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Arm Vein as a Last Autogenous Option for Infrainguinal Bypass Surgery: It is Worth the Effort

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Objectives. *Considerable evidence exists for the use of arm vein conduit in lower limb bypass surgery. The use of arm vein in preference to synthetic conduit as a last autogenous option was assessed for patency and limb salvage outcomes.*
Materials and methods. *A prospective database was interrogated and checked against TQEH operating theatre database to detect all infrainguinal arm vein bypasses performed between 1997 and 2005. Patency, limb salvage and survival data for 37 arm vein bypasses was calculated using the Kaplan-Meier survival estimate method.*
Results. *There were no perioperative deaths. 30 day patency rates were 89% primary, 95% secondary and 95% limb salvage. 12 month patency rates were 56% primary, 79% secondary and 91% limb salvage. 5 year patency rates were 37% primary, 76% secondary and 91% limb salvage. There was no significant patency advantage for primary vs. "redo" grafts ($p = 0.54$), single vessel vs. spliced conduits ($p = 0.33$) or popliteal vs tibial outflow ($p = 0.80$). Patient survival rate was 92% and 65% at 1 and 5 years respectively.*
Conclusion. *Lower limb bypasses using arm vein can be performed with favourable patency and limb salvage compared to synthetic conduits. However, secondary interventions are frequently required to maintain patency. We recommend a vigilant surveillance program for early identification of patency threatening disease.*

Keywords: Arm vein; Infrainguinal bypass graft; Vascular conduit.

Introduction

Great saphenous vein (GSV) is the preferred vascular conduit for infra-inguinal bypass grafting because it has proven thrombo-resistance and long term durability when compared to other grafts.[1–3] In 20–25% of people ipsilateral GSV is unavailable because of absence or unsuitability.[4,5] Commonly used alternative conduits include autogenous small saphenous (SSV) and arm vein both of which may be a single vein segment or spliced. Synthetic and biological substitute grafts are often readily available and save time in preparation. The majority of surgeons on our unit have practiced an "all-autogenous" policy, preferring to use arm vein in preference to synthetic grafts when either GSV or SSV is unavailable. Autogenous conduit is preferred to reduce graft infection rates and improve patency whilst achieving the goal of limb salvage.

Arm vein was first reported as a vascular conduit by Kakkar in 1969.[6] Since that time there have been a number of large case series from centres that practice arm vein bypass as the first alternative for infrainguinal bypass surgery when ipsilateral GSV is not available.[7–9] These show excellent medium to long term patency, however may not reflect the practice of centres that prefer to exhaust other autogenous options before utilising arm vein.

Many vascular centres use contralateral GSV or SSV as the first alternatives to ipsilateral GSV and use arm vein only as a last autogenous option. By this time patients have had multiple hospitalisations and often arm vein instrumentation and cannulation. These centres seek to establish whether last autogenous option arm vein bypasses are indeed superior to the alternative poly-tetra-fluoro-ethylene (PTFE) and Dacron synthetic conduits with and without vein cuffs, and those newer conduits bonded with heparin.[10]

The aim of this series is to present data from a busy vascular surgical unit that has used arm vein conduit as a last autogenous option, to provide generalisable

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patency and limb salvage information for comparison with synthetic grafts.

Materials and Methods

Between May 1997 and August 2005 a consecutive series of patients undergoing infrainguinal arterial reconstruction for arterial occlusive disease at The Queen Elizabeth Hospital were recorded prospectively in a computerised database. The database included patient demographics, procedure and outcome data. To ensure complete detection of cases the HAS Operating Theatre database was also searched using the relevant codes to identify all infrainguinal bypass operations performed. Every operation note was hand searched for the use of arm vein conduit. Data was then collected retrospectively using a standardized datasheet encompassing clinical data which included presenting symptoms, investigation findings, operation details, and follow up.

Over this period 37 infrainguinal arterial reconstructions with arm vein conduit were performed on 36 limbs in 35 patients (63% male) for the treatment of lower extremity ischaemia. Patient demographic data is presented in Table 1. The indication was limb salvage (89%) or disabling claudication (11%) in the absence of suitable ipsilateral or contralateral GSV or SSV in all cases (54% previous lower limb surgery, 41% inadequate length or calibre of vein, 5% previous coronary grafting). In 21 (57%) cases the surgery was for first bypass grafts and 16 (43%) were "redo" operations for failed previous grafts, 3 (8%) of which were skip grafts from earlier bypasses. Patients ranged in age from 55 to 84 years with a median age of 73 years.

Preoperative duplex mapping was used routinely to assess conduit suitability and mark the veins. They were then harvested as previously described through continuous upper limb incisions.[9] Vein abnormalities were either patched or resected and when required for length veno-venostomy was performed in the standard fashion with a continuous 7−0 polypropylene suture. The graft was gently distended and kept in a cool, balanced heparin/normal saline solution to maintain endothelial integrity. Grafts were reversed without exception before anastomosis from inflow to outflow vessel as described in Table 2. Completion angiography was performed with any irregularities identified and corrected at the time of surgery. The grafts consisted of either single vessel arm vein segments or spliced arm to arm vein or GSV (Table 3).

Follow up was performed post-operatively at 3 months, then 6 months for 2 visits and 12 monthly thereafter. Patency was assessed by means of routine clinical assessment, ankle-brachial indices and colour flow duplex ultrasound with selective use of digital subtraction angiography. This was completed within the environment of a formalised surveillance clinic. Follow up data was obtained from hospital records, outpatient charts, and from individual surgeons private practices. All definitions and categories were from the Ad Hoc Committee on Reporting Standards appointed by the Society of Vascular Surgery, and the North American chapter of the International Society of Cardiovascular Surgery.[11] The follow up period ranged from 2 to 72 months, with an average of 26 months.

Graft patency, limb salvage and survival were calculated using the Kaplan-Meier survival estimate method. Comparison between survival curves was performed using the log-rank test for significance. Figures were presented as mean value ± standard error. A P value of less than 0.05 was considered significant.

Table 1. Patient demographics

Characteristic	Percentage ($n = 35$)
Male/Female	63/37
Hypertension	74
Hypercholesterolaemia	57
COPD	49
Diabetes Mellitus	40
Chronic Renal Failure	17
Cardiac Failure	6
Ischemic Heart Disease	37
Current/Ex Smoker	60
Prothrombotic Disorder	6

COPD, Chronic Obstructive Pulmonary Disease.

Results

Mortality and complication rates. There was no perioperative mortality. Perioperative morbidity is listed in Table 3. There were six (16%) unplanned returns to theatre for haematoma evacuation (2), graft

Table 2. Graft configuration for inflow and outflow vessels

Graft Inflow Artery	Number (%)
External Iliac	2 (5)
Common Femoral	15 (41)
Profunda Femoris	6 (16)
Superficial Femoral	8 (22)
Popliteal	3 (8)
Previous Vein Graft	3 (8)
Graft Outflow Artery	
Profunda Femoris	1 (3)
Superficial Femoral	0
Popliteal Above Knee	2 (5)
Popliteal Below Knee	14 (38)
Tibial	15 (41)
Pedal	5 (14)

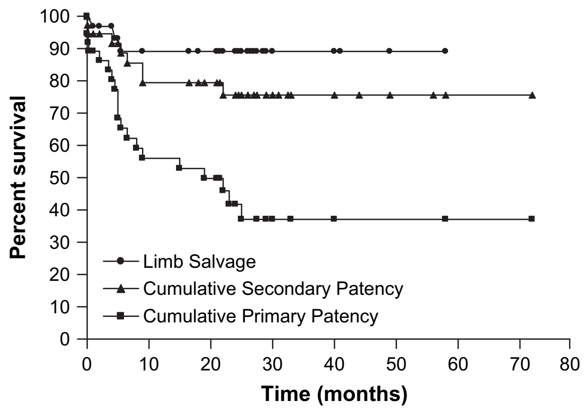
Table 3. Perioperative morbidity

Morbidity	Percentage ($n = 35$)
Wound Haematoma	8
Myocardial Infarction	5
Cardiac Arrhythmia	10
Pneumonia	8
Renal Dysfunction	5
Urinary Tract Infection	3
Partial Lower Limb Wound Dehiscence	11
Area of Arm Paraesthesia	3
Cellulitis	3
Oedema	3

thrombectomy (2), wound debridement (1) and major amputation after graft thrombosis (1).

Patency and limb salvage. The primary patency, secondary patency, limb salvage and survival rates are presented in Fig. 1. Thirty day patency rates were primary $89\% \pm 5\%$, secondary $95\% \pm 4\%$ and limb salvage $95\% \pm 4\%$. Twelve month patency rates were primary $56\% \pm 9\%$, secondary $80\% \pm 7\%$ and limb salvage $91\% \pm 5\%$. Five year patency rates were primary $37\% \pm 9\%$, secondary $76\% \pm 8\%$ and limb salvage $91\% \pm 5\%$.

Ten grafts were revised before occlusion. There were eight simple patch angioplasties and one interposition graft for stenosis, while the final graft underwent 3 separate patch angioplasties and an interposition graft at different time points to remain patent at the time of patient's death. Of the 8 grafts that occluded only 2 were revised. One had a simple thrombectomy remaining patent for another twenty-four hours; the other underwent thrombectomy and interposition graft remaining patent for the remaining sixteen month follow up.



Number at risk

• Limb salvage	32	21	19	5	4	2	1	
• Secondary	37	26	23	10	6	3	1	1
• Primary	37	18	15	5	3	2	1	1

Fig. 1. Kaplan-Meier analysis displaying limb salvage, primary and secondary patency rates for all 37 arm vein bypass grafts.

Patency rates in first bypass operations were compared with those for redo surgery. There was no primary ($p = 0.54$, hazard ratio 1.31, 95% CI 0.54 to 3.20) or secondary patency advantage ($p = 0.62$, hazard ratio 0.70, 95% CI 0.17 to 2.83) seen in these first bypass grafts.

There were similar proportions of single vessels and spliced vessels used as conduit (Table 4). There was a trend towards improved secondary patency with single vessel conduits (Fig. 2) however this was not significant ($p = 0.33$, hazard ratio 1.99, 95% CI: 0.49 to 8.07). Patency rates were higher for grafts whose outflow vessel was the popliteal artery rather than a tibial vessel, however these differences were also not significant (Primary $p = 0.80$, hazard ratio 1.12, 95% CI 0.44 to 2.88; Secondary $p = 0.67$, hazard ratio 0.73, 95% CI 0.16 to 3.22).

The overall patient survival rate was 92% and 65% at 1 and 5 years respectively (Fig. 3). The median survival was 72 months post bypass surgery.

Discussion

A number of centres have published data with arm vein patency rates superior to synthetic grafts when used as a primary alternative to ipsilateral GSV.[7–9] They use angioscopy to painstakingly inspect each arm vein for valve lysis and irregularities that may reduce patency. This process is time consuming and their results may not reflect those in the wider vascular community.

There remains considerable concern over the fragile nature, frequent endothelial irregularities and iatrogenic trauma and stenoses seen with arm vein conduit.[12] Iatrogenic trauma is common with more frequent admissions to hospital as with multiple redo bypass surgery. In addition arm vein segments may provide insufficient length necessitating one or more veno-venostomies which some authors believe reduces patency.[13,14]

These concerns have led to several authors postulating that synthetic grafts may provide a less time consuming option that combined with various patency manoeuvres rivals the durability of ''last resort'' arm vein grafts. Despite the more convenient nature of these grafts a multitude of large randomised trials

Table 4. Arm vein characteristics

Conduit	Number (%)
Single Vessel (Ceph, Brach or Basilic)	20 (54)
Arm Vein/Arm Vein – Spliced	8 (22)
Arm Vein/GSV – Spliced	9 (24)

Ceph, Cephalic vein; *Brach*, Brachial vein; *GSV*, Great Saphenous Vein.

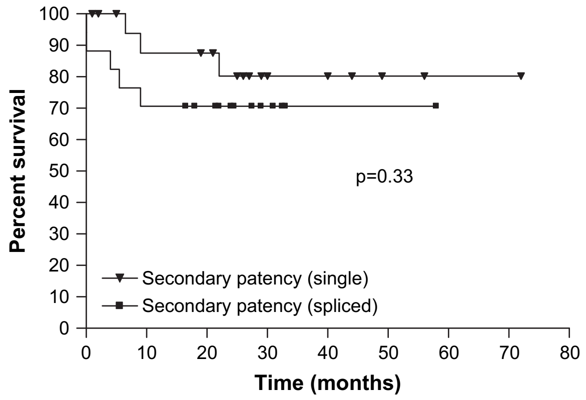


Fig. 2. Kaplan-Meier analysis displaying no difference in secondary patency rates between spliced and single vessel graft conduits ($p = 0.33$).

have seen conventional synthetic grafts underperform when compared to our arm vein patency and limb salvage rates.[15–17] A multicentre trial by Devine *et al*. randomised 209 patients to heparin bonded dacron (HBD) or conventional expanded PTFE.[10] They found no difference in secondary patency rates between the two groups at 5 years and both were inferior to our arm vein rates (HBD 47%, ePTFE 36%: Arm vein 75.6%). Limb salvage was also examined and again found to be reduced when compared to our series (HBD 86% vs. ePTFE 74%; $p < 0.025$: Arm vein 91%). Stonebridge *et al*. examined the effect of ePTFE with vein cuff in 261 above and below knee femoropopliteal bypass grafts.[18] Although their 12 month patency rates for above knee grafts were equivalent to ours at 80%, by 2 years this had dropped to 72% below our 5 year patency of 76%. Below knee grafts were again equivalent at 12 months with a patency of 80% however considerably inferior by 2 years with a patency of 52%. In addition limb salvage was lower in their series at 84% after 2 years compared with our 91% after 5 years.

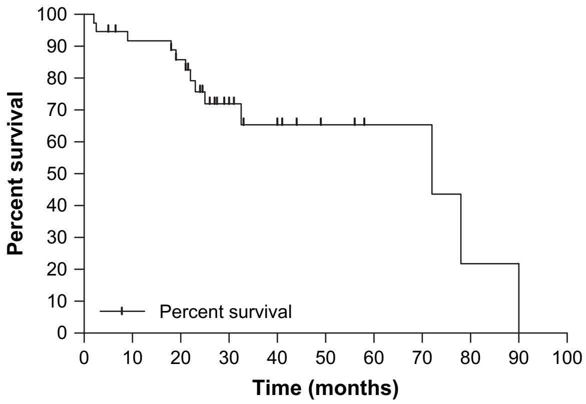


Fig. 3. Kaplan-Meier analysis of survival post arm vein bypass surgery.

Almost half of arm vein bypasses we performed were for redo operations. This reflects the unit approach of using arm vein as the last available autogenous option. There was no patency reduction with redo grafts compared with primary grafts despite the more technically challenging nature of the dissection and the presumed inferiority of the inflow and outflow vessels which may have been responsible for previous graft failure. This finding is consistent with previous studies suggesting that quality of conduit is a more important factor than previous surgery influencing patency.[7,19]

Our patency figures demonstrated a trend towards improvement with single length vein conduit over spliced vein. This difference was not statistically significant. Other studies have demonstrated such an advantage and it may be that as our experience grows this small difference will reach significance.[7,20] If so it is probably a consequence of poor vein quality rather than problems relating to the veno-venostomy which were not a feature in our series.

The difference in primary and secondary patency rates serves to emphasise how effectively patency can be preserved by vigilant surveillance, repair and revision. Many authors consider that the ongoing patency of the graft and a functional healed limb are the critical endpoints, discounting the inconvenience of patency interventions.[21,22] This is because of the quality of life benefits that ensue from an intact limb. These functional endpoints are best reflected in our outcome measures of secondary patency and limb salvage, which remain excellent despite poor primary patency. Economically it would seem that cost too favours limb salvage surgery with Wixon *et al*. finding that the 5 year cost of infrainguinal bypass grafting, surveillance and revision was less than or equal to the cost of primary amputation.[23]

A number of authors have demonstrated that up to 74% of arm vein bypasses have some form of intraluminal abnormality detected when inspected with angioscopy.[24,25] This may be partly responsible for the high rate of reinterventions that were required in our series despite the routine use of completion angiography. Our results have demonstrated that with preoperative duplex mapping, completion angiography and careful graft surveillance excellent graft patency and limb salvage can be achieved without the use of routine angioscopy.

The revisions performed in our series were all open surgical, either patch angioplasties, interposition grafts or thrombectomies. The authors are not averse to using endovascular methods to overcome patency threatening lesions however we feel that arm vein stenoses are often complicated lesions lending themselves to definitive surgical correction to avoid recurrent stenoses. Many large series have successfully used predominantly open surgical repair[26] and others have noted the need for repeated treatments when endovascular techniques are used[27,28] lending support to this centre's practice.

In such a lengthy procedure the authors have found it useful to have dual operating teams. One team harvests and prepares the arm vein whilst the second exposes the inflow and outflow vessels then performs the anastomoses. This significantly reduces the operating time making the procedure eminently manageable.

Adequate patency and limb salvage rates can be achieved with single vessel or spliced arm vein bypass grafts for both primary and redo surgery. The high rates of limb salvage demonstrable with arm vein redo bypass should serve to reinforce the value of infrainguinal revascularisation over amputation even in the absence of GSV. Good quality autogenous vein is the best conduit for these bypasses and effort should be made to harvest and prepare any and all alternative vein present.

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