

Comparison of Early and Late Post-operative Outcomes after Supra-inguinal Bypass for Aortoiliac Occlusive Disease[☆]

Zein M. Saadeddin^a, Denis V. Rybin^b, Gheorghe Doros^b, Jefferey J. Siracuse^c, Alik Farber^c, Mohammad H. Eslami^{a,*}

^a Division of Vascular Surgery, University of Pittsburgh Medical Centre, Pittsburgh, PA, USA

^b Department of Biostatistics, Boston University School of Public Health, Boston, MA, USA

^c Division of Vascular and Endovascular Surgery, Boston University School of Medicine, Boston, MA, USA

WHAT THIS PAPER ADDS

This large registry study compares different surgical procedures for aortoiliac occlusive disease and shows that femorofemoral bypass (FFB) leads to significantly lower rates of post-operative complications. One year limb salvage and long-term survival rates for FFB are comparable to aortofemoral bypass (AFB), the standard operation. FFB may serve as the extra-anatomical operation of choice in high risk patients with extensive disease, who cannot undergo AFB. AFB should be performed preferentially in low risk patients with appropriate anatomy. Owing to its higher rates of complications, the study suggests that axillofemoral bypass preferably should be limited to patients with no other option for revascularisation.

Objective: The choice for surgical revascularisation for aortoiliac occlusive disease is often tempered by patient comorbidities. This study compares peri-operative outcomes and the association between choice of operation and one year major adverse limb event (MALE) free survival and five year mortality.

Methods: The Vascular Study Group of New England (VSGNE) dataset for supra-inguinal bypass operations from 2009 to 2015 was queried. This study excluded cases with bypass other than aortofemoral (AFB), axillofemoral (AXB), and femorofemoral (FFB), and those with endovascular interventions or femoral endarterectomy. Cases combined with other procedures, indications other than occlusive disease, and missing pathology were also excluded. Patients were divided into three groups: AFB, AXB, and FFB. Thirty day post-operative death (POD) and adverse events were compared using univariable and multivariable analyses. One year MALE free survival was compared between groups with log rank test and Kaplan–Meier plot. Proportional hazard Cox regression was used for adjusted comparison of MALE free and five year survival.

Results: In total, 1,602 cases were included: 207 (12.9%) AXB; 872 (54.4%) AFB; 523 (32.6%) FFB. AXB patients were older with more comorbidities. Post-operative complications and POD rates were significantly higher for AXB ($p < .05$). On adjusted analyses, AXB increased the hazard of one year MALE (hazard ratio [HR] 1.76, 95% confidence interval [CI] 1.12–2.78; $p = .014$) and five year mortality (HR 1.54; 95% CI 1.11–2.41; $p = .009$). Both FFB and AFB had similar one year MALE free survival but significantly better one year MALE free survival than AXB.

Conclusion: After adjusting for confounding variables, and while acknowledging limitations related to the VSGNE data set, FFB led to significantly lower rates of post-operative complications than AXB. FFB may serve as the extra-anatomical operation of choice in high risk patients with extensive disease, who cannot undergo AFB, provided that anatomy permits. AFB should be performed preferentially in low risk patients with appropriate anatomy. Owing to its higher complications rates, the study suggests that AXB should be limited to patients with no other option for revascularisation.

Keywords: Arterial occlusive disease, Axillofemoral bypass grafting, Prognosis, Vascular grafting

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INTRODUCTION

Aortoiliac occlusive disease (AIOD) is often a manifestation of diffuse, multilevel atherosclerotic disease and a relatively common cause of lower extremity ischaemia. Its management represents one of the most common therapeutic challenges encountered by vascular surgeons. The paradigm shift towards endovascular and other less invasive procedures has greatly diminished the need for conventional open

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* Corresponding author. Division of Vascular Surgery, University of Pittsburgh School of Medicine, 200 Lothrop Street, PUH, Suite 1010-A, Pittsburgh, PA 15232, USA.

E-mail address: eslamimh@upmc.edu (Mohammad H. Eslami).

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in line reconstructions, limiting their use to a second or even third line therapy among those with failed endovascular treatment or exceptionally extensive disease where an endovascular intervention is otherwise no longer recommended.^{1,2} Such a change in treatment approach may explain the potentially increased complexity of open reconstructions, including aortofemoral bypass (AFB), which are now essentially reserved for more surgically challenging cases.^{2,3} This paradigm shift has also affected training programs so that now AFB is hardly performed by the graduating trainees of vascular programs.^{1,4,5} Older patients with more advanced comorbidities and diffuse atherosclerosis or a combination of more proximal aneurysmal disease and common/external iliac occlusive disease are still more likely to require open surgical therapy.⁶

The anatomical and technical complexity of the disease and the patient's comorbidities may influence the choice for open surgical revascularisation.⁷ Nevertheless, older patients with more extensive patterns of disease requiring revascularisation may be poor candidates for both endovascular therapy and AFB.^{6–8} In such cases, extra-anatomical bypasses, including femorofemoral bypass (FFB) or axillofemoral bypass (AXB), may serve as alternative revascularisation options.

While the choice for open surgical revascularisation for AIOD is often influenced by the patient's risk profile, contemporary comparisons of these different open surgical options are lacking. Most of the available studies come from small single institution series generally comparing patency results alone. This is an observational study that aimed to compare baseline characteristics of patients who had open supra-inguinal bypass for AIOD and to evaluate the association between the choice of operation and in hospital post-operative complications, one year major adverse limb event (MALE) free survival and five year mortality.

METHODS

Study design and data collection

This was a retrospective observational study designed to compare outcomes in patients with AIOD who underwent open supra-inguinal bypass surgery using the Vascular Study Group of New England (VSGNE) supra-inguinal dataset. The VSGNE registry is extensively described in numerous publications. Details of the registry are available online (<https://www.vqi.org/>). In brief, it is a regional quality improvement initiative created in 2002 to prospectively collect data on patients undergoing vascular procedures with the goal of improving the care and regional outcomes of patients with vascular disease.⁹ This database has expanded to include data collected on at least 100 clinical and demographic variables, along with peri-operative complications, from > 30 academic and community hospitals across all six New England states.¹⁰ The VSGNE captures and keeps track of post-operative outcomes, including in hospital mortality, adverse events, and long-term survival by matching patients with their Social Security Death Index. For this study, the Institutional Review Board at Boston University School of

Medicine approved the use of de-identified data, and as data were de-identified, patient informed consent was not required.

Study cohort

All patients who underwent open supra-inguinal bypass for AIOD in the various VSGNE centres from 2009 to 2015 were identified. The study excluded cases with bypass procedures of origin other than AFB, AXB, and FFB, and endovascular interventions or femoral endarterectomy. Cases combined with other procedures, with indications other than occlusive disease, and those with missing indications or pathology were also excluded. A remaining total of 1 602 occlusion cases with supra-inguinal bypass were included. The study sample was then divided into three cohorts according to bypass origin: AFB, AXB, and FFB.

Study variables and end points

In this analysis, patient demographics, baseline clinical characteristics, and operative details were reviewed. The primary end points of interest were one year freedom from MALE, defined as ipsilateral amputation or major secondary intervention (e.g., graft revision), and both one and five year mortality across the bypass groups. Secondary outcomes included adverse post-operative events: cardiac and respiratory complications, change in renal function, defined as an increase in creatinine of > 44 $\mu\text{mol/L}$ (0.5 mg/dL), or need for haemodialysis,¹¹ 30 day all cause mortality, and the composite adverse outcome. Cardiac complications involved the occurrence of events such as myocardial infarction, arrhythmias, and cardiac arrest.

Statistical analysis

Descriptive analyses were performed to identify and compare risk factors, which were reported as number of cases and percentages for each of the three bypass cohorts. The groups were compared with respect to their demographics, pre-operative medical history, and procedural characteristics (Table 1). Chi-square test was used for categorical variables and Student *t* test for continuous variables. Continuous variables throughout the text are displayed as mean \pm SD.

Both univariable and multivariable analyses were obtained to identify factors associated with post-operative adverse events across the three groups. To adjust for confounding variables, multivariable logistic regression analyses were used to compare the bypass groups for adverse cardiac events, respiratory complications, change in renal function, 30 day post-operative death (POD), and the composite outcome. Covariates included in the multivariable comparison included age, sex, comorbidities (hypertension, diabetes mellitus, coronary artery disease [CAD], chronic obstructive pulmonary disease, congestive heart failure [CHF]), history of prior peripheral vascular interventions, elevated creatinine level, and urgency of the admission. Type of operation was also included in these analyses with FFB as the reference procedure (i.e., AFB vs.

Table 1. Baseline characteristics and procedural details of the patient cohort undergoing supra-inguinal bypass surgery of different origin

Characteristic	Overall n = 1 602	Axillofemoral bypass n = 207	Aortofemoral bypass n = 872	Femorofemoral bypass n = 523	p
Age – y	63.4 ± 10.1	69.6 ± 9.8	59.6 ± 8.5	67.1 ± 10.2	<.001
Male sex	941 (58.7)	108 (52.2)	517 (59.3)	316 (60.4)	.11
Independent ambulatory status	1 371 (85.6)	143 (69.1)	796 (91.3)	432 (82.6)	<.001
Missing data ^a	2	1	0	1	
Ever Smoking	1 548 (96.6)	193 (93.3)	855 (98.1)	500 (95.6)	.001
<i>Medical history</i>					
Hypertension	1 300 (81.1)	181 (87.4)	669 (76.7)	450 (86.0)	<.001
Diabetes	399 (24.9)	64 (30.9)	186 (21.3)	149 (28.5)	.001
Coronary artery disease	430 (26.8)	70 (33.8)	181 (20.7)	179 (34.2)	<.001
Congestive heart failure	151 (9.4)	45 (21.7)	35 (4.0)	71 (13.6)	<.001
Chronic obstructive pulmonary disease	539 (33.6)	78 (37.7)	267 (30.6)	194 (37.1)	.020
Previous bypass	226 (14.1)	31 (15.0)	90 (10.3)	105 (20.1)	<.001
Previous carotid endarterectomy/carotid artery stenting	150 (9.4)	20 (9.7)	65 (7.5)	65 (12.4)	.007
Missing data ^a	5	1	0	4	
Previous aneurysm repair	71 (4.4)	10 (4.8)	6 (0.7)	55 (10.5)	<.001
Previous peripheral vascular intervention	410 (25.6)	36 (17.4)	211 (24.2)	163 (31.2)	<.001
Missing data ^a	1	1	0	0	
Previous major amputation	13 (0.8)	2 (1.0)	3 (0.3)	8 (1.5)	.056
<i>Procedure</i>					
Creatinine > 133.5 µmol/L	82 (5.1)	16 (7.7)	21 (2.4)	45 (8.6)	<.001
Missing data ^a	26	8	5	13	
<i>Urgency</i>					
Elective	1 249 (78.0)	124 (59.9)	757 (86.8)	368 (70.4)	<.001
Urgent	257 (16.0)	48 (23.2)	100 (11.5)	109 (20.8)	
Emergent	96 (6.0)	35 (16.9)	15 (1.7)	46 (8.8)	
<i>American Society of Anesthesiologists' class</i>					
Normal/mild	107 (6.7)	1 (0.5)	79 (9.1)	27 (5.2)	<.001
Severe	1494 (93.3)	205 (99.0)	793 (90.9)	496 (94.8)	
Missing data ^a	1	1	0	0	
<i>Indication</i>					
Claudication	727 (45.4)	46 (22.2)	489 (56.1)	192 (36.7)	<.001
Rest pain	444 (27.7)	56 (27.1)	240 (27.5)	148 (28.3)	
Tissue loss	223 (13.9)	52 (25.1)	82 (9.4)	89 (17.0)	
Acute ischaemia	208 (13.0)	53 (25.6)	61 (7.0)	94 (18.0)	
<i>Pathology</i>					
Occlusive	1 602 (100)	207 (100)	872 (100)	523 (100)	NA
<i>Graft recipient 1</i>					
Common femoral	1 396 (87.1)	147 (71.0)	792 (90.8)	457 (87.4)	<.001
Profunda	170 (10.6)	52 (25.1)	64 (7.3)	54 (10.3)	
Superficial femoral artery	36 (2.2)	8 (3.9)	16 (1.8)	12 (2.3)	
<i>Graft recipient 2</i>					
None	523 (32.6)	0 (0)	0 (0)	523 (100)	<.001
Common femoral	923 (57.6)	149 (72.0)	774 (88.8)	0 (0)	
Profunda	127 (7.9)	46 (22.2)	81 (9.3)	0 (0)	
Superficial femoral artery	29 (1.8)	12 (5.8)	17 (1.9)	0 (0)	

Data are given as n (%) or mean ± standard deviation (SD). NA = Not available.

^a Number of patients with missing data are given when larger than zero.

FFB or AXF vs. FFB). Results were presented as odds ratios (OR) with their corresponding 95% confidence interval (CI) and p values. Missing data were deleted and not included in the analyses to avoid any statistical confounding.

One year MALE free survival and mortality at the one and five year follow ups were presented using Kaplan–Meier survival curves, and the log rank test was obtained to compare the three groups. To adjust for possible

confounders, multivariable Cox regression analyses were used to compare these primary outcomes of interest and adjust for the same covariates used in the multivariable logistic regression analyses. Results are expressed as hazard ratio (HR) with their corresponding 95% CI.

Statistical analyses were performed using SAS version 9.3 software (SAS Institute, Cary, NC, USA). All tests were considered statistically significant at p < .05.

RESULTS

Patient characteristics

In total, 1 602 patients with AIOD who underwent suprainguinal bypass surgery from 2009 to 2015 were identified, of whom 872 (54.4%) had AFB, 523 (32.6%) FFB, and 207 (12.9%) AXB. Table 1 summarises the baseline characteristics of the patient cohort included in this study and the procedures performed. Overall, AXB patients were older, with a mean age of 69.6 ± 9.8 years, and less physically independent with generally higher rates of comorbidities compared with each of the AFB and FFB patients. Those who underwent AFB were the youngest, with the lowest rates of previous bypass (10.3%), carotid endarterectomy/stenting (7.5%), aneurysm repair (0.7%), and major amputations (0.3%). FFB patients had the most significant ($p < .05$) history of prior vascular procedures and peripheral vascular interventions, major amputations, and elevated creatinine levels $\geq 133.5 \mu\text{mol/L}$ ($\geq 1.51 \text{ mg/dL}$) at the time of surgery.

Procedural details

The majority of patients (94.8%) had normal creatinine levels peri-operatively. Elective procedures accounted for 78.0% of all cases. AXB patients had the highest proportion (40.1%) of urgent and emergency cases. Claudication represented the most frequent indication for open suprainguinal bypass surgery (45.4%), in general, and for the AFB group (56.1%), in particular. The primary anastomotic site of the recipient artery used for all three bypass origin grafts was most frequently the common femoral artery. While none was required for FFB grafts, the secondary graft

recipient artery for both AXB and AFB grafts, similarly, was most often the common femoral artery.

Post-operative complications and outcomes

Fig. 1 illustrates and compares the distribution of the post-operative complications of interest across the three procedure cohorts. Overall 30 day mortality was 3.1% ($n = 50$), with the lowest mortality among patients undergoing AFB ($n = 15$; 1.7%) and highest in those undergoing AXB ($n = 20$; 9.7%). The rate of post-operative cardiac, respiratory, and renal complications and the composite outcome were also significantly highest in AXB patients ($p < .05$ for all comparisons) but lowest in the FFB group. The overall incidence of the composite outcome was 11.4% in those who received FFB vs. 24.5% and 29.7% in AFB and AXB patients, respectively ($p < .001$).

Immediate in hospital post-operative graft thrombosis occurred in 53 (3.3%) patients in total. Of these, 13 (6.3%) cases failed following AXB surgery for revascularisation, 28 (3.2%) following AFB, and 12 (2.3%) following FFB ($p = .024$). Although the mean length of in hospital stay was similar for those who underwent AXB (7.1 ± 7.2 days) or AFB (7.8 ± 5.3 days), patients who received FFB had a significantly shorter stay (4.5 ± 5.8 days; $p < .001$).

Multivariable analysis for post-operative adverse events

In the adjusted multivariable analysis (Table 2), only AXB significantly increased the 30 day risk of POD (OR 3.50, 95% CI 1.65–7.41; $p = .001$). Mortality risk was increased by 37% following AFB vs. FFB, although the results were not statistically significant (OR 1.37, 95% CI 0.56–3.34;

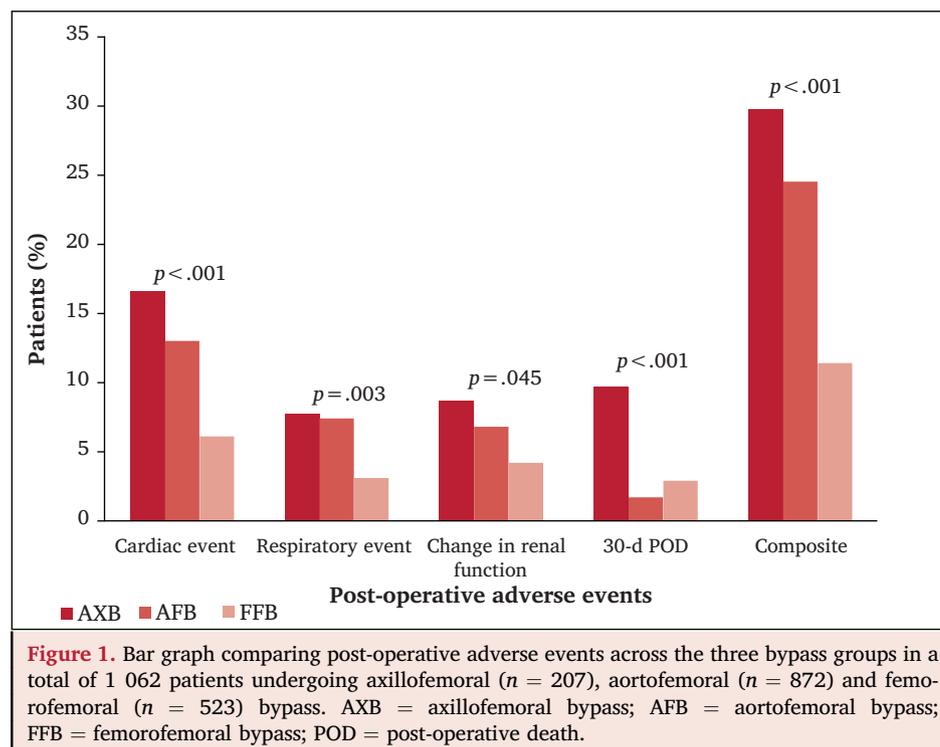


Table 2. Multivariable logistic regression analyses comparing the bypass origin groups for post-operative adverse events in total 1 062 patients undergoing axillofemoral ($n = 207$), aortofemoral ($n = 872$) and femorofemoral ($n = 523$) bypass

Predictor	Cardiac		Respiratory		Change in renal function		30 day post-operative death		Composite	
	OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>
AFB vs. FFB	3.57 (2.23–5.72)	<.001	5.47 (2.80–10.67)	<.001	3.18 (1.75–5.78)	<.001	1.37 (0.56–3.34)	.49	4.18 (2.86–6.11)	<.001
AXB vs. FFB	2.47 (1.43–4.28)	.001	2.61 (1.22–5.56)	.013	1.90 (0.94–3.84)	.075	3.50 (1.65–7.41)	.001	2.78 (1.79–4.34)	<.001
Age	1.03 (1.01–1.05)	.001	1.03 (1.00–1.05)	.048	1.02 (0.99–1.04)	.24	1.04 (1.00–1.07)	.058	1.02 (1.00–1.03)	.027
Sex	1.09 (0.78–1.52)	.63	1.01 (0.65–1.57)	.97	0.52 (0.33–0.84)	.007	1.15 (0.60–2.20)	.67	1.07 (0.81–1.41)	.62
Hypertension	0.77 (0.50–1.18)	.23	1.55 (0.79–3.04)	.20	1.90 (0.92–3.93)	.083	6.08 (0.81–45.61)	.079	1.14 (0.78–1.66)	.50
Diabetes	0.82 (0.55–1.21)	.32	1.31 (0.82–2.09)	.25	1.20 (0.75–1.92)	.45	1.04 (1.00–1.07)	.96	0.89 (0.65–1.21)	.46
CAD	1.23 (0.84–1.80)	.29	1.23 (0.75–2.01)	.41	0.87 (0.53–1.45)	.60	2.46 (1.26–4.80)	.008	1.22 (0.89–1.68)	.21
CHF	3.49 (2.15–5.68)	<.001	1.86 (0.95–3.62)	.069	2.75 (1.48–5.09)	.001	2.04 (0.94–4.40)	.070	2.91 (1.88–4.50)	<.001
COPD	1.32 (0.94–1.85)	.12	1.51 (0.97–2.35)	.066	1.67 (1.08–2.57)	.021	1.12 (0.59–2.13)	.72	1.30 (0.98–1.71)	.070
PVI	1.06 (1.06–1.55)	.78	1.12 (0.69–1.83)	.65	1.01 (0.62–1.65)	.97	0.38 (0.15–0.96)	.040	0.86 (0.63–1.19)	.37
Creatinine ^a	1.10 (0.53–2.28)	.79	1.33 (0.54–3.28)	.54	4.85 (2.59–9.10)	<.001	1.75 (0.68–4.48)	.25	1.74 (1.00–3.01)	.049
Urgency ^b	0.90 (0.58–1.37)	.61	2.55 (1.58–4.13)	<.001	1.44 (0.87–2.38)	.16	2.41 (1.26–4.61)	.008	1.54 (1.11–2.13)	.076

OR = odds ratio; CI = confidence interval; AFB = aortofemoral bypass; FFB = femorofemoral bypass; AXB = axillofemoral bypass; CAD = coronary artery disease; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; PVI = peripheral vascular intervention

^a >133.5 $\mu\text{mol/L}$ vs. 0–133.5 $\mu\text{mol/L}$.

^b Urgent/emergent vs. elective.

$p = .448$). As for the other adverse post-operative outcomes, both AFB and AXB independently increased the odds of 30 day cardiac and respiratory events. Although only 21/872 (2.4%) AFB patients had a baseline elevated creatinine (Table 1), they were more likely to experience a change in renal function (OR 3.18, 95% CI 1.75–5.78; $p < .001$) than FFB patients. The odds for the composite adverse outcome were also significantly higher following AFB and AXB vs. FFB.

Advancing age was associated with adverse post-operative events, significantly for cardiac (OR 1.03; 95% CI 1.01–1.05; $p = .001$) and respiratory complications (OR 1.03, 95% CI 1.00–1.05; $p = .048$), and the composite outcome (OR 1.02, 95% CI 1.00–1.03; $p = .027$). Patients with a history of CAD and those admitted urgently or emergently had a significantly increased risk of 30 day POD.

Primary end points

A Kaplan–Meier plot for MALE free survival at one year is shown in Fig. 2A. The estimated values of proportion of MALE free survival during one year of follow up were consistently lowest for AXB patients ($p < .001$). In terms of survival and as with the MALE free end point, the cumulative survival rates were constantly lowest for AXB and highest for AFB at both one (Fig. 2B) and five (Fig. 2C) years of follow up ($p < .001$).

Fig. 3 summarises the results of the multivariable Cox regression analysis for the primary outcomes of interest. In the adjusted analysis, AXB retained significance as an independent predictor of MALE at one year (Fig. 3A) compared with FFB (HR 1.7, 95% CI 1.12–2.78; $p = .014$). There was no difference in the occurrence of MALE in the AFB group vs. FFB. Likewise, only AXB maintained its

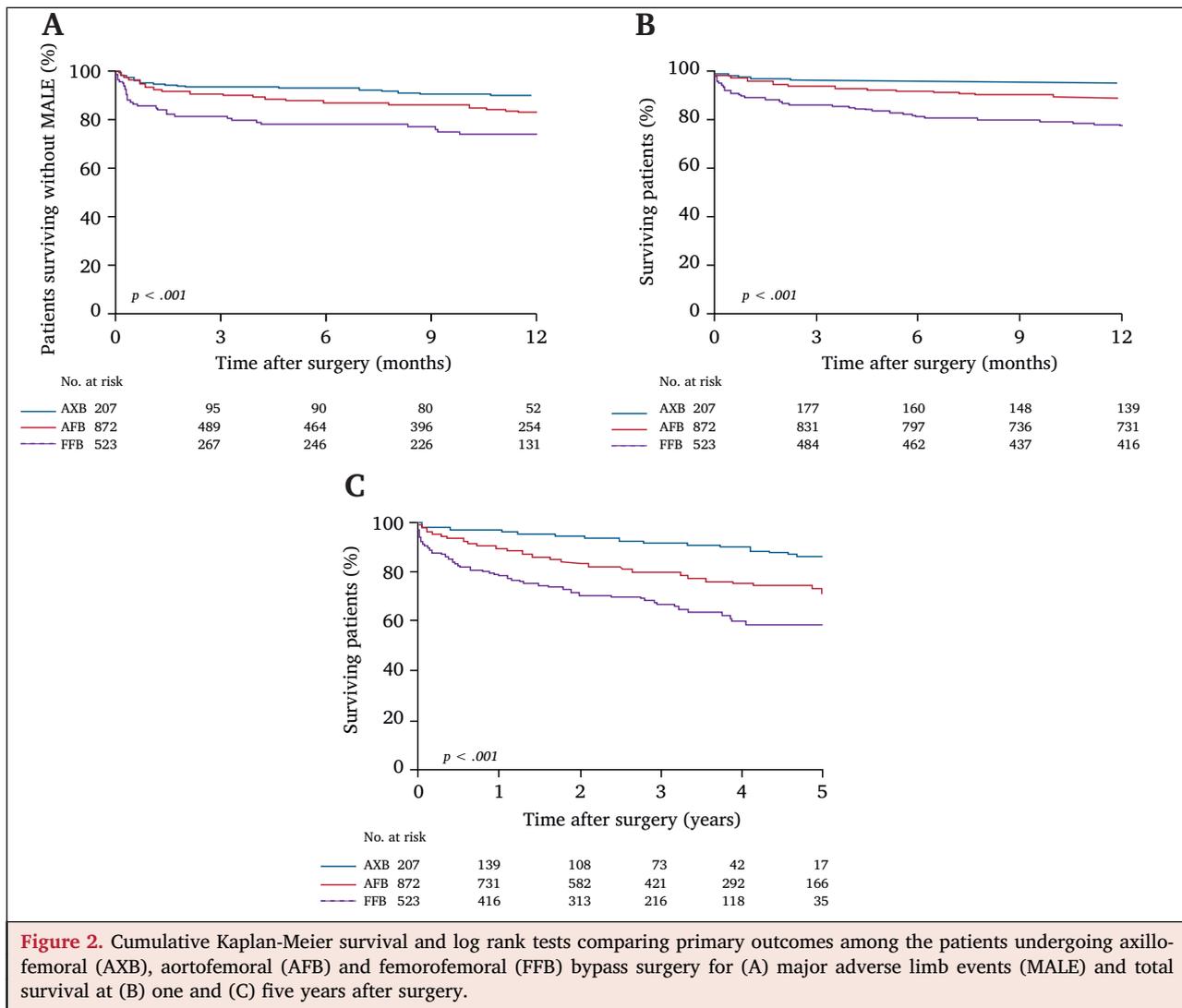
significance as an independent predictor of mortality after one year (HR 3.50; 95% CI 1.65–7.41; $p = .003$) and five years (HR 1.54, 95% CI 1.11–2.14; $p = .009$) follow up (Fig. 3B and C). Late mortality rates did not differ significantly between the AFB and FFB groups.

Urgent and emergency operations were significantly associated with increased risk of one year MALE and mortality at one and five year follow up. History of CHF was an independent predictor of increased risk of one year MALE and death at five years. Baseline CAD was predictive of worse late mortality rates.

DISCUSSION

Using a large, multicentre registry database, the results show that although AXB patients were older with more complicated comorbidities than the other bypass cohorts, their outcomes, even on adjusted analyses, were relatively poor with increased risk of death post-operatively and at one and five year follow up and the worst risk of adverse limb events at one year. AXB was also associated with increased risk of post-operative cardiac and respiratory complications. At the same time, FFB led to significantly lower rates of complications in patients with occlusive disease.

Various options are available for the management and treatment of AIOD. The use of AFB, one of the most widely used surgical reconstructions for more than a quarter of a century, has significantly declined with a concomitant 850% increase in percutaneous angioplasty/stenting.¹ Although endovascular therapy is no longer limited to focal disease, older patients with extensive atherosclerotic disease and those who failed percutaneous interventions would benefit more from open surgery.^{6,7} Because it is unlikely that the different bypass options will be subjected to the rigors of a



randomised trial, this study sought to summarise and compare the risks and outcomes of a family of open suprainguinal bypass procedures.

Current recommendations support AFB as a next step in patients with diffuse disease not amenable to an endovascular approach and in those with associated aneurysmal disease.⁶ Several studies confirmed its superiority as a durable revascularisation intervention with patency rates exceeding 85% at five years.^{12,13} In this study, the majority (54.4%) of the patients with occlusive disease treated by open surgery received AFB. In total, 1.7% of AFB patients died within 30 days. However, according to a recent meta-analysis by Chiu *et al.*,¹³ the overall operative mortality of direct anatomical bypass is higher (4.1%), and systemic morbidity rate may be as high as 16%.

Given the relatively high morbidity rates despite the generally excellent patency results following AFB, caution is necessary with high risk patients.³ AFB patients were relatively young, with a mean age of 59.6 ± 8.5 years, which is consistent with the average age reported in other studies.^{13–15} Overall, AFB patients in this series had the least comorbidities and were less likely to have elevated serum

creatinine. Similar to other studies,^{3,13,16} claudication was the most common indication for AFB, and was elective in 86.8%.

AFB, nevertheless, is not always the surgical operation of choice, especially among high risk patients with multiple comorbidities. Under the special circumstances of extensive occlusive disease with coexisting active infection, a “hostile” abdomen due to multiple prior operations, or other factors precluding both AFB and endovascular therapy, a less invasive, extra-anatomical approach may be indicated. For AIOD, this refers predominantly to FFB, first described by Freeman and Leeds in 1952,¹⁷ and AXB, which was introduced by Blaisdell and Hall,¹⁸ along with Louw *et al.*,¹⁹ in the 1960s.

AXB and FFB patients in this study were older with more comorbidities and a more significant history of previous bypass and aneurysm repair compared with the AFB group. In total, 40.1% of AXB cases were urgent or emergencies. In a study examining the role of AXB in contemporary practice by Nguyen *et al.*, it was found that indications for AXB have changed and it is currently used significantly more for urgent or emergency problems.²⁰

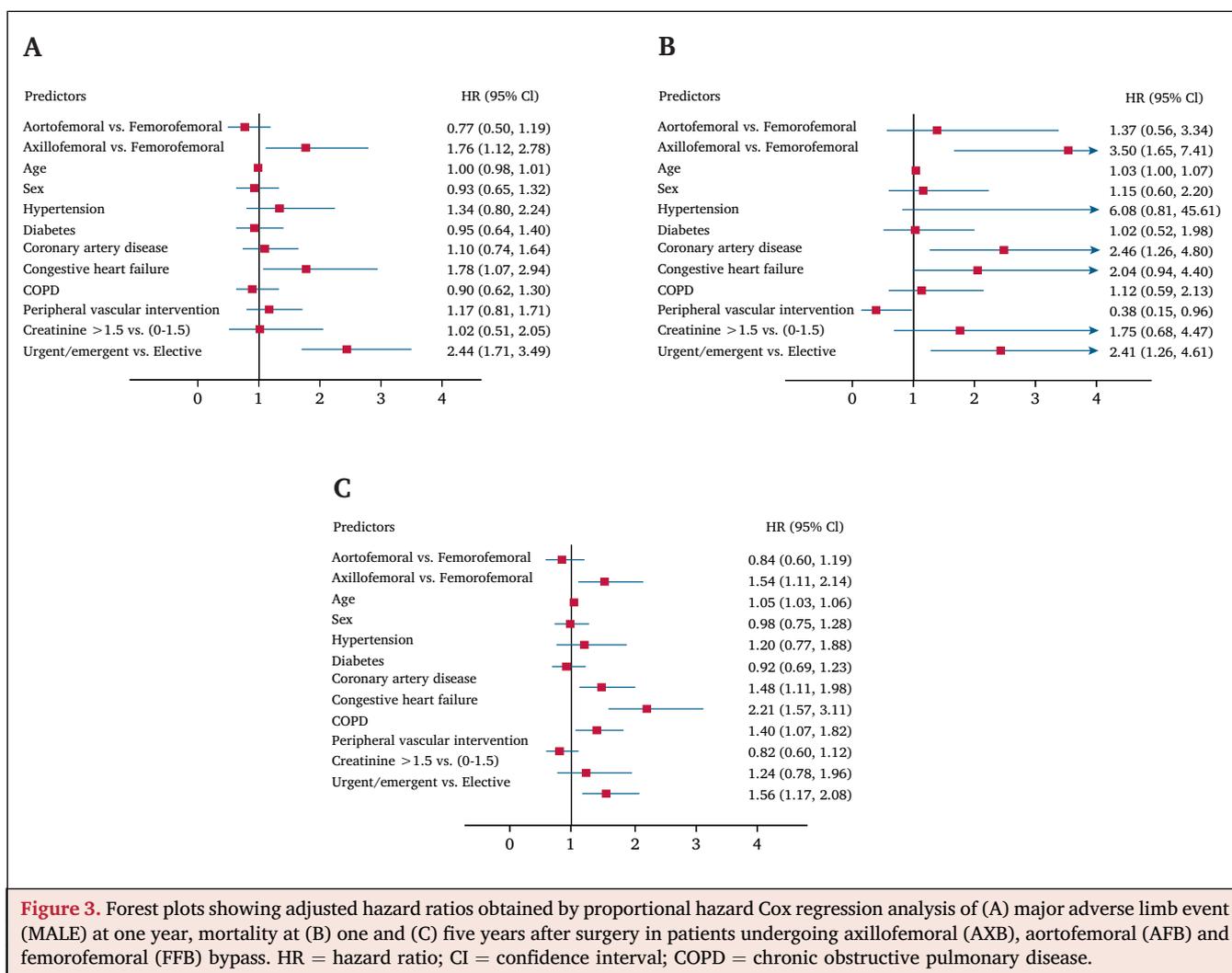


Figure 3. Forest plots showing adjusted hazard ratios obtained by proportional hazard Cox regression analysis of (A) major adverse limb event (MALE) at one year, mortality at (B) one and (C) five years after surgery in patients undergoing axillofemoral (AXB), aortofemoral (AFB) and femorofemoral (FFB) bypass. HR = hazard ratio; CI = confidence interval; COPD = chronic obstructive pulmonary disease.

Comparing the three bypass cohorts, post-operative adverse events occurred most frequently following AXB and least frequently after FFB. Additionally, on multivariable adjusted analyses, only AXB was independently associated with higher operative mortality. In another series by Hertzler *et al.*, the absolute risks of operative mortality were also highest in those who received AXB and in patients aged > 65 years.¹⁶ Although age increased the odds of 30 day POD in this study, the results were not significant (OR 1.04, 95% CI 1.00–1.07; *p* = .058). To account for non-random technical and clinical parameters, McPhee *et al.* used a multi-institutional veteran patient population to compare AFB with alternative inflow procedures, including FFB, AXB, iliofemoral bypass, and femoral reconstruction with iliac stents, in a propensity matched analysis,²¹ which was lacking in the present study. Results showed a trend toward higher 30 day morbidity and in the AFB group but similar rates between the two procedure groups by 90 days.

As with post-operative adverse events, a similar pattern was observed for late survival and major limb events. Lower one and five year survival was independently associated with AXB, as well as age, heart disease, and the urgency of the case. Likewise, the incidence of adverse limb events

after one year was significantly increased following only AXB. Similarly, Harrington *et al.* found low limb salvage rates (74.8%) and even lower rates of survival (39.2%) at five years, and concluded that AXB is a compromised bypass that should be limited to compromised patients.²² Other studies found that while late survival rates were statistically lower, limb salvage rates after AXB did not differ significantly at five years when compared with AFB.^{15,16} Onohara *et al.* found no significant difference for survival at five years between AXB and AFB groups.²³

No significant differences in limb salvage and late survival rates were observed between AFB and FFB patients in this series. Nevertheless, FFB had the lowest mean in hospital stay and the lowest risk of adverse post-operative complications, even after adjusted analyses. In a randomised control trial,¹² limb salvage rates were not significantly different, with a rate of 98.6% for FFB and 98.5% for AFB. However, late patency rates, which were not assessed in this study, were found to be significantly higher after AFB, in agreement with the findings of other studies.^{16,24} However, Mingoli *et al.* found that early and long-term patency results may be similar to those of reconstructions from the aorta if FFB is performed as a

primary operation.²⁵ Thus, FFB may serve as a reasonable option in patients with anatomical constraints that make them ineligible for endovascular therapy and are too high risk with prohibitive peri-operative risks to undergo AFB. Among the sicker patient cohort with bilateral severe iliac disease who are too high risk of AFB, AXB may still serve as the only alternative. A recent study suggested that AXB performed using modern protocols and technology can result in lower morbidity and mortality rates and may render AXB a primary intervention if a direct aortic procedure is too high risk.²⁶

There are several limitations to this study. A major limitation is its retrospective study design with all the inherent selection biases of a retrospective study. The data were obtained from the VSGNE, a prospectively maintained database with possible errors in data entry. Queries of the data represent observations that cannot account for causality, unlike randomised controlled trials. It is difficult to determine with certainty whether a procedure performs poorly owing to the specific indications and type of patients selected, or to the inherently less durable and riskier nature of the procedure. As an observational analysis however, this study can summarise and compare a family of different open bypasses, especially in the light of the difficulties of running prospective controlled trials to establish such comparisons. Although multivariable analyses were made to control for possible confounders, these observational data lacked propensity matched analysis to reduce the bias due to confounding variables found in an estimate of treatment effect obtained by simply comparing outcomes. Moreover, details on the patency of the iliac sector, along with other anatomical differences and clinical findings, which would have allowed for a more accurate comparison of the different surgical procedures for AIOD, are lacking. Nevertheless, in the absence of contemporary studies, this large registry study provides a detailed association of the baseline characteristics of different open supra-inguinal bypasses and head to head comparisons of outcomes, including post-operative morbidity and mortality and long-term limb salvage and survival rates, although patency rates were lacking.

CONCLUSIONS

AFB is the standard open revascularisation operation of choice in low risk patients with extensive lower extremity occlusive disease. While AXB was associated with the worst risks of immediate and long-term adverse outcomes, FFB significantly led to the lowest risks of post-operative complications. In contrast to the study by Samson *et al.*,²⁶ the current results suggest that FFB should serve as the extra-anatomical operation of choice in patients in whom AFB is high risk or likely to be complicated. Given the advances in endovascular therapy that allow for an endovascular recanalisation of completely occluded iliac arteries, perhaps both of these operations are generally the last options to be offered. But, because the results showed that AXB has a significantly higher association with immediate and one

year adverse outcomes than FFB, the study suggests that AXB should preferably be used when no other options appear applicable.

CONFLICT OF INTEREST

None.

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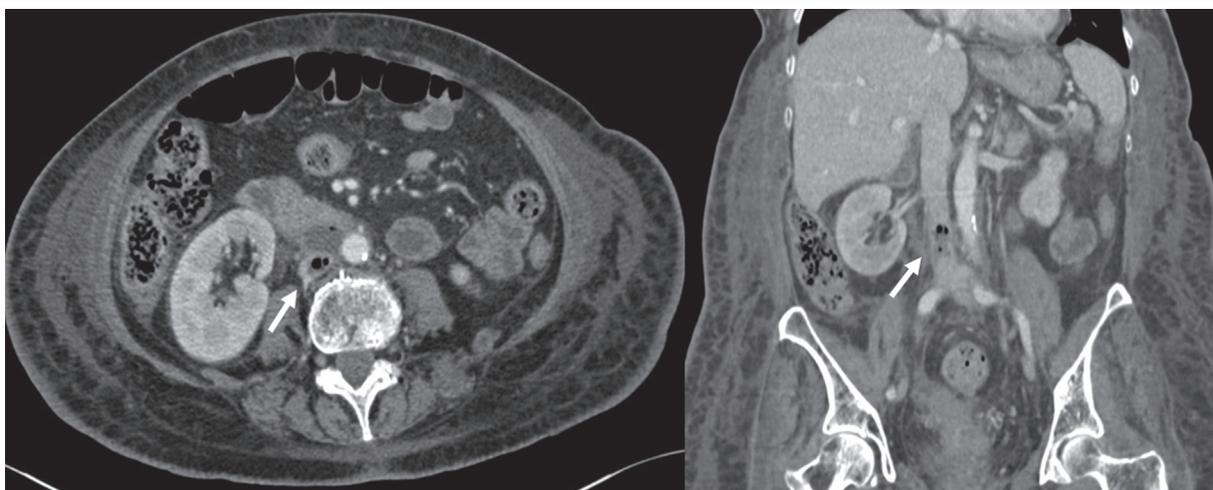
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COUP D'OEIL

Spontaneous Duodenocaval Fistula During Chemo-Radiotherapy

Xavier Tenezaca-Sari*, Marvin García-Reyes

Department of Vascular Surgery, Endovascular Surgery and Angiology, Vall d'Hebron University Hospital, Barcelona, Spain



A 69 year old woman with a diagnosis of advanced cervical squamous cell carcinoma underwent retroperitoneal laparoscopic lymphadenectomy for staging, with a normal post-lymphadenectomy computed tomography (CT) scan. Seven months later while receiving palliative chemo-radiotherapy (bevacizumab), she was admitted with malaise and pancytopenia. In hospital she developed fever, haemodynamic instability, and dyspnoea. Blood cultures revealed *Citrobacter koseri*, and piperacillin-tazobactam was started. CT angiography showed air bubbles surrounded by a thrombus in the inferior vena cava, adjacent to a peri-duodenal collection, indicating a duodenocaval fistula. Her poor prognosis meant that she was considered unfit for surgery and died six weeks later.

* Corresponding author.

E-mail address: axtenezaca@hotmail.com (Xavier Tenezaca-Sari).

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