Distal vein patch with an arteriovenous fistula: A viable option for the patient without autogenous conduit and severe distal occlusive disease

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Background: The addition of a distal arteriovenous fistula (DAVF) to improve patency in lower extremity bypass is well described. This report describes a technique of using a distal AVF to enhance a distal vein patch (DVP) in patients without adequate autogenous conduit and who have concomitant severely disadvantaged arterial runoff.

Methods: A retrospective review from May 2002 to May 2007 analyzed 270 tibial bypasses. DVP-AVF was the conduit in 30 bypass grafts. Patient demographics included 16 men, 14 women, diabetes mellitus (67%), and chronic renal failure (20%). All patients had limb-threatening ischemia manifest as rest pain or tissue loss, with 20 patients referred after failed prior revascularization: 11 failed bypasses, and nine failed endovascular interventions. In each case, the only outflow artery available was an isolated tibial segment or a diseased pedal vessel not ordinarily deemed suitable for bypass. At surgery, a common ostium AVF was created between the outflow tibial artery and corresponding tibial vein before DVP construction. Follow-up was 1 to 24 months, with graft function evaluated by pulse examination and duplex surveillance.

Primary patency and limb salvage ± SE were determined by life-table analysis using Rutherford criteria.

Results: The proximal anastomosis originated from the external iliac (23%), common femoral artery (43%), and superficial femoral artery (35%). Outflow arteries included the anterior tibial (40%), posterior tibial (30%), and peroneal (30%). Venous hypertension in the bypassed limb was noted, but not considered problematic in any patient. Perioperative graft failure occurred in one patient. Six graft failures led to six major amputations (1 above knee; 5 below knee). One patent graft was excised due to infection. Primary patency at 6, 12, 18, and 24 months was 78.3% ± 6.8%, 78.3% ± 10.5%, 62.6% ± 11.1%, and 62.6% ± 15.6%; limb salvage was 78.7% ± 6.7%, 78.7% ± 10.1%, 78.7% ± 10.1%, and 57.7% ± 12.5%.

Conclusion: This early experience describes a modification of the DVP technique in patients with threatened limb loss and severely disadvantaged tibial runoff. The addition of an AVF may reduce outflow resistance, thereby contributing to higher flow rates and improved graft patency. Further investigation is warranted because the DVP-AVF technique may result in acceptable graft patency and limb salvage for patients with no other alternative than amputation. (J Vasc Surg 2009;50:83–8.)

Despite the development of endovascular techniques, tibial artery bypass remains an important option for revascularization of the threatened limb. However, distal bypass is often relegated to those patients with severe, long segment tibial disease not deemed suitable for an endovascular approach. Although it is recognized that prosthetic grafts have been used with uniformly poor results for tibial bypass, other conduits such as arm vein or spliced autologous vein may be of inadequate length or quality, especially in reparative situations.1,2

We have previously reported the use of a distal vein patch (DVP) to enhance the performance of polytetrafluoroethylene (PTFE) as a conduit for tibial revascularization in those patients lacking adequate autogenous conduit.3,4

A subset of these patients presented with concomitant severely compromised arterial outflow for revascularization. Other authors have reported success for difficult tibial artery bypass with the use of a distal arteriovenous fistula (AVF).5-8 We extrapolated from this experience to optimize bypass patency in those patients lacking autogenous conduit and disadvantaged arterial runoff by combining the DVP technique with a common ostium AVF.

METHODS

The Institutional Review Board approved a retrospective medical records review that was performed from the date of the first DVP/AVF bypass (May 2002 to May 2007). During this 5-year interval, 270 tibial artery bypass procedures were performed, including 95 in which a DVP was used as the conduit. A common ostium distal AVF was incorporated with the technique in 30 of these DVP procedures, representing 11.1% of all tibial revascularizations performed during the study period. A retrospective review of these 30 patients assessed graft patency and limb salvage. Patient medical records were reviewed from the office and vascular laboratory, and clinical status was updated by direct contact with the patient or family as of July 2007.

All patients were evaluated preoperatively with vascular laboratory studies and contrast arteriography to plan the
appropriate revascularization. None of the 30 study patients had adequate autologous venous conduit for bypass due to prior harvesting for cardiac or vascular procedures, or venous stripping. The lack of vein was confirmed by physical examination and evaluation with duplex ultrasound (DUS) imaging. In all 30 patients, the target artery for distal revascularization was an isolated paramalleolar tibial segment or small diseased pedal artery (Fig 1). However, there was no prospective definition of “poor runoff” or scoring of arterial segments for any of these patients.

Distal bypass was performed under general or epidural anesthesia as determined by the patient’s medical condition and the opinion of the anesthesia team. The inflow artery was exposed in the standard fashion, and distal exposure varied according to the tibial artery chosen for the procedure. After exposure of the tibial artery and corresponding tibial veins, a 2- to 4-cm autogenous patch was harvested from ipsilateral or contralateral venous remnants, femoral vein, or endarterectomized segments of thrombosed superficial femoral artery (SFA). The patch configuration requires less material than other reported cuffs.

We used endarterectomized SFA in four DVP patients instead of arm vein or small saphenous vein to avoid the additional incisions and dissection in the arm or posterior calf. The occluded SFA was available through the dissection already performed for the inflow anastomosis. In none of the AVF patients was a concomitant endarterectomized SFA used as the patch. The autogenous tissue remnants were irrigated with prepared vein solution composed of buffered saline solution (Plasma-Lyte-A; Cardinal Health, Dublin, Ohio; 1000 mL, pH 7.4), heparin (5000 U), calcium chloride 10% (100 mg), and papaverine (120 mg).

An externally reinforced, 6-mm, thin-walled stretch PTFE graft was tunneled between the proximal and distal arterial dissections. Systemic heparinization was performed before arterial clamp placement. An end-to-side proximal anastomosis was performed using two Prolene sutures (Ethicon, Somerville, NJ) and a “parachute” technique to secure the heel and toe of the anastomosis. The proximal PTFE graft was controlled with a soft-jawed clamp, and flow was re-established through the native circulation by clamp removal from the inflow artery.

The distal anastomosis was then addressed. First, a common ostium AVF was created between the recipient tibial artery and corresponding tibial vein. Both vessels were controlled, and a longitudinal arteriotomy and corresponding venotomy was performed. The central medial walls of the artery and vein were sewn together with a 7-0 Prolene suture in a continuous fashion, evertting the edges so that the suture material did not impinge into the lumen, with knots secured outside the lumen (Fig 2). The previously harvested autogenous patch was then sewn in place by performing patch angioplasty over the common ostium using 7-0 Prolene suture (Fig 3). The PTFE was anasto-
mosed to the common ostium patch using a 6-0 Prolene suture with the “parachute” configuration, as previously described for the DVP bypass3 (Fig 4). Completion arteriography was performed in each case.

Patients were transferred to the intensive care or step-down unit based on their medical condition. A heparin infusion was started 4 to 6 hours postoperatively, and oral anticoagulation with warfarin was started on postoperative day 1. Patients were continued on long-term anticoagulation to maintain an international normalized ratio of 2.0 as a goal.

Patients were evaluated in the office 10 to 14 days postoperatively with a pulse evaluation and hand held Doppler interrogation. Formal graft surveillance was performed with DUS imaging at 3, 6, 12, and 18 months, and, then annually. Postoperative DUS assessment was performed according to the routine for graft surveillance. Graft patency was the major concern, but venous flow in the fistula can also be appreciated during insolation of the distal anastomosis, although this is not part of the surveillance protocol. Arteriography or magnetic resonance angiography was performed if any problem was indicated by the surveillance DUS examination. Amputations or other morbidity were noted. Primary patency and limb salvage were reported by life-table and Kaplan-Meier analysis using the Rutherford criteria.

RESULTS

The 30 patients in the study cohort were a mean age of 73.5 years and comprised 16 men (54%) and 14 women (46%). Six patients (20%) had dialysis-dependent renal failure, and 20 (67%) had diabetes mellitus. All 30 patients had critical limb ischemia as an indication for intervention, manifest as rest pain or tissue loss, or both; three (10%) had rest pain, and 27 (90%) had tissue loss. All patients were considering primary amputation if additional revascularization was not possible.

The referral for 20 patients (67%) occurred after previous attempts at revascularization had failed; 11 presented with a prior failed bypass, and nine after a failed catheter-based intervention. The proximal anastomosis originated at the common femoral artery (CFA) in 13 (43.3%), the SFA in 10 (33.3%), or external iliac artery in seven (23.3%). Recipient arteries included the anterior tibial in 12 (40%), posterior tibial in nine (30%), or peroneal in nine (30%). In each case, this recipient artery was an isolated paramalleolar tibial segment or a diseased pedal vessel not deemed optimal for bypass as assessed by preoperative angiography. A mild to moderate degree of postoperative venous hypertension due to the AVF in the bypassed limb was routinely noted. No AVFs were ligated due to edema. The edema resolved with time in most patients and was not considered problematic. If edema persisted >3 months, patients were prescribed a light compression stocking.

Follow-up ranged from 1 to 48 months, with patency and limb salvage data assessed at 6-month intervals to 24 months (Table). Perioperative graft failure occurred in one patient, with one patent graft excised ≤3 months due to infection. Five late graft failures occurred in follow-up, and in all, the AVF was occluded at the time of failure. Owing to the severity of distal disease, these patients chose to proceed with amputation at the time of graft failure. The AVF did not affect the level of amputation or hasten the need for amputation. The AVFs were patent at the time of the original bypass (intraoperative arteriogram or intraoperative US scan) and were all thrombosed at the time of graft failure. This resulted in six major amputations (1 above knee, 5 below knee) and a 78% primary patency by life-table
analysis at 1 year and 62% at 2 years in a smaller number of patients (Fig 5).

During the period of analysis, three patients had patent bypass grafts >2 years, with the longest patency interval being 42 months. Limb salvage rates were 78% at 1 year and 57% at 2 years (Fig 6). The limb salvage rate was less than patency to a degree that reflects our previous series. If the graft remains patent, then the limb team can usually manage the soft tissue to save the limb. This is a strong argument to the team approach to limb salvage.

**DISCUSSION**

Patients in need of distal bypass who lack both adequate autogenous conduit and a good target artery for bypass are a small but challenging group. Our total DVP experience now numbers >300 patients, this series examines our results in this subset of our DVP experience in which an AVF was added to the distal anastomosis in an effort to improve graft performance in the face of disadvantaged arterial runoff. In our experience, precuffed or “hooded” PTFE grafts led to early graft failure, and our experience with CryoVein (CryoLife Inc, Kennesaw, Ga) has been equally poor.

This suboptimal experience led to the search for a better option and development of the DVP bypass technique. Our experience with arm vein has been good, but given the success of the DVP technique, we reserve the use of arm vein for younger, good-risk patients without renal failure who have upper extremity dialysis access requirements. Therefore, the additional 65 patients without autogenous vein during the contemporaneous time period underwent a standard DVP bypass. The fistula group comprised a small cohort during this time, and surgeon judgment about the severity of distal disease for bypass was a key factor in the use of a concomitant AVF. The extent of distal disease precluded consideration of endovascular therapy in this patient cohort.

AVFs have been hypothesized to benefit lower extremity revascularization in two ways. Before the advent of direct arterial bypass, fistulas were constructed to create flow reversal in the venous circulation and carry arterial blood to the capillary bed in a retrograde fashion.10,11 With the advance of standard bypass techniques, direct revascularization of the arterial tree became a more effective method than retrograde venous flow reversal to alleviate ischemia in the lower extremity. AVFs were then proposed as a method to decrease outflow resistance and improve prosthetic graft performance.12,13 The venous circulation accepts much of the flow overload in the high resistance arterial circuit, thereby increasing graft flow above the critical thrombotic threshold in a disadvantaged runoff situation.14 Although construction of an AVF does increase graft flow, it has been difficult to demonstrate that this leads to improvement in graft patency.15 Adding an AVF to the DVP configuration may decrease outflow resistance and improve graft hemodynamics. Although this does not directly correlate with a reduction in the formation of intimal hyperplasia, it may improve graft performance from a hemodynamic approach.
Several configurations have been described for the construction of an AVF to improve distal bypass graft performance. In 1980, Ibrahim and Dardik reported the use of a common ostium fistula between the tibial artery and vein before anastomosis with a human umbilical vein graft. The authors updated their experience in 1991, reporting 210 tibial bypasses with adjunct fistulas. The results improved during a 10-year period, with 44% patency in the final group from 1983 to 1986. In this group, fistulas were used with both prosthetic and autogenous grafts. The authors noted an increase in mean graft velocity and flow volume, with no instances of proximal arterial steal by arteriography and DUS. If the fistulas remained patent, graft patency was 58% at 2 years compared with 25% graft patency without fistulas.

Ascer et al described an AVF created by distal ligation of a tibial vein with subsequent anastomosis of the proximal venous segment to the corresponding tibial artery. A prosthetic graft was then sutured to the anterior surface of the venous hood, “piggybacking” the graft onto the AVF at the anastomosis. Banding of the proximal tibial vein was performed in 38% of these bypasses. The cumulative 3-year patency was 62%, with 77% limb salvage.

Poor tibial runoff has prompted other groups to add an adjunct AVF remote from the actual distal anastomosis. In this configuration, the fistula was added to improve graft performance to disadvantaged tibial arteries for infrapopliteal bypass using PTFE. Paty et al describe a fistula constructed 5 to 15 cm distal to the anastomosis in an attempt to increase flow not only in the graft but also in the artery between the anastomosis and the fistula. At 1 year the patency was 67% in 16 patients. However, although increased flow velocity was noted in the graft (264 mL/min) and the fistula (170 mL/min), flow decreased in the distal artery (19 mL/min). This technique requires additional tibial vessel dissection remote from the anastomosis and may not be possible due to length restrictions in the distal third of the leg.

In a later publication, the authors compared PTFE bypasses with a distal vein cuff to bypasses using the remote AVF. Primary patency and limb salvage rates were 76% and 92% for the distal vein cuff group, and 48% and 76% for the fistula group, respectively. In the grafts that failed, the authors noted that the distal vein cuff remained patent, allowing for simpler graft revision compared with the grafts with a remote fistula that were totally occluded at failure.

Our DVP experience confirms this observation. Although the prosthetic graft may occlude, the vein patch area of the anastomosis remains patent after graft thrombosis, allowing for easier thrombectomy with re-establishment of secondary patency. In our series, if the DVP-AVF bypass failed, then amputation was performed because the severe distal disease precluded hope for durable secondary patency.

Ducasse et al also assessed the usefulness of a fistula in bypasses using PTFE with a vein cuff. Primary patency was 68%, 53%, and 44% at 1, 2, and 3 years, respectively. These authors concluded that the fistula allowed patients with poor runoff to achieve comparable, but not improved, results compared with direct PTFE bypass. Laurila et al compared infrapopliteal vein bypass with vein grafts to “poor-outflow arteries.” Although the fistula did not improve results, they did note that an adjunct fistula allowed patients with poor runoff to achieve comparable results for infrapopliteal bypass with superior runoff. Graft flow was significantly higher in the fistula group.

In our series, a common ostium fistula similar to the Dardik configuration was combined with the DVP technique. The DVP technique lends itself to this type of common ostium adjunctive fistula. There is minimal additional dissection required of the corresponding tibial vein, and suturing the common medial walls of the artery and vein adds only 10 to 15 minutes to the procedure. Interposition of the autogenous vein patch over the entire common ostium configuration was performed before the PTFE anastomosis. This configuration resulted in a complete autogenous tissue interface with the tibial artery around the entire anastomosis. This is beneficial in two ways: technical ease of the anastomosis, and a theoretic advantage for minimizing the formation of anastomotic hyperplasia.

We have previously theorized that the benefits of a DVP for prosthetic bypass may include factors that improve graft hemodynamics or create a biologic “buffer zone” at the anastomosis, or both. However, these anastomotic factors do not address outflow resistance or resulting graft flow velocity and flow volume. These obviously important factors for graft performance may reach critical importance with severely disadvantaged arterial runoff. The construction of an AVF at the distal anastomosis may affect these factors through several mechanisms. The AV communication involves reduction of outflow resistance. This enhanced outflow may also sustain a threshold level of graft flow needed to maintain patency. It remains difficult to prove any definite advantage for addition of an AVF at the distal anastomosis in the subset of patients with severe distal occlusive disease and no autogenous conduit for bypass. A comparison of patency rates between this small cohort and our original DVP experience indicates that the addition of an AVF may allow comparable patency to be reached at 1 year in these patients with poor distal targets for bypass. This adjunctive technique adds little in terms of operative time and in this initial experience demonstrates reasonable outcomes in a patient population otherwise facing amputation. It may be considered if an aggressive attempt at limb salvage is warranted.

CONCLUSIONS

An aggressive approach to limb salvage will continue to require the use of distal bypass in certain patients, even in the era of endovascular therapy. As in other vascular beds, lower extremity bypass will become increasingly challenging as catheter-based therapies evolve. Surgical bypass will be required in the setting of severe distal occlusive disease without available autogenous conduit. Although it is difficult to prove a definite benefit without randomized data,
innovative surgical techniques may prove useful in practices that are dedicated to limb salvage in these challenging patients.

In this early experience we describe acceptable early patency and limb salvage in a technique that combines a DVP with an AVF. The procedure does not increase patency compared with our other DVP patients. However, addition of the AVF does result in similar patency and limb salvage in a group of patients in whom that was not to be expected. This patient group was to be offered primary amputation due to the poor distal arterial anatomy in consideration of bypass. Construction of the AVF does not increase operating time to any meaningful degree because the exposure and vascular control is the same with or without the AVF. Further investigation is warranted with increased numbers and longer follow-up to confirm that the technique is a useful addition to the armamentarium of options for those patients with disadvantaged runoff and no autogenous conduit.

**AUTHOR CONTRIBUTIONS**

Conception and design: RN, NS
Analysis and interpretation: RN, NS
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**REFERENCES**


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