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Research Article

Axillofemoral Bypass using Vein Grafts for Complicated Peripheral Arterial Disease

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ABSTRACT

Introduction: Critical Limb Ischaemia (CLI) with tissue loss secondary to lower limb Peripheral Arterial Disease (PAD) requires consideration for intervention in the form of endovascular and / or open surgical procedures to achieve improved perfusion and limb preservation. An Axillo-Femoral Bypass (AxFB) is only considered in cases where an endovascular or abdominal surgical approach to aortoiliac disease is not possible or is deemed too hazardous. Such patients may have an unfavourable pattern of arterial disease, significant co-morbidities and / or a hostile abdomen. Although prosthetic grafts are typically employed for AxFB procedures, vein grafts are an alternative with a lower risk of infection. We present our experience of AxFB grafting using autologous venous conduits in a select group of patients with CLI and tissue loss in the context of significant co-morbidities and elevated infection risk.

Methods: A retrospective study of all unilateral AxFB grafts using autologous venous conduits performed at our limb salvage unit over a five year period (January 2014-December 2018) was conducted. Data is collected from written and electronic medical records as well as radiology, haematology and biochemistry reports.

Results: Seven unilateral AxFB procedures using vein grafts were performed on five patients with CLI and tissue loss. Two patients had a second AxFB on the contralateral side on a separate occasion for progressive disease. Four patients were male and one was female with an age range of 55–79 years. There were no surgical site infections and no perioperative deaths. Graft patency was 86% at one year and 71% at two years. Three out of seven grafts (43%) failed during follow up. Two patients with graft occlusion developed CLI and tissue loss, one required above knee amputation and the other further bypass surgery. Six patients achieved complete wound healing. One patient died from lung cancer.

Conclusion: Our results indicate that AxFB using an autologous venous conduit can be successful in patients with CLI and tissue loss in the context of significant co-morbidities and increased risk of infection. Further evidence is needed to support our findings and potentially stratify which patients would benefit from a venous, rather than a prosthetic, graft.

Keywords: Axillo-femoral bypass; Venous graft; Critical limb ischaemia; Peripheral arterial disease; Aortoiliac disease

ABBREVIATIONS

AF: Atrial Fibrillation; AxFB: Axillo-Femoral Bypass; CIA: Common lliac Artery; SFA: Superficial Femoral Artery; PFA: Profunda Femoral Artery; IHD: Ischaemic Heart Disease; HTN: Hypertension; PAD: Peripheral Arterial Disease; DVT: Deep Venous Thrombosis; COPD: Chronic Obstructive Pulmonary Disease; MI: Myocardial Infarction; IVDU: Intravenous Drug User; CVA: Cerebrovascular Accident; TIA: Transient Ischaemic Attack; TASC: Inter-Society Consensus For the Management of Peripheral Arterial Disease.

INTRODUCTION

The incidence and prevalence of Critical Limb Ischaemia (CLI) secondary to Peripheral Arterial Disease (PAD) is reported to be around 400 cases per million population per year and one in 2500 respectively [1]. A significant proportion of these patients require intervention in the form of an endovascular and / or open surgical procedure as a limb saving, and often life saving, measure.

Axillo-Femoral Bypass (AxFB) grafting is reserved for patients in

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whom first line direct techniques for occlusive aortoiliac disease are considered unsuitable. From an anatomical perspective, the pattern of arterial disease or the lack of a suitable infrarenal aortic segment may preclude direct aortic grafting or endovascular intervention. From a clinical perspective, AxFB grafting provides a less invasive option for comorbid patients who are in poor condition with depleted physiological reserves. In patients with a hostile abdomen AxFB grafting is an alternative procedure that avoids abdominal exploration and its associated difficulties with potential to reduce surgical time and decrease the risk of complications, including infection.

The choice of conduit includes a prosthetic graft, commonly polyester or polytetrafluoroethylene (PTFE), or an autologous vein. The long saphenous and short saphenous veins are favoured [2] but the cephalic and basilic veins provide alternatives. In supra-inguinal revascularisation, including extra-anatomical bypass grafts such as AxFB, a prosthetic graft is generally preferred. The use of prosthetic material, however, is associated with an increased risk of infection and associated adverse outcomes in the presence of intra-abdominal sepsis or peripheral tissue loss with infection [3,4]. An autologous vein is the preferred conduit for infra-inguinal bypass [5] but they are seldom used for supra-inguinal procedures or extra-anatomical bypass grafts such as AxFB [6]. The use of venous conduits for arterial bypass is not without complication. Variable calibre, length and quality of veins can present challenges. Small calibre veins have a greater risk of stenosis [2] while large veins may have pre-existing varicosities which necessitate additional procedures at the time of surgery including segmental splicing or plication. The presence of areas of weakness where a vein has been spliced or repaired may render the venous graft more prone to postoperative problems such as graft stenosis, aneurysmal dilatation or thrombosis.

In this retrospective review we sought to evaluate patient selection and performance of autologous veins as conduits in AxFB grafting at our vascular unit. In particular we considered whether the use of venous grafts was beneficial in a select group of patients in whom a prosthetic AxFB graft was considered more hazardous due to the greater risk of infection and its associated complications.

MATERIALS AND METHODS

The limb salvage unit is led by two consultant vascular surgeons situated in a district general hospital serving a principally Caucasian population of approximately 240,000. All patients who had an AxFB procedure using an autologous venous conduit at our unit over a five year period (January 2014 to December 2018) were identified retrospectively.

Data is collected from written and electronic medical records as well as radiology, haematology and biochemistry reports. Information collected included patient demographics, co-morbidities and pre-operative condition, pattern of arterial disease, operative details and post-operative complications including surgical wound infection, graft occlusion and mortality. Particular attention was given to the rationale for use of a venous rather than prosthetic conduit in each case.

At our unit all patients presenting with CLI and lower limb tissue loss have a Consultant assessment and a baseline US Doppler waveform / Ankle Brachial Pressure Index (ABPI) at the first encounter. This is followed by CT or MR angiography if revascularisation is being considered. Cases are then discussed at the local Multidisciplinary Team (MDT) meeting during which revascularisation approaches are considered. Where appropriate, a plan is then discussed with the patient together with clinical assessment of the axillary artery, Doppler waveform of upper limb arteries and referral for vascular anaesthetic opinion.

After AxFB grafting all patients are entered into a surveillance protocol and outreach service, coordinated by the vascular specialist nurse, to facilitate close follow up for the patient, their graft and wounds. An US duplex scan of the graft is arranged prior to discharge and follow up in clinic is initially arranged at two, six and twelve weeks. US duplex scans are booked at two monthly intervals for the first six months and then twice yearly for two years.

RESULTS

Seven unilateral AxFB procedures using autologous venous grafts were performed on five patients during the study period. Two patients had a second AxFB on the contralateral side on separate occasions for progressive disease. The grafts were performed as a joint procedure by the two consultants at the unit in all cases except one. All five patients had been referred to the vascular service with CLI and had lower limb tissue loss at presentation. Patient demographics, clinical condition and comorbid status is summarised together with the classification of their arterial disease using the Rutherford and TASC classification systems (Table 1).

The AxFB procedure details are summarised in Table 2. Four right-sided and three left-sided AxFB procedures were performed. In four cases (57%) the long saphenous vein alone was used while two

Table 1: Patient demographics, comorbidities and disease classification per procedure.

Variables		No. (%) or mean ± SD
Age at operation (years)		66±8
Gender	Male	M=4 (80)
	Female	F=1 (20)
Smoker	Former	5 (71)
	Current	2 (29)
Comorbidities	Hypertension	2 (29)
	Dyslipidaemia	7 (100)
	Diabetes mellitus	2 (29)
	Atrial fibrillation	3 (43)
	End stage renal failure	0 (0)
Low BMI (<18.5kg/m2)		3 (43)
Hostile abdomen		1 (14)
Pre-operative blood results*	Haemoglobin g/L	123 ±19.8
	Low	5 (71)
	White cell count ×10⁹/L	10.6 ± 2.4
	Elevated	3 (43)
	CRP mg/L	54±57
	Mild–Moderately raised (5-50)	3 (43)
	Significantly raised (>50)	3 (43)
	Albumin g/L	36 +/- 6.2
	Low	3 (43)
	eGFR (ml/min/1.73m2)	>90 (100)
ASA grade	3	5 (71)
	4	2 (29)
Rutherford grade	III 5	7 (100)
TASC classification	C	3 (43)
	D	4 (57)

SD:Standard Deviation *Reference ranges: Haemoglobin 115-165g/L (F) &130-180 g/L (M); White Cell Count 4-11 × 10⁹/L; CRP <5mg/L; Albumin 35-50 g/L, eGFR >90 ml/min/1.73m2

cases (29%) used a combination of upper and lower limb veins and one case (14%) used the cephalic vein alone. Common Femoral and Profunda Femoris artery (CFA and PFA) endarterectomies were performed synchronously in four cases (57%) to establish or improve outflow.

Data on peri-operative and early post-operative complications is summarised in Table 3. There were no surgical site infections and no peri-operative deaths. All grafts were patent at discharge from the hospital. One patient required a return to theatre for graft thrombectomy two weeks post-operatively to restore graft patency and recovered well.

Data on long-term outcomes is summarised in Table 4. The mean follow up period was 24 months (range 6-60 months). Three grafts (43%) required secondary intervention; all three underwent angioplasty +/- stenting for graft stenosis and one graft also required open repair of an aneurysmal segment. Graft occlusion occurred in three cases and was detected at 4, 8.5 and 19 months. Two patients with graft occlusion developed tissue loss during the follow up period. Forefoot amputation and adjuvant conservative measures were initially successful with improvement in symptoms and evidence of wound healing for one of these patients. However, following a period of missed appointments, the leg deteriorated and the patient required an above knee amputation. The other patient had a revascularisation procedure performed at another unit during the follow up period. At one year complete wound healing had been achieved in six (86%) limbs. The limb salvage rate was 100% at one year and 86% at two years despite three grafts occluding. The only death during the follow up period was due to lung cancer with no deaths related to vascular disease or intervention.

The images in Figure 1 were taken at the follow up appointment of one patient who had a left AxFB graft followed by a right AxFB graft at a later date using an autologous venous conduit in both incidences (Figure 1a and 1b). At this review the left foot wound had completely healed and the right foot wound showed evidence of healing with healthy granulation tissue at its base (Figure 1c). The right foot wound went on to heal completely over the following months. Patient consent for these unidentifiable photos was not obtained due to the death of the patient and no next of kin could be found.

Table 2: Procedure details.

Procedure details		No (%)
Procedure	Left AxFB	3 (43)
	Right AxFB	4 (57)
Conduit	Long saphenous vein	4 (57)
	Cephalic vein	1 (14)
	LSV+CV	1 (14)
	SSV+BV	1 (14)
Adjuvant procedure	SFA+PFA endarterectomy	4 (57)

LSV:Long Saphenous Vein; CV: Cephalic Vein; SSV: Short Saphenous Vein; BV: Basilic Vein

Table 3: Early outcomes (<30 days post-operation).

VariableS		No (%) or mean ± SD
Complications	Bleeding	0
	Surgical site infection	0
	Graft thrombosis	1 (14)
Secondary intervention	Thrombectomy	1 (14)
Peri-operative mortality		0

Table 4: Long-term outcomes during follow-up period.

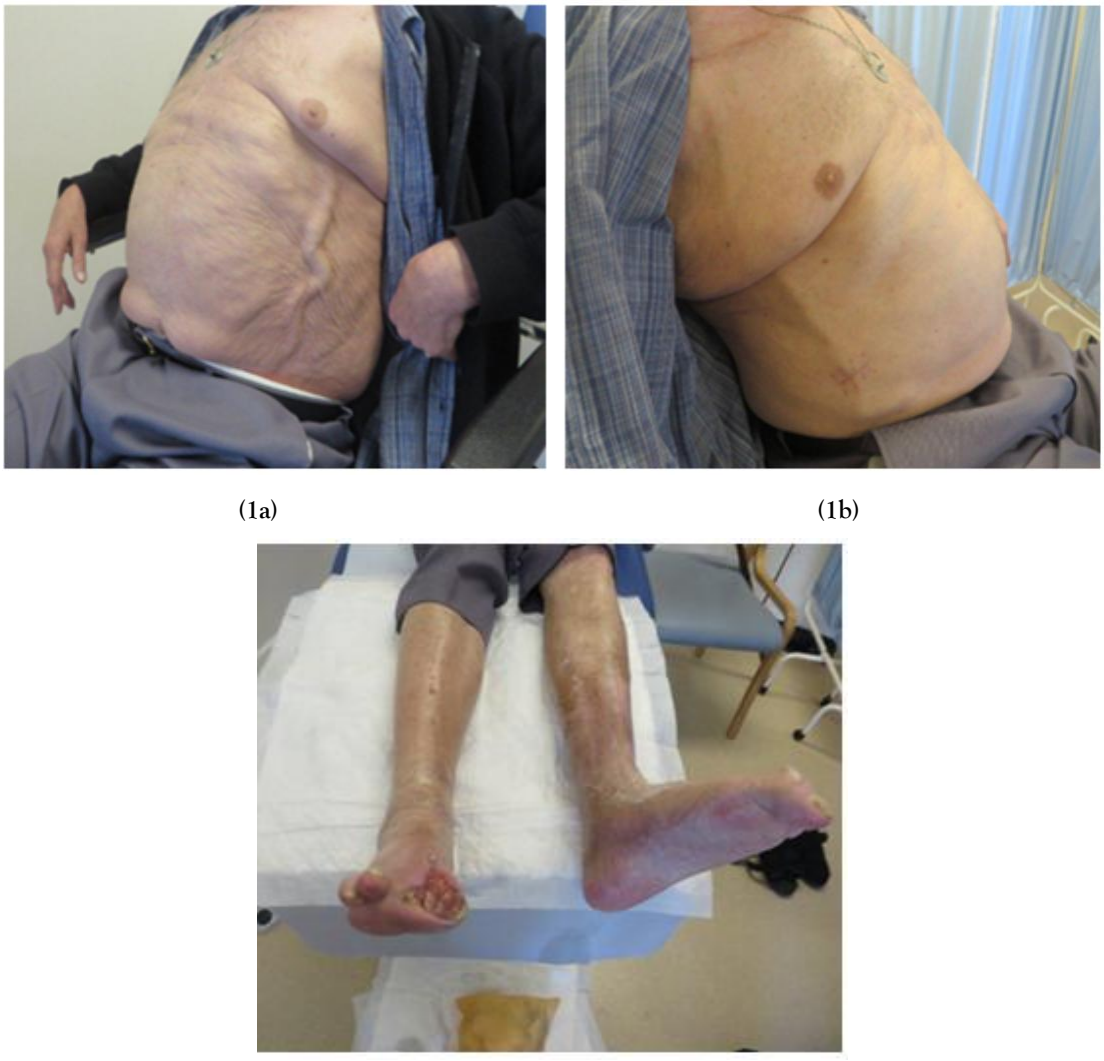
Variables		No (%) or mean ± SD
Duration of follow up (months)		24 (6-60)
Graft complications	Stenosis	3 (43)
	Angioplasty ± stenting	3 (43)
	Aneurysm	1 (14)
	Open repair	1 (14)
Graft patency	2 months	7 (100)
	4 months	6 (86)
	6 months	6 (86)
	12 months	5 (71)
	18 months	5 (71)
Graft occlusion during follow up	Total number	3 (43)
	Time to detection (months)	10.5 ± 6.3
	<6 months	1 (14)
	>6 months	2 (28)
Wound healing	1 year	6 (86)
Limb salvage	1 year	7 (100)
	2 years	6 (86)
Mortality during follow up		1 (14)*

SD: Standard deviation; *Patient had bilateral AxFB with both grafts patent at 5 years and 2.5 years post-operatively during follow up period; death due to lung cancer

DISCUSSION

Options for revascularisation in occlusive aortoiliac disease have expanded with advances in endovascular intervention. When a surgical procedure for re-vascularisation of the lower limb is indicated in the presence of aortoiliac disease, the preferred approach is to explore the aorta and iliac vessels. For those in whom this is anatomically unsuitable or too hazardous due to co-morbidities or a hostile abdomen, an AxFB graft provides a simpler and less invasive option [7-10]. Recent studies have reported acceptable patency rates [11-13] and limb salvage rates [12,14] with a low associated mortality despite significant co-morbidity and reduced life expectancy in their patient population [11,13]. Advances in endovascular intervention have been crucial in providing minimally invasive strategies to address graft problems such as stenosis thereby maintaining patency [11,15,16].

AxFB grafting was deemed the optimal revascularisation strategy in all seven cases. The patients were in poor clinical condition with significant co-morbidities and depleted physiological reserves. The ASA grades in all cases were high at 3 and 4 in 71% and 29% respectively. In a significant proportion of cases there was a low body mass index (BMI) (43%) and /or hypoalbuminaemia (43%); factors which are associated with increased risk of post-operative infection and poor outcomes [3,17,18]. Anaemia and raised inflammatory markers were also prominent in this group. In one patient (14%) the presence of a hostile abdomen with multiple abdominal and groin scars was a further consideration in favour of AxFB vein grafting, to avoid the technical difficulties associated with a direct



(1a) (1b)

(1c)

Figure 1: Images of a patient who underwent left AxFB grafting followed by right AxFB grafting using autologous venous conduits in both instances. **(1a)** Left AxFB graft; **(1b)** Right AxFB graft and **(1c)** The left foot wound has completely healed and the right foot wound is healing with healthy granulation tissue at its base.

aortoiliac procedure, reducing surgical time and minimising the risk of complications, including infection.

All patients included in this study presented acutely with deteriorating wounds containing areas of necrosis and / or amorphous material that were clinically highly suspicious of infection or had microbiology confirmed infection. All patients were administered antibiotics on presentation that were continued after surgery.

Infection is one of the three major categories used to stage a threatened limb in the WIfI (Wound, Ischaemia and Foot Infection) classification system [2,19]. In a study of patients undergoing infra-inguinal bypass for CLI, the presence of foot infection was identified as an independent predictor of major amputation [3]. In addition post-operative sepsis would be particularly hazardous in this population of comorbid patients with poor physiological reserve. Although a prosthetic graft is the usual conduit of choice in supra-inguinal bypass, the use of an autologous venous graft for arterial bypass is less likely to be complicated by infection [3,20-23]. Venous grafts have been employed to address a variety of challenging clinical situations involving infection [20,24-27]. In this study, patients had an elevated risk of surgical wound complications including infection. Wound healing was potentially compromised by general frailty, co-morbidity and poor physiological reserve in all patients. Surgical site scarring for one patient with a history of multiple iliofemoral vascular procedures and another with a history of intravenous drug use and multiple groin sinuses was an additional consideration for wound complications. In the patients with a low BMI there was additional concern that healing and immune function were impaired and a prosthetic graft may erode through the subcutaneous tissues and become exposed. Further, all patients possessed a source of sepsis with clinically suspected or proven infection in deteriorating lower limb wounds.

Autologous vein grafts were therefore employed in all cases to minimise the risk of surgical wound complications. Despite the high risk of infection in our patients there were no cases of surgical site wound complications or graft infection in this study (Tables 3 and 4).

There was one graft thrombosis at two weeks which required a return to theatre for thrombectomy to restore patency after which the patient recovered well. Graft stenosis developed in three cases (43%) for which successful endovascular intervention was performed. Advances in endovascular techniques have provided a minimally invasive way to address these problems and maintain graft patency [11,15,16]. A graft aneurysm developed in one case

following an endovascular procedure (14%) and required an open repair.

There were three graft occlusions during the follow up period at 4, 8.5 and 19 months. One graft occlusion occurred in a patient with very complex vascular disease who had a petite stature and a low BMI. The diameter of the veins was small at 2-3mm. A prosthetic graft had not been chosen as there was a concern that it could erode through the scarred subcutaneous tissues leading to exposure and infection. One patient did not attend clinic or graft surveillance and eventually presented acutely with return of foot tissue loss and an occluded graft beyond salvage. The final patient, who had multiple procedures on the graft, presented at his routine graft surveillance stating that his walking distance had reduced slightly to 150 metres. The scan demonstrated an occluded graft.

In this study the wound healing and limb salvage rates were encouraging. Within one year, complete wound healing was achieved in six (86%) limbs despite two grafts occluding. The limb salvage rate was 100% for all seven procedures at one year despite two grafts occluding and 86% (6 out of 7) at two years despite three grafts occluding. There were no deaths related to vascular disease or intervention during follow up. The only death was due to lung cancer.

These findings indicate that AxFB grafting with an autologous venous conduit can be considered in a select group of patients with high operative risk and increased risk of infection where major amputation or palliation might have been considered. We recognise that the small sample size and retrospective nature of this study from a single unit are limitations and that there is no comparison with prosthetic graft use for patients with CLI and similar co-morbidities. However, there is a paucity of reports on the use of autologous venous conduits in AxFB grafting and the number of procedures included is very low. This study demonstrates that limb salvage is achievable for patients with significant co-morbidities presenting with limb and life threatening CLI and tissue loss associated with aortoiliac disease who are at a high risk of complications that may otherwise have faced major amputation or palliative management. Although further evidence is needed to establish the role of AxFB grafting with an autologous venous conduit for this profile of patients, the outcomes in this study are encouraging.

CONCLUSION

These findings indicate that unilateral AxFB grafting using autologous vein can be employed in a select group of patients with CLI and lower limb tissue loss in the context of high operative risk and increased risk of infection. In this select group of patients, where therapeutic options were limited, this approach has been associated with low perioperative complications and achieved limb preservation in the majority of patients.

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