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Superficial Femoral Artery Occlusion Reduces Aortofemoral Bypass Graft Patency☆

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WHAT THIS PAPER ADDS

The long-term patency after aortofemoral bypass surgery in the setting of femoropopliteal artery occlusion has not been well documented. In this paper, it is demonstrated that occluded superficial femoral arteries adversely affect patency of open aortofemoral bypasses. However, concomitant revascularisation of the occluded superficial femoral artery did not improve patency and increased early mortality.

Objectives: The effect of superficial femoral artery (SFA) occlusion on long-term patency of aortofemoral bypasses (AFBs) for aortoiliac occlusive disease (AIOD) was examined.

Methods: The AIOD database was reviewed to identify risk factors for AFB failure. The status of the SFA at AFB procedure was categorised as patent; diseased treated (DT), if the SFA occlusion was intervened on concomitant to AFB; or diseased untreated (DU), if the SFA was occluded but not revascularised. Censoring hierarchies for primary patency and patent graft survival time were constructed. Data were analysed by contingency table, Kaplan–Meier, and Cox regression analysis.

Results: Between 2004 and 2015, 122 AFB (9 unifemoral, 113 bifemoral) for AIOD were performed. Seventy-five (61%) were female and the mean age was 60 ± 10 years. At the time of AFB, 50 (41%) had occluded SFAs (DT/DU). Of these, 15 had concomitant SFA revascularisation (i.e., DT) at the time of AFB. Patients with occluded SFAs had greater history of prior aortoiliac/infrainguinal procedures (aortoiliac 54% vs. 22%, infrainguinal 58% vs. 25%, both $p < 0.001$), Trans-Atlantic Inter-Society Consensus II classification of femoropopliteal type D lesions (78 vs. 10%, $p < 0.001$), Rutherford 4–6 categories (80% vs. 57%, $p = 0.011$), and longer hospital stay (median 11 vs. 7 days, $p < 0.004$). SFA status did not affect 30 day mortality (overall 9%); however, sub-analysis showed DT had significantly higher mortality than DU ($p < 0.03$). Over a median follow up of 7.7 (IQR 4.3–11.4) years, primary patency at one and five years was 98.3% and 91.2% in patients with patent SFAs, 87.9% and 82.7% in DU, and 72.7% and 43.6% in DT ($p < 0.001$), respectively. On multivariable analysis, low baseline glomerular filtration rate (HR 1.01, $p = 0.022$), DT (HR 3.7, $p = 0.020$), Rutherford 4–6 (HR 9.1, $p = 0.048$), and occluded SFA (HR 3.9, $p = 0.009$) adversely affected primary patency of AFBs. Long-term mortality was not different between the SFA status groups ($p = 0.279$).

Conclusion: Baseline SFA occlusion predicted a fourfold increased hazard of primary AFB failure. Concomitant SFA revascularisation did not improve AFB durability and was associated with increased in hospital mortality.

Keywords: Aortoiliac occlusive disease, Superficial femoral artery, Aortofemoral bypass
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INTRODUCTION

Among patients with symptomatic peripheral artery disease, aortoiliac occlusive disease (AIOD) is seen in more than 40% of the patients.[1] Aortofemoral bypass (AFB) has been the standard surgical technique to treat extensive AIOD for more than six decades.[3,4] Although nearly half of the patients with AIOD are known to have coexisting femoropopliteal artery occlusion,[2] the management strategy of such lesions at the time of AFB is not well established. Current guidelines by European Society for Vascular Surgery encourages concomitant AIOD and infrainguinal revascularisation in patients with chronic critical limb ischaemia "when necessary".[4] There is no clear consensus on the management of multilevel occlusive disease, except to treat

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the inflow (i.e., aortoiliac lesion) first,[5] which is partly due to controversial data in the literature on the patency of AFB grafts in the presence of SFA occlusion.[6–11] Hill et al.[7] reported AFB, in patients with occluded SFA, will relieve only 26% of intermittent claudication, while Pearce et al.[12] showed that AFB with extended profundaplasty provided excellent AFB graft limb patency with limb salvage rate. Previous studies on AFB grafts in patients with SFA occlusions were reported in the 1980s and 1990s with limited follow up.[6–11] Thus, the experience with AFB for AIOD was reviewed to examine the impact of an occluded SFA on the long-term patency of the bypass conduit in the modern era. The hypotheses were that (1) an occluded SFA would be a risk factor for AFB limb thrombosis but that (2) concomitant SFA revascularisation would mitigate the deleterious effect on patency.

METHODS

Patients and data collection

The Committee for Protection of Human Subjects, the local institutional review board, approved this study with a waiver of informed consent. The study included patients who had AFB between 2004 and 2015. The follow up end date was January 17, 2017, for patients who were alive on that date. For those who were lost to follow up, the end date of the study was the last recorded on the medical record. The follow up endpoints were death and occlusion of the graft. Follow up data regarding clinic visits, recent imaging, deaths, and secondary procedures (re-intervention, additional revascularisation) were obtained retrospectively by medical record review, direct patient contact, telephone interview, or the National Death Index. Data were managed in a database with encrypted patient identifiers under an approved protocol. The database of AIOD was reviewed to identify risk factors for AFB failure. The SFA status at index AFB procedure at the institution was categorised as patent or occluded at the time of study. Both unilateral and bilateral SFA occlusion were reported as occluded SFA. The patients with occluded SFAs were then further subcategorised to the following two groups: diseased treated (DT), if the SFA occlusion was intervened on concomitant to AFB; or diseased untreated (DU), if the SFA was occluded but not revascularised at the time of index AFB. Pre-operative aortoiliac and femoropopliteal occlusive lesions were defined in accordance with the Trans-Atlantic Inter-Society Consensus (TASC) II classification.[13] Pre-operative clinical symptoms were categorised using the Rutherford classification.[14] The estimated glomerular filtration rate (GFR) was calculated by the Cockcroft–Gault method. Acute renal failure was defined using the RIFLE criteria.[15] Respiratory failure was defined as prolonged ventilation (>72 h), re-intubation, or tracheostomy. To evaluate follow up completeness, the follow up index was analysed.[16] The follow up protocol is annual physical examination, ankle brachial index at the six month post-operative visit, and annually thereafter. When a change was noted, arterial duplex scan, computed tomography angiography, magnetic resonance angiography, or angiogram was performed. Patients who were not directly followed up by the clinic were interviewed by clinical staff and medical records and images for review, as per the protocol, were requested and obtained.

Statistics

The study followed a historical cohort design and the STROBE guidelines.[17] Univariable analysis for categorical data was performed using contingency tables. Continuous variables were expressed as median (interquartile range [IQR]) and categorical variables were expressed as number (%). Student's *t* test or the Wilcoxon rank sum test was used for continuous dependent variables, depending on the distribution of the data. Univariable regression models were computed for independent and dependent continuous variables. Failure time distributions were assessed by stratified and unstratified Kaplan–Meier methods. Failure time outcomes were modelled using multiple Cox regression. Multivariable adjusted analysis using generalised linear regression modelling for attributable risk estimation, and multiple logistic regression for short-term categorical dependent variables (less than 30 days or in hospital) were performed to identify determinants of graft occlusion and to assess the impact of SFA occlusion and its constituent elements. All the pre-operative variables were screened to identify the predictors of graft occlusion, and variables with $p < 0.05$ on univariable analysis were incorporated into multivariable models. All computations were performed using SAS 9.4 software (SAS Institute Inc, Cary, NC).

RESULTS

Pre- and intra-operative characteristics and grouping

Between 2004 and 2015, AFB for AIOD was performed in 122 patients. The pre-operative characteristics of patients and subgroups are detailed in Table 1. Of 122 AFBs, nine were unifemoral and 113 were bifemoral bypasses. Twenty-eight (23%) were urgent or emergency operations due to acute on chronic ischaemia. Seventy-five patients (61%) were female and the median age was 60 years (IQR 52–67). At the time of AFB, 50 (41%) patients had occluded SFAs (DT or DU); 24 had bilateral SFA occlusion; and 26 had unilateral SFA occlusions. Of these, 15 had the occluded SFA treated at the time of AFB (DT group) and 35 did not receive concomitant intervention to the SFA lesions (DU group) (Fig. 1). When compared with patients with patent SFAs, patients with occluded SFAs had greater history of prior aortoiliac and femoropopliteal procedures (aortoiliac, 54% vs. 22%, $p < 0.001$; femoropopliteal, 58% vs. 25%, $p < 0.001$), TASC classification of femoropopliteal type D lesions (78% vs. 10%, $p < 0.001$), and critical limb ischaemia (Rutherford classification 4–6, 80% vs. 57%, $p = 0.011$). Between the two treatment subgroups of DT and DU, there was no significant difference observed in the pre-operative characteristics. As an adjunctive procedure, profundaplasty was performed in five of 72 patent SFAs, six of 15 patients in DT, and 18 of 35 patients in DU group.

Table 1. Pre-operative/intra-operative characteristics.

Variables	Overall $n = 122$	SFA patent	SFA occluded		DT	DU	
		$n = 72$	$n = 50$	p value[a]	$n = 15$	$n = 35$	p value[b]
Age	60 (52–67)	58 (51–66)	61 (54–69)	.062	60 (53–69)	63 (55–71)	.319
eGFR, mL/min	79 (56–102)	83 (56–109)	75 (54–93)	.14	76 (56–92)	65 (54–96)	.704
BMI, kg/m^2	25 (22–29)	25 (23–28)	24 (21–23)	.641	24 (21–30)	24 (21–30)	.882
Diabetic mellitus	35 (29.2)	17 (23.9)	18 (36.7)	.155	6 (40.0)	12 (35.3)	.753
Hypertension	113 (92.6)	66 (91.7)	47 (94.0)	.455	15 (100)	32 (91.4)	.545
Hyperlipidaemia	97 (79.5)	59 (81.9)	38 (76.0)	.424	14 (93.3)	24 (68.6)	.079
Female	75 (61.5)	43 (59.7)	32 (64.0)	.633	11 (73.3)	21 (60.0)	.368
CAD	57 (46.7)	33 (45.8)	24 (48.0)	.814	8 (53.3)	16 (45.7)	.621
COPD	92 (75.4)	55 (76.4)	37 (74.0)	.763	10 (66.7)	27 (77.1)	.439
CVA	19 (15.6)	11 (15.3)	8 (16.0)	.914	4 (26.7)	4 (11.4)	.220
Prior AI procedures	43 (35.3)	16 (22.2)	27 (54.0)	<.001	9 (60.0)	18 (51.4)	.577
Endovascular	20 (16.4)	4 (5.6)	16 (32.0)	<.001	5 (33.3)	11 (31.4)	1
Open	23 (18.9)	12 (16.7)[c]	11 (22.0)	.488	4 (26.7)	7 (20.0)	.713
AxFem	1 (.8)	1 (1.4)	0 (0)	1	0 (0)	0 (0)	1
AFB/AIB	13 (10.7)	6 (8.3)	7 (14.0)	.390	2 (13.3)	6 (17.1)	1
Fem–Fem	10 (8.2)	6 (8.3)	4 (8.0)	1	2 (13.3)	1 (2.9)	.211
Prior FP procedures	22 (18.0)	2 (2.8)	20 (40.0)	<.001	8 (53.3)	12 (34.3)	.208
Endovascular	7 (5.7)	1 (1.4)	6 (12.0)	.019	2 (13.3)	8 (22.9)	.702
Open	15 (12.3)	1 (1.4)	14 (28.0)	<.001	6 (40.0)	4 (11.4)	.048
TASC AI A	0 (.0)	0 (.0)	0 (.0)	1	0 (.0)	0 (.0)	1
TASC AI B	6 (4.9)	4 (5.6)	2 (4.0)	1	0 (.0)	2 (5.7)	1
TASC AI C	5 (4.1)	4 (5.6)	1 (2.0)	.648	1 (6.7)	0 (.0)	.3
TASC AI D	111 (91.0)	64 (88.9)	47 (94.0)	.522	14 (93.3)	33 (94.3)	1
TASC FP A	11 (9.0)	8 (11.1)	3 (6.0)	.522	1 (6.7)	2 (5.7)	1
TASC FP B	8 (6.6)	2 (8.3)	2 (4.0)	.469	0 (.0)	2 (5.7)	1
TASC FP C	5 (4.1)	2 (2.8)	3 (6.0)	.399	1 (6.7)	2 (5.7)	1
TASC FP D	46 (37.7)	7 (9.7)	39 (78.0)	<.001	12 (80.0)	27 (77.1)	1
Rutherford 1–3	41 (33.6)	31 (43.1)	10 (20.0)	.008	1 (6.7)	9 (25.7)	.246
Rutherford 4–6	81 (66.4)	41 (56.9)	40 (80.0)	.011	14 (93.3)	26 (74.3)	.246
DFA status							
Stenosed	25 (20.5)	10 (13.9)	15 (30.0)	.03	4 (26.7)	11 (31.5)	1
Occluded	13 (10.7)	0 (.0)	13 (26.0)	<.001	6 (40.0)	7 (20.0)	.14
Occluded IMA	36 (29.5)	22 (30.6)	14 (28.0)	.761	3 (20.0)	11 (31.4)	.687
Occluded IIA	78 (63.9)	40 (55.6)	38 (76.0)	.021	14 (93.3)	24 (68.6)	.079
Intra-operative							
Suprarenal clamp	9 (7.3)	7 (9.7)	2 (4.0)	.306	0 (.0)	2 (5.7)	1
Aorto-unifemoral	9 (7.3)	6 (8.3)	3 (6.0)	.736	0 (.0)	3 (8.6)	.545
Profundaplasty	29 (23.8)	5 (6.9)	24 (48.0)	<.001	6 (40.0)	18 (51.4)	.459

Continuous variables are expressed as median (interquartile range). Categorical variables are expressed as n (%). AI = aortoiliac; BMI = body mass index; CAD = coronary artery disease; COPD = chronic obstructive pulmonary disease; CVA = cerebrovascular accident; DFA = deep femoral artery; DT = disease treated = a subset of SFA occluded patients who had simultaneous intervention to the SFA at the time of aortofemoral bypass; DU = disease untreated = a subset of SFA occluded patients whose SFA lesion was not treated at the time of aortofemoral bypass; eGFR = estimated glomerular filtration rate; FP = femoropopliteal; IIA = internal iliac artery; IMA = inferior mesenteric artery; SFA = superficial femoral artery; TASC = Trans-Atlantic Inter-Society Consensus.

[a] Comparison between SFA patent group and SFA occluded group.

[b] Comparison between DT group and DU group.

[c] One of 12 patients who had prior failed aortofemoral bypass and femorofemoral bypass.

In hospital outcomes

The summary of in hospital outcomes is shown in Table 2. The incidence of complications was similar between the SFA status groups. Patients with occluded SFAs had a longer hospital stay (median 11 vs. 7 days; $p = 0.004$). Three of the DU patients (8.6%) required additional unplanned infrainguinal revascularisation within the same AFB grafting admission: two femoropopliteal bypasses because of acute limb occlusion of the AFB graft; and one femorotibial bypass because of persistent ischaemic limb pain. No patient with a patent SFA or in the DT group required unplanned infrainguinal interventions during the same admission as AFB grafting. Overall, the 30 day mortality was 9.0%, which was not affected by urgency or Rutherford classification (elective 9.6% vs. urgent 7.1%, $p = 1.000$; Rutherford category 1–3, 7.5% vs. Rutherford category 4–6, 9.6%, $p = 1.000$); the causes of 11 deaths included bowel ischaemia in four patients, myocardial infarction in three patients, respiratory failure in three patients, and stroke in one patient. The 30 day mortality rate did not significantly differ between the patent and occluded SFA groups. However, within the occluded SFA patient population, DT had

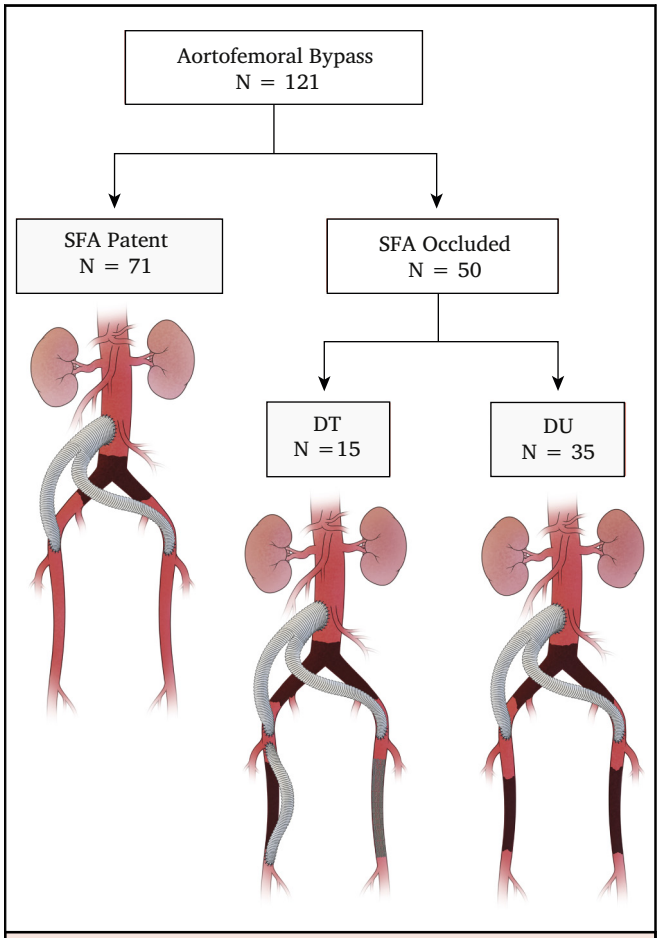

Figure 1. Grouping/subgrouping of aortofemoral bypass. Schematic drawing of grouping. Proximal anastomosis was either performed side to end or end to end depending on the series. The distal anastomosis was performed simply to the common femoral artery or with profundaplasty when indicated. SFA = superficial femoral artery; DT = disease treated patients who had simultaneous intervention to the SFA at the time of aortofemoral bypass; DU = disease untreated patients whose SFA lesion was not treated at the time of aortofemoral bypass.

significantly higher 30 day mortality than DU (26.7% vs. 2.9%; $p = 0.024$).

Long-term results

Median follow up was 7.7 (IQR 4.3—11.4) years. Follow up was complete in 96 of 122 patients with a follow up index of 0.87 ± 0.30. The long-term survival rate was not different between the SFA status groups (survival rate at one and five years, overall cohort 88.2 ± 3.0% and 67.3 ± 5.0%; patent SFA, 91.4 ± 3.4% and 72.9 ± 6.3%; occluded SFA, 83.7 ± 5.3% and 59.9 ± 7.8%; log rank $p = .279$). However, sub-analysis among the patients with an occluded SFA demonstrated an inferior survival rate in DT group (survival rate at one and five years, DU group 87.9 ± 5.7% and 82.7 ± .7%; DT 72.7 ± 13.4% and 43.6 ± 17.9%; patent SFAs vs. DU vs. DT, log rank, $p < 0.001$). In addition, Rutherford category 4—6 had a significantly lower survival rate than Rutherford category 1—3 (one year survival, Rutherford 4—6 86.4 ± 3.9% vs. Rutherford 1—3 92.0 ± 4.4%; five year survival, Rutherford 4—6 57.4 ± 6.5% vs. Rutherford 1—3 88.2 ± 5.7, log-rank $p = 0.008$; Fig. 2).

Infrainguinal revascularisation was additionally required in 11 patients during the follow up period: four patients in the patent SFA group (5.6%) (2 femoropopliteal bypasses, one popliteal—popliteal bypass, and one percutaneous angioplasty of tibial arteries); two patients in DT (13.3%) (one percutaneous angioplasty of the SFA and one femoropopliteal bypass); and four patents in DU group (11.4%) (three femoropopliteal bypasses, one femorotibial bypass). Thus, a total of seven (20%) (three during same admission as AFB grafting, and four in the follow up period) patients in DU group required infrainguinal revascularisation after AFB.

There were 20 AFB bypass occlusions, eight in patent SFA and 12 in occluded SFA patients (six in DT, six in DU), during the study period. The laterality of the occlusion of the limb and the pre-operative SFA occlusion corresponded in 11 of 12 occlusions (five of six AFB occlusions in DU and six of six occlusions in DT). The primary patency of AFB grafts was significantly higher in the patients with patent SFAs than occluded SFAs (DT+DU). The primary patency at one and five years was overall population, 92.4 ± 7.5% and 80.3 ± 16.3%; patent SFAs, 98.3 ± 1.7% and 91.2 ± 0.4%; occluded SFAs, 84.0 ± 5.6% and 73.0 ± 7.7%; log rank $p = 0.015$. Within the occluded SFA group, primary AFB graft patency at one and five years was 87.9 ± 5.7% and 82.7 ± 0.7% in DU, and 72.7 ± 13.4% and 43.6 ± 17.9% in DT. Among the three groups, patent SFAs vs. DU vs. DT, there was a significant difference in primary AFB patency evaluated with Kaplan—Meier analysis, DT having the lowest patency rate (log rank, $p < 0.001$; Fig. 3). Secondary patency of AFB grafts in the DT group had a lower patency rate among occluded SFA patients. Secondary patency at one and five years was 96.0 ± 2.0% and 93.1 ± 2.8% in the overall population, 98.3 ± 1.7% and 91.2 ± .4 in patent SFAs, 93.3 ± 4.6% and in 93.3 ± 4.6% in DU, and 90.9 ± 8.8% and 79.6 ± 13.1% in DT (log rank, $p = 0.029$). Prior aortoiliac intervention significantly reduced the primary patency rate (HR 2.86, $p = 0.05$; Fig. 4), but was not a risk factor in adjusted multivariable analysis. On multivariable analysis, low baseline GFR (hazard ratio [HR] 1.01, $p = 0.010$), DT (HR 4.08, $p = 0.013$), Rutherford class 4—6 (HR 9.06, $p = 0.048$), and occluded SFA (HR 4.45, $p = 0.006$) adversely affected the primary patency of AFBs (Table 3).

Of note, bilateral SFA occlusion had a higher patency than unilateral occlusion (one year primary patency, bilateral SFA occlusion 91.3 ± 5.9%; unilateral SFA occlusion 76.9 ± 9.1%; patent SFA 98.3 ± 1.7%; five year primary patency, bilateral SFA occlusion 79.1 ± 9.6%, unilateral SFA occlusion 69.9 ± 10.6%; patent SFA 91.2 ± 0.4%, log rank $p = 0.007$). However, when survival was investigated, bilateral SFA occlusion had the lowest survival rate, though the difference between three groups did not reach statistical significance. The one year survival rates were bilateral SFA occlusion 84.6 ± 7.1%; single SFA occlusion 97.0 ± 7.0%; patent SFA 91.4 ± 3.4%. The five year survival rates were patent SFA 89.9 ± 3.6%; bilateral SFA occlusion

Table 2. Post-operative in hospital outcomes.

Variables	Overall $n = 122$	SFA patent	SFA occluded		DT	DU	
		$n = 72$	$n = 50$	p value[a]	$n = 15$	$n = 35$	p value[b]
ICU stay, days	2 (1–4)	2 (1–4)	3 (2–5)	.159	4 (2–6)	3 (1–4)	.506
LOS, days	9 (6–14)	7 (6–12)	11 (7–18)	.004	10 (6–15)	11 (8–18)	.297
Unplanned infrainguinal intervention	3 (2.5)	0 (0)	3 (6.0)	.066	0 (0)	3 (8.6)	.545
Stroke	2 (1.6)	0 (0)	2 (4.0)	.166	1 (6.7)	1 (2.9)	.514
Myocardial infarction	5 (4.1)	4 (5.6)	1 (2.0)	.648	1 (6.7)	0 (0)	.300
Atrial fibrillation	6 (4.9)	4 (5.6)	2 (4.0)	1.000	0 (0)	0 (0)	1
VT/Vfib	9 (7.4)	6 (8.3)	3 (6.0)	.736	2 (13.3)	1 (2.9)	.211
Respiratory failure	11 (9.0)	7 (9.7)	4 (8.0)	1	2 (13.3)	2 (5.7)	.574
GI bleeding	2 (1.6)	1 (1.4)	1 (2.0)	1	1 (6.7)	0 (0)	.3
Bowel ischaemia	5 (4.1)	4 (5.6)	1 (2.0)	.648	1 (6.7)	0 (0)	.3
Acute kidney injury	24 (19.7)	15 (20.8)	9 (18.0)	.699	4 (26.7)	5 (14.3)	.423
Dialysis	5 (4.1)	3 (4.2)	2 (4.0)	1	2 (13.3)	0 (0)	.086
UTI	11 (9.0)	5 (6.9)	6 (12.0)	.355	2 (13.3)	4 (11.4)	1
SSI	3 (2.5)	1 (1.4)	2 (4.0)	.567	0 (0)	2 (5.7)	1
30 - day mortality	11 (9.0)	6 (8.3)	5 (10.0)	.758	4 (26.7)	1 (2.9)	.024

Continuous variables are expressed as median (interquartile range). Categorical variables are expressed as n (%). GI = gastrointestinal; ICU = intensive care unit; LOS = length of stay; SSI = surgical site infection; UTI = urinary tract infection; Vfib = ventricular fibrillation; VT = ventricular tachycardia; SFA = superficial femoral artery; DT = disease treated patients who had simultaneous intervention to the SFA at the time of aortofemoral bypass; DU = disease untreated patients whose SFA lesion was not treated at the time of aortofemoral bypass.

[a] Comparison between SFA patent group and SFA occluded group.

[b] Comparison between DT group and DU group.

45.6 ± 11.0%; unilateral SFA occlusion 75.5 ± 10.0%; patent SFA 72.9 ± 6.3%; log rank $p = 0.060$). Thus, the death censored graft primary patency (graft patent survival rate) was lowest in the bilateral SFA occlusion group. The one year graft patent survival rates were bilateral SFA occlusion 76.6 ± 8.3%; unilateral SFA occlusion 69.5 ± 9.6%; patent SFA 88.3 ± 4.1%. The five year patent survival rates were bilateral SFA occlusion 31.6 ± 10.7%; unilateral SFA occlusion 53.5 ± 11.1%, patent SFA 66.4 ± 6.5%; log rank $p = 0.034$; Fig. 5.

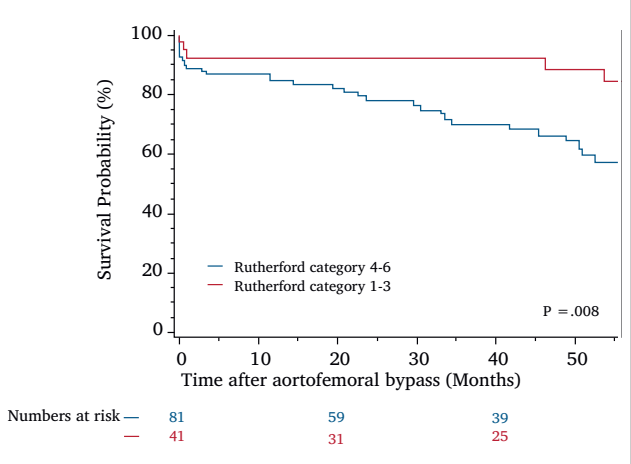

Figure 2. Kaplan Meier estimates of survival rates after aortofemoral bypass by Rutherford classification. Rutherford category 4–6 had significantly lower survival rate than Rutherford category 1–3 (one year survival, Rutherford 4–6 86.4 ± 3.9% vs. Rutherford 1–3 92.0 ± 4.4%; five year survival, Rutherford 4–6 57.4 ± 6.5% vs. Rutherford 1–3 88.2 ± 5.7, log rank $p = .008$).

DISCUSSION

In the presence of multilevel arterial occlusive disease, including aortoiliac and femoropopliteal lesions, there is a consensus that the revascularisation of AIOD is the first step in the treatment to increase overall inflow.[4,16] However, the timing of intervention regarding the outflow disease, i.e. SFA occlusion, remains controversial. Despite the high rate of prior aortoiliac interventions, the primary patency of AFB grafts in this study at five years was 80% with a secondary

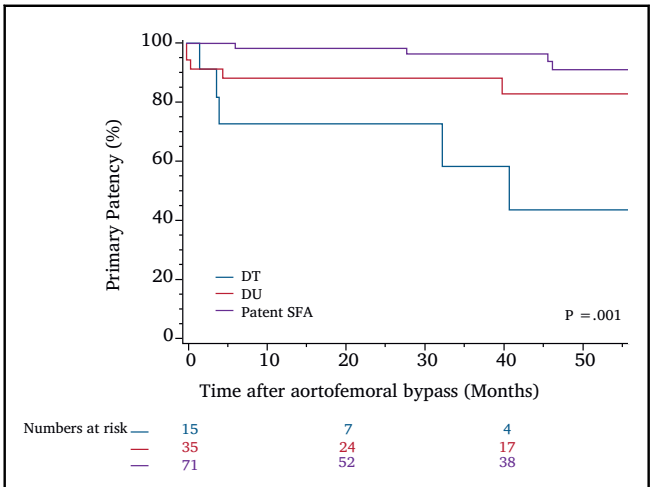

Figure 3. Kaplan Meier estimates of primary aortofemoral bypass patency, stratified by superficial femoral artery status and treatment. There was a significant difference in primary aortofemoral bypass patency, DT having the lowest patency rate (log rank, $p < .001$). SFA = superficial femoral artery; DT = disease treated patients who had simultaneous intervention to the SFA at the time of aortofemoral bypass; DU = disease untreated patients whose SFA lesion was not treated at the time of aortofemoral bypass.

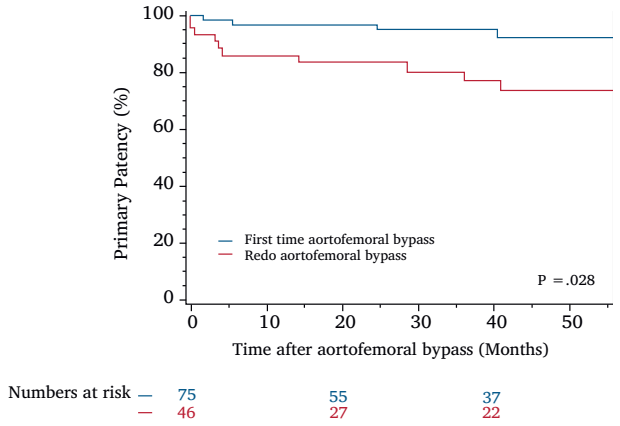

Figure 4. Primary patency of aortofemoral bypass by redo operation status (Kaplan Meier estimates). Prior aortoiliac intervention, including both endovascular and open surgical intervention, significantly reduced the primary patency rate.

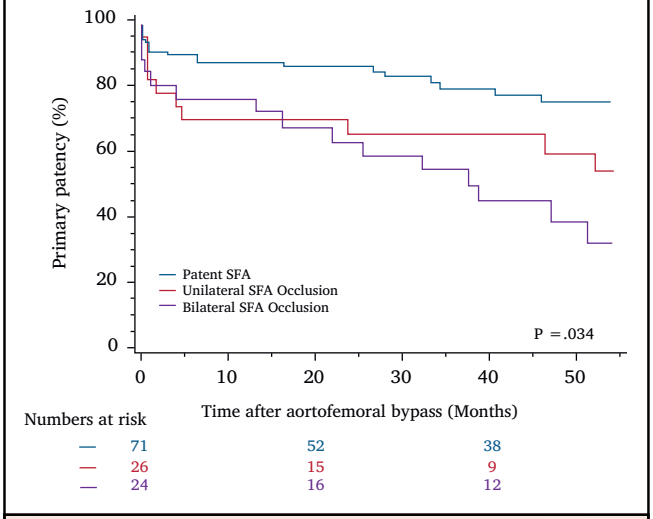

Figure 5. Death censored primary patency of aortofemoral bypass by superficial femoral artery (SFA) status (Kaplan Meier estimates). Patients with bilateral patent SFAs had highest aortofemoral bypass (AFB) primary patency.

patency of 93%, which was similar to previous reports.[17–21] It has been demonstrated that the presence of SFA occlusion negatively affected the long-term patency of AFB. In the reports by Madiba et al.[8] and Hill et al.,[7] cumulative aortobifemoral bypass patency rates tended to be higher with patent SFA, although the findings did not reach statistical difference. These studies probably did not reach significant difference because of their limited patient number and short follow up period (mean 2.3–3.3 years). There are few series with follow up periods beyond five years. A study by Nevelsteen et al.[11] with a mean follow up of 5.5 years showed that SFA occlusion was a risk factor for limb loss and restenosis. Similarly, Szilagyi et al.[20] reported a study with mean follow up of seven years, which demonstrated SFA occlusion was a risk factor for both mortality and bypass restenosis/failure. Thus, the presence of SFA occlusion at the time of AFB grafting may reduce the patency of AFB grafts in the long-term, and especially, when the patient has bilateral SFA occlusion, the patency worsens further.

It has also been said that AFB may not resolve ischaemic symptoms in the presence of SFA occlusion.[5,7] In patients with multilevel arterial occlusions, one third of patients who only received AFB will not have resolution of ischaemic symptoms. The efficacy of profundaplasty without infrainguinal bypass in patients with AIOD and SFA occlusion was described by Pearce and Kempczinski[12] with excellent results. However, it was unclear how many of these patients had critical limb ischaemia. Particularly for patients with tissue loss (i.e., Rutherford 5–6), profundaplasty may be inferior to complete revascularisation by bypass or endovascular interventions.[22] In the current study, seven of 35 (20%) patients in DU group, who did not have simultaneous revascularisation of occluded SFAs, required subsequent outflow revascularisation for either AFB limb occlusion ($n = 2$) or unresolved rest pain/non-healing wound ($n = 5$). This low incidence of unresolved symptoms in the DU cohort may reflect the selection bias that patients with severe ischaemic symptoms (rest pain or ulcer/gangrene) were treated by concomitant infrainguinal procedures, and patients in the DU cohort had less severe symptoms.

Concomitant SFA revascularisation was expected to provide superior AFB patency but the long-term patency was significantly worse in the DT than DU or patent SFA groups. In addition, the DT group had a significantly higher mortality rate than the DU group. Most of the DT groups were patients with severe rest pain or tissue loss, who would benefit from concomitant femoropopliteal bypass or angioplasty to secure in line pulsatile blood flow to the threatened limb.[10] The high mortality and low patency of

Table 3. Multivariable analysis for graft occlusion.

Variables	Hazard ratio	95% CI	Parameter estimate	Standard error	*p* value
Low eGFR	1.01	1.00–1.03	0.01	0.01	.010
Occluded SFA	3.99	1.54–12.84	1.49	0.54	.006
DT Group	3.68	1.34–12.41	1.40	0.57	.013
Rutherford 4–6	9.06	1.02–80.72	2.20	1.12	.048

CI = confidence interval; DT = disease treated = a subset of SFA occluded patients who had simultaneous intervention to the SFA at the time of aortofemoral bypass; eGFR = estimated glomerular filtration rate; SFA = superficial femoral artery.

AFB grafts in the DT group is believed to reflect the heavier atherosclerotic burden in this group, though pre-operative characteristics did not demonstrate a significant difference. Nonetheless, concomitant SFA revascularisation may still be offered to selected patients but these results have demonstrated that femoropopliteal bypass did not improve long-term AFB patency and is associated with increased mortality. As covered endovascular reconstruction of the aortic bifurcation, being less invasive than AFB, has shown durable outcomes in a selected AIOD population,[23] concomitant infrainguinal revascularisation with covered endovascular reconstruction of the aortic bifurcation may be a more feasible procedure in patients with SFA occlusion and AIOD.

The current study also demonstrated that low GFR is an independent predictor of graft occlusion in the long term. This finding is consistent with the fact that chronic kidney disease is often associated with accelerated cardiovascular disease.[24] Impaired renal function is often a result of systemic atherosclerotic changes from hypertension, hyperlipidaemia, and diabetes.[25] Renal dysfunction promotes vascular calcification. Thus, the low baseline GFR could be a surrogate for more severe systemic atherosclerotic disease.

Patients who would benefit from additional infrainguinal revascularisation could not be definitively identified. Future studies are warranted to determine who would benefit from AFB with simultaneous or staged femoropopliteal procedures.

Limitations

This is a retrospective study with a relatively small number of patients. Although known selection bias in the analysis was accounted for, there are certainly unaccounted biases between DT and DU groups. It may be that DT patients had more severe disease, a heavier atherosclerotic burden, and had more severe tissue loss. Current chronic ischaemia grading systems accounting for severity of tissue loss were not in use for most of the study period. Thus, larger and prospective studies may be warranted to further evaluate the relationship between pre-operative status and outcomes of AFB.

CONCLUSION

Baseline SFA occlusion predicted a fourfold increased risk of primary aortofemoral bypass graft failure. Concomitant SFA revascularisation did not improve AFB durability and was associated with increased in hospital mortality.

CONFLICT OF INTEREST

None.

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COUP D'OEIL

Isolated Hepatic Aneurysm

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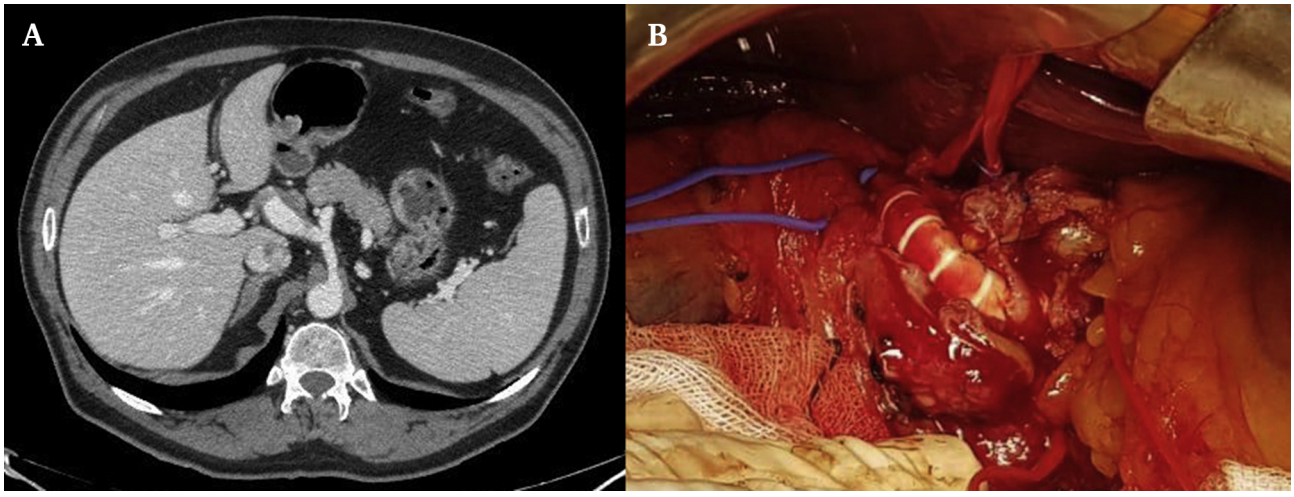

A 63 year old smoker with a history of peptic oesophagitis, colonic diverticular disease and polyposis was diagnosed with a 24 mm asymptomatic true hepatic artery aneurysm (panel A) during a colonic surveillance computed tomography (CT) scan. The aneurysm had not been present on CT four years previously. There were no associated aortic/peripheral aneurysms and no suitable necks for endovascular treatment. The hepatic aneurysm was resected electively through a right subcostal laparotomy with interposition of a hepatohepatic 6 mm Propaten® graft (panel B), anastomosed proximally at the hepatic artery origin and distally at its bifurcation, preserving both main branches. The patient recovered uneventfully.

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