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Retrograde Angioplasty: A Simple Bailout Technique for Failed Antegrade Crossing of Femoropopliteal and Tibial Lesions

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ABSTRACT
Background: Endovascular revascularization is the preferred treatment for chronic limb-threatening ischemia (CLTI). However, standard antegrade approaches often fail in complex infragenicular occlusions. Retrograde tibial artery access has emerged as a viable alternative, offering improved technical success rates and procedural feasibility.
Objective: This study aimed to evaluate the feasibility, safety, and early outcomes of retrograde ankle tibial artery access in patients with below-the-knee CLTI who failed conventional antegrade recanalization.
Patients and methods: This prospective study included 19 patients (and 68% were males) with a mean age of 71.3 ± 11.8 years with Rutherford class 4–5 CLTI who underwent endovascular recanalization via retrograde tibial access after failed antegrade attempts. Technical success, procedural complications, and six-month outcomes, including patency and limb salvage, were assessed.
Results: Retrograde tibial access was successfully established in 18 patients (95%), with lesion crossing and revascularization achieved in 16 (84%). The six-month primary and secondary patency rates were 68% and 89%, respectively. Amputation-free survival at six months was 79%, with major amputations required in three cases (16%). Retrograde access-related complications occurred in four patients (21%) but were minor and managed conservatively. No procedure-related mortality was reported.
Conclusion: Retrograde tibial artery access is a safe and effective bailout strategy for failed antegrade revascularization in CLTI patients, demonstrating high technical success and acceptable long-term patency. This approach may serve as a valuable alternative to more complex techniques in challenging infragenicular occlusions.
Keywords: Retrograde angioplasty, Chronic limb-threatening ischemia, Tibial artery access, Endovascular revascularization, Critical limb ischemia.

INTRODUCTION
Critical limb ischemia (CLI) represents an advanced and severe manifestation of peripheral arterial occlusive disease (PAD), necessitating timely intervention to mitigate the risks of limb loss and associated complications.

The global incidence of lower limb ischemia is projected to rise considerably, largely driven by an aging population, the increasing prevalence of diabetes mellitus, and ongoing challenges in curbing tobacco use [1, 2]. Patients with PAD frequently present with concurrent coronary artery disease, visceral ischemia, and cerebrovascular impairment, collectively classified as multisystem arterial disease (MSAD). Although, only a minority of these patients ultimately require surgical or endovascular revascularization, evidence suggests that symptomatic PAD is associated with a significant mortality risk approximately 30% within five years, primarily due to myocardial infarction or stroke [3].

Endovascular therapy has become a cornerstone in CLI management. However, its success is often hindered by extensive multilevel arterial involvement, complex and long-segment occlusive lesions, and tibial vessel disease, all of which pose technical challenges. To address these difficulties, various interventional strategies have been developed to enhance procedural success and optimize clinical outcomes [4].

Over the past two decades, the prevalence of PAD, particularly its most advanced stage, chronic limb-threatening ischemia (CLTI) has risen markedly, affecting an estimated 200 million people worldwide. Among these patients, the rate of amputation ranges from 15% to 20% within a year of diagnosis [5].

Recanalizing complex infrainguinal arterial occlusions remains technically demanding, with standard antegrade techniques failing in up to 30% of chronic total occlusion (CTO) cases [6]. As a result, retrograde endovascular intervention via popliteal or tibial access has gained recognition as a viable alternative, particularly in patients for whom antegrade approaches are unsuccessful [7].

Retrograde tibial access was first introduced by Iyer in 1990, with the first reported cases detailing successful recanalization of an occluded posterior tibial artery (PTA) using a surgical cut-down technique at the ankle [8]. Among the tibial arteries, the dorsalis pedis and posterior tibial arteries are the most accessible for retrograde percutaneous puncture at the foot or ankle. In

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contrast, the peroneal artery is more challenging to access due to its deep anatomical location, making puncture and subsequent hemostasis more difficult [7]. The retrograde technique presents several advantages over the conventional antegrade approach, which contribute to its higher success rates:

1. The distal cap of a CTO tends to be less fibrotic and more compliant than its proximal counterpart, facilitating easier wire crossing when accessed retrogradely [7].
2. The closer proximity of the access site to the lesion enhances wire pushability and maneuverability, allowing more controlled navigation through the occlusion [9].
3. Unlike antegrade approaches, which are prone to wire deviation into collateral branches, the retrograde method maintains a more direct path within the primary vessel, as collateral vessels typically extend in the opposite direction [10].

Hence, this study aimed to evaluate the feasibility, safety, and early outcomes of retrograde ankle tibial artery access in patients with below-the-knee CLTI who failed conventional antegrade recanalization.

PATIENTS AND METHODS

Study design and population: This study was conducted on 19 patients who underwent endovascular treatment for CLI at Mataria Teaching Hospital and Nasser Institute.

Inclusion criteria: Patients were included in the study based on the presence of angiographically confirmed CTO lesions involving the distal popliteal and/or infrapopliteal arterial segment, with at least one tibial artery providing adequate runoff at the ankle. Only patients who provided informed consent and had failed conventional antegrade recanalization, necessitating a retrograde approach, were enrolled. The study population consisted of individuals diagnosed with CLTI, presenting either with rest pain, classified as Rutherford class 4, or with tissue loss, classified as Rutherford class 5. The severity of ischemia was classified using the Rutherford classification system [11]. Although, this classification remains the standard, it requires refinement for CLI patients, as category 5 incorporates a broad spectrum of foot lesions.

Exclusion criteria: Patients with a history of previous infrainguinal arterial surgery and arteritis, or acute limb ischemia. Cases with prior limb amputation and asymptomatic chronic ischemia or those classified as claudicants. Patients without adequate distal runoff as assessed by duplex ultrasound or angiography either preoperatively or intraoperatively. Additionally, those presenting with Rutherford grade 6 ischemia or life-threatening infections necessitating primary major amputation. Bedridden patients and those who refused consent.

Data collection and preoperative assessment: The demographic and clinical characteristics of all patients were recorded including age, sex, weight, and body mass index (BMI). The presence of comorbid conditions such as diabetes mellitus (DM), coronary artery disease (CAD), chronic obstructive pulmonary disease (COPD), chronic renal insufficiency (CRI), and hyperlipidemia was documented.

Each patient underwent a comprehensive medical history assessment, which included evaluation of presenting symptoms, indications for the procedure, past medical and surgical history, a list of current medications, history of allergies, and identification of vascular risk factors for atherosclerosis. A detailed physical examination was performed, including vascular assessment through palpation of peripheral pulses and evaluation of capillary refill time. The ankle-brachial index (ABI) was measured as a hemodynamic indicator. The skin was examined for temperature, color changes, and ulceration, while a neurological examination was conducted to assess sensation and muscle strength. A general examination was also performed to identify any systemic illnesses that could impact procedural outcomes.

Investigations: Preoperative laboratory testing included a complete blood count with platelet count, blood glucose levels, renal function tests, liver function tests, and a coagulation profile. Radiological investigations were performed to assess vascular anatomy and plan the intervention. Duplex ultrasound was used to evaluate the arterial tree, including inflow and runoff segments. Computed tomography angiography (CTA) was performed for detailed visualization of arterial occlusions and collateral circulation.

Retrograde approach techniques: The procedure was performed in an angiographic suite or an operating room equipped with a C-arm fluoroscopy system. The puncture site was prepared with an antiseptic solution, and the patient was draped under sterile conditions. Local anesthesia was administered before the procedure. In all cases, retrograde access was attempted only after the failure of an antegrade approach to cross the CTO. Patients initially underwent an antegrade approach using a 6-Fr ipsilateral or contralateral sheath, or a left brachial approach with a 6-Fr, 90-cm long sheath. Once the sheath was in place, unfractionated heparin (UFH) was administered intravenously at a dose of 5000 U, with an additional 1000 U given every hour for interventions lasting more than one hour. For pedal artery access, if the anterior tibial artery (ATA) was the target vessel, the C-arm was positioned in an anteroposterior and cranial view. For the posterior tibial artery (PTA), a lateral view was used for needle alignment. After puncturing the tibial artery, a sheath wire was inserted, followed by a dilator to facilitate passage through the subcutaneous tissue. In deeper arteries, the wire was exchanged, and a sheathless technique was used by advancing the balloon over the wire.

Tibial arterial puncture at the ankle was performed in seven patients via the PTA, in ten patients via the ATA, and in two patients via both arteries. All tibial punctures were performed under fluoroscopic guidance with roadmap imaging and Duplex ultrasound. Following successful arterial puncture, retrograde wire advancement was achieved using a 0.035-inch hydrophilic Terumo™ wire in 13 patients, while a 0.018-inch floppy tip wire (V-18™) was used in the remaining six patients **(**Figure 1).

The lesion was crossed in all patients using a percutaneous sheath in eight cases, while a sheathless wire passage was performed in 11 cases. Among those with sheathless passage, six patients had a guiding catheter for support, while five patients had a low-profile balloon for wire advancement.

Figure (1): Retrograde PTA access.

Wire retrieval through the antegrade sheath was achieved in 15 patients by engaging the wire with an antegrade Bernstein catheter, while in four cases, the wire was retrieved directly through the sheath opening (Figure 2). Following successful CTO dilation, the femoral sheath remained in place, and hemostasis at the tibial artery puncture site was achieved by inflating a balloon for five minutes, combined with external compression.

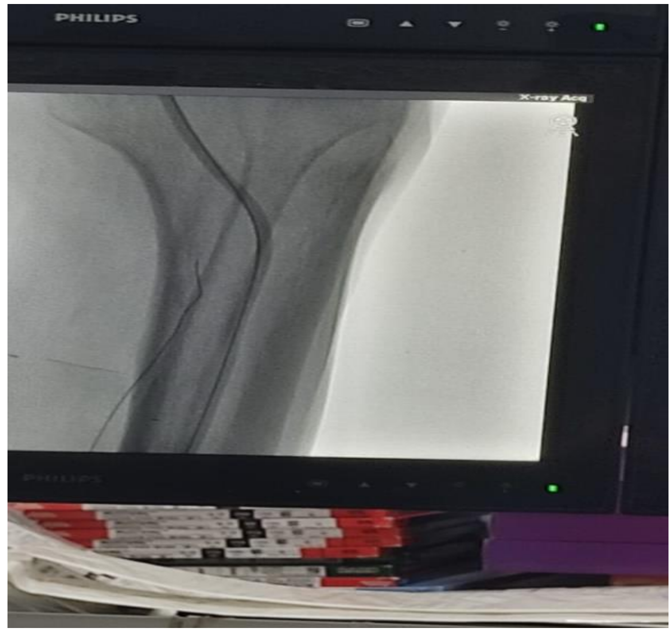

Figure (2): Retrograde wire passage.

If lesion crossing was unsuccessful through the retrograde approach, a "double-balloon" technique was employed. In this method, two balloons, one positioned antegradely and the other retrogradely, were simultaneously inflated within the occlusion. The balloons were placed 5 mm apart without overlap, and after wire withdrawal, they were inflated briefly to disrupt the dissection membrane. The balloons were then retracted by a few centimeters, allowing for another attempt to pass the wire in both directions.

Transluminal angioplasty was performed through antegrade ballooning without stenting. Nitroglycerin (200 µg) was administered antegradely to prevent vasospasm in the retrograde approach. Diluted nitroglycerin was injected through the angioplasty balloon lumen to minimize arterial spasm. Conventional angiography was performed at the end of the procedure to confirm technical success. Following the intervention, dual antiplatelet therapy was initiated, consisting of aspirin (150 mg/day) and cilostazol (100 mg twice daily) for three months, followed by lifelong aspirin monotherapy. Duplex ultrasound was performed on the first post-procedure day to assess vessel patency and detect any complications at the puncture sites. Clinical follow-up was conducted monthly for at least three months, with additional follow-up at six months and one year to evaluate outcomes and complications.

Technical success and procedural outcomes: Technical success of the retrograde approach was defined as successful distal access acquisition, intraluminal wire insertion, and the delivery of adjunctive therapy, leading to vessel patency with residual stenosis of less than 30%. Procedural success was determined based on technical success and the completion of the intervention without significant complications.

Major adverse events were classified as perioperative death within 30 days and major amputation, or the need for repeat revascularization. Complications were categorized based on severity. Mild complications were those that resolved spontaneously or required minimal intervention, without prolonging hospital stay or causing permanent disability. Moderate complications necessitated significant medical intervention, extended hospitalization beyond 24 hours, or resulted in minor amputations or disabilities that did not interfere with daily activities. Severe complications were defined as those requiring major surgical, medical, or endovascular interventions, leading to prolonged recovery, major amputation, permanent disability, or death [12].

Ethical considerations: The study was done after being accepted by The Research Ethics Committees, Mataria Teaching Hospital and Nasser Institute. All patients provided written informed consents prior to their enrolment. The consent form explicitly outlined their agreement to participate in the study and for the publication of data, ensuring protection of their confidentiality and privacy. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical Analysis

Data analysis was performed using SPSS version 26 (IBM Inc., Chicago, IL, USA). The Shapiro-Wilk test and histogram analysis were used to assess the normality of data distribution. Parametric quantitative data were expressed as mean and standard deviation (SD), while non-parametric quantitative data were presented as median and interquartile range (IQR). Qualitative variables were summarized as frequencies and percentages.

RESULTS

Among the 19 patients included in the study, 13 were male and six were females. The mean age was 71.3 ± 11.8 years. The baseline characteristics of the patients who underwent the procedure are summarized in table (1). During the study period, from October 2023 to April 2024, all 19 patients underwent endovascular treatment for popliteal and infrapopliteal-tibial occlusions using retrograde tibial access after a failed antegrade approach. The prevalence of diabetes mellitus, hypertension, and smoking among the study population was 68%, 32%, and 63%, respectively. The most common clinical presentation was rest pain, classified as Rutherford category 4, which was observed in 12 patients (63%). The remaining seven patients (37%) had Rutherford category 5 disease, presenting with tissue loss. The target for CTO recanalization was the posterior tibial artery in nine patients (47%), the anterior tibial artery in seven patients (37%), and both arteries in three patients (16%) (Table 1). Retrograde access was performed under angiographic guidance in six cases (32%) and under duplex ultrasound guidance in 13 cases (68%) (Figure 3). Retrograde access was successfully established in 18 cases (95%), while one patient required operative arterial exposure. The use of the retrograde approach facilitated successful CTO lesion crossing and delivery of adjunctive therapy. In 11 cases (58%), the procedure was completed using a sheathless approach, whereas in eight cases (42%), a 4-Fr sheath was inserted to enhance wire pushability or accommodate larger-profile catheters or re-entry devices. In 17 cases (89%), retrograde access was used exclusively for lesion crossing, with definitive therapy delivered from an antegrade approach.

Figure (3): Retrograde ultrasound-guided PTA puncture.

Following device removal, a 4-Fr sheath was provisionally introduced in some cases to achieve intraprocedural hemostasis. Popliteal and tibial occlusions were successfully crossed via the retrograde approach in 18 cases (95%), with an intimal approach performed in 15 cases (79%). The mean time from puncture to retrograde crossing was 25 minutes, and technical success was achieved in 95% of cases. The average time required to achieve hemostasis was 15 minutes. A final angiogram confirmed complete hemostasis at the puncture site in all cases. Acute vascular access site complications (VASCs) occurring within 30 days were observed in four patients. One patient developed a small puncture site hematoma, which resolved spontaneously. Another patient developed a pseudoaneurysm that required prolonged ultrasound-guided compression. Additionally, two cases of dissection (10%) occurred following the endovascular intervention, necessitating additional endovascular treatment during the same procedure. None of these complications prolonged hospital stay. Procedural success was achieved in 16 cases (84%). The 30-day amputation-free survival rate was 89%, while the six-month amputation-free survival rate was 79% (Table 2).

Outcomes and complications: During follow-up after successful retrograde tibial angioplasty, one patient (5%) died due to myocardial infarction, and three patients (16%) underwent major amputations within six months, including two below-the-knee amputations and one above-the-knee amputation. The six-month primary patency rate was 68%, with reocclusion observed in five patients, as confirmed by Duplex ultrasound follow-up. Among these patients, one presented with recurrent rest pain, while four had ischemic tissue loss. The patient with rest pain responded well to aggressive medical therapy, with complete symptom resolution. The four patients with ischemic tissue loss required redo angioplasty following more than four months of aggressive medical treatment and wound care. Notably, these four patients underwent successful tibial angioplasty via an antegrade approach, achieving 100% technical success with improved clinical response, resulting in limb salvage. This led to a six-month secondary patency rate of 89%. Throughout the six-month follow-up period, complete healing of minor ischemic tissue loss was documented in 11 patients (58%), while improvement in rest pain was noted in four patients (21%). The limb salvage rate for the procedure was 79% at six months. The six-month complete healing rate for minor ischemic wounds was 58%, while improvement in rest pain was observed in 21% of cases (Table 1 and 2).

Table (1): Baseline characteristics, clinical presentation, and procedural details of the study population (n=19)

Parameters	No=19	%
Age (years)	71.3	71.3±11.8 59.5-83.1
Sex (male/ female)	13 m 6 f	68% 32%
Diabetes Mellitus	13	68%
Hypertension	6	32%
Heart disease (ischemic)	7	37%
Smoking	12	63%
Rutherford category		
Rest pain	12	63%
Tissue loss and gangrene	7	37%
Target recanalization vessel		
ATA	7	37%
PTA	9	47%
Both	3	16%
Access guidance		
Angiographic	6	32%
Duplex	13	68%
Successful retrograde approach	18	95%

Table (2): Procedural outcomes and complications at follow-up

Outcome/Complication	Number (%)
Vascular Access Site Complications (VASCs)	1 (5%)
- Hematoma (Resolved Spontaneously)	1 (5%)
- Pseudoaneurysm (Required Prolonged U/S Guided Compression)	1 (5%)
Dissection (Resolved by Prolonged Dilatation)	2 (10%)
Follow-Up Mortality (Myocardial Infarction)	1 (5%)
Post-Procedural Major Amputation	3 (16%)
- Below-Knee Amputation (BKA)	2
- Above-Knee Amputation (AKA)	1
6-Month Primary Patency	13 (68%)
6-Month Secondary Patency	17 (89%)
6-Month Complete Healing of Minor Ischemic Tissue Loss	11 (58%)
6-Month Improvement in Rest Pain	4 (21%)
Procedural Success	16 (84%)
6-Month Amputation-Free Survival	79%

DISCUSSION

Peripheral arterial disease (PAD) is primarily influenced by age, which is recognized as the strongest risk factor. The mean age of the patients included in this study was 71.3 years. The observed male predominance (68%) among the study population may be attributed to the higher incidence of PAD in Egyptian males compared to females. Increased tobacco consumption among men is likely a contributing factor to the higher prevalence of severe PAD, particularly CLTI, in males. Several studies have similarly reported a higher incidence of severe PAD in men [13, 14].

Regarding the anatomical pattern of arterial lesions and their association with risk factors, it has been observed that tibial and pedal lesions are more frequently associated with advanced age, male sex, and diabetes mellitus [15]. In this study, all patients presented with CLTI, which was attributed to the involvement of the infrapopliteal arterial tree by CTO. More than 50% of the patients had isolated tibial artery CTO, while the remaining cases exhibited concurrent involvement of the popliteal and superficial femoral arteries.

Several advantages of the retrograde access approach have been documented. The distal cap of the occlusion is often softer than the proximal cap due to lower calcific content, facilitating easier guidewire penetration. The proximity of the access site to the occluded segment enhances wire pushability and torquability, improving the likelihood of successful crossing [7, 13, 16]. Additionally, the small caliber of the tibial vessels further aids catheter manoeuvrability. Moreover, collateral vessels originating from the proximal cap of the occlusion often complicate antegrade wire passage. Another advantage of the retrograde approach is its cost-effectiveness. In more complex cases where a simple retrograde approach is insufficient, advanced interventional techniques such as the controlled antegrade and retrograde tracking (CART) and the subintimal arterial flossing with antegrade-retrograde intervention (SAFARI) technique may be required [17].

In this study, retrograde access was achieved through ATA ankle puncture in 11 patients (58%) and PTA puncture in eight patients (42%). Peroneal artery access was not attempted. The primary consideration for access site selection was the availability of suitable pedal artery runoff, as assessed by diagnostic angiography and Duplex ultrasound performed during the intervention [7]. The decision to exclude peroneal access was based on its deep anatomical location in the posterior compartment of the leg, which makes external compression challenging and increases the risk of hematoma and compartment syndrome. In contrast, **El-Sayed *et al.*** [13] utilized retrograde access via the ATA, PTA, and peroneal artery, selecting the puncture site based on the angiosome distribution principle.

In this study, technical success was achieved in 95% of cases, defined as successful lesion crossing and restoration of inline flow to the ankle with no significant residual stenosis. Only one case of hemorrhagic complication (5%) was observed at the retrograde access site, with no other significant procedural complications.

At six months postoperatively, mortality was 5%, attributed to myocardial infarction as a major adverse cardiac event (MACE). The primary patency rate at six months was 68%, with a reintervention rate of 25% due to occlusion in patients with non-healing ischemic foot lesions. This resulted in a secondary patency rate of 89%, which is consistent with findings from other studies investigating retrograde tibial access for infragenicular arterial insufficiency [18]. **El-Sayed *et al.*** [13] reported an assisted patency rate of 84% and a secondary patency rate of 94%, with a redo-angioplasty rate of only 9.5%. Considering the short follow-up duration of this study, the limb salvage rate at six months (79%) was comparable to rates reported in the literature. For instance, **Bazan *et al.*** [7] reported a limb salvage rate of 77% at 17 months, **El-Sayed *et al.*** [13] reported 88% at one year, and **Mostafa *et al.*** [18] reported 93.75% at six months. The working group of **Mostafa *et al.*** [18] suggested that lesions requiring retrograde access may be associated with a higher incidence of reintervention and target vessel revascularization (TVR).

The results of **Minici *et al.*** [19] support the feasibility, efficacy, and safety of retrograde tibial access for femoropopliteal occlusions in cases where antegrade access has failed. However, long-term clinical data, including wound healing rates, amputation-free survival in CLTI patients, and improvements in Rutherford classification and pain-free walking distance in claudicants, are needed to further support the widespread use of retrograde recanalization [13, 20].

LIMITATIONS

The primary limitation of this study was the absence of a control group for direct comparison between retrograde and antegrade approaches.

CONCLUSION

The findings of this study indicated that retrograde crossing of infragenicular occlusions via tibial artery access is a feasible, easily applicable, effective, and safe alternative in cases where the antegrade approach has failed. This approach offered several advantages, including better pushability of the retrograde wire due to the small caliber of tibial arteries, improved penetration of the distal fibrous cap of the CTO, which is histologically softer than the proximal cap, and better wire control due to the short distance between the ankle and the CTO. Retrograde pedal access angioplasty for below-knee CLTI is a viable alternative to antegrade tibial angioplasty when the latter fails. This approach demonstrates comparable limb salvage rates and acceptable complication profiles, though it may be associated with a higher rate of reintervention. Further large-scale, multicenter, prospective randomized controlled trials with longer follow-up periods are needed to validate these findings and further establish the role of retrograde access in the treatment of CLI.

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