Peroneal artery: single-vessel runoff revascularization in critically ischemic limb and limb salvage rate

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Aim
To evaluate the efficacy of peroneal artery endovascular revascularization as a single-vessel runoff in the management of patients with critical limb ischemia, caused by infrapopliteal arterial occlusive disease.
Patients and methods
This retrospective study was carried out from February 2015 to March 2021 at Sohag University Hospitals on patients complaining of critical limb ischemia, Rutherford category '5' caused by infrapopliteal arterial occlusive disease and with angiographic evidence based on the peroneal artery-only runoff vessel. Patients with technically successful revascularization of the peroneal artery were divided into two groups according to the peroneal artery connections by its terminal branches to the foot arch and its collateral circulations. Group A: patent peroneal artery connected to the pedal arch or associated with considerable collateral circulations and group B: patent peroneal artery with poor collateral circulations to the foot. Limb salvage and wound healing rates were evaluated and compared between the two groups.
Results
Group A consisted of 14 patients while group B consisted of 18 patients. Both limb salvage rate, wound healing rate, and primary patency rate showed highly significant statistical difference (*P*Ë,0.01). Limb salvage rate was 71.4% (10 patients) in group A and 44.4% (eight patients) in group B. Complete wound healing rate was achieved in 64.3% (nine patients) in group A and 44.4% (eight patients) in group B. Primary patency rate was 64.3% (nine patients) in group A and 27.8% (five patients) in group B.
Conclusion
Peroneal artery as a single-vessel runoff showed a reasonable limb salvage rate especially when it is continued through its branches to the pedal arch. It should not be ignored when there are no other alternatives.

Keywords:
critical ischemic limb, limb salvage rate, peroneal artery, single-vessel runoff

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Introduction

Critical limb ischemia (CLI) is estimated to develop in 500–1000 individuals per million per year in the general population. It has a major impact on the quality of life with high rate of morbidity and mortality [1]. With the increase in its prevalence, many patients, for example diabetics, smokers, and patients with renal failure are presented with complex crural arterial disease. When revascularization is not performed or in cases of technical failure, 40–50% of these complex lesions will end by major amputation within 6 months and the mortality rate reaching about 20% of those patients [2]. The hope of such management is to relieve the ischemic pain, enhance wound healing, and to increase limb salvage rate [3].

Peroneal artery as the only patent vessel in critical limb ischema is debatable. The particularity of the peroneal artery is in the fact that it does not end in direct communication with the major pedal vessels and gives angiosomes of limited extent [4]. Angiosomal concept suggests that it is better for wound healing to recanalize the artery, which directly feeds the ischemic ulcer instead of revascularization of other arteries. However, it is not always feasible in all cases and then, the operator may find only a single available vessel runoff irrespective to this angiosomal strategy and has to improve the foot perfusion through indirect flow. This procedure is a questionable maneuver that may or may not be effective [5,6]. Other studies did not find a significant difference to this angiosome concept of wound healing and explained this controversy by that

the blood flow to the foot can be restored through inter-angiosomal choke vessel or through the pedal arch [7].

Peroneal artery is relatively spared from the terminal stages of atherosclerosis and is often the last infrapopliteal vessel to become occluded in diabetes and end-stage renal disease [8]. Despite it having an extensive collateral arterial bed, the targeted ischemic area may be inadequately perfused especially in cases of tissue loss [9]. Others [10] reported that these collaterals act as a bridge to access the tibial arteries from the view of angiosomal territory.

Raftery *et al.* [11] demonstrated that peroneal angioplasty is effective in limb salvage and has recently shown to be comparable to open bypass procedures. Slim *et al.* [12] appreciated the endovascular option as the first modality of treatment.

The aim of this series is to evaluate the efficacy of peroneal artery endovascular revascularization as a single-vessel runoff regarding limb salvage in the management of patients with CLI caused by infrapopliteal arterial occlusive disease.

Patients and methods

This retrospective study was carried out from February 2015 and March 2021 at Sohag University Hospitals on patients complaining of CLI, caused by infrapopliteal arterial occlusive disease matched with the following inclusion criteria:

(1) Patients with Rutherford category '5.'
(2) Patients with angiographic evidence of peroneal artery-only runoff vessel.

Exclusion criteria

The following were the exclusion criteria:

(1) Patients associated with proximal lesions above the infrapopliteal vessels.
(2) Patients with successful recanalization of either anterior tibial artery or posterior tibial artery besides the peroneal artery.
(3) Patients with nonsalvageable limb or those with life-threatening infection.
(4) Patients with nonatherosclerotic infrapopliteal disease.
(5) Patients developed acute thrombosis, flow-limiting dissection, or perforation in the peroneal artery during intervention.

This series was approved by the hospital ethics committee. As the study was retrospective, the need for written informed consent was waived. Patients' demographics, associated comorbidities, clinical presentation, details of the procedures, and postoperative follow-up were reviewed. Clinical assessment included history of risk factors, for example diabetes mellitus, smoking, hypertension, cardiovascular, cerebrovascular diseases, renal insufficiency, and previous endovascular intervention or bypass surgery. All patients were examined carefully including the level of occlusion, ankle brachial pressure index (ABI), and site of the wound/ulcer. Duplex ultrasound and computed tomography angiography were performed for all cases as well as laboratory investigations especially the renal functions and coagulation profile.

Technique: preprocedural medications with dual antiplatelet therapy; salicylates 75 mg and clopidogrel 300 mg as a loading dose, followed by a daily maintenance dose of 75 mg continued postoperatively. The procedure was done under local anesthesia in all cases through ipsilateral femoral access using a 6 Fr sheath. A measure of 70–100 U/kg of unfractionated heparin was injected intra-arterially immediately after sheath insertion. Preintervention angiography was performed to assess the infrapopliteal vessels, for example lesion criteria, length, stenosis/occlusion, distal runoff vessels, and the possible vessels to be tried first for revascularization.

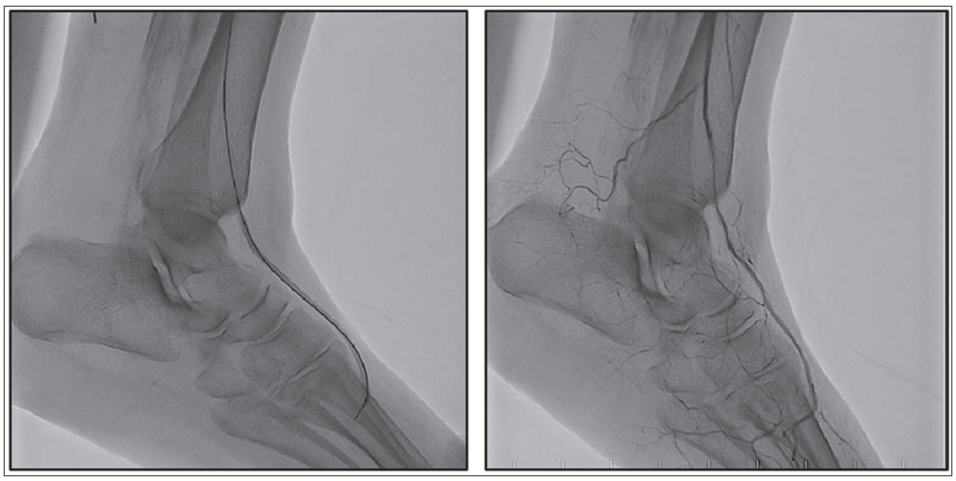
The strategy of treatment was to recanalize the whole probable vessels as possible to gain maximum perfusion to the foot. V-18 guidewire (Boston Scientific, Boston, Massachusetts, USA) or 0.014-inch hydrophilic guidewire (PT2; Boston Scientific) was supported by a 4 Fr vertebral catheter to cross the lesion either intraluminally or subintimally, followed by reentry to the true lumen. Balloon dilatation with 2, 2.5, or 3 mm diameter low-profile balloons (Sterling Balloon; Boston Scientific) was performed for 1–2 min nitroglycerin 100–200 mcg was helpful to overcome the vessel spasm in some cases. All trials to revascularize any of the infrapopliteal vessels rather than the peroneal artery were unsuccessful and finally, the peroneal artery was the only canalized vessel.

Completion angiography was performed to evaluate the technical success, blood flow to the foot especially to the ischemic area, collateral circulations from branches of the peroneal artery, and assessment of foot arch patency (Figs 1 and 2).

Figure 1

Infrapopliteal arterial occlusive disease with distal runoff based on peroneal artery only: (a) CTA showing patent proximal peroneal artery with totally occluded ATA and PTA, (b, c) crossing the lesion by wire up to its bifurcation, (d) after balloon dilatation, (e, f) poor collateral circulations. ATA, anterior tibial artery; CTA, computed tomography angiography; PTA, posterior tibial artery.

Figure 2



(a) Navigation by wire through its branch to the pedal arch followed by balloon dilatation and (b) completion angiography.

Patients with technically successful revascularization of the peroneal artery without residual stenosis more than 30%, occurrence of flow-limiting dissection, perforation or acute thrombosis were divided into two groups according to the peroneal artery connections by its terminal branches to the foot arch as well as the state of collateral circulations; group A: patent peroneal artery connected to the pedal arch or associated with considerable collateral circulations and group B: patent peroneal artery with poor collateral circulations to the foot.

Follow-up was conducted daily during the period of admission and then in the outpatient clinic at 1, 3, 6, 9, and 12 months of follow-up period. Patients with ischemic ulcers or gangrene received wound management; debridement, toe amputation, and/or midtarsal amputation. During follow-up visits, clinical assessment was performed regarding the disappearance of rest pain, wound healing, ABI measurements, and recorded any observed complications. Duplex examination was done routinely in each visit.

Definitions

(1) Limb salvage: freedom from major amputation.
(2) Major amputation means above-ankle amputation.
(3) Healing wound: wound with clean base, with healthy granulation tissue and decreasing in size.
(4) Complete wound healing: complete epithelialization of the wound/ulcer.
(5) Technical success: less than 30% residual stenosis.

Study outcome

Primary outcomes: limb salvage rate and wound healing rate.

Secondary outcomes: Primary patency rate.

Statistical analysis

Continuous variables are expressed as mean±SD. Categorical variables are expressed as percentage. Mann–Whitney test was used to compare continuous variables. χ^2 and Fisher's exact test were used for categorical variables. Kaplan–Meier method was applied to the study outcome. Groups were compared using log-rank test. Statistical significance was defined as *P* value less than 0.05.

Results

Data was collected and reviewed from patients' records. Revising these files revealed that there were 146 patients presented with CLI, Rutherford category '5' caused by infrapopliteal arterial occlusive disease during the period between February 2015 and March 2021. In all, 96 patients were managed by revascularization of tibial vessels other than the peroneal artery and, therefore, were excluded from the study. Technical failure was observed in 18 patients by the occurrence of flow-limiting dissection in 13, perforation in three, and acute thrombosis in two patients. Those patients were also excluded from the study. The remaining 32 patients were managed by revascularization of the peroneal artery as the only runoff vessel with successful technical results. Those patients were enrolled in this study and were classified into two groups. Group A consisted of 14 patients where the peroneal artery was connected to pedal arch and/or associated with heavy collaterals. Group B consisted of 18 patients where the peroneal artery had poor collateral circulations to the foot. Clinical presentation, wound characteristics, operative details, and follow-up were analyzed retrospectively for this study.

The most common risk factors were diabetes mellitus and smoking in both groups (78.6, 71.4 and 77.8, 72.2%, respectively). In group A, the mean age was 54 (42–68) years, and nine (64.3%) patients were males. In group B, the mean age was 56 (43–71) years, and 11 (61.1%) patients were males. Baseline characteristics and risk factors are shown in Table 1. Total arterial occlusion was more common than stenosis in both groups (71.4, 66.7 vs. 28.6, 33.3%, respectively). There were no significant differences in patient baseline criteria between the two groups.

The ABI was evaluated before and after intervention for all patients. Peroneal artery signal was not used for calculating ABI measurements. The tibial vessels were noncompressible in most of the patients and, therefore, ABI readings analysis was of little value.

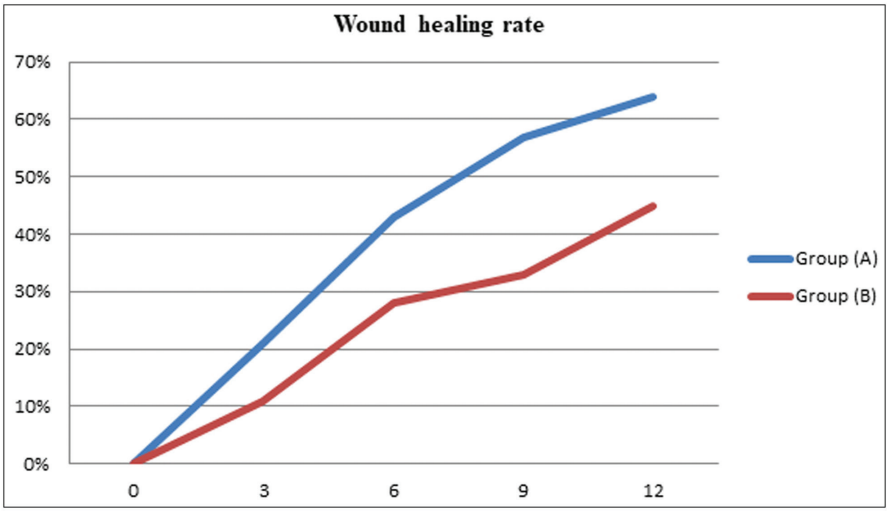
The most common site of ischemic wound/ulcer was toes in both groups (57.1, 55.6%, respectively) while heal area was recorded in 28.6 and 33.3%, respectively.

Complete wound healing rate was achieved in 64.3% (9/14 patients) in group A and 44.4% (8/18 patients) in group B (*P*Ë,0.01) (Fig. 3). Analysis of these results revealed that wound healing in group B was favorable when the collateral circulation were nearly related to the wound/ulcer area but when these collaterals were away from the targeted foot lesion, progress of wound healing was unsatisfactory. Debridement and minor amputation were performed in all cases within few days after the endovascular procedure. In group A, five patients had incomplete healing with chronic ulceration and frequent infections; two patients continued on frequent dressing with

Table 1 Demographic data and risk factors

	Group A (*N*=14) [*n* (%)]	Group B (*N*=18) [*n* (%)]
Age	54 (42–68)	56 (43–71)
Male/female	9/5	11/7
Risk factors		
Diabetes mellitus	11 (78.6)	14 (77.8)
Smoking	10 (71.4)	13 (72.2)
Hypertension	9 (64.3)	12 (66.7)
Ischemic heart disease	5 (35.7)	6 (33.3)
Renal impairment	2 (14.3)	3 (16.7)
Cerebral stoke	1 (7.1)	1 (5.6)
Site of the foot lesion		
Toes	8 (57.1)	10 (55.6)
Heel area	4 (28.6)	6 (33.3)
Extended ischemic area	2 (14.3)	2 (11.1)
Lesion characteristics		
Stenosis	4 (28.6)	6 (33.3)
Occlusion	10 (71.4)	12 (66.7)

Figure 3



Group A patients showed highly significant wound healing rate, value less than 0.01.

repetitive debridement, two patients underwent below-knee amputations, and the fifth one died. In group B, 10 patients had incomplete healing and those cases underwent below-knee amputations in six patients, two patients were lost to follow–up, and two patients died.

Limb salvage rate was statistically significant (*P*Ë,0.01): 71.4% (10/14 patients) in group A and 44.4% (8/18 patients) in group B (Fig. 4). Primary patency rate was 64.3%, (nine patients) in group A and 27.8% (five patients) in group B (*P*Ë,0.01).

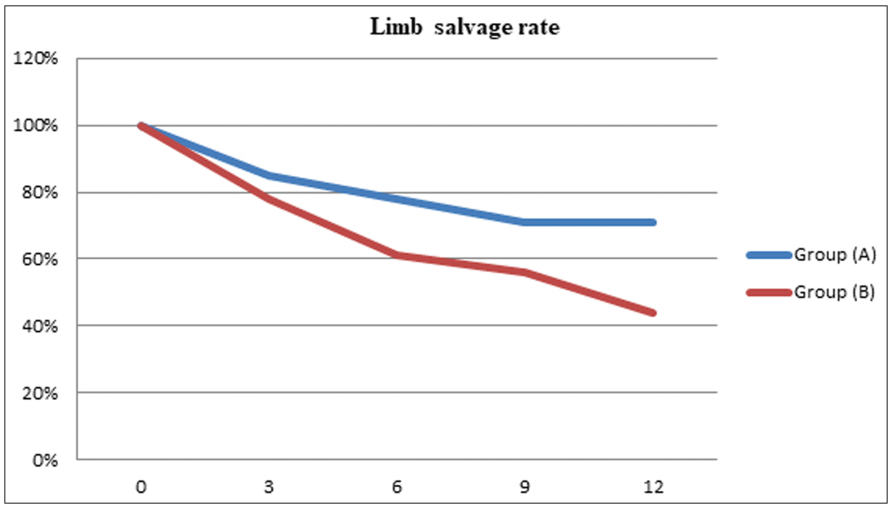
Regarding procedure-related complications, it should be noted that all patients that developed acute thrombosis, flow-limiting dissection, or perforation in the peroneal artery during intervention were not enrolled in the study. Access site hematoma was recorded in 4/32 (12.5%) patients among all patient cohorts of this study and resolved spontaneously. Mortality rate was 9.4% (3/32 patients) because of associated comorbidities.

Discussion

In this study, the aim was to describe the limb salvage and limb-related outcomes in patients undergoing revascularization of the peroneal artery as a single runoff vessel.

Faglia *et al.* [13] had analyzed their results regarding the direct in-line flow to the foot compared with the indirect flow and suggested that peroneal artery angioplasty may be inadequate in some patients; however, one cannot specify the patients who would do well and would not with peroneal revascularization.

Figure 4



Limb salvage rate was statistically highly significant than group B patients, *P* value less than 0.01.

In this series, limb salvage rate was achieved in 10/14 (71.4%) patients of group A and in 8/18 (44.4%) patients of group B with highly significant statistical results, *P* value less than 0.01. Nearly similar results were obtained by others [8,9]. Ricco *et al.* [14] had reported that peroneal artery outflow depends on the channels connected by its branches to the pedal arch, which are responsible for feeding the ischemic area indirectly. These connections are the cornerstones in limb salvage and amputation-free survival.

Peroneal artery angioplasty is an argumentative issue. Investigators [9] found that single peroneal runoff vessel showed slightly little limb salvage rate compared with single other tibial vessel runoff. On the other hand, Graziani *et al.* [15] achieved reasonable results and acceptable healing and limb salvage rates using the peroneal artery. Also, Dosluoglu *et al.* [16] reported that there was no statistically significant difference in the 1-year primary patency rate or limb salvage among patients treated with peroneal artery compared with those with anterior or posterior tibial single-vessel runoff.

It was reported that many factors are responsible for the outcome of peroneal artery revascularization, and may lead to less favorable results especially the limb salvage rate and wound healing rate, patency of peroneal branches, incomplete pedal arch, and location of foot ulcer [14,17]. Also, Dosluoglu *et al.* [16] had reported another predicators for limb loss, for example extensive gangrene, overwhelming infection, and uncontrolled diabetes and, therefore, they concluded that limb loss may still be an inevitable outcome even if adequate perfusion is restored.

Wound healing was achieved in 9/14 (64.3%) patients of group A and in 8/18 (44.4%) patients of group B with highly significant *P* value less than 0.01. These results highlighted the effectiveness of peroneal artery revascularization in wound healing, especially when it is connected to the pedal arch. Similarly, Mohapatra *et al.* [8] had attained 68.6% wound healing in patients with patent peroneal artery connected to a patent pedal arch. Ballotta *et al.* [18] compared wound healing rate after peroneal artery angiolplasty and other infrapopliteal arteries and found that there were comparable to each other. Utsunomiya *et al.* [19] had used the wound blush, which is a contrast opacification during the procedure around the wound as an indicator for adequate flow to the targeted tissue and therefore proper healing.

Primary patency rate was 64.3% (nine patients) in group A and 27.8% (five patients) in group B; *P* value less than 0.01. Ingle *et al.* [20] reported in his series that 1-year primary patency rate in crural vessels varied widely between 13 and 81%. Discrepancy between patency and limb salvage rates are of less importance as the primary goal is limb salvage rather than vessel patency [21,22].

Dosluoglu *et al.* [16] concluded that major amputations may occur even with patent revascularized vessels and this fearful concern is not exclusive to the peroneal artery but it was reported to occur in 17% of all tibial revascularizations.

Peroneal bypass surgery achieves comparable hemodynamic results and limb salvage rate to other infrapopliteal bypasses. There were guidelines that favored bypass as the first option. Few years ago, Aboyans *et al.* [23] had reported in their guidelines that in long occlusions of crural arteries, bypass with autologous

vein provides superior long-term patency and limb salvage. Also, Darling *et al.* [24] in last decades stated that they previously studied bypasses to the peroneal artery compared with those to a dorsalis pedis artery, finding 1-year secondary patency of 89 and 96% limb salvage rate. However, bypass surgery requires a suitable vein conduit; it is not feasible in all cases because of the multistenotic nature of the atherosclerotic disease, difficult exposure of peroneal artery to some extent, carries incidence of local and systemic complications reaching up to 25% of cases. Also, its role in the presence of extensive gangrene and infection needs to be clarified [16,23,25,26]. In this series, all revascularization procedures were endovascular intervention and no cases of peroneal bypass surgery was included.

On the contrary, Mohapatra *et al.* [8] had assumed that even if peroneal angioplasty results in poorer primary patency rates compared with surgical bypass, it provides similar wound healing and limb salvage rates and, therefore, they appreciated the endovascular intervention as a low-risk intervention procedure that may be sufficient to heal ischemic wounds. Also, they concluded that peroneal runoff by itself does not negatively affect limb outcomes. It provides acceptable patency and limb salvage rates whatever the form of revascularization either bypass or angioplasty. Although, it does not have direct perfusion to the foot, it should not be ignored or abandoned.

Conclusion

Peroneal artery as a single-vessel runoff showed a reasonable limb salvage rate especially when it is continued through its branches to the pedal arch. It should not be ignored when there are no other alternatives.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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