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The Small Saphenous Vein: An Underestimated Source for Autologous Distal Vein Bypass

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WHAT THIS PAPER ADDS

If no other autologous vein material is available, the small saphenous vein is a valuable alternative for peripheral vein bypass. It provides excellent short- and long-term patency and limb salvage.

Objectives: The small saphenous vein (SSV) is a potential vein source for bypass if neither greater saphenous vein nor arm vein is available. This study reports experience using SSV as part of an all autologous vein bypass policy.
Methods: This study comprised single centre retrospective data analysis of all consecutive patients treated at an academic tertiary referral centre from January 1998 to February 2017 using the SSV as the main peripheral bypass graft. Study endpoints were primary patency, secondary patency, limb salvage, and survival.
Results: One hundred and twenty operations were performed in 118 patients using SSV. Indications were peripheral arterial occlusive disease ($n = 91$; Rutherford classification 3: $n = 11$; 4: $n = 21$; 5,6: $n = 59$), acute ischaemia ($n = 14$), popliteal artery aneurysm ($n = 12$), and bypass revisions ($n = 3$). Median follow up was 30.5 months (10 months–13.7 years). Primary patency after one, three and five years was 68% (CI: 59–77%), 58% (49–68%), and 54% (45–64%). Secondary patency was 83% (76–89%) after one year and 77% (69–85%) after three and five years. Limb salvage after one year was 88% (82–94%) and 78% (70–86%) after five years. Survival was 96% (92–99%) after one year and 91% (85–97%) at five years. Multivariable analysis identified redo surgery as an independent risk factor. Patients receiving a primary ($n = 59$) vs. a redo bypass ($n = 61$) were compared. Primary patency and secondary patency were both significantly better in the primary bypass group than in the redo group ($p = .0036$ and $p = .0003$, respectively). Limb salvage was also significantly better in primary bypass patients than in the redo group ($p = .0007$), whereas overall survival did not differ significantly ($p = .48$).
Conclusion: The SSV is a valuable alternative vein graft in peripheral bypass surgery. It achieves excellent long-term results, particularly in patients with primary procedures but also acceptable results in patients with redo surgery.

Keywords: Alternative vein bypass, Peripheral artery disease, Peripheral vein bypass, Small saphenous vein
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INTRODUCTION

Peripheral bypass grafting is performed for severe peripheral artery disease and acute ischaemia, and autologous vein has proven to be superior to prosthetic grafts in peripheral bypass surgery.[1] The ipsilateral greater saphenous vein (GSV) is the most commonly used bypass conduit, but up to 45% of patients requiring bypass have unsuitable or unavailable ipsilateral GSV.[2] For this reason, other options have been investigated. Use of the contralateral GSV and arm veins has been studied extensively,[3,4] and there seems to be no difference between these,[5] giving no definitive answer for which is the second best vein graft. There has been far less interest in the use of the small saphenous vein (SSV). The first description of its use for peripheral arterial bypass was published more than 30 years ago,[6] with the only larger series published 31 years ago[7] and 25 years ago.[8] In an outstanding paper, Chang et al.[8] included over 300 patients in screening for SSV as a potential bypass graft. In that study, the SSV was found in more than 90% of patients, and was of comparable quality to the GSV. However, since this landmark paper, there have been only few reports on the use of SSV in peripheral bypass surgery.[3,6,7,9–11] The present study reports experience with this graft as part of an all autologous vein bypass policy.

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MATERIALS AND METHODS

Procedures with SSV as the main graft for peripheral vascular bypass performed between January 1998 and February 2017 were analysed. Procedures were performed at a tertiary referral academic teaching centre. Data were collected from a dedicated prospectively maintained database. The Institutional Review Board approved the study and the requirement for informed patient consent was waived because of the retrospective design of the study.

Indication

Graft choice was based on the planned bypass operation and availability of autologous vein material. Pre-operative duplex of the lesser saphenous vein was carried out in all patients with the patient in prone or supine position. The diameter of the vein was measured at the distal and proximal ends. Veins were regarded as a suitable bypass graft if the diameter was $>$2.5 mm, and there was no thrombosis or extensive sclerosis.

Operative technique

Harvesting of the SSV was performed in the supine position by a continuous incision starting at the level of the ankle up to the knee crease (Fig. 1). With this access there is no need to reposition and redrape the patient had vein harvesting been performed in the prone position. The incision was closed with running subcuticular sutures and running absorbable skin sutures with no drainage. Post-operatively, relief of strain and pressure on the vein harvest site is essential and is achieved using pillows and soft pad dressings over the wound and early mobilisation.

Standard antithrombotic treatment consisted of one daily dose of 100 mg ASA. In patients with known aspirin intolerance, a single daily dose of 75 mg clopidogrel was given. Oral anticoagulants were prescribed in patients with atrial fibrillation. A combination of antithrombotic and anticoagulant drugs was initiated in patients with poor distal runoff and in those with recurrent bypass occlusion on antithrombotic therapy alone.

Follow up

Patients were followed up in the outpatient department at one, three and six months, and then at 12 month intervals. At each visit bypass patency was evaluated by physical examination, oscillographic and ankle brachial index (ABI) measurements. When graft failure was suspected (absence of pulsation, decreased walking distance, ABI reduction) duplex screening was performed, and stenoses were treated by plain balloon PTA. Only if the balloon angioplasty was insufficient, was a stent placed in the bypass graft. The study closing date was 30 September 2018. All patients with valid contact details were invited to the outpatient clinic around this date for clinical assessment, including physical examination, oscillographic measurement, and duplex screening of the bypass.

Definitions and study endpoints

Study endpoints were primary patency, secondary patency, limb salvage, and survival. Primary patency was defined as

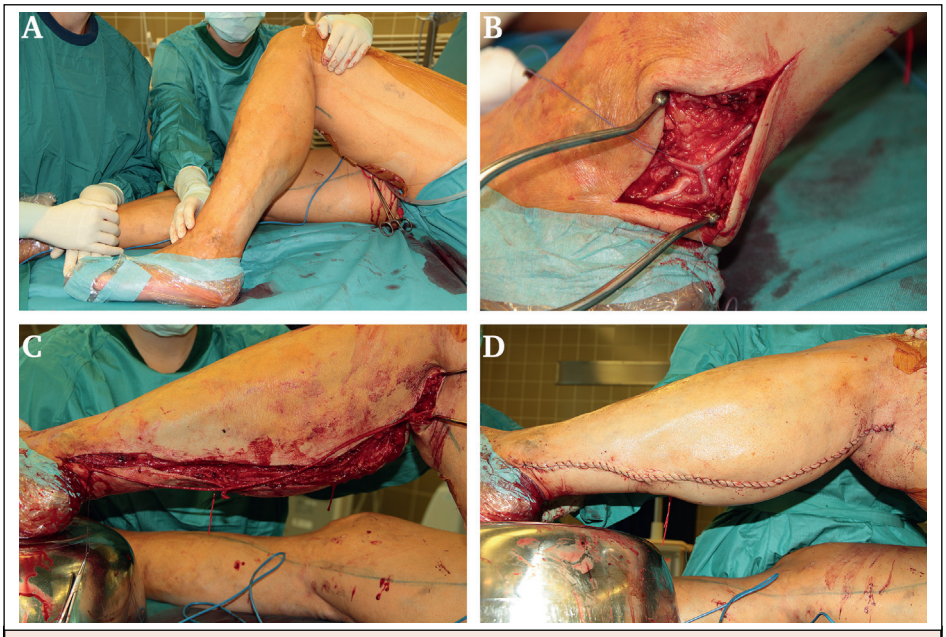

Figure 1. Small saphenous vein (SSV) harvesting procedure. The patient is kept in a supine position with the knee bent at about 90° and pulled slightly medially by the assisting surgeon (A). The continuous incision starts at the level of the ankle and is followed up to the knee crease (B). With this access, it is possible to harvest the complete SSV and perform the bypass procedure without repositioning the patient (C). The incision is closed with running subcuticular sutures and running absorbable skin sutures with no drainage (D).

freedom from re-intervention to maintain bypass patency. Secondary patency included all interventions to restore patency after occlusion.

Statistical methods

To evaluate differences between groups, demographics (sex, age, indication) cardiovascular risk factors (smoking, hypertension, hyperlipidaemia, diabetes, renal failure, coronary artery disease), pre-operative Rutherford category, as well as bypass characteristics (kickoff and target artery, spliced or non-spliced vein graft, reversed or non-reversed vein graft, bypass length) were compared by multivariable analysis.

Data consistency was checked and data were screened for outliers and normality using quantile plots. Continuous variables were also tested for normality using the Kolmogrov—Smirnov test. Cross tabulation tables with Fisher's Exact test or Pearson's test were used to analyse cross tabulations. Student *t* tests and Mann—Whitney *U* test were used to test continuously distributed variables. The Cox proportional model (type III test) and Kaplan—Meier method were used to estimate primary patency, secondary patency, limb salvage, and overall survival. To analyse the effects of several risk factors, the Cox proportional model used sigma restricted coding of factors, Breslow's method for the adjustment of ties, and a forward variable selection algorithm. The differences between groups were assessed with log rank tests and, if possible, with the Cox F test. All reported tests were two sided, and p values $< .05$ were considered to be statistically significant. All statistical analyses in this report were performed with NCSS (NCSS 10, NCSS, LLC. Kaysville, UT), STATISTICA 13 (Hill, T. & Lewicki, P. Statistics: Methods and Applications. StatSoft, Tulsa, OK), and PASW 21 (IBM SPSS Statistics for Windows, Version 21.0., Armonk, NY), by one of the authors (WH).

RESULTS

One hundred and twenty bypass procedures using the SSV as the main conduit were performed in 118 patients. Over the same time period, a total of 2,686 bypass operations were performed at the study institution, including 1,901 procedures with ipsilateral GSV, 163 with contralateral GSV, 442 with arm vein, and 60 PTFE procedures. The patients had a mean age of 68.6 (range 18—99) years, and 85 were male (71.3%) and 35 female (28.7%). In 59 patients a primary bypass was performed, whereas in 61 patients a secondary arterial reconstruction was performed after failed previous bypass.

Follow up ranged from 12 days to 13.7 years (median follow up was 61.3 months). Follow up was completed in 94 patients (78.3%). In total, 24 patients were lost to follow up before the five year follow up was completed. Table 1 shows demographics, characteristics, and risk factors of the whole patient series and the two groups compared.

The major indication for bypass surgery was peripheral arterial occlusive disease ($n = 91$), with the majority of patients presenting with Rutherford Stage 5 ($n = 59$) disease. However, operations were also performed on patients presenting with Stage 3 ($n = 11$) and Stage 4 ($n = 21$). Fourteen patients presented with acute ischaemia and 12 patients with aneurysms of the popliteal artery. In three patients revision of a previous vein bypass was performed because of bleeding ($n = 2$) or stenosis ($n = 1$) using the SSV as an interposition graft.

The main arteries used for graft origin were the common femoral artery (CFA; $n = 31$), the superficial femoral artery (SFA; $n = 18$), and the popliteal artery (level I $n = 21$; level II $n = 1$; level III $n = 18$). Crural arteries such as the anterior tibial and the posterior tibial arteries, were used in 11 procedures. Further, the profunda femoris artery (PFA) was used in six procedures and the external iliac artery (EIA) in one. In 13 procedures, a pre-existing bypass was used as the inflow vessel.

The above knee popliteal artery was the target artery in 20 patients (17%). Below knee target arteries included the popliteal in 29 patients (24%) and a tibial artery in 35 patients (29%). In 36 patients (30%), the target artery was located at the foot level.

The overall 30 day mortality was 2%. Major cardiac events requiring further therapy were rare ($n = 3$; 0.03%). Wound infections occurred mainly in the groin ($n = 13$; 9.2%) but infrequently at the site of vein harvest ($n = 7$; 5.8%). However, in two patients very early in the series, severe wound healing problems at the harvest site led to loss of limbs, despite a patent graft.

In the majority of patients ($n = 96$) the SSV was used as a single piece conduit. In 24 patients it was spliced to another vein (GSV $n = 14$; arm vein $n = 4$; GSV + arm vein $n = 1$) or prosthetic grafts ($n = 5$). Veins were reversed in 45 patients (38%), and non-reversed in the remainder. A trend was observed that spliced vein grafts had poorer patency than non-spliced vein grafts, but this effect was only significant in the redo group ($p < .05$). Graft orientation had no significant impact on patency, limb salvage, or survival. The ipsilateral SSV was used in 100 patients. In two patients both SSVs were used for femorocrural bypass. The mean length of the SSV was 46 cm in men and 41 cm in women. Bypasses were divided into short (length < 35 cm) and long (>35 cm) bypasses. With regard to length, bypasses were equally distributed between the two groups. Neither origin of the SSV nor graft length had an influence on study endpoints.

Antithrombotic therapy consisted of antiplatelets (79 patients/66%), anticoagulants (13/11%), or a combination of both (28/23%). There was no significant difference in antithrombotic therapy regimens between the two groups, and composition of antithrombotic therapy had no influence on outcome parameters.

Primary and secondary patency rates, limb salvage, and survival were analysed. Patients were further analysed with regards to target artery. Bypasses with distal anastomoses to the popliteal artery (either below or above knee) had significantly better secondary patency than those with connection to a tibial or inframalleolar artery ($p = .03$).

Table 1. Demographics, cardiovascular risk factors, indications, bypass characteristics, and outcome in 120 operations using the small saphenous vein as the main conduit

	All bypasses (n = 120)	Primary bypass (n = 59)	Redo bypass (n = 61)	p value
Male/female	71%/29%	76%/24%	66%/34%	.23[2]
Mean age ± SD, years[1]	68.6 (12.4)	67.0 (12.9)	70.2 (11.8)	.15[1]
Median follow-up (range), years	2.54 (0–13.7)	2.61 (0–7.9)	2.47(0–13.7)	.53[3]
Risk factors				
Hypertension	87 (73%)	38 (64%)	49 (80%)	.065[2]
Coronary heart disease	38 (32%)	20 (34%)	18 (30%)	.69[2]
Smoking	34 (28%)	18 (31%)	16 (26%)	.68[2]
Diabetes	45 (38%)	21 (36%)	24 (39%)	.71[2]
Renal impairment	4 (3%)	1 (2%)	3 (5%)	.62[2]
Hyperlipidaemia	61 (51%)	23 (39%)	38 (62%)	.017*[2]
Indications				Overall p = .038[3]
Rutherford 3	11 (9%)	8 (14%)	3 (5%)	.12[2]
Rutherford 4	21 (18%)	7 (12%)	14 (23%)	.039[2]
Rutherford 5	59 (49%)	27 (45%)	32 (52%)	.47[2]
Popliteal aneurysm	12 (10%)	10 (17%)	2 (3%)	.015[2]
Acute ischaemia	14 (12%)	7 (12%)	7 (11%)	1.0[2]
Complications (bleeding, stenoses)	3 (3%)	0 (0%)	3 (5%)	.24[2]
Target artery				Overall p = .058 [3]
Above knee popliteal	20 (17%)	12 (20%)	8 (13%)	[4]
Below knee popliteal	29 (24%)	19 (32%)	10 (16%)	[4]
Tibial	35 (29%)	12 (20%)	23 (38%)	[4]
Inframalleolar	36 (30%)	16 (27%)	20 (33%)	[4]
Main source vein				Overall p = .18[3]
Small saphenous vein (SSV)	96 (80%)	47 (80%)	49 (80%)	[4]
SSV + greater saphenous vein (GSV)	14 (12%)	10 (17%)	4 (7%)	[4]
SSV + arm vein	4 (3%)	2 (3%)	2 (3%)	[4]
SSV + GSV + arm vein	1 (1%)	0 (0%)	1 (2%)	[4]
SSV + prosthetic graft	5 (4%)	0 (0%)	5 (8%)	[4]
Reversed	45 (38%)	28 (47%)	17 (28%)	.038[2]
Spliced	24 (20%)	12 (20%)	12 (20%)	1.0[2]
30 day survival	98% (96–100)	98% (96–100)	98%(96–100%)	[4]
30 day graft patency rate (= primary patency < 30 days)	85% (78–91)	89% (84–96)	80% (71–89%)	[4]

Data are presented as numbers (%) unless indicated otherwise. Characteristics for the whole patient group and for patients with primary bypass and redo bypass. As no significant difference was found for the survival comparison over the whole time range (global p value = .48), it is concluded that there is no significant difference after 30 days (local p value). GSV = greater saphenous vein; SSV = small saphenous vein; SD = standard deviation.

[1] Independent Student t test.

[2] Fisher's Exact test.

[3] Mann–Whitney U test.

[4] No significant difference was found (Z test, p = .993).

Primary patency, limb salvage, and survival were not affected by the level of the target artery. Hence, the only factor significantly influencing outcome was redo surgery.

Patients were therefore divided into two groups: patients who had a primary bypass procedure performed on this extremity (primary graft group) and patients who had already undergone one or more arterial reconstructions in the ipsilateral leg (redo grafts). There was an equal distribution between primary (n = 59) and redo (n = 61) procedures. Fig. 2 shows Kaplan-Maier estimates for primary (Fig. 2A) and secondary patency (Fig. 2B), limb salvage (Fig. 2C), and survival (Fig. 2D) for the whole patient group, whereas Fig. 3 shows primary (Fig. 3A) and secondary (Fig. 3B) patency, limb salvage (Fig. 3C) and survival (Fig. 3D) between primary bypass and redo bypass patients. In the primary bypass group, primary patency after one, three and five years was, respectively, 83% (73–93%), 76% (65–88%), and 68% (55–82%), and 53% (40–66%), 41% (28–49%), and 41% (28–49%) in the redo group (p = .0036). Secondary patency in the primary bypass group after one, three and five years was 96% (95% CI 91–100%), 90% (81–98%), and 90% (81–98) in the primary bypass group and, respectively, 69% (57–81%), 66% (53–78%), and 66% (53–78%) in the redo bypass group (p = .0003).

Limb salvage was also significantly better in primary bypass patients after one year (98% vs. 78%; p = .0002) and remained high after five years in the primary bypass group (87%) while continuously declining in the redo bypass group

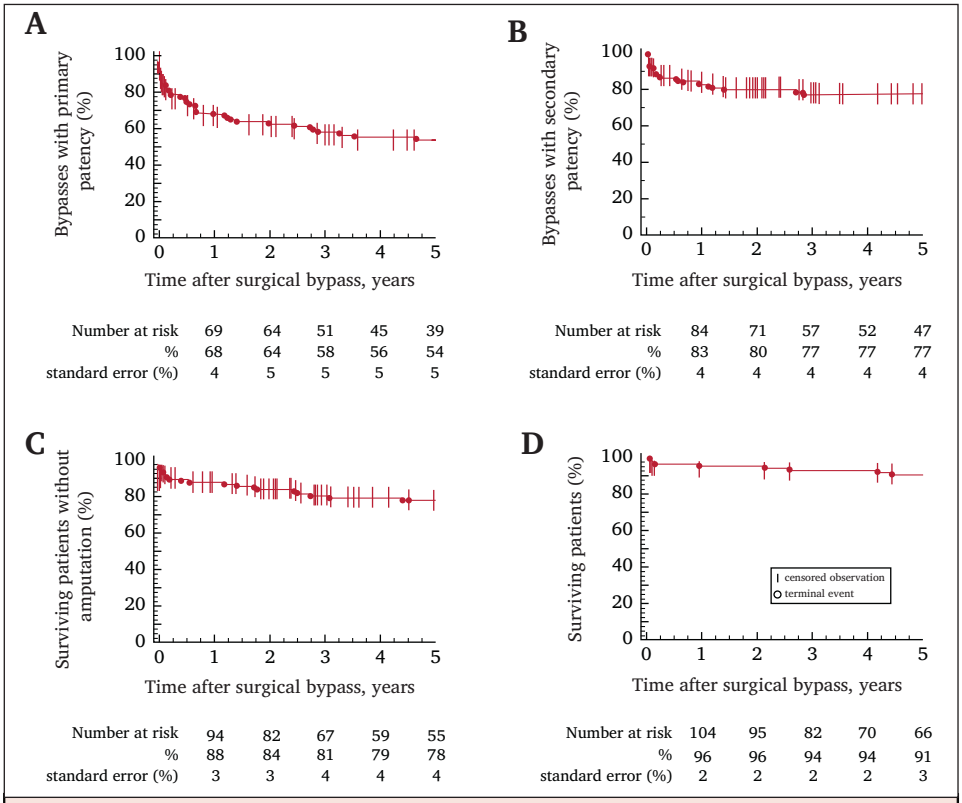

Figure 2. Cumulative Kaplan-Meier estimates of primary patency (A), secondary patency (B), limb salvage (C), and survival (D) for the whole series.

(65%). No statistically significant difference in overall survival between the two groups was detected ($p = .48$). Thirty day mortality was 98.3% (95% CI 96—100) in primary bypass and 98.3% (95% CI 96—100) in the redo bypass group. No significant difference was found (Z test, $p = .0993$).

The ratio between investigated follow up period and the theoretically possible follow up period up to the study end date was assessed using the follow up index (FUI) index.[12] Means and SD for various endpoints are primary patency (mean 0.75, SD 0.36), secondary patency (mean 0.65, SD 0.36), limb salvage (mean 0.71, SD 0.34), and survival (mean 0.70, SD 0.34).

In patients with popliteal artery aneurysm, primary patency rates of 80% were observed after one and three years and 53% after five years. Secondary patency was 100% after one and three years and 75% after five years. Survival was 100% after one and three years and 86% after five years.

DISCUSSION

In times of increasing endovascular treatment, the need for surgical reconstructions has been reduced but not diminished. After the armoury of endovascular options has been exhausted, most patients need a surgical solution and often no suitable graft is present. At the present authors' department, the strategy is to complete all distal bypass procedures with autogenous material whenever possible. Results are superior to prosthetic grafts with regard to patency and late complications, especially in tibiodistal reconstructions.[13,14] The latest guidelines from the European Society for Vascular Surgery also favour use of vein bypass, especially in longer lesions.[15] GSV is regarded as the primary choice; however, if the GSV is not available because of previous harvesting for coronary artery bypass or peripheral arterial reconstruction, varicose vein surgery, or unusable because of poor quality, the question of which alternative is the preferred graft remains.

There are reports comparing the outcomes of contralateral GSV with arm vein bypass, but, so far, no consensus has been reached on which vein gives better results. If both veins are present many surgeons tend to use the contralateral GSV as it is more convenient to harvest and is less fragile.[3] Although arm vein is reported to produce good long-term patency while causing less wound problems in the contralateral groin and leg,[16—19] there is reluctance to use it routinely. A recent prospective randomised study showed no significant difference in outcome between contralateral GSV and arm vein.[5] In the case of missing suitable autologous options, some argue for the use of prosthetic conduits.[20—22] Most published studies show superiority of vein bypass over synthetic conduits.[23—27] Some report equal short-term results for prosthetic bypass, but inferior long-term results.[28,29]

The SSV is a potential alternative that should not be underestimated. The first small patient series on the use of the SSV in five patients was published in 1987. Weaver reported primary patency rates of 72% after one year and 60% after two years in 56 patients using SSV.[7] The largest series of the use of SSV for peripheral bypass was 25 years ago and showed excellent results with patency rates of 77%

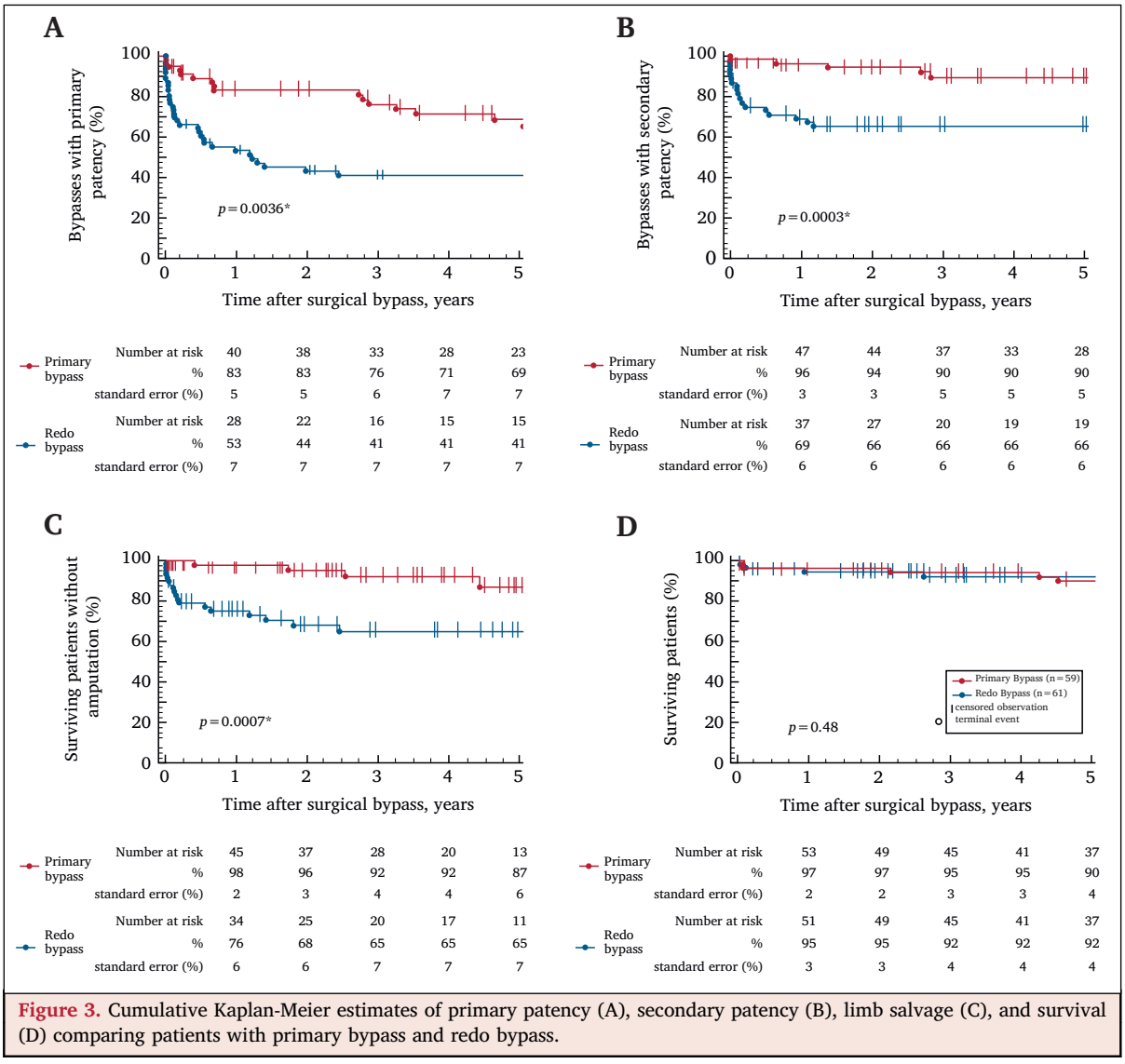

Figure 3. Cumulative Kaplan-Meier estimates of primary patency (A), secondary patency (B), limb salvage (C), and survival (D) comparing patients with primary bypass and redo bypass.

after two years.[8] Interestingly, Calligaro's group only achieved primary patency rates of 17.7% and secondary patency rates of 34.3% in 17 patients using the SSV.[9] Chew and colleagues performed SSV bypass in 10 patients but there are no published patency rates of this patient subgroup.[3] The most recent study by Goyal et al. showed excellent primary patency results of 89% after one year and 77% after two years.[11] Since then, no larger series have been published. To the authors' best knowledge, the present work represents the largest series of lesser saphenous vein grafts with the longest reported follow up.

A decision making algorithm has been established at the study department to facilitate bypass graft selection. If the iGSV is absent and a long bypass graft is needed, first, attempts are made to look for the cGSV and, then, for arm veins. If neither is available, attempts are made to look for the SSV. In fact, in cases where only a short bypass graft is needed, initial attempts are always for the SSV. So far, there are no guidelines published dealing with graft selection.

For complete absence of cGSV or arm veins, the authors recommend use of the SSV before prosthetic grafts based on the present results. The SSV has many advantages: access for harvest is easy and rarely causes wound infections. In particular, using a posterolateral approach can avoid creation of a large skinflap at high risk of wound infection. Rarely, severe wound infections were encountered at the harvest site. In two patients, large infected skin defects present pre-operatively in combination with wound infection of the vein harvest site led to loss of limbs The length is mostly sufficient to cover distances above and below the knee. Also, in two patients SSV was used to perform a femorotibial bypass. If too short, the SSV can be used as a bridging graft serving as the target vessel for a prosthetic graft. Bypass using the SSV can be performed under regional anaesthesia, which is rarely possible with arm vein.

Use of the SSV is not restricted to secondary reconstructions or for patients in whom there is remaining autologous vein material. In some patients it might be considered as the conduit of first choice even in the presence of cGSV or arm vein. For patients who need a very short distal bypass, the authors recommend considering the use of SSV first, even in presence of the iGSV or cGSV

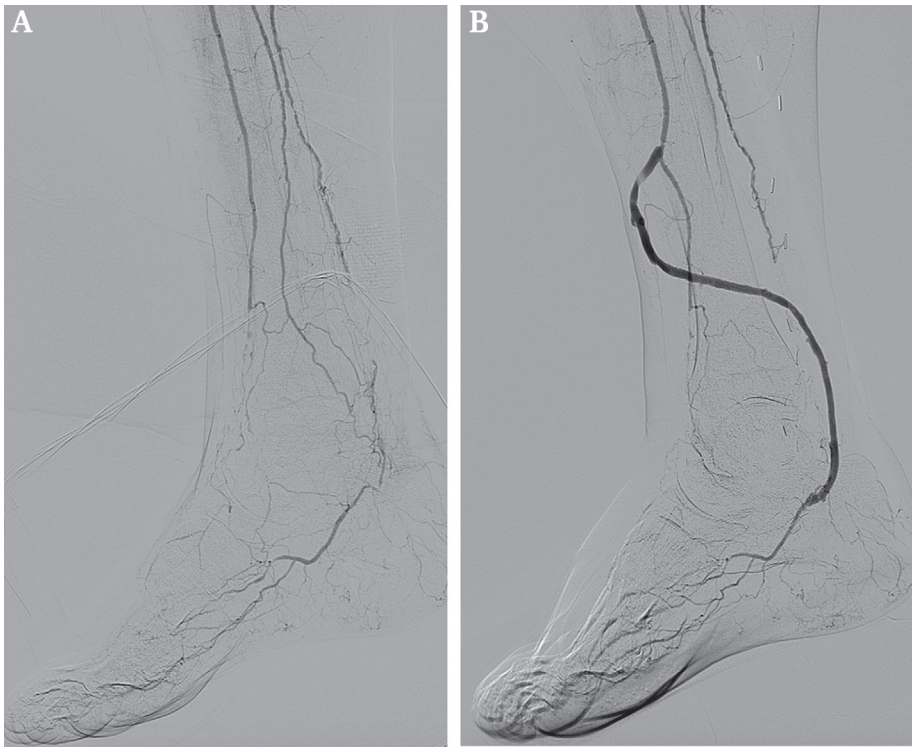

Figure 4. Pre-operative (A) and completion (B) angiography of a patient with critical limb ischaemia (Rutherford Stage 5). The small saphenous vein was used for a short tibial-pedal bypass from the distal anterior tibial artery to the plantar artery.

(Fig. 4). Also, for treatment of aneurysms of the popliteal artery, use of the SSV has produced good results in patients and may be used as an alternative to the GSV. The authors strongly advise examining the SSV first in these cases and, if useable, to use it. If later, a bypass for ipsilateral or contralateral limb reconstruction is required, the full range of possibilities remains available.

Discussion of vein graft splicing is controversial in the literature. There are series reporting poorer results,[23,30] whereas others report excellent outcomes with spliced vein grafts.[31] In the present patients, spliced vein grafts had a trend towards worse patency rates than non-spliced. This effect was only significant in the redo group.

The reported primary patency rates for above knee femoropopliteal bypass are 81% for venous bypass and 67% for PTFE bypass after two years, and 69% vs. 49% after five years, respectively. Reported secondary patency rates were 77% vs. 75% after two years and 65% vs. 60% after five years, respectively.[14,32] With arm vein, secondary patency rates of around 60% have been reported widely,[17,33] but rates of up to 90% after five years have been published in the literature.[34] The present authors achieved similar results with iGSV (patency rates $>$ 80% after five years), cGSV and arm vein (patency $>$ 60% after five years in both groups), and PTFE (patency $<$ 50% after five years) as reported in the literature. In patients receiving a bypass using the SSV, five year patency rates of 77% were achieved. Patency was significantly better in primary surgery patients (90% after five years). Seventy-eight per cent of limbs were saved after five years. In primary procedures, limb salvage was achieved in 87%.

Patients were followed up at frequent intervals, as mentioned in the Methods section. An additional final assessment was arranged at the outpatient clinic at the end date of the study to maximise completeness of follow up and minimise attrition bias.

Choice of antithrombotic management is often a difficult issue in these patients. There are reports that oral anticoagulation with warfarin can improve the outcome of infrainguinal vein bypass at high risk of failure.[35] In patients with poor outflow, a combination of antithrombotic and anticoagulation drugs was also prescribed.

The limitations of this study are its retrospective design and the high selection bias in this patient group as patients with recurrent bypass procedures have worse local situations and often present in poor general condition.

In conclusion, the SSV is a valuable alternative as a graft for arterial reconstructions. It has excellent results in patients undergoing primary arterial reconstruction. Although the cGSV and arm vein remain more common options for peripheral bypass, use of the SSV should be a tool for every vascular surgeon.

CONFLICT OF INTEREST

None.

FUNDING

None.

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