VASCULAR AND ENDOVASCULAR TECHNIQUES

Peter F. Lawrence, MD, Section Editor
From the Society for Vascular Surgery

Using the diamond intermediate anastomosis in composite sequential bypass grafting for critical limb ischemia

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Composite sequential bypass grafting is an effective alternative in the treatment of peripheral vascular disease when autologous vein is limited. We describe a modified technique for composite sequential bypass grafting anastomosis using a combination of synthetic graft with native vein connected via a common intermediate anastomotic junction, which also benefits from having additional outflow at the native, noncontiguous arteriotomy in a diamond configuration. This technique was piloted on six patients to treat critical limb ischemia when no other revascularization options were deemed suitable. Limb salvage with resolution of symptoms was achieved in all six patients at the 6-month follow-up. The diamond anastomosis is a promising method to maximize limb salvage using a unique composite sequential bypass configuration when native vein is limited. (J Vasc Surg 2016;63:1116-20.)

Autologous saphenous vein is considered the ideal conduit for surgical infracrural revascularization due to its resistance to infection and superior longevity compared with prosthetic grafting. Autologous vein availability is limited in up to 30% of patients undergoing lower limb revascularization due to a history of harvesting for coronary artery bypass grafting or other bypass procedure, varicose vein surgery, or simply lack of suitability.[1,2] Synthetic grafting offers an alternative when vein length is lacking, but with inferior patency rates, especially when extended to below the knee.

Many composite grafting technique combinations have been described, restricting synthetic material for use proximally and reserving native vein for the distal component; these are summarized elsewhere.[3] A simple end-to-end synthetic-vein composite graft anastomosis has demonstrated little superiority over synthetic-only grafts, probably due to the low flow dynamics in the synthetic graft combined with graft-vein compliance mismatch with neointimal hyperplasia formation at the level of the graft-vein anastomosis.[4-9] Other options that combine the use of synthetic grafts with venous cuffs or patches have demonstrated improved success rates[10-12] but comprise longer lengths of synthetic material proximally and crossing the knee joint, relying on short segments of vein just at the distal anastomosis. Composite sequential grafting using an intermediate arterial anastomosis is an alternative technique, where the synthetic and vein grafts are both anastomosed to an intermediate artery (eg, popliteal artery) thereby providing two arterial outflow points, maximizing available vein, with improved graft runoff and longevity.[13,14]

Many configurations of an intermediate graft anastomosis have been described, typically landing the synthetic graft onto the native artery as a single graft-artery anastomosis, followed by "piggybacking" of the vein from the graft hood.[3] However, this conformation also results in compliance mismatch, seen in typical synthetic bypass grafting, leading to a higher risk of graft occlusion. Other techniques aimed at overcoming this synthetic-to-artery compliance mismatch have been described in distal bypasses by incorporating vein within the anastomosis, including the Miller cuff,[10] Taylor patch,[11] and the St. Mary's boot.[15] Although compliance may be improved, the use of a venous cuff does not address the issue of turbulence at the anastomotic site, which is thought to be increased in such configurations due to the deep anastomotic reservoir created[16-18] and by virtue of the highly angulated inflow to the cuff.[19-21] Turbulence leads to increased shear stress at the anastomotic site with reduced graft longevity.

Mahmood et al[14] have described a technique of composite sequential bypass grafting whereby the spatulated ends of the proximal synthetic graft and distal vein graft

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Author conflict of interest: none.
Presented in the International Fast Talk Forum at the 2015 Vascular Annual Meeting of the Society for Vascular Surgery, Chicago, Ill, June 17-20, 2015.
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The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.
0741-5214

http://dx.doi.org/10.1016/j.jvs.2015.12.019

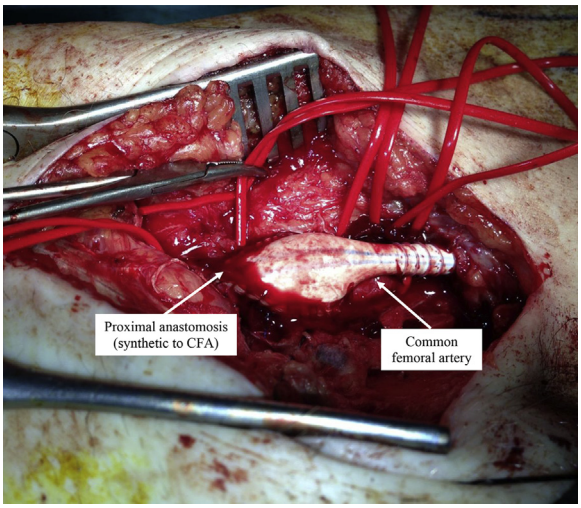

Fig 1. End-to-side proximal anastomosis with a synthetic expanded polytetrafluoroethylene (ePTFE) graft to the common femoral artery (*CFA*).

are anastomosed together in a side-by-side fashion and incorporated into the intermediate arterial anastomosis as a single common anastomosis. This technique has shown promising primary and secondary patency rates, but there are similar concerns as with the Miller cuff, with the potential for poor angulation of the grafts in addition to the deep reservoir created with increased turbulence at the intermediate site. The Taylor patch technique overcomes some of these challenges using a longer arteriotomy with minimized anastomotic reservoir and turbulence. In addition, this technique optimizes graft-artery angulation, allowing the graft to lie in a more natural position that facilitates a more streamlined flow of blood.[17,18] The more tapered, funnel-shaped anastomosis in theory reduces turbulence at the anastomotic site,[11] and the venous patch addresses compliance mismatch concerns. We have used these principles to devise a modified technique for composite sequential bypass—the diamond intermediate anastomosis.

Where no patent popliteal artery segment is available, a popliteal endarterectomy has been proposed by Mahmood et al[14] to allow siting of the intermediate anastomosis; however, we did not perform this in our current study.

Here we describe a novel composite sequential grafting technique for limb salvage in patients lacking adequate quality vein length for femorodistal bypass grafting. We hypothesize that combining the best elements of the side-to-side composite graft with a Taylor patch-like configuration leads to less turbulence at the intermediate anastomosis (through reduced angulation and a shallower reservoir) and improved compliance mismatch (with the vein hood-patch technique) while maximizing the use of vein to the below-knee segment and improving graft runoff with two arterial outflow points. In theory, this will lead to improved primary and secondary outcomes, including graft patency and limb salvage.

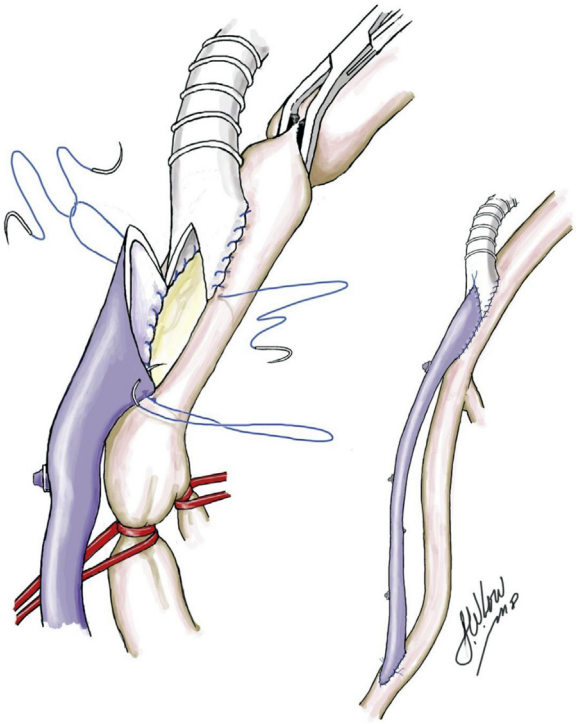

Fig 2. Drawing shows the diamond anastomosis, with an expanded polytetrafluoroethylene (ePTFE) graft proximally and an autologous vein graft anastomosed to the proximal and distal portions of the popliteal arteriotomy, respectively.

SURGICAL TECHNIQUE

All conduits were a combination of the expanded polytetrafluoroethylene (ePTFE) pre-cuffed Venaflo graft (Bard, Tempe, Ariz) and autologous reversed long saphenous vein graft, extending from the common femoral artery to a distal vessel. Computed tomography, magnetic resonance, or formal catheter-directed angiography was performed preoperatively, and images were reviewed to identify a suitable patent, noncontiguous arterial landing zone in the popliteal artery for our intermediate diamond anastomosis.

Inflow was created with an end-to-side anastomosis using prosthetic graft, typically at the common femoral artery (Fig 1). The proximal prosthetic graft was tunnelled anatomically in the subsartorial canal to access the popliteal fossa. If the below-knee popliteal artery was chosen for the intermediate anastomosis, the graft was tunnelled anatomically through the popliteal fossa, exiting at the below knee segment. After exposure from a medial approach to the popliteal artery, a longitudinal arteriotomy (approximately twice the normal length) was created. The proximal (prosthetic) portion of the intermediate anastomosis was fashioned by dividing the graft with an oblique end as standard, followed by removal of a triangular segment from the upper wall of the hood (Fig 2), and anastomosing