Ann R Coll Surg Engl 1996; 78: 497–500

Arm vein reconstruction for limb salvage: long-term outcome

P V Tisi FRCSEd
Research Fellow in Vascular Surgery

C P Shearman MS FRCS
Consultant Vascular Surgeon

A J Crow
Research Associate

Department of Vascular Surgery, Royal South Hampshire Hospital, Southampton

Key words: Arm vein; Revision vascular surgery; Critical ischaemia

A series of 42 consecutive patients undergoing infrainguinal vascular reconstruction for limb salvage using vein harvested from the arm were followed prospectively to determine the long-term graft patency and stenosis rates. Vein harvested from the arm ('arm vein') was used for secondary or tertiary reconstruction in 22 patients (52.4%). The outflow was to a single calf vessel in 37 grafts (88.1%). The cumulative primary, primary assisted and secondary graft patency rates were 35.6%, 49.6% and 59.5% at 2 years, respectively, and the limb salvage rate was 69.0% at 2 years. Eight grafts developed stenoses detected by a graft surveillance programme. Six stenoses were dilated successfully with percutaneous transluminal angioplasty (PTA) and one was treated with an interposition vein graft. Bypass using arm vein is time-consuming and technically demanding as multiple anastomoses are often required. Arm vein grafts, however, have no greater incidence of stenosis than long saphenous vein grafts and these stenoses may be dilated with PTA with good results. The long-term outcome suggests that an arm vein graft is an important treatment option in the absence of the long saphenous vein.

Bypass to a single calf vessel is often required for limb salvage, and particularly in revision surgery. Long saphenous vein is the graft of choice *(1)*, but problems arise when this is unusable or unavailable. The contralateral long saphenous vein is not always a viable option as harvesting this would lead to impaired wound healing in a limb which is likely to have some degree of ischaemia. This vein may also be required for a future graft. Alternative conduits include arm vein, short saphenous vein, deep femoral vein and polytetrafluoroethylene (PTFE) with a vein patch/cuff. The results of PTFE with a vein patch/cuff to a crural vessel are disappointing, with patency rates of 43% and 30% at 1 and 3 years, respectively *(2)*. The study reviews our experience with the use of arm vein as a conduit, with particular regard to the long-term durability and management of graft-related problems.

Correspondence to: Mr P V Tisi, Department of Vascular Surgery, Royal South Hampshire Hospital, Brintons Terrace, Southampton, Hampshire SO14 0YG

Patients and methods

Over a 6 year period (November 1988 to March 1995), 42 consecutive patients underwent vascular reconstruction using arm vein. All were selected for femorodistal reconstruction according to clinical *(3)* and angiographic evidence. Arm vein was considered if the long saphenous vein was unavailable or unusable on surgical exploration.

Preoperatively, veins on the dorsum of the hand were used for blood sampling to preserve the arm vein. An internal jugular central venous line was inserted for intraoperative venous access and a radial arterial line was used for invasive blood pressure monitoring.

The site of arm vein harvest was determined by preoperative clinical assessment, but intraoperative exploration was performed if there was any doubt regarding the quality of the vein. Vein was harvested from the cephalic and/or basilic veins of the upper arms, avoiding an incision across the elbow joint. Venovenous anastomoses were performed when several segments of vein were required or if a composite graft using part of the long saphenous vein was undertaken. The vein was generally used reversed. The outflow artery was determined by a combination of preoperative Doppler ultrasound assessment *(3)*, arteriography and surgical exploration. An operative diagram was used to record the

orientation of vein segments and site of anastomoses to aid any future surgical intervention or graft surveillance. Postoperatively, the arm was elevated in a Bradford sling (Bradford University Research Ltd, Bradford, UK) and use of the hand encouraged to reduce early swelling.

All grafts were entered into a graft surveillance programme with duplex ultrasound starting at 6 weeks postoperatively. Data were collected prospectively and patency, limb salvage and survival rates were analysed according to the life-table method *(4)*.

Results

The median age of the 42 patients was 68 years (range 44–87 years) and 31 (73.8%) were men. Cardiovascular risk factors included diabetes mellitus in 10, hypertension in seven and ischaemic heart disease in 13 patients. The majority were current (19.0%) or ex-smokers (52.4%).

In two patients the long saphenous vein had been stripped during previous varicose vein surgery and in one patient the vein had been harvested for a coronary artery bypass graft. In all, 27 patients (64.3%) had undergone at least one previous lower limb vascular reconstruction (50 procedures). In 22 patients this was a secondary or tertiary reconstruction to the same limb. Five patients had a previous contralateral above-knee amputation and limb salvage was therefore of the utmost importance.

The indication for operation was critical ischaemia in 38 patients (90.5%), two grafts were for disabling intermittent claudication, one graft was for an anastomotic false aneurysm and a further graft was for a long saphenous vein graft aneurysm; 81.0% were elective procedures. The outflow was to a single calf vessel in 37 cases (88.1%) (Table I) of which 20 grafts were to the level of the ankle. Arm vein was used alone in 28 grafts (66.7%) or as a composite with long saphenous vein remnants in 12, short saphenous vein in one and PTFE in one graft. In this last case, PTFE was anastomosed to an isolated popliteal segment and then arm vein used to reconstruct to a crural vessel. The mean operative time was 268 min.

The cumulative primary graft patency was 61.1% and 35.6% at 1 and 2 years, respectively (Fig. 1). The primary assisted patency was 66.2% and 49.6% at 1 and 2 years. A total of 10 grafts occluded within the first week, of which two were salvaged by graft thrombectomy and one in which the outflow was revised further distally. A further graft occluded at 3 weeks and the limb was salvaged by a PTFE graft with a Miller cuff. The cumulative secondary patency (Fig. 1) was 75.9% and 59.5% at 1 and 2 years, respectively. Morbidity from the arm incision occurred in two patients. One patient had a sensory deficit in the medial cutaneous nerve of the forearm territory. A further patient required revision of a scar across the elbow joint.

Table I. Outflow vessel for arm vein graft

	No.
Femoropopliteal long saphenous vein graft	1
Below-knee popliteal	4
Tibioperoneal trunk	3
Anterior tibial	12
Posterior tibial	9
Peroneal	13
Level of crural bypass	
Upper third crural vessel	8
Middle third crural vessel	6
Lower third crural vessel	20

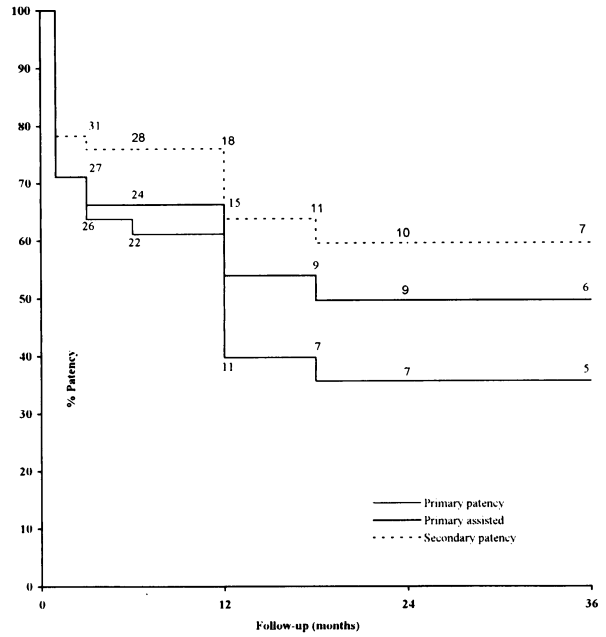

Figure 1. Cumulative patency rates.

The cumulative limb salvage rate was 78.0% and 69.0% at 1 and 2 years. There were 12 major amputations of which seven were within the first month.

Eight grafts developed stenoses, defined as a segmental peak velocity increase of >3.0 times on duplex scanning *(5)* at a mean of 10.6 months (range 2–32 months) postoperatively. The stenoses were treated with percutaneous transluminal angioplasty, of which six were successfully dilated and remained patent at a mean of 14 months (range 4–26 months) after the procedure. One patient required surgical excision of the stenosed segment with an interposition vein graft, and one patient had a technically failed angioplasty and subsequently underwent revision surgery using a PTFE graft with a Miller cuff.

The cumulative mortality was 42.3% at 3 years ($n=11$). There were 10 deaths from myocardial infarction, of whom four patients had an occluded graft (with a subsequent amputation in three cases), one had a previous successful angioplasty and one patient had a failed angioplasty followed by revision surgery; one further death was caused by staphylococcal septicaemia from an unrelated cause.

Discussion

The annual incidence of critical ischaemia is 500–1000 per million population *(2)*. Inevitably, as surgical and

anaesthetic techniques improve, revision femorodistal surgery will be considered rather than an amputation for clinical and socioeconomic reasons. Cheshire *et al. (6)* found that 30% of 395 patients required revision surgery for recurrence of ischaemia in the ipsilateral limb over 3 years (a mean of 1.75 further operations per patient). An increasing number of patients will therefore have had their long saphenous vein used for a previous lower limb reconstruction or harvested for a coronary artery bypass graft.

Prosthetic grafts reduce operation time and require two small incisions for exposure of inflow and outflow vessels, but the cost in terms of graft material and poor long-term outcome is considerable. PTFE grafts to a single calf vessel have a patency of 43–48% and 20–30% at 1 and 3 years *(2,7)*. The results may be improved with the use of an interposition vein patch or cuff. Tyrrell *et al. (8)* used PTFE with a vein collar in 30 distal reconstructions for critical ischaemia. The secondary patency rate was 47% at 1 year. This is similar to our experience with PTFE and a Miller cuff. Patency rates in some cases may be improved if PTFE is anastomosed to an isolated popliteal segment and ectopic vein used to reconstruct distally *(9)*.

Short saphenous vein is an alternative conduit but requires a more difficult additional incision on the posterior aspect of the leg and is therefore not always used.

Arm vein should be considered as a 'second best' conduit. Forearm veins are often unusable because of previous phlebotomy and intravenous cannulation. Upper arm vein (cephalic, basilic and brachial) is generally of good quality *(10)* and our policy is to explore the upper arm veins through a medial incision. However, a composite graft of several short lengths of vein may be needed to create a suitable length for a distal anastomosis. The venovenous anastomoses are time-consuming and technically demanding. The composite graft is sited non-reversed, using the same technique as an *in situ* vein graft. An alternative technique used in our series is to harvest the cephalic and basilic veins of the upper arm in a continuous loop via medial and lateral incisions, to create a graft which is reversed distally and non-reversed proximally *(11)* and which has excellent patency rates up to 1 year *(12)*.

The majority of our graft occlusions (37.5%) occurred within 1 week. Evidence suggests that the presence of intraluminal abnormalities in the graft appears to be the most important factor in early occlusion. Marcaccio *et al. (13)* performed intraoperative angioscopy in 113 arm vein grafts. Intraluminal disease was found in 62.8% of veins, webs in 54%, vein sclerosis in 22.1%, stenosis in 9.7% and thrombus in 6.2%. The basilic vein was the least diseased. Stonebridge *et al. (14)* compared 27 arm vein grafts monitored by intraoperative angioscopy with 39 grafts monitored by conventional continuous wave Doppler and completion arteriography. Angioscopy identified and corrected intraluminal abnormalities in 74% of grafts. The primary patency of the angioscopy group was 100% at 1 month compared with 82% in the conventional group.

The cumulative secondary patency of 56.6% is in line with previous reports of 52–82% patency at 3 years *(8, 15–17)*.

One potential problem with arm vein is the development of stenoses. Arm vein is generally thinner than long saphenous vein and is handled considerably during the venovenous anastomoses. The incidence of arm vein graft stenosis in this series is 16.7%. Six out of seven stenoses were demonstrated by duplex ultrasound in the first 12 months. Harward *et al. (16)* retrospectively reviewed 43 patients undergoing infrageniculate bypass using a single segment of arm vein ($n=6$), multiple segments of arm vein ($n=19$) or segments of arm and long saphenous veins ($n=18$). During the mean follow-up of 15 months, six grafts (14%) developed a stenosis, of which three were salvaged. Taylor *et al. (18)* prospectively followed 412 patients undergoing femorodistal reconstruction with long saphenous vein, arm vein, or PTFE, of which 122 grafts were to a crural vessel. In all, 66 grafts (16%) had a stenosis detected by duplex scanning and intravenous digital subtraction angiography within 12 months, and no further stenoses were detected after a mean follow-up of 22 months (range 9–48 months). The highest incidence of stenosis was in femorocrural vein grafts in which 23 of 87 (26%) developed a stenosis. It was concluded that graft surveillance with duplex ultrasound is only worthwhile in the first year. If this policy was adopted in our series, one late stenosis (as well as two late occlusions) would have been missed. We consider that duplex is of undoubted value in graft follow-up, with stenoses identified according to standard criteria *(19)*. However, venovenous anastomoses and stenoses may be difficult to distinguish on duplex ultrasound. An operative diagram recording the site of anastomoses minimises this problem.

Percutaneous transluminal angioplasty of arm vein is useful in the management of graft stenosis with good long-term patency rates. Out of seven stenoses in our series, six were dilated successfully. Taylor *et al. (18)* reported 13 patients undergoing PTA for haemodynamically significant stenoses in femorodistal grafts. Six grafts were dilated successfully and remained patent at a mean of 15.5 months after the procedure. They suggest that only web stenoses and short segment stenoses should be treated with angioplasty and that long segment stenoses should be treated with surgical patch angioplasty or a jump graft. Recurrent stenosis after angioplasty is well reported. Dunlop *et al. (5)* reported that 52% of a series of femorodistal grafts (predominantly long saphenous vein) developed recurrent stenosis after angioplasty. We have no evidence of re-stenosis after a mean of 14 months (range 4–26 months) follow-up of our grafts treated successfully with PTA.

In conclusion, arm vein should be considered as the graft of choice for distal reconstruction in the absence of the long saphenous vein. Arm vein appears to have no greater incidence of stenosis than long saphenous vein and the stenoses may be treated successfully by angioplasty.

References

1 Budd JS, Brennan J, Beard JD, Warren H, Burton PR, Bell PRF. Infrainguinal bypass surgery: factors determining late graft patency. *Br J Surg* 1990; **77**: 1382–7.

2 Wolfe JHN, Tyrrell MR. Justifying arterial reconstruction to crural vessels—even with a prosthetic graft. *Br J Surg* 1991; **78**: 897–9.

3 Shearman CP, Gwynn BR, Curran F *et al.* Non-invasive femoropopliteal assessment: is that angiogram really necessary? *Br Med J* 1986; **293**: 1086–9.

4 Rutherford RB, Flanigan DP, Gupta SK *et al.* Suggested standards for reports dealing with lower extremity ischaemia. *J Vasc Surg* 1984; **4**: 80–94.

5 Dunlop P, Varty K, Hartshorne T *et al.* Percutaneous transluminal angioplasty of infrainguinal vein graft stenosis: long-term outcome. *Br J Surg* 1995; **82**: 204–6.

6 Cheshire NJ, Noone MA, Wolfe JHN. Re-intervention after vascular surgery for critical leg ischaemia. *Eur J Vasc Surg* 1992; **6**: 545–50.

7 Bergen JJ, Veith FJ, Bernhard VM *et al.* Randomization of autogenous vein and polytetrafluoroethylene grafts in femoral-distal reconstruction. *Surgery* 1982; **92**: 921–30.

8 Tyrrell MR, Grigg MJ, Wolfe JHN. Is arterial reconstruction to the ankle worthwhile it the absence of autologous vein? *Eur J Vasc Surg* 1989; **3**: 429–34.

9 Hickey NC, Thompson IA, Shearman CP, Simms MH. Aggressive arterial reconstruction for critical lower limb ischaemia. *Br J Surg* 1991; **78**: 1476–8.

10 Sladen JG, Reid JDS, Riggs MO. Harvest of brachio-basilic vein complex for arterial bypass. *J Cardiovasc Surg* 1992; **33**: 169–71.

11 Grigg MJ, Wolfe JHN. Combination reversed and non-reversed upper arm vein for femoro-distal grafting. *Eur J Vasc Surg* 1988; **2**: 49–52.

12 Holzenbein TJ, Pomposelli FB, Miller A *et al.* The upper arm basilic-cephalic loop for distal bypass grafting: technical considerations and follow-up. *J Vasc Surg* 1995; **21**: 586–94.

13 Marcaccio EJ, Miller A, Tannenbaum GA *et al.* Angioscopically directed interventions improve arm vein bypass grafts. *J Vasc Surg* 1993; **17**: 994–1002.

14 Stonebridge PA, Miller A, Tsoukas A *et al.* Angioscopy of arm vein infrainguinal bypass grafts. *Ann Vasc Surg* 1991; **5**: 170–5.

15 Andros G, Harris RW, Salles-Cunha SX *et al.* Arm veins for arterial revascularization of the leg: arteriographic and clinical observations. *J Vasc Surg* 1986; **4**: 416–27.

16 Harward TR, Coe D, Flynn TC, Seeger JM. The use of arm vein during infrageniculate arterial bypass. *J Vasc Surg* 1992; **16**: 420–6.

17 Londrey GL, Bosher P, Brown PW *et al.* Infrainguinal reconstruction with arm vein, lesser saphenous vein and remnants of greater saphenous vein: a report of 257 cases. *J Vasc Surg* 1994; **20**: 451–7.

18 Taylor PR, Wolfe JHN, Tyrrell MR *et al.* Graft stenosis: justification for 1-year surveillance. *Br J Surg* 1990; **77**: 1125–8.

19 Chalmers RT, Hoballah JJ *et al.* The impact of colour duplex surveillance on the outcome of lower limb bypass with segments of arm veins. *J Vasc Surg* 1994; **19**: 279–86.

Received 13 February 1996