Part VII

Surgical treatments

Complementary Distal Arteriovenous Fistula Combined and Deep Vein Interposition: A Technique to Improve Infrapopliteal Prosthetic Bypass Patency

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Evolution of vascular surgery techniques in the past decade, combined with the availability of an adequate venous conduit, has permitted a liberal and aggressive approach to salvage ischemic limbs caused by advanced atherosclerosis.

This approach is epitomized by the construction of arterial bypasses to the terminal branches of tibial vessels (1). However, significant numbers of patients will continue to face the threat of a major amputation because of insufficient vein necessary to perform a totally autogenous bypass to one of the infrapopliteal arteries. In these instances, less durable grafts made of prosthetic material must be used if limb salvage is to be attempted. Accordingly, several adjunctive techniques have been designed in an attempt to improve the poor patency results achieved with prosthetic bypasses.

These include the administration of immediate and chronic anticoagulants (2), the construction of a vein patch or cuff at the distal anastomosis to prevent occlusion by intimal hyperplasia (3,4) and the creation of a distal arteriovenous fistula to increase graft blood flow in high outflow resistance systems (5,6). Still, none of these adjunctive techniques have generated sufficiently adequate results.

For that reason, we have developed a simple technique that combines some of the aforementioned principles. We utilize a PTFE graft in combination with a distal arterio-venous fistula (AVF) as well as a vein interposition (VI) at the distal anastomosis in a single technique in patients presenting with critical lower limb ischemia and in whom a standard infrapopliteal vein bypass is not feasible. Our combined AVF/VI technique attempts to correct the two main causes of infrapopliteal PTFE graft failure – limited runoff and intimal hyperplasia.

General Considerations

Indications for surgery are restricted to ischemic ulcers, gangrene or rest pain. Preoperative evaluation with non-invasive segmental blood pressure measurements and pulse volume recordings are useful, not only to document and confirm clinical impressions but, also as a comparison for postoperative surveillance. Angiography may be used to visualize both inflow and outflow sites. In general, the most distal available inflow site is utilized to shorten the length of the graft. Time-delayed imaging may be required to visualize the foot arteries because of reduced flow. The use of magnetic resonance angiography has proven to be beneficial of late in identifying patent lower extremity arteries not visualized by conventional arteriographic techniques, particularly in view of the recent advances in imaging software and hardware (7). Finally, high-resolution duplex imaging has now become a viable alternative for visualization of inflow and outflow sites with the added advantages of cost reduction, fewer complications associated with angiography and the ability to identify the least calcified artery segment (8,9).

Surgical Technique

Basic surgical principles involved in creating a complementary distal AVF/VI are the same as for any infrapopliteal bypass. Crucial elements for the success of these reconstructions are meticulous technique, excellent illumination, fine instrumentation and, most importantly, commitments of time and effort. Additional strategies to deal with intraoperative problems are applied whenever indicated either to facilitate the operation or to improve distal runoff. We use a previously described fracture technique in heavily calcified arteries to overcome the rigidity of the arterial wall rendering it suitable for occlusion, incision and suture placement (10). A short stenotic arterial segment may be used as an outflow site, widening the vein interposition portion of the bypass and thereby decreasing the total outflow resistance via graft angioplasty (11).

Adequate exposure of the recipient artery and its adjacent deep veins is achieved by using standard approaches. Once the better of the two deep veins is selected, extreme care and patience is required during dissection of both the artery and vein. Every attempt should be made to avoid injury to the vein wall during dissection since control of bleeding may be difficult without further compromising vein integrity. All vein branches are carefully isolated, doubly ligated with 5-0 silk and divided. Severe inflammatory reaction of the

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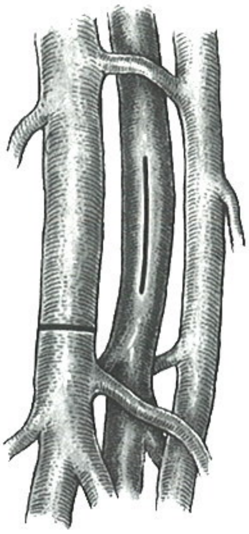

FIGURE 1a
Depicts the preferred site of transection of the adjacent vein relative to the arteriotomy.

FIGURE 1b
Shows the vein prepared for an end-to-side anastomosis to an infrapopliteal artery.

surrounding tissue may be encountered that causes the vein and the artery to firmly adhere to each other. This should not discourage proceeding with the operation but rather encourage more precise dissection. Extensive mobilization of the vein is demanded by this technique to permit transposition onto the artery without undue tension. At least two centimeters proximal and one centimeter distal to the length of the arteriotomy is usually necessary to accomplish this goal. Next, the recipient artery is mobilized and secured with Silastic vessel loops.

After dissection of the inflow artery, an appropriate tunnel is constructed and a 6mm ringed PTFE graft is placed into the tunnel. After accomplishing these steps, intravenous heparin is initiated. An arteriotomy ranging in length from 1.3 to 2cm is performed in the recipient vessel and the adjacent deep vein is ligated and transected at a level anywhere from 0.5 to 1cm distal to the endpoint of the arteriotomy (Figures 1a, 1b). This is an important technical detail since both ends of the vein will retract upon transection and the proximal end may

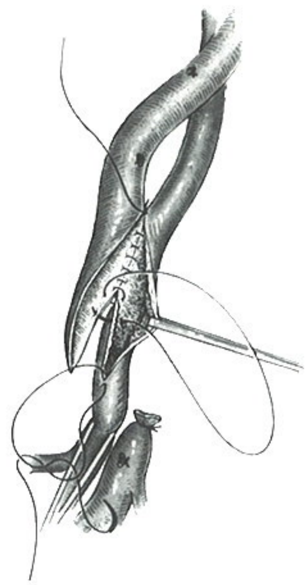

FIGURE 2a
Illustrates the technique to perform the distal arteriovenous fistula.

FIGURE 2b
Location for venotomy for constructing graft to distal arteriovenous fistula anastomosis.

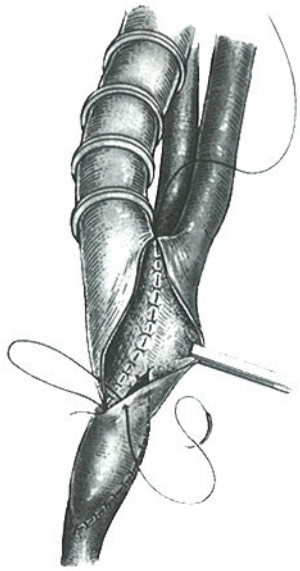

FIGURE 2c

Technique for performing the distal arteriovenous fistula combined with deep vein interposition.

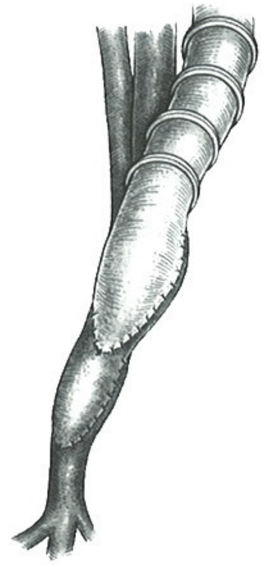

FIGURE 2d

Completed bypass demonstrating the final configuration of the distal arteriovenous fistula combined with deep vein interposition.

be too short to reach the toe of the anastomosis. The open end of the central portion of the vein is then fashioned and anastomosed to the adjacent artery with continuous monofilament 7-0 sutures in a four-quadrant technique where every stitch is applied under direct vision (Figure 2a).

This is followed by a venotomy that is initiated over the hood of the anastomosis and is extended proximally beyond the level of the heel of the arteriovenous anastomosis to prevent potential stricture of the vein (Figure 2b). Next, an end-to-side anastomosis is accomplished between the distal end of the PTFE graft and the vein utilizing similar techniques (Figure 2c). Configuration of the complementary AVF/VI technique in now complete (Figure 2d).

Routine intraoperative measurements of arterial

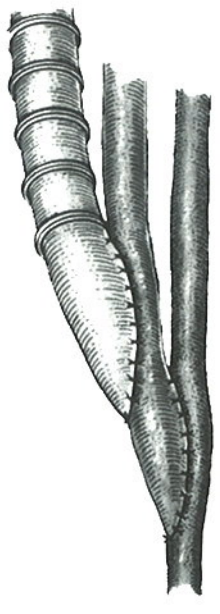

FIGURE 3a

Lateral view of the distal arteriovenous fistula combined with deep vein interposition.

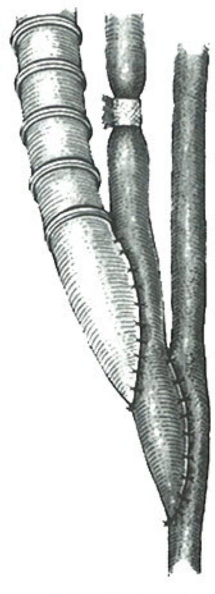

FIGURE 3b

Illustration of the distal arteriovenous fistula combined with deep vein interposition and PTFE venous band in place.

bypass pressures are recorded in all cases by inserting a 23-gauge butterfly needle into the graft at the distal anastomosis. A short sleeve of PTFE is wrapped around the vein proximal to the distal anastomosis or placed before the construction of the fistula (Figure 3a, 3b). This will narrow the vein in those cases where a gradient over 30mmHg was detected between the bypass and the radial systolic pressures or when the absolute graft systolic pressure was less than 100mmHg. This pressure will provide sufficient blood flow to heal a foot lesion. The amount of banding necessary to produce this pressure or to decrease a significant gradient is guided by a continuous and simultaneous monitoring of intragraft and radial artery pressures. Measuring intragraft pressures and banding the graft when indicated is an important step that may prevent bypass failure by avoiding the "steal" phenomenon. The same needle is now used to perform a completion arteriogram (in all cases) to evaluate the adequacy of the technique (Figure 4). After the proximal anastomosis is completed in a standard manner, the clamps are released and hemostasis is achieved by reversing the effects of heparin with protamine sulphate.

Complications

The usual vascular operative complications must be anticipated and managed accordingly. These complications include inadequate wound healing; groin lymphorrhea and graft infection. Full thickness skin necrosis over the distal portion of the graft may also ensue. This can be avoided by careful technique. Anticoagulation therapy may produce significant hemorrhage and may necessitate temporary cessation of anticoagulation.

Postoperative swelling of the lower extremity has not been a major factor in limiting ambulation. We have observed a dramatic improvement in the amount of leg edema 3 to 4 weeks after the operation. In the event of severe initial swelling, bed rest and leg elevation for approximately 1 week postoperatively may be required.

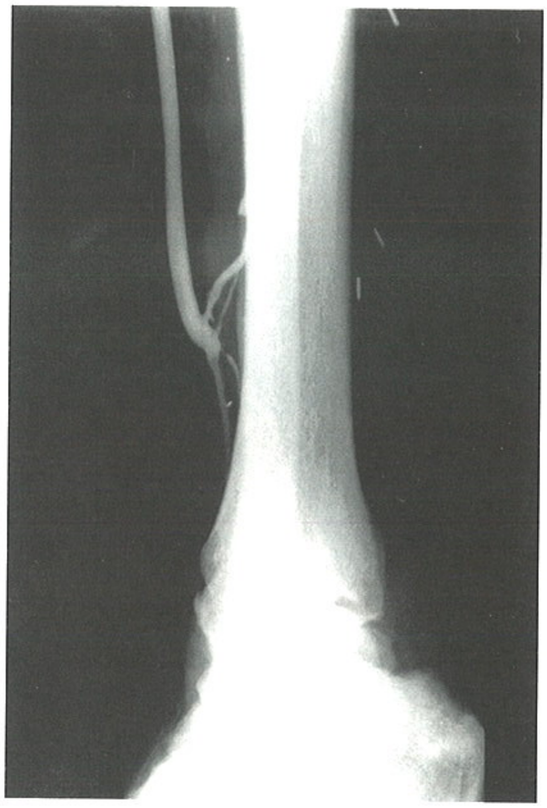

FIGURE 4
Intraoperative completion arteriogram demonstrating a patent PTFE bypass to the distal anterior tibial artery and free flow into the vein portion of the fistula as well as into the distal circulation.

Follow-Up

Graft and fistula patency are evaluated by physical examination (auscultation of a bruit over the distal anastomosis) and by noninvasive parameters including pulse volume recording tracings and duplex scanning. Worsening of noninvasive vascular examination or recurrence of symptoms are indications for new arteriographic studies.

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