Results of prosthetic-vein composite graft with remote popliteal arteriovenous fistula in infragenicular bypass

L. P. Palerme, MD, John D. S. Reid, MD, Arthur M. T. Chan, MD, Ramesh Lokanathan, MD, Shaun MacDonald, MD, and Joseph G. Sladen, MD, Vancouver, British Columbia

Objective: The purpose of this study is to report the results of a novel procedure for femoral-distal bypass grafting using a composite graft with an adjunctive remote popliteal fistula distal to the prosthetic portion of the graft. This reconstruction was developed for use in limb salvage in the absence of satisfactory autogenous vein.

Method: Data were collected prospectively on all patients undergoing this procedure from January 1, 1993 to December 31, 1999. Graft patency was determined from follow-up duplex scanning. Patient survival was determined by clinic follow-up.

Results: A total of 43 procedures were performed in 38 patients. In 34 patients, 72 previous arterial operations had been previously performed on the ipsilateral limbs. There were 20 men and 18 women with a mean age of 72 years. The indication for surgery was limb salvage in all, with rest pain in 30, and tissue loss in 13. The outflow artery was the below-knee popliteal artery in 10 and a tibial artery in the remainder. Operative mortality was 6.8%. Mean follow up was 26.9 months. The primary patency was 54% at 12 months. Six reconstructions were revised for a primary assisted patency of 60% at 16 months. Secondary patency was 69% at 16 months. Patient survival was 62% at 2 years and 26% at 5 years.

Conclusions: The technique of composite grafting with remote popliteal arteriovenous fistula may be a useful alternative in infragenicular bypass when a satisfactory autogenous vein is not available. (J Vasc Surg 2002;36:330-5.)

The greater saphenous vein is the conduit of choice for femoral-distal bypass grafting. However, the vein may be unavailable because of previous harvest for extremity or coronary arterial bypass surgery, or it may be inadequate because of small size, short length, or damage from previous phlebitis. In this setting, the options for graft material are vein from another source or prosthetic grafts, which can be augmented with distal vein cuffs or arteriovenous fistulae in a variety of configurations. We have previously described a novel procedure using a prosthetic-vein composite graft with a remote popliteal arteriovenous fistula, created distal to the prosthetic segment. This study reports our experience.

METHODS

The study included all patients undergoing this procedure from January 1, 1993 until December 31, 1999, as well as 13 patients (14 limbs) that were reported previously. Patients were selected for this procedure on the basis of availability of adequate vein to span the distance from groin to the infragenicular arteries. Although an autogenous conduit would be our preference, we would choose this technique rather than attempting to create an all-autogenous reconstruction that required multiple vein harvest sites and multiple venovenostomies, or to use wholly prosthetic grafts in those situations requiring long grafts to span the distance from groin to the infragenicular arteries. The indication for the procedure was critical ischemia, defined as rest pain or tissue loss. Data were collected prospectively and recorded in a database. The patients were followed clinically with graft patency determined by using duplex scanning criteria. Graft patency and patient mortality was calculated with use of Kaplan-Meier analysis.

The detailed operative technique has been described previously. A composite graft of prosthetic material and vein from the femoral to a distal arterial outflow artery is constructed with a remote popliteal arteriovenous fistula (Fig 1). An inflow site that has adequate flow to support a distal outflow bed, consisting of both arteriovenous fistula and artery, is chosen on the basis of the preoperative angiogram. The inflow usually is the ipsilateral common femoral artery, but the ipsilateral or contralateral iliac arteries can be used, with approach to these vessels through a retroperitoneal incision. We favor the use of 8-mm externally supported polytetrafluoroethylene for the prosthetic portion of the graft. Vein is harvested to span the distance from the site of the arteriovenous fistula to the distal arterial outflow site. Because the distal end of the prosthetic graft will be anastomosed into the proximal portion of the harvested vein, we seek to harvest vein that has a large diameter. Upper arm, brachial-basilic vein has been ideal for this purpose. When placed in a nonreversed orientation after removing the venous valves with a Mills valvulotome, it provides a large diameter vein into which the prosthetic graft can be anastomosed.
The site of the arteriovenous fistula can be either the above- or below-knee popliteal vein. This decision is based on the site of the target outflow artery. The fistula is constructed to the above-knee popliteal vein when the target artery is the below-knee popliteal artery or a proximal infragenicular tibial artery, and usually constructed to the below-knee popliteal vein when the target artery is more distal.

The technique requires four anastomoses. The upper end of the prosthetic graft is anastomosed to the inflow artery. Next, the arteriovenous fistula is constructed. The end of the harvested vein is anastomosed to the side of the popliteal vein. To avoid the problem of developing an arterial steal from competitive flow through the fistula, the size of the arteriovenous connection must be limited to 4 mm. To aid in sizing of the fistula, the anastomosis is not completed until it can be probed through the venotomy created for the distal-prosthetic to harvested vein anastomosis. The arteriovenous fistula is constructed with a continuous suture to reduce later dilation of the fistula. The distal-prosthetic to harvested vein anastomosis is now completed. Finally, the harvested-vein to target outflow artery anastomosis is constructed.

The effect of the arteriovenous fistula is measured by placing a 22-gauge needle attached to an arterial transducer into the graft system just below the fistula. A mild arterial steal seems to be well tolerated, but if the systolic blood pressure index between the arm and the graft is less than 0.8, additional sutures are placed to narrow the fistula.

Antiplatelet or anticoagulation medications to improve graft patency are not used routinely.

Patients were followed with duplex scanning surveillance of their grafts, usually at intervals of 3, 6, 12, 18, and 24 months, and then annually. Graft patency was determined by use of duplex scanning examination, by using previously established criteria, and vascular clinic follow-up. Clinic or telephone contact with the patient or primary care physician was used to determine limb loss and long-term patient survival. The study endpoints were primary, primary assisted, and secondary patency, and limb loss and patient survival.

**RESULTS**

There were 20 male and 18 female patients with a mean age of 72 years. Comorbidity is shown in the table. The presenting complaint in 30 limbs was rest pain and in 13 limbs was tissue loss. Three patients died, all from cardiac causes, within 30 days of the procedure (operative mortality, 6.9%). Mean follow-up was 26.9 months (range, 1.5–88 months). One patient was lost to follow-up.

A total of 43 procedures were performed in 38 patients. Two patients underwent bilateral procedures, whereas three had complete redo procedures for failed reconstructions. All but four patients had had previous arterial bypass surgery in the ipsilateral limb. There had been 72 previous operations in the remaining 34 patients. The four patients with primary operations had an inadequate saphenous vein.

The prosthetic portion of the graft was constructed of Dacron in 13 limbs early in the study. Later, externally

<table>
<thead>
<tr>
<th>Factor</th>
<th>No. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac</td>
<td>7</td>
</tr>
<tr>
<td>Angina</td>
<td>7</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>10</td>
</tr>
<tr>
<td>Previous cardiac surgery</td>
<td>1</td>
</tr>
<tr>
<td>Previous myocardial infarction</td>
<td>1</td>
</tr>
<tr>
<td>Cerebrovascular</td>
<td>1</td>
</tr>
<tr>
<td>Previous transient ischemic attack</td>
<td>5</td>
</tr>
<tr>
<td>Previous stroke</td>
<td>5</td>
</tr>
<tr>
<td>Previous endarterectomy</td>
<td>2</td>
</tr>
<tr>
<td>Hypertension</td>
<td>15</td>
</tr>
<tr>
<td>Diabetes</td>
<td>15</td>
</tr>
<tr>
<td>Oral hypoglycemic agent</td>
<td>2</td>
</tr>
<tr>
<td>Insulin</td>
<td>3</td>
</tr>
<tr>
<td>Smoking</td>
<td>7</td>
</tr>
<tr>
<td>Never smoked</td>
<td>7</td>
</tr>
<tr>
<td>Ex-smoker &gt; 1 mo</td>
<td>21</td>
</tr>
<tr>
<td>Smoker</td>
<td>10</td>
</tr>
</tbody>
</table>

![Figure 1](https://example.com/fig1.png)
supported polytetrafluoroethylene was favored with 6-mm graft used in one limb, 6-mm externally supported graft in one limb, and 8-mm externally supported graft used in 28 limbs. Arm vein placed in a nonreversed orientation was used for the autogenous portion in 35 limbs, and in the remainder with a segment of greater saphenous vein. In 24 limbs, the arteriovenous fistula was constructed to the above-knee popliteal vein, whereas the remainder were to the below-knee popliteal vein. The common femoral artery was the usual inflow artery, whereas the ipsilateral iliac artery was used in two limbs and the contralateral iliac artery in one limb. The outflow was to the below-knee popliteal artery in 10 limbs, to the peroneal artery in 20 limbs, to the anterior tibial artery in 8 limbs, and to the posterior tibial artery in 5 limbs. Primary patency was 54% at 12 months (standard error [SE], 9.76%) (Fig 2).

Six patient reconstructions were revised: two for inflow stenoses, three fistulae for arterial steal, and one to repair a late false aneurysm. Primary assisted patency was 60% at 16 months (SE, 9.78%) (Fig 3).

The created arteriovenous fistula enlarged in four patients causing an arterial steal from competitive flow through the fistula. This caused reduced ankle brachial indices and return of claudication symptoms. One patient declined further surgery because his return of symptoms was mild compared to his presenting complaint of rest pain.
the remaining three patients were revised with reoperation to narrow the fistulae. In two, the fistula was redissected and additional sutures placed to narrow the neck, and in one a cuff of Dacron was placed around the fistula as a banding to achieve narrowing. Intraoperative pressure monitoring as noted earlier, was performed to monitor the effect of the fistula narrowing on distal arterial outflow. There was one known late occlusion of an arteriovenous fistula in association with a false aneurysm that occurred at the composite anastomosis. Although the false aneurysm was repaired, the arteriovenous fistula was not reestablished; however, in this case the graft has remained patent.

Inflow stenosis was repaired with prosthetic patch angioplasty of a distal external iliac narrowing found on follow-up duplex scanning in one case. In a second case, rest pain returned on sitting. This graft had been implanted 1 year previously by using Dacron for the prosthetic portion anastomosed to the ipsilateral iliac artery. Clinical examination and arteriography determined that the graft was kinking in its upper portion on sitting. The inflow was replaced with externally supported polytetrafluoroethylene.

In four cases the distal venous portion of the graft beyond the composite anastomosis occluded. However, the prosthetic portion of the graft remained patent on flow...
through the popliteal arteriovenous fistula. The occluded vein was replaced with a new vein anastomosed to the still-patent prosthetic portion of graft. One failed 5 months later. Three remained patent at a mean follow-up of 1 year. These four cases were classified as graft occlusions; therefore, secondary patency was 69% at 16 months follow-up (SE, 9.93%) (Fig 4).

In five patient in whom the graft failed, four had subsequent amputations: three below the knee and one above the knee.

Patient survival was 62% at 2 years and 26% at 5 years.

DISCUSSION

This procedure was developed with the aim of more easily spanning the distance from a good inflow artery to an infragenicular artery in arterial bypass. Although very acceptable results can be obtained from the harvest of alternate autogenous vein, with assisted patency rates above 70% at 5 years, it can be technically challenging to harvest and splice together enough vein to graft to an infrapopliteal artery. When adequate vein is available, it would be our choice in distal reconstructions; however, spanning the distance can require multiple vein harvest sites and may require multiple venovenostomies, and in our experience, good vein is often in short supply in this group of patients who have had many previous vein harvesting procedures. However, it is usually possible to obtain a single piece of good quality vein to span the distance from the arteriovenous fistula to the distal outflow artery. We have found that of vein harvested from the upper arm, usually the brachial-basilic is ideal for this procedure, although vein from other harvest sites can be used if the quality is acceptable. We suggest a vein free from previous phlebitis, from thrombosis or venipunctures, and of at least 4 mm to 5 mm in diameter in the portion that will be accepting the anastomosis of the distal end of the prosthetic portion of the graft. The use of wholly prosthetic graft to span the distance from the groin to a distal leg artery facilitates the procedure; the distal vein to artery anastomosis brings together a good quality vein and a small artery and can be performed in the usual manner, thereby avoiding the extra complexity of constructing a vein patch or arteriovenous fistula at this site. Each component of the procedure should be familiar to the surgeon who is performing arterial reconstructions. The inflow is a large artery-to-prosthetic graft anastomosis, whereas the outflow is a vein-to-small artery anastomosis. The construction of the arteriovenous fistula, while being remote from the distal tibial anastomosis, involves a large vein to prosthetic anastomosis.

In the current series, a steal syndrome has occurred in four cases. The remoteness of the fistula from the distal anastomosis facilitated the narrowing of the fistula at a second procedure in three of these cases, and no graft was lost as a result of this problem or intervention. The steal syndrome was a late phenomenon resulting from the gradual enlargement of the fistula, and we have attempted to limit its occurrence by using a small fistulous connection constructed with a continuous suture anastomosis and by balancing the flow between the fistula and the distal tibial artery by intraoperative pressure monitoring.

In four cases, the distal venous portion of the graft occluded. Although secondary patency was achieved by replacing this part of the graft, the role of the arteriovenous fistula in causing the distal thrombosis is unclear. It may be possible that an enlarged fistula could produce a steal sufficient to reduce distal flow, thereby causing failure of this portion of the graft. However, other factors may be playing a part. When replaced, the distal grafts maintained good long-term patency in three of the four cases without modification of the fistula itself.

Interventions were required in six patients to achieve an assisted patency of 60% at 16 months and in an additional
four patients to achieve a secondary patency of 69% at 16 months. The nature of the interventions—fistula narrowing, repair of inflow stenoses, false aneurysm repair, and distal venous graft replacement—were relatively limited and well tolerated.

Patients with an advanced generalized atherosclerotic burden of disease in whom multiple previous vascular procedures have been performed have poor long-term survival. In our series, the low patient survival of 26% at 5 years made it difficult to accumulate long-term follow-up or patency data. The majority of the patients in this group had had a mean of more than two vascular procedures, and likely represent a more challenging subset when revascularization procedures are undertaken. This technique may represent another approach that could be considered between the option of multiple vein harvest sites and venovenous grafts or the use of a wholly prosthetic graft. Our preference, given the option, would be the former, as we have been unimpressed with the results of prosthetic grafts to below-knee or tibial arteries. Patients who are appropriate for the procedure described in this study are those in whom a single portion of good quality vein can be easily harvested from one site and in whom multiple vein harvesting was a significant challenge largely because of previous vein harvests. We feel that the chief advantages of this technique are the ability to span a long distance easily with a simple vein-to-artery anastomosis at the lower end. The addition of the arteriovenous fistula in a position that permits manipulation of the flow into both the fistula itself and the arterial outflow tract offers a theoretical advantage over the use of a composite graft. Although the cohort of patients is small, the results appear promising and bear further study.

CONCLUSION

The group of patients with critical limb ischemia presented in this study have poor long-term survival, and with multiple previous vein harvests or inadequate veins present a significant challenge to revascularization of the distal leg. The prosthetic-vein composite graft with remote popliteal arteriovenous fistula technique described can easily span the distance required for distal bypass grafting and may offer some advantages over achieving the necessary graft length through multiple-site vein harvesting with multiple venovenous grafts or the use of wholly prosthetic grafts. With this small cohort of patients, the results appear promising and further study is warranted.

REFERENCES


Submitted Jan 16, 2002; accepted Apr 17, 2002.