosis.\(^10\)

To avoid these problems, we have used the Lemaitre valvulotome to excise the valves and allow reversed flow in the saphenous vein graft. Lysis of the valves assures maximum flow and allows the vein to be oriented so that the large end is anastomosed to the cervical carotid artery and the narrow distal end is anastomosed to the small cranial branches.

Operative Technique

For large-vessel bypasses we prefer to harvest the saphenous vein from the upper thigh. Identification of the saphenous vein is simplified by localizing its proximal end in the groin where it joins the common femoral vein.
Once identified, the vein is followed distally and exposed by a continuous incision. Dissection must be meticulous, with care exerted to avoid subjecting the vein to undue traction. Use of topical papaverine (15 mg/ml) during dissection can help limit spasm. Side branches are identified and ligated with 4-0 silk sutures, taking care to avoid any impingement on the lumen of the vein. The proximal end of the vein is tagged with a marking pen or silk suture, and the harvesting is completed. Next, the proximal end of the graft is occluded with a temporary aneurysm clip, and the graft is distended under gentle controlled pressure (not to exceed 150 mm Hg). We have previously described our hydrostatic dilation system consisting of high-pressure tubing, an arterial pressure bag, flush valve, and transducer. This system prevents endothelial damage and disruption while ensuring that the vessel remains at its maximum diameter; it also reveals leaks from small tributaries, which can be repaired with fine silk or nylon sutures.

Before the valvulotome is inserted, the vein should be flushed with a mixture of papaverine and heparin to prevent the vein’s smooth muscle from constricting around the instrument. The venous valve leaflets are then lysed with the valvulotome (Fig. 1); no valves should be retained. As described by Worsey, et al.,11 care must be taken to ensure complete lysis because incompletely incised valves can lead to thrombosis and early graft failure. Valvulotomes are available in multiple sizes from No. 3 to No. 5 French. The largest valvulotome that will readily pass through the vein should be used for lysis of the valves. Valvulotomes are available in multiple sizes from No. 3 to No. 5 French. The largest valvulotome that will readily pass through the vein should be used for lysis of the valves.

With the valves lysed, the vein can be used in either direction as a free graft. The smaller, tapered end is anastomosed first to the distal recipient vessel. The vein graft is then tunneled subcutaneously to the proximal anastomotic site. The anastomoses are performed using standard microsurgical techniques with 8-0 monofilament nylon. After ensuring hemostasis and patency, the wounds are closed in the usual fashion.

We have used reversed-flow saphenous vein bypass grafts with good results in five patients. There have been no complications related to use of the valvulotome. An illustrative case is depicted in Fig. 3, which shows a reversed graft used in an internal carotid artery (ICA)–petrous ICA bypass.
Discussion

The technique of in situ saphenous vein grafting for lower-extremity revascularization has been well documented in the vascular surgery literature, with favorable results reported by multiple authors.1,2,8 These groups emphasize that the use of modern valvulotomes involves minimal trauma and results in more physiological normal flow. An analogous situation exists when saphenous vein grafts are used for cerebral revascularization. Valvulotomy and the reversal of flow through the vein graft eliminate the flow restrictions created by the valves and allow a much better match of vessel size at the proximal and distal anastomotic sites.

By providing a graft that approximates the tapering of the normal ICA, this configuration provides a more physiologically appropriate vascular conduit. The velocity of blood flow at the anastomotic sites matches the faster blood flow that occurs at the distal and the slower blood flow at the proximal anastomosis.

Outflow is related to the number and diameter of the distal vessels. Factors thought to contribute to intimal hyperplasia, which include a mismatch of the graft’s mechanical properties with the recipient vessel and the resultant local turbulence, can adversely affect streamlined flow. In addition, when the graft diameter is larger than that of the recipient vessel, decreased flow velocity and stasis in the distal segment of the graft may increase the risk of thrombosis.

A potential drawback of using the valvulotome for valve lysis is endothelial damage; however, experiments in dogs indicate that there are no discernible differences in fibrolytic activity or histology of endothelial cells from in situ and reversed grafts at either 24 hours or 6 weeks post-surgery.1,3 Although there is a learning curve for mastering the valvulotome, this device is relatively simple to use. The necessity for gentle handling of the vein during dissection, distention, and anastomosis cannot be overstressed.

References


Manuscript received March 3, 1997.
Accepted in final form June 23, 1997.
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