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Peroneal artery angioplasty as an alternative for limb salvage in patients with critical threatening limb ischemia

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ORIGINAL STUDY

Peroneal artery angioplasty as an alternative for limb salvage in patients with critical threatening limb ischemia

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Abstract

Background: **Chronic limb-threatening ischemia (CLTI) presents a significant health concern, particularly among patients with blockages in the lower leg arteries.**

Objectives: **This prospective investigation aimed to evaluate the results of revascularization in CLTI patients, with particular attention to the peroneal artery as the preferred target vessel for limb salvage.**

Patients and methods: **Fifty CLTI patients were enrolled in the study and underwent thorough clinical evaluation, laboratory tests, and duplex scanning at regular intervals. Revascularization procedures, primarily using the antegrade femoral approach on the same side as the affected limb, involved balloon angioplasty. Postoperative outcomes were assessed based on the rates of sustained vessel openness, limb preservation, and major amputation.**

Results: **The study population had a high prevalence of smoking (68%), diabetes (88%), and other health conditions. Nearly all lesions were classified as Trans-Atlantic Inter-Society Consensus type D (98%). Successful recanalization of the peroneal artery was achieved in all cases, with favorable postoperative results observed in 86% of patients at the 18-month follow-up.**

Conclusion: **This study underscores the effectiveness of revascularizing the peroneal artery in CLTI patients, demonstrating positive outcomes concerning limb preservation and vessel patency rates.**

Keywords: Chronic limb-threatening ischemia, Ipsilateral antegrade femoral approach, Limb salvage, Peroneal artery, Revascularization

1. Introduction

Lower extremity occlusive disease ranges from asymptomatic cases to severe limb-threatening gangrene [1]. Clinical classifications such as the Fontaine *et al*. [2] and Rutherford *et al*. [3] systems help standardize diagnostic assessments and treatment reporting.

Severe leg ischemia significantly impacts global morbidity, mortality, and healthcare utilization [4]. Chronic limb-threatening ischemia (CLTI), the advanced stage of peripheral arterial disease, arises from severe multilevel peripheral arterial disease and presents with rest pain, ulcers, or gangrene, associated with high rates of limb loss and mortality compared to other occlusive arterial diseases [5].

Revascularization, including bypass surgery or endovascular therapy, is critical for preventing major amputations, enhancing quality of life, and prolonging survival in CLTI patients [6]. While bypass surgery has been traditional, endovascular therapy offers advantages such as minimally invasive intervention, shorter recovery times, and suitability for high-risk patients [7].

Infrapopliteal occlusions are common in CLTI, posing challenges for endovascular interventions. The goal of below-knee limb salvage angioplasty is to restore inline flow to the foot arches [8]. The peroneal artery, often spared in advanced atherosclerosis, is crucial for its collaterals supplying pedal arteries [9].

Poor runoff has been associated with reduced patency and limb salvage rates in endovascular

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literature. Studies suggest that greater institutional experience with peroneal artery revascularization improves patency and limb salvage rates [9,10], while others demonstrate comparable outcomes with anterior or posterior tibial single-vessel runoff [11–13]. This study aims to evaluate the effectiveness of peroneal artery angioplasty as an alternative for limb salvage in patients with critical limb ischemia at Shebin El-Kom Teaching Hospital.

2. Patients and methods

A total of 50 patients diagnosed with CLTI and blockages in the arteries below the knee were recruited from the Vascular and Endovascular Department at Shebin Elkoom Teaching Hospital between October 2022 and October 2023. Before undergoing any procedure, all participants provided informed consent after receiving detailed information about the procedure, potential complications, benefits, risks, and alternative treatments.

The clinical evaluation included a thorough medical history, physical examination, assessment of risk factors for atherosclerosis, and classification of chronic lower limb ischemia using the Rutherford classification. Patients underwent standard laboratory tests and Duplex scanning before the intervention and at 3-, 6-, and 12-month follow-ups to evaluate anatomical details, blockages or narrowings, blood flow to the foot, and glycemic control.

Inclusion criteria encompassed patients with critical chronic lower limb ischemia affecting the arteries below the knee with adequate blood flow to the foot. Exclusion criteria involved claudication, presence of open anterior or posterior tibial arteries, lack of adequate blood flow to the foot, aneurysms, arteriovenous fistulae, known allergies to study medications or contrast agents, and limbs deemed unsalvageable.

Before the procedure, patients were admitted either 1 day before or on the day of the intervention. Both groin areas were prepared with an antiseptic solution, and local anesthesia (2% lidocaine) and 5000 IU heparin were administered after inserting the sheath. The choice of femoral artery access was determined by the location of the arterial blockage.

2.1. Preoperative work up

This includes history taking, vascular surgery examination, and assessment of ankle brachial index and toe pressure. All patients had arterial Doppler. Lower limb arterial Doppler is sufficient to decide for intervention provided there's no stenosis/occlusion or aneurysmal dilatation of aortoiliac and femoropopliteal segments. Otherwise, we request preoperative computed tomography angiography with contrast.

The primary endpoint is limb salvage. The secondary endpoints include wound healing and all-cause mortality.

2.2. Procedures

All procedures were performed percutaneously at the common femoral artery by an antegrade access under local anesthesia. A bolus of unfractionated heparin was administered at a dose of 70–100 IU/kg to achieve an activated clotting time of 250 s during the procedure. Firstly, we do completion angiography to detect the site of lesion and distal runoff and to compare it with the preoperative computed tomography angiography. Followed by the insertion of guide wire; standard hydrophilic 0.035 GW and standard hydrophilic 0.018 (Command, Abbott, Lake County, Illinois, USA) were used in all cases. All cases needed 6 French sheeth (Cook, Bloomington, Indiana, USA) for common femoral artery access, a guiding catheter to manipulate the wire to gain its access in the target vessel (BERN 4 Fr; Boston Sceintific, Marlborough, Massachusetts, USA), about half of the cases needed supporting catheter to increase possibility of GW (Rubicon; Boston Scientific) (CXI, Cook). Two types of balloons were used, standard and high pressure. There was no role for drug-eluting balloons. Balloon diameter size: 3 mm was used in all cases, and 2.5 mm was used in only two cases to correct foot. Intraluminal crossing of the lesion or subintimal crossing was achieved by creating a “Bolia loop” with J tip hydrophilic wire (Terumo). The wire was initially supported by a 4 Fr or using a supporting catheter followed by a balloon. Once re-entry has been achieved and confirmed, the subintimal channel is immediately dilated with an appropriate balloon.

2.3. Postprocedure protocol

The patients were routinely treated indefinitely with aspirin 100 mg once daily and statins. Clopidogrel was administered for a minimum of 3 months, although it was common for patients to continue taking clopidogrel for substantially longer periods. For patients who required anticoagulant agents for other indications, the anticoagulant therapy was continued, and an antiplatelet drug was added to the medication regimen.

The success of the procedure was evaluated based on immediate clinical improvement, angiographic success (defined as <30% residual narrowing), and

hemodynamic success (defined as increased peak systolic velocity).

The arterial sheath was typically removed immediately after the procedure, and patients were instructed to limit movement for 12–24 h. Digital compression was applied near the puncture site, and patients were discharged on the second day with instructions for managing risk factors and prescribed medications.

Follow-up assessments included evaluating clinical improvement, Duplex scanning at 3 and 6 months to identify any new issues, and monitoring for target lesion revascularization and target vessel revascularization.

3. Results

This prospective study included 50 patients presenting to the Vascular and Endovascular Surgery Department at Shebin Elkoom Teaching Hospital between October 2022 and October 2023. These patients exhibited CLTI, and the peroneal artery was identified as the optimal target vessel for revascularization for limb salvage. The study enrolled participants based on predefined inclusion criteria from the pool of cases with CLTI presented at our institute.

The cohort had a mean age of 63.00 ± 7.1 years, with an age range of 45–81 years. Of the participants, 34 (68%) were males and 16 (32%) were females.

The study revealed that 68% of the patients were smokers and 88% were diabetics, with a mean duration of diabetes mellitus being 15 years. Additionally, 54% of the patients were receiving insulin, and the mean glycated hemoglobin was 7.6 ± 1.8%. Other comorbidities included hypertension (76%), ischemic heart disease (32%), end-stage renal disease (2%), cerebrovascular events (4%), and hyperlipidemia (8%) (Table 1).

Ten percent of the patients had contralateral major amputations, with above-knee amputation in one case and below-knee amputation in four cases. Twelve percent had a history of previous ipsilateral angioplasty, superficial femoral artery angioplasty, and anterior tibial artery angioplasty (Table 2). According to the Rutherford–Baker scale, 20% had ischemic rest pain, 56% had minor tissue loss, and 24% had major tissue loss. According to the Trans-Atlantic Inter-Society Consensus (TASC) II classification, 98% of the limbs had TASC type D lesions.

All procedures utilized the ipsilateral antegrade femoral approach. The sheath size was 6 Fr (100%), and wires of varying sizes (0.035 inch, 0.014 inch) were used. Balloon angioplasty was performed in all cases, with different balloon sizes (2.5 and 3) and inflation pressures based on lesion characteristics. No drug-coated balloons were used.

Table 1. Patient characteristics (demographics and comorbidity).

Patient demographics	*n* (%)
Age (mean ± SD)	63.0 ± 7.1
Sex	
Male	34 (68.0)
Female	16 (32.0)
Comorbidity (risk factors)	
Smoke +ve	34 (68.0)
DM	
+ve	44 (88.0)
Insulin therapy	27 (54.0)
Duration of DM	15 years
HTN +ve	38 (76.0)
CHD +ve	16 (32.0)
Cerevascular stroke +ve	2 (4.0)
Renal +ve	1 (2.0)
Hyperlipidaemia +ve	4 (8.0)

Table 2. Lesion's morphology of the infrainguinal disease.

	n (%)
Contralateral amputation	
AKA	1 (2.0)
BKA	4 (8.0)
No	45 (90.0)
Previous angioplasty	
+ve	6 (12.0)
−ve	44 (88.0)

AKA, above-knee amputation; BKA, below-knee amputation.

The peroneal artery was the primary and only target vessel for revascularization in all cases of critical limb ischemia for limb salvage. Post-angioplasty, all limbs had patent peroneal arteries with good distal runoff to pedal vessels.

Duplex scanning showed an increase in post-operative peak systolic velocity. Follow-up at various intervals demonstrated sustained patency rates, limb salvage rates, and major amputation rates. Successful revascularization, defined by rest pain relief, ulcer healing, or minor amputation, was observed in 86% of patients at the 18-month mark (Table 3).

Complications included groin hematomas, wire perforation, and dissection, all of which were effectively managed. One case experienced mortality due to myocardial infarction three days after infrapopliteal angioplasty (Figs. 1 and 2).

4. Discussion

The current prospective study aimed to assess the outcomes of revascularization in patients diagnosed with CLTI, with a specific focus on targeting the peroneal artery.

Table 3. Follow-up of patient post peroneal artery angioplasty.

	0 month	3 months	6 months	12 months	18 months
PP (primary patency)	47 (94)	43 (86)	42 (84)	40 (80)	40 (80)
SP (secondary patency)	–	–	–	2 (4)	2 (4)
Limb salvage	47 (94)	44 (88)	43 (86)	43 (86)	43 (86)
Major amputation	BKA	2 (4)	4 (8)	4 (8)	4 (8)
	AKA	1 (2)	2 (4)	3 (6)	3 (6)
Freedom from major amputation	47 (94)	44 (88)	43 (86)	43 (86)	43 (86)
Successful angioplasty	94%	88%	86%	86%	86%

AKA, above-knee amputation; BKA, below-knee amputation.

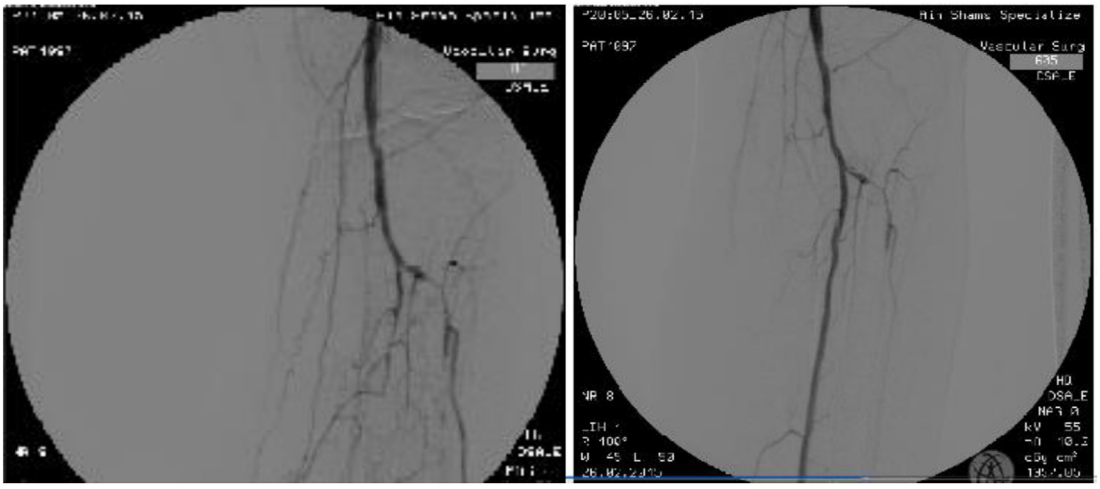

Fig. 1. Preangioplasty and postangioplasty of peroneal artery.

Fig. 2. Healing stump of ulcer preangioplasty and postperoneal artery angioplasty.

Our study consisted of 50 CLTI patients, with an average age of 63.00 ± 7.1 years, and a male predominance of 68%. These demographics mirror the typical profile of CLTI patients, highlighting the prevalence of vascular diseases in older males. High rates of smoking (68%) and diabetes (88%) further underline the association of these risk factors with CLTI. The mean duration of diabetes was 15 years, indicating a significantly higher risk of lower extremity amputation in individuals with diabetes. Similarly, current smoking was associated with a 40% increased risk of CLTI, regardless of diabetes status. Additionally, hypertension (76%), ischemic heart disease (32%), and hyperlipidemia (8%) were prevalent comorbidities, emphasizing the multifaceted nature of CLTI.

Regarding tissue damage, our study identified varying degrees of tissue loss, with 20% experiencing ischemic rest pain, 56% minor tissue loss, and 24% major tissue loss according to the Rutherford–Baker

scale. The majority of limbs (98%) exhibited advanced TASC type D lesions, indicating the need for comprehensive revascularization strategies.

Revascularization procedures primarily utilized the ipsilateral antegrade femoral approach, reflecting the established preference for treating peripheral arterial disease. The selection of the peroneal artery as the primary target vessel aligns with its recognized significance in CLTI management. Balloon angioplasty, performed in all cases, demonstrated the adaptability of this technique, with balloon sizes and pressures tailored to lesion characteristics.

Postoperative evaluation, including duplex scanning, revealed a notable increase in postoperative peak systolic velocity, indicating improved arterial flow. Sustained patency rates, limb salvage rates, and major amputation rates observed during follow-up underscored the effectiveness of the revascularization procedures. Successful revascularization, defined by rest pain relief, ulcer healing, or minor amputation, was achieved in 86% of patients at the 18-month mark.

Biagioni et al. [14] reported that single-vessel intervention targeting the peroneal artery yielded better wound healing outcomes compared to the posterior and anterior tibial arteries. Contrary to expectations of similar [15,16] or inferior [17,18] results, the peroneal artery was prioritized for recanaliza- tion only when it exhibited favorable runoff through communicating perforating branches. This prefer- ence, coupled with the relatively shorter length of the recanalized peroneal artery, likely contributed to the more favorable wound healing results.

Despite favorable outcomes, procedural complications such as groin hematomas, wire perforation, and dissection were observed. Unfortunately, one case resulted in mortality due to myocardial infarction 3 days after infrapopliteal angioplasty, underscoring the importance of refining procedural safety protocols.

While this study provides valuable insights, it is essential to acknowledge its limitations, including the relatively small sample size and single-center design, which may limit the generalizability of the findings. Future research with larger cohorts and multicenter collaborations could offer a more comprehensive understanding of peroneal artery revascularization outcomes in CLTI patients.

4.1. Conclusion

In conclusion, our study contributes to the growing body of evidence supporting the efficacy of revascularization procedures, particularly focusing on the peroneal artery as the only vessel in patients with CLTI for limb salvage. The multifaceted approach to patient selection, procedural techniques, and postoperative care outlined in this study provides valuable insights for clinicians involved in the management of CLTI. Continuous efforts to refine and individualize revascularization strategies will further enhance the outcomes and overall quality of life for CLTI patients.

Institutional Review Board (IRB) Approval Number

HSH00057.

Ethics statement

I confirmed that this is original, not funded, and has not been published elsewhere. We formulated this study and we got acceptance from our ethical committee which held at general organization of teaching hospitals and institute. IRB code: HSH00057.

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Conflict of interest

There are no conflicts of interest.

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