ANGIOLOGIA E CIRURGIA VASCULAR
PUBLICAÇÃO OFICIAL SPACV

ORIGINAL ARTICLE

Outcomes of bypass versus endovascular procedures in long chronic total occlusions of the superficial femoral artery – a 10-year cohort study

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Submitted: April 22, 2025; **Reviewed:** November 30, 2025; **Accepted:** December 21, 2025
Presented at: Annual Meeting of the Portuguese Society of Angiology and Vascular Surgery, 2025

ABSTRACT

BACKGROUND: With the development of advanced endovascular technologies to treat chronic total occlusions of the superficial femoral artery (SFA-CTO), endovascular procedures have become more common, with supragenicular femoropopliteal artery bypasses reserved for a subset of patients. We aim to compare outcomes of long SFA-CTOs treated with surgical bypass versus endovascular procedures.

METHODS: Single-centre retrospective cohort study in a tertiary centre including all patients with SFA-CTOs (femoropopliteal GLASS grade 4/TASC-II D) submitted to a supragenicular femoropopliteal artery bypass (OR group) or endovascular revascularisation procedure (EVT group) from February 2015 to January 2025. Patients undergoing revascularisation of other anatomical sectors were excluded. Baseline characteristics, peri-procedural and follow-up data were obtained. The primary endpoint is major adverse limb events (MALE). The secondary endpoints are MALE-free survival, reintervention rates, amputation rates, and mortality rates.

RESULTS: 119 patients were included (71 in the OR group vs. 48 in the EVT group). Eighty-six per cent (N=61) of the OR group received a prosthetic conduit. Median age was 68 years (IQR 63-74), and 75 patients (63%) had chronic limb-threatening ischemia. The median hospital stay was shorter in the EVT group (2 vs. 9 days; p<.001). Other characteristics, such as age, risk factors, and Leriche-Fontaine classification, did not differ between groups. During a median follow-up period of 51 months (IQR 26-78), MALE were higher in the OR group (44% vs. 25% – p=.038) despite no significant differences in MALE-free survival. A higher rate of reintervention was also found in the OR group (39% vs. 21%, p=.033). There were no significant differences in amputation or mortality rates between groups.

CONCLUSION: Patients with long SFA-CTOs had similar rates of limb salvage and mortality after bypass or endovascular interventions. Despite similar comorbidity burdens in both groups, MALE and reintervention rates were higher after bypass, suggesting an endovascular-first approach.

Keywords: Peripheral artery disease; femoropopliteal disease; chronic total occlusion; superficial femoral artery; open surgery; endovascular treatment

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Angiol Vasc Surg 2025;21(3):129-34
DOI: https://doi.org/10.48750/acv669

INTRODUCTION

Superficial femoral artery (SFA) disease accounts for an important proportion of peripheral artery disease (PAD) cases, with 40% of symptomatic patients having a chronic total occlusion (CTO).[1] According to the TransAtlantic Inter-Society Consensus for the Management of Peripheral Arterial Disease II (TASC II), SFA-CTOs are best approached with surgical revascularisation with bypass surgery, particularly in low comorbidity patients with an available autologous conduit.[2]

However, modern advancements in endovascular technologies and increasing practice of surgeons have allowed for a gradual rise in endovascular procedures in these cases, with a favourable technical success rate and clinical results and lower periprocedural morbidity and hospital stay, thus reserving femoro-supragenicular popliteal artery bypasses for a specific reduced subset of low-risk patients[1,3-5] The aim of this study is to compare outcomes of long SFA-CTOs treated with bypass surgery versus endovascular procedures.

METHODS

A retrospective single-centre cohort study of a prospectively maintained database from a tertiary Vascular Surgery institution was conducted over a 10-year period, from February 2015 to January 2025.

Study population

One hundred and nineteen patients (resulting in one hundred and nineteen operated limbs) with long SFA-CTOs (total extension of occlusion >20cm), classified as femoropopliteal GLASS grade 4 and TASC II D, who were submitted to a primary revascularisation procedure for chronic limb ischemia (CLI) from February 2015 to January 2025, were included.

Patients underwent either supragenicular femoro-popliteal artery bypass (OR group) or endovascular surgery (EVT group). The decision to perform open or endovascular surgery for each patient was based on the patient's surgical risk (age and comorbidities) and the surgeon's preference. Patients who underwent revascularisation of other anatomical sectors (aortoiliac, popliteal, or tibioperoneal) or who had a previous revascularisation procedure were excluded from this study.

Data collection

Institutional medical record review was performed, and baseline characteristics, clinical presentation, and peri-procedural and follow-up data were obtained. Reintervention was defined as a subsequent vascular revascularisation procedure performed on the same limb due to clinically driven restenosis/occlusion associated with recurrence/maintenance of symptoms of CLI. Additionally, in the OR group, subsequent procedures for ultrasound-detected vein graft lesions in asymptomatic patients to maintain graft patency, according to the ESVS Global Vascular Guidelines on the Management of Chronic Limb-Threatening Ischaemia[6] were also included as reinterventions.

In our institution, follow-up after an endovascular procedure is clinical except in cases of failure to improve or recurrence of symptoms, when a duplex ultrasound is performed.

Major amputation was defined as a transfemoral or transtibial amputation.

Endpoints

The primary endpoint is major adverse limb events (MALE). The secondary endpoints are MALE-free survival, reintervention rates, amputation rates, and mortality rates.

Statistical analysis

Descriptive statistics were used to report data. Continuous data were presented as mean ± standard deviation or as median (interquartile range). Kolmogorov-Smirnov and Shapiro-Wilk tests were used to assess the normal distribution of data, and t-test or Mann–Whitney U statistics were used, respectively, to compare continuous Gaussian and non-Gaussian data.

Dichotomous variables are expressed as counts (percentages) and compared between groups using Pearson's chi-square test. Survival curves for endpoints were estimated by Kaplan–Meier plots, and equality between groups was evaluated with the Mantel-Cox log-rank test.

All statistical tests were two-sided and considered statistically significant when the p-value was <0.05 All analyses were performed using IBM SPSS Statistics version 29.0 software.

RESULTS

One hundred and nineteen patients were included in this study, 71 in the OR group and 48 in the EVT group. Eighty-six per cent (N=61) of the OR group received a prosthetic bypass.

Median age was 68 years (IQR 63-74), 100 patients (84%) were male, and 75 (63%) had chronic limb-threatening ischemia (CLTI).

Baseline characteristics are depicted in Table 1. Men most commonly underwent bypass surgery (64%), whereas women were most frequently submitted to an endovascular procedure (63%), p = 0.027.

Other characteristics, such as age, cardiovascular risk factors, and Fontaine classification, did not differ between groups.

As for periprocedural details, patients in the OR group mostly underwent prosthetic graft bypasses (61 patients, 86%), whereas in the EVT group, stenting was the most common definitive treatment (28 patients, 58%). The median duration of hospital stay was lower in the EVT group (2 vs. 9 days – p < 0.001) – Table 2.

Table 1. Baseline characteristics of patients with long SFA-CTOs who underwent a revascularisation procedure, per group.

Baseline characteristics	**OR group (n=71)**	**EVT group (n=48)**	***p*-value**
Female – n (%)	7 (10)	12 (25)	0.027
Age (years) – median (IQR)	68 (63-74)	71 (62-75)	0.219
Hypertension – n (%)	56 (79)	37 (77)	0.817
Diabetes – n (%)	38 (54)	27 (56)	0.769
Hypercholesterolaemia – n (%)	42 (59)	25 (52)	0.445
Ischaemic heart disease – n (%)	21 (30)	17 (35)	0.503
Prior cerebrovascular event – n (%)	11 (16)	7 (15)	0.892
CKD under dialysis – n (%)	4 (6)	5 (10)	0.333
Smoking (prior or active) – n (%)	28 (39)	18 (38)	0.831
Fontaine classification:			
- Grade IIb – n (%)	25 (35)	19 (40)	0.628
- Grade III – n (%)	15 (21)	4 (8)	0.062
- Grade IV – n (%)	31 (44)	25 (52)	0.291

OR: Open revascularisation; **EVT:** Endovascular therapy; **CKD:** chronic kidney disease; **IQR:** interquartile range

Table 2. Periprocedural characteristics of patients with long SFA-CTOs who underwent a revascularisation procedure, per group.

Periprocedural characteristics	**OR group (n=71)**	**EVT group (n=48)**	***p*-value**
Conduit for bypass:			
- Prosthetic graft – n (%)	61(86)		
- Vein graft – n (%)	10 (14)		
Definitive endovascular treatment:			
- Plain balloon angioplasty alone – n (%)		8 (17)	
- Drug-coated ballooning – n (%)		12 (25)	
- Stenting (bare metal, drug-elluting) – n (%)		28 (58)	
Duration of hospital stay (days) – median (IQR)	9 (6-18)	2 (2-13)	<0.001
Follow-up period (months) – median (IQR)	60 (29-84)	45 (19-74)	0.339

OR: Open revascularisation; **EVT:** Endovascular therapy; **IQR:** interquartile range

The median follow-up period was not statistically different between the groups (60 months in the OR group versus 45 months in the EVT group; p = 0.339). Patients in the OR group had a higher rate of MALE (44% vs. 25%, p = 0.038) despite non-statistically significant differences in MALE-free survival. Likewise, a higher reintervention rate was observed in the OR group (39% vs. 21%, p = 0.033), and this was associated with a higher reintervention-free survival in the EVT group (42 vs. 30 months, p=0.049). No differences were found in amputation or mortality rates, amputation-free survival or survival in general, Table 3, Figures 1 and 2. A detailed list of reinterventions per group is depicted in Table 4.

Table 3. Outcomes for patients with long SFA-CTOs who underwent a revascularisation procedure, per group..

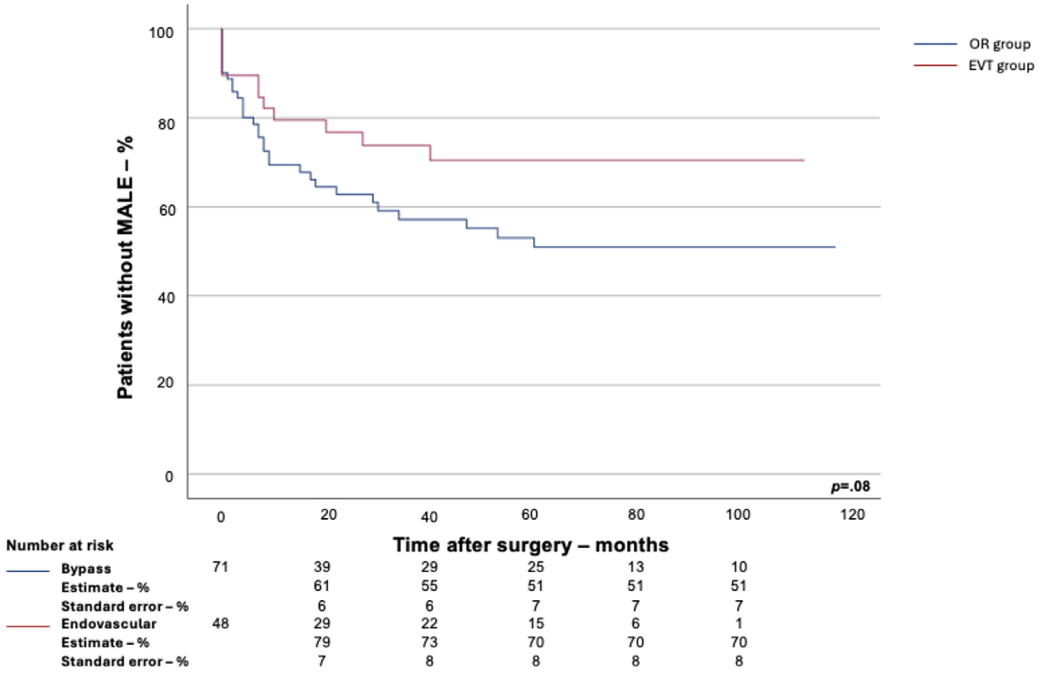
Outcomes	OR group (n=71)	EVT group (n=48)	*p*-value
MALE – n (%) MALE-free survival in months – median (IQR)	31 (44) 26 (6-75)	12 (25) 33 (6-72)	**0.038** 0.08
Reintervention – n (%) Reintervention-free survival in months – median (IQR)	28 (39) 30 (7-75)	10 (21) 42 (8-75)	**0.033** **0.049**
Amputation – n (%) Amputation-free survival in months – median (IQR)	12 (17) 55 (23-80)	4 (8) 56 (14-76)	0.179 0.217
Mortality – n (%) Survival in months – median (IQR)	28 (39) 59 (29-84)	14 (29) 45 (19-74)	0.250 0.796

MALE: Major adverse limb events; **IQR:** interquartile range

Table 4. Reinterventions in patients with long SFA-CTOs who underwent a revascularisation procedure, per group.

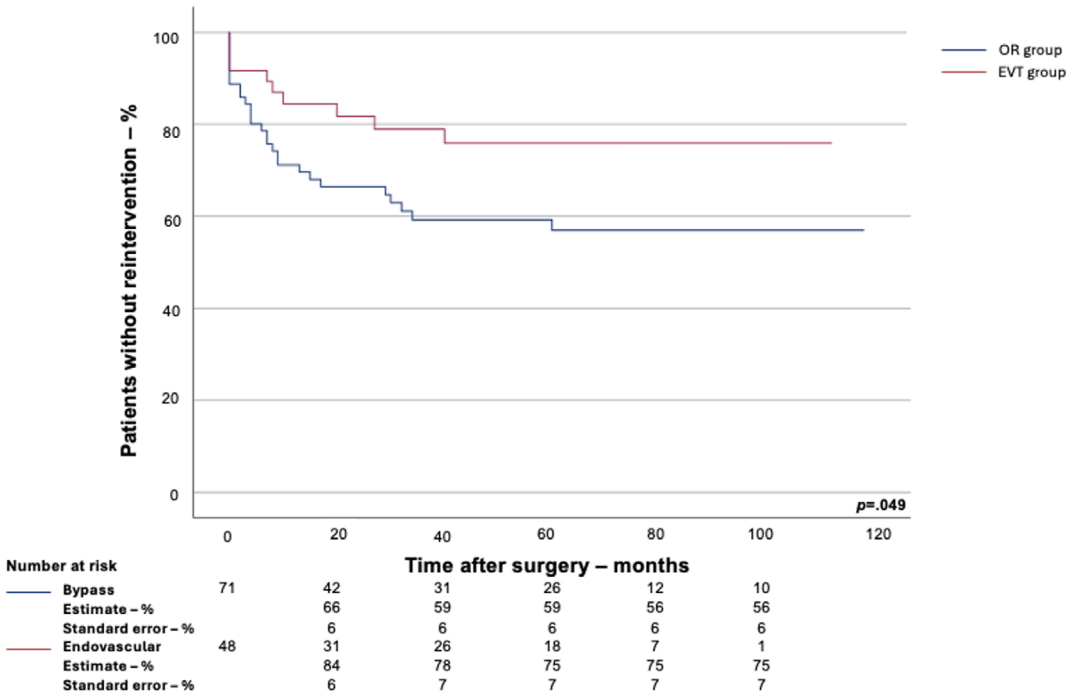
OR group (n=71)		EVT group (n=48)	
Reinterventions (n=28)	**n (%)**	**Reinterventions (n=10)**	**n (%)**
Endovascular revascularization	10 (36)	Endovascular revascularization	4 (40)
New bypass surgery	6 (22)	Catheter-directed intra-arterial thrombolysis	2 (20)
Surgical thrombectomy	4 (14)	Bypass surgery	2 (20)
Jump graft to previous bypass	4 (14)	Hybrid treatment (surgical thrombectomy + endovascular revascularization)	2 (20)
Hybrid treatment (surgical thrombectomy + endovascular revascularization)	4 (14)		

Figure 1. Cumulative Kaplan-Meier estimate of freedom from MALE in patients with long SFA-CTOs who underwent a revascularisation procedure, per group.



OR: open revascularisation; **EVT:** endovascular treatment; **MALE:** Major adverse limb events

Figure 2. Cumulative Kaplan-Meier estimate of freedom from reintervention in patients who underwent bypass and endovascular procedures.



OR: open revascularisation; **EVT:** endovascular treatment;

DISCUSSION

Developments in endovascular devices have revolutionised PAD treatment over the last few decades. The high surgical risk due to significant cardiovascular disease that accompanies patients with PAD has called for more minimally invasive therapeutic measures with adequate short and long-term outcomes. Nonetheless, surgical bypass remains the recommended treatment for low-risk patients with TASC II C and D lesions, although these recommendations are mostly based on historical studies when endovascular treatment of long SFA occlusions was not on par with the current state-of-the-art.[2]

In our population, most bypass procedures were performed with a prosthetic graft (86%) due to a lack of adequate venous conduit or surgeon preference. Despite initial studies showing similar patency rates between ePTFE and vein conduits at this location, subsequent reports showed better long-term patency of vein bypasses, particularly in patients with chronic limb-threatening ischemia, which may have biased our results in the OR group.[5]

Regarding definitive treatment of patients undergoing an endovascular procedure, most patients (58%) underwent SFA stenting. In our institution, stenting in the femoropopliteal segment is performed in cases of failure of plain balloon angioplasty, defined by severe elastic recoil, flow-limiting dissection, or residual stenosis >30%. A retrospective study by Dosluoglu et al. compared stenting vs supragenicular ePTFE bypass in femoropopliteal TASC II D patients and reported lower 2-year assisted-primary patency in the stenting group but no significant differences in secondary patency rates between both groups, concluding that stenting may be a safe first choice in high-risk CLTI patients.[5]

Cardiovascular risk factors were similar between the OR and EVT groups, suggesting a similar surgical risk between groups in this study. The majority of patients were male and had hypertension, diabetes and dyslipidemia, which is the norm in most PAD studies.[3-7] A shorter hospital stay was observed in patients undergoing endovascular treatment, largely due to the less invasive nature of these procedures, which may also support an endovascular approach in higher-risk patients.

In this study, bypass surgery was associated with a higher rate of MALE (44%) when compared to endovascular treatment (25%) in long SFA-CTOs without concomitant popliteal artery disease. Likewise, a higher rate of reintervention (39%) and lower reintervention-free survival was also found in the OR group. Previous literature differs in these outcomes. A study by Veraldi et al. involving 80 limbs reports a 20% reintervention rate in the bypass group versus 45% in the endovascular group (p = 0.03), with higher freedom from reintervention in the bypass group.[9] Contrastingly, a study by Korhonen et al. described a similar rate of freedom from reintervention between groups.[8] On the other hand, we found similar rates of short and long-term limb salvage and freedom from amputation in both groups, which is similar to most previous retrospective studies,[3-5,7], despite a propensity score analysis showing more favourable results for bypass surgery.[6]

We believe there are several reasons for our higher rate of MALE and reintervention in bypass surgery. Firstly, the supragenicular popliteal artery is commonly affected by PAD, which may challenge surgical anastomosis and lead to technical defects; this is not an issue in endovascular treatment. Furthermore, PAD progression may compromise outflow in bypass grafts in the long term, with greater consequences that require reintervention when compared to PAD progression after endovascular treatment. We also believe that our longstanding and evolving practice in endovascular PAD treatment, including the development of lesion-crossing, vessel-preparation, and definitive techniques, enables us to achieve satisfactory results in the endovascular treatment of long SFA-CTOs. Lastly, in this study, ultrasound-based asymptomatic graft revisions were performed to maintain graft patency, according to ESVS Global Vascular Guidelines on the Management of Chronic Limb-Threatening Ischemia,[6] which is associated with a higher number of reinterventions and MALE in the OR group and may hinder results.

Likewise, mortality rates did not differ between groups, as in previous studies.[4,9] There are no randomised controlled trials comparing surgical bypass with endovascular treatment in patients with SFA disease alone. However, a third of patients in the surgery arm of the BASIL trial underwent an above-knee anastomosis. Although angioplasty-first patients showed an initial short-term benefit, long-term results at 2 years indicate lower amputation and mortality rates.[10] Nevertheless, these findings should be considered in light of data collected over 20 years ago, when endovascular treatment was less advanced than it is today. The BASIL-2 trial, however, focuses on patients requiring an infra-popliteal procedure. In this study, the bypass group had higher rates of major amputation and all-cause mortality, with no significant differences in MALE, which may point to a benefit of an endovascular-first approach for these patients.[11] In our view, if carefully performed, long SFA-CTO endovascular treatment is safe and feasible and does not compromise subsequent bypass surgery.

This study has certain limitations. Firstly, it is a single-centre retrospective study, which is associated with inescapable biases. Secondly, results were based on a heterogeneous, small population, which interfered with the ability to both stratify results into smaller groups and draw solid statistical conclusions, thereby underpowering this study. Furthermore, patency rates are unavailable because there is no ultrasound-based follow-up protocol after endovascular procedures at our institution. Likewise, the post-operative therapeutic regimen – namely antithrombotics, statins, and general cardiovascular risk factor control – was heterogeneous across both groups and over the 10-year follow-up period, with significant missing data, so it is not described in this study despite its significance to the results.

CONCLUSION

In this single-centre retrospective study, patients with long SFA-CTOs had similar rates of limb salvage and mortality after bypass or endovascular interventions. However, despite similar comorbidity burdens in both groups, MALE and reintervention rates were higher after bypass, suggesting that an endovascular-first approach for these lesions is safe and adequate. Further current studies, particularly randomised controlled trials, are needed in order to outline the best initial approach for these patients.

Acknowledgements: None

Conflicts of interest: None

Funding: None

Data availability: By request to authors

Ethics Approval: Not applicable

Informed Consent: No written informed consent was required due to the study design

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process: AI-assisted translation to British English language was utilised. No AI generative technology was applied in the writing or editing of scientific content.

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