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ORIGINAL ARTICLE

Role of Solitary Peroneal Artery Angioplasty for Lower Limb Salvage in Patients With Critical Limb Ischemia

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Abstract

Background: **Ischemic limb discomfort or amputation may be the result of critical limb ischemia (CLI), which is caused by a reduction in blood flow to the limb. The lack of sufficient blood flow to oxygenate the leg that results from peripheral arterial occlusive disease. Peripheral arterial disease's 'end stage' is CLI.**

Objectives: **To identify the role of peroneal artery angioplasty as a single runoff vessel in the salvage of lower limb of persons with CLI, and to avoid major amputations in these patients.**

Patients and methods: **Forty participants took part in this prospective trial that was presented to the Vascular and Endovascular Department in Al-Azhar University Hospitals and Kobri Elkobba Military Hospital with critical lower limb ischemia with peroneal artery as the best target vessel for revascularization between January 2021and December 2022.**

Results: **In this study the overall limb salvage rate was 70 % at 18 months follow up, 12 (30 % cases) patients had major amputation, out of them eight cases had Above knee amputation (AKA) and four cases had Below knee amputation (BKA).**

Conclusion: **When compared with open lower extremity revascularization, endovascular revascularization is less invasive and causes less morbidity; as a result, it has been increasingly used to treat more complex lesions among individuals who regularly present with progressing disease. Endovascular revascularization has also become increasingly popular. The peroneal artery was evaluated as a single-vessel runoff and demonstrated satisfactory long-term patency as well limb salvage rates.**

Keywords: Limb ischemia, Limb salvage, Peroneal artery angioplasty

1. Introduction

The term 'critical limb ischemia' (CLI) refers to limb discomfort that is present even when the affected extremity is at rest or impending limb loss that is brought on by a severe reduction in the amount of blood supply to the affected extremity. Despite the fact that peripheral arterial occlusive disease is characterized by a problem of supply against demand, in other words, an insufficient amount of blood flow to give the necessary oxygen that is required by the limb, this is not the case. Therefore, CLI is regarded as the 'end stage' of peripheral arterial disease.[1]

The diagnosis of hemodynamically significant peripheral arterial disease should be objectively confirmed if there is ischemic rest pain with an ankle−brachial index less than 0.4, an ankle systolic pressure less than 40 mmHg or toe systolic pressure less than 30 mmHg; or if the individual has a systolic blood pressure of under 60 mmHg in their ankles, flat metatarsal pulse volume recordings, or a toe pressure of below 40 mmHg with an ulcer or gangrene.[2]

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In the past, open surgical bypass was the gold standard for treating patients in need of limb revascularization. However, in the last decade, endovascular techniques have been developed and introduced, greatly expanding the range of possible therapies. Life expectancy, functional status, the morphology of the artery occlusive disease, along with surgical risk all play a role in determining the best course of treatment for CLI. Endovascular therapy is now the standard of care for individuals with aorto-iliac illness and aorto-femoral bypass surgery is a highly effective as well as long-lasting treatment for those with the most severe patterns of occlusion. Based on the current data, surgical bypass with vein is the recommended treatment for infrainguinal disease in CLI persons expected to live 2 years or longer, as well as in patients with lengthy segment occlusions or severe infrapopliteal disease who can tolerate the surgical risk. People with a shorter expected life span, those at higher surgical risk, those without a suitable vein for bypass, as well as individuals with less severe arterial occlusions may all benefit more from endovascular therapy.[3]

2. Patients and methods

This prospective trial was performed on 40 patients presented to the Vascular and Endovascular Department in Al-Azhar University Hospitals and Kobri Elkobba Military Hospital with critical lower limb ischemia with peroneal artery as the best target vessel for revascularization between January 2021and December 2022. Informed consent was gained after participants were given information about the procedure's potential advantages, dangers as well as alternative interventions. Approval from the ethical committee in Al-Azhar University was taken before the beginning of the study.

2.1. Methodology

Clinical assessment: history taking and clinical examination was completed for all cases: Age also sex, main risk factors for atherosclerosis together with: smoking, hypertension, diabetes mellitus, cardiac diseases (period of the disease, medications, previous complaints, whether admitted to critical care unit before or not, previous cardiac catheterization), chest diseases, renal insult, and stroke or transient ischemic attacks (history of previous admission to stroke unit, medications), history of present illness (onset, course, duration of rest pain, tissue gangrene. Effect of elevation, exercise, dependency on symptoms. Associated pain in the back was recorded), family history of aneurysmal diseases or any collagen diseases were being asked about and finally clinical categorization of chronic lower limb ischemia was done. As part of the preoperative vascular assessment, the extent of tissue loss was reported and arterial pulsation was also assessed.

Physical examination: patients were examined carefully as follows: vital signs: patient's blood pressure was checked (hypertensive or not), pulse (rate, rhythm, palpable or not, vessel wall condition, equal on both sides or not), respiratory rate, and examination of arterial system all over the body. We checked carotid, subclavian, axillary, brachial, radial, and ulnar pulsation.

Abdominal examination was done to detect aortic pulsation then examination of the groins for femoral pulses: bilateral popliteal and pedal pulses were checked, local examination of the affected limb (inspection for ischemic ulcers, gangrene and tissue loss, edema of lower limbs, hair loss, and brittle nails. Extent and type of gangrene whether dry or wet was recorded) and finally, palpation of femoral, popliteal, and pedal pulses and comparison to other side. Assessment of coldness level, capillary refilling, and assessment of motor power also were done.

2.2. Preprocedural investigations

Routine laboratory tests: they were done to assess patient fitness for the procedure. They included liver function tests, complete blood picture, blood glucose level, renal function, lipid profile, and coagulation profile.

Arterial scanning of lower limb: all patients were scheduled either for CTA or Duplex scanning before intervention with proper assessment of the site and length of the lesion and the distal run off vessels.

A nephroprotection protocol: N-acetyl-cysteine 1200 mg twice daily was given orally to individuals having creatinine levels above 1.1 mg/dl on the day before and the day of the surgery.

Inclusion criteria: cases with critical chronic lower limb ischemia with lesions involving the infrapopliteal vessels with peroneal artery as the best target vessel for revascularization with or without proximal lesions presenting with ischemic rest pain and tissue loss as nonhealing foot ulcers or focal gangrene.

Exclusion criteria: patients with claudication either capacitating or incapacitating, patients who have patent anterior tibial artery or posterior tibial artery, aneurysmal disease or AVF, contraindication to anticoagulation or antiplatelet therapy and non-salvageable foot.

2.3. Technique used

Everyone who underwent surgery provided written consent before the operation. The angiography suite was the setting for all interventions. The day before, all of the patients were admitted. Clopiodogrel (300 mg) was administered as a loading dose the night before the operation.

Preprocedural preparations: the patients were admitted 1 day before the procedure, both groins were prepared using an antiseptic solution (povidon). All equipment was checked including monitors, different sized balloons, light system, connections, wires, sheaths, catheters, and stents. The case was lie in the supine position also a local anaesthetic was given (lidocaine2%). 5000 IU heparin was given to the patient after insertion of the sheath if the surgery took more than an hour, extra heparin was administered.

Access site: femoral artery access was used either ipsilateral antegrade or depending on where the Duplex or diagnostic angiography showed the lesion to be located, either contralaterally retrograde or antegrade in the femoropopliteal segment. Ipsilateral antegrade femoral access was used in lesions involving the mid to distal femoropopliteal or infrapopliteal arteries. Contralateral retrograde femoral access was used in atherosclerotic lesions of the iliac, CFA, ostial lesion of the profunda femoris or proximal SFA and obesity. We injected the dye intraarterial to localize the site of lesions before introducing the balloon.

Crossing the lesion: we tried to cross occlusive lesions transluminally, if failed subintimal method was tried. We used wires 0.35, 0.18, 0.14, balloons 3×8, 2.5×8, or 2.5×10 cm for infrapopliteal lesions. We used balloons with diameters ranging from 2.5 to 3 mm, lengths slightly longer than the lesion to perform the PTA with the fewest number of inflations as we believe that this reduces complications, as well as inflated the balloon at a pressure of close to 8 mmHg for 2 min before moving on to the next lesion distally. Each variety of balloon has a unique inflation pressure profile, between the nominal and burst pressures. The duration of inflation was among 2–3 min.

If the wire made it to the end of the vessel, we would inflate the balloon backwards also reinject dye.

After the balloon was deflated, the catheter was removed to its starting point in the middle of the superficial femoral artery. If it was not contraindicated, 100–200 μg of intraarterial nitroglycerin would be injected. Finally, we did completion angiogram intraoperative. Redilatation was done whenever required. Complete hemostasis was achieved via local compression at the conclusion of the surgery.

2.4. Procedural outcome

The procedure was considered to achieve objectives based on the following: immediate success, that is, edema, revascularization warmness, and disappearance of rest pain if present preprocedure. Angiographic success was defined as under 30 % residual stenosis measured with foot perfusion and arch revascularization at the circulatory system's narrowest point.

Procedural complications: represented by major complications include: death or need for emergency operation owing to major bleeding, arterial perforation, or acute thrombotic occlusion and minor problems include: groin hematoma, peripheral emboli, nonflow limiting dissection, or spasm of the tibial vessels which was treated by tridil.

Postprocedural management: it was standard practice to take off the arterial sheath after surgery. The puncture site was manually compressed for 15–20 min, as well as movement was delayed for 12–24 h. Depending on whether or not they had dyslipidemia, individuals were given low-molecular weight heparin subcutaneously for a period of 2 days on therapeutic dose, aspirin 150 mg/day for life, clopidogrel 75 mg/day for a minimum of 3 months, as well as antihyperlipidemic drugs before being sent home the following day. Before being sent home, patients' feet were cared for with wound dressing, restricted amputations, mild debridement, infection control measures, along with appropriate footwear.

Postprocedural follows up searching for: clinical improvement (evaluation of the ulcer or amputation site healing, resolution of infection), Duplex surveillance program: follow-ups 3, 6, and 12 months committed to serving as reliable guidelines for the development of the condition (estimated the length of affected segment, degree of patency of stenosis) and new lesions detected at follow up.

2.5. Study outcomes

Surgery or percutaneous revascularization of an ischemic limb to avert amputation as well as, in an ideal case, promote wound healing and relief from chronic ischemia discomfort or gangrene is considered limb salvage. Amputation of the toe, ray, or transmetatarsal region of the foot was included in this category. Primary patency is referred to the lack of

occlusion or substantial restenosis within the treated segment during the course of follow-up. When an occluded arterial section is treated as well as subsequent patency is achieved, this is known as secondary patency. The operation to remove the limb above the ankle was considered a major amputation. Limb salvage failure was not defined as an amputation at or beyond the tarsometatarsal joints.

2.6. Statistical analysis

The statistical software for social sciences, version 20.0, developed by SPSS Inc. in Chicago, Illinois, USA, was utilized to do the analysis on the data that was recorded. The results of the quantitative study were presented as the mean together with the SD. The frequency and percentage of occurrence were used to express the qualitative data.

3. Results

Regarding patient characteristics among studied group, age ranged between 45 and 80 years with mean 60.7 ± 9.70. There were 70 % of patients were males and 30 % were females (Table 1, Fig. 1).

The study showed that the highest risk factor was hypertension (87.5 %), then diabetic (82.5 %), while the lowest risk factor was cerebrovascular stroke (5 %) (Table 2, Fig. 2).

As regards operative history of the patients, there were four patients who had contralateral major amputation two of them above knee and two below knee. There were five patients had ipsilateral angioplasty of SFA (Table 3).

Regarding indication for revascularization among studied group. There were 20 % ischemic rest pain, 17.5 % major tissue loss above transmetatarsal level, and 62.5 % gangrene of toes (Table 4, Fig. 3).

Regarding site of lesion among studied group, there were 62.5 % infrapopliteal lesion, 30 % femoropopliteal and infrapopliteal lesion, and 7.5 % iliac, femoropopliteal and infrapopliteal lesion (Table 5, Fig. 4).

The 0.035 inch (Terumo) wire was used in 27 (67.5 %) cases, the 0.14 wire was used in two (5 %) cases, and the 0.18 wire was used in 11 (27.5 %) cases (Table 6).

Table 1. Patient characteristics among studied group.

	Patient's group ($N = 40$)
Age (years)	
Mean ± SD	60.7 ± 9.70
Median (IQR)	59 (52.5–69)
Range	35 (45–80)
Sex [n (%)]	
Male	28 (70)
Female	12 (30)

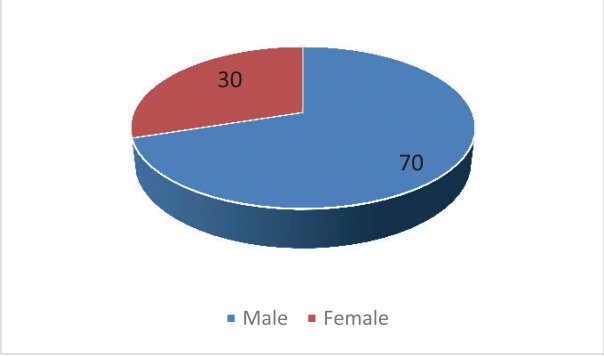

Fig. 1. Sex distribution among included participants.

Table 2. Risk factors for atherosclerosis among studied group.

	Patient's group ($N = 40$) [n (%)]
Diabetic	33 (82.5)
Smoker	25 (62.5)
Hypertension	35 (87.5)
IHD	15 (37.5)
Cerebrovascular stroke	2 (5)
Hyperlipidemia	10 (25)

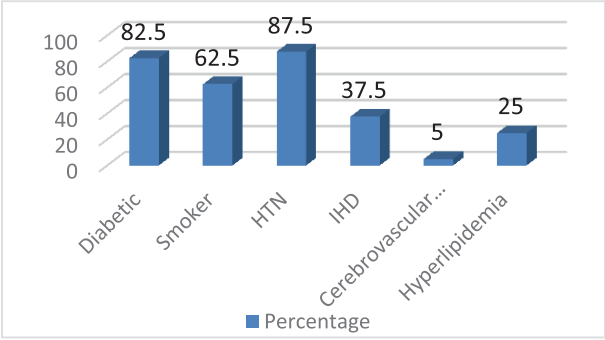

Fig. 2. Risk factors for atherosclerosis among studied group.

Table 3. Operative history among studied group.

	Patient's group ($N = 40$) [n (%)]
Patients had contralateral major amputation	
Above knee	2 (5)
Below knee	2 (5)
Patients had ipsilateral angioplasty of SFA	5 (12.5)

Table 4. Clinical presentation and indication for revascularization.

	Patient's group ($N = 40$) [n (%)]
Ischemic rest pain	8 (20)
Major tissue loss above trans metatarsal level	7 (17.5)
Gangrene of toes	25 (62.5)

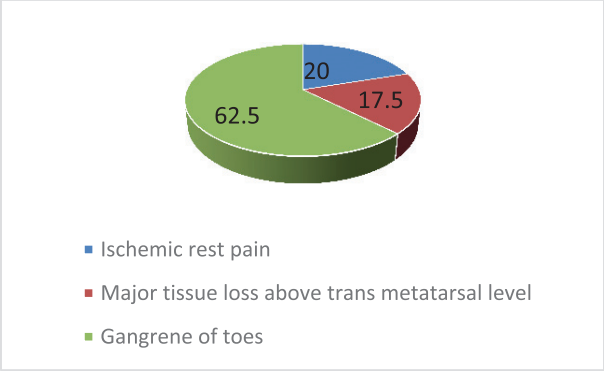

Fig. 3. Clinical presentation and indication for revascularization.

Table 5. Anatomical characters: site of lesion.

	Patient's group ($N = 40$) [n (%)]
Infrapopliteal lesion	25 (62.5)
Femoropopliteal and infrapopliteal lesion	12 (30)
Iliac, femoropopliteal, and infrapopliteal lesion	3 (7.5)

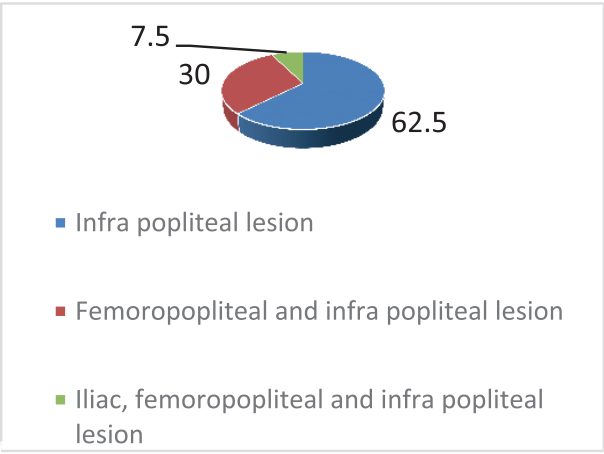

Fig. 4. Anatomical characters: site of lesion.

Table 6. The wires used.

	Patient's group ($N = 40$) [n (%)]
0.35	27 (67.5)
0.35 + 0.18	11 (27.5)
0.35 + 0.14	2 (5)

The intraluminal approach was used in 27 (67.5 %) cases while the subintimal approach was used in 13 (32.5 %) cases (Table 7, Fig. 5).

After angioplasty, at 3 months follow up the PP rate was 92.5 % ($n = 37$) while LS rate was 92.5 % ($n = 37$), at 6 months follow up the PP rate was 82.5 % ($n = 33$) while LS rate was 87.5 % ($n = 35$).

Table 7. The Methods of crossing the lesion.

	Patient's group ($N = 40$) [n (%)]
Intraluminal	27 (67.5)
Subintimal	13 (32.5)

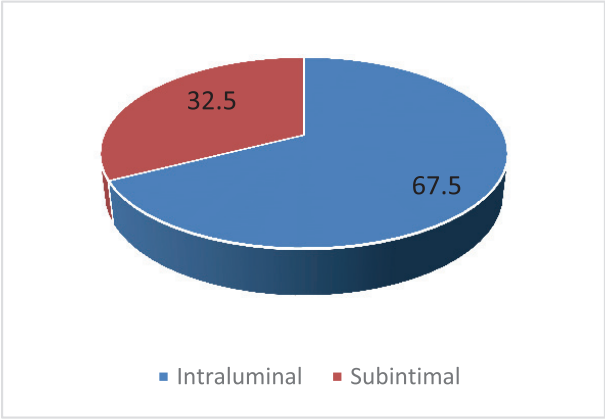

Fig. 5. The Methods of crossing the lesion.

The 12 months follow up the PP rate was 75 % ($n = 30$), the SP rate was 25 % ($n = 10$), while LS rate was 80 % ($n = 32$). On last follow up (18 months) the PP rate was 70 % ($n = 28$), SP rate 25 % ($n = 10$) while LS rate was 70 % ($n = 28$) (Table 8).

The major amputation rate at 3 months follow up was 7.5 % ($n = 3$) BKA, at 6 months follow up the major amputation rate was 12.5 % ($n = 5$). The 12 months follow up the major amputation rate was 20 % ($n = 8$). On last follow up (18 months), there are 12 (30 %) cases that had major amputation (Fig. 6).

Technical success rate was to achieve at least one patent tibial feeding vessel for every treated limb with the peroneal artery as the best target vessel for revascularization and to avoid major amputation (Table 9, Fig. 7).

4. Discussion

It is estimated that 202 million people throughout the world are living with chronic lower limb ischemia, making it one of the most common reasons patients present themselves to vascular surgeons.[4] CLI is predicted to manifest in 25 % of them. CLI is a chronic condition defined by the Trans-Atlantic Society of Cardiovascular Surgery as the presence of ischemic ulcer necrosis or rest pain, limb-threatening ischemia (requiring amputation within 6 months), as well as particular ankle and toe pressure thresholds.[5]

It is questionable whether the peroneal artery should be the only patent vascular in the crucial

Table 8. Follow up data.

	Patient's group ($N = 40$) [n (%)]			
	3 months	6 months	12 months	18 months
Primary patency	37 (92.5)	33 (82.5)	30 (75)	26 (65)
Secondary patency	0	0	10 (25)	10 (25)
Limb salvage	37 (92.5)	35 (87.5)	32 (80)	28 (70)
Major amputation	3 (7.5)	5 (12.5)	8 (20)	12 (30)

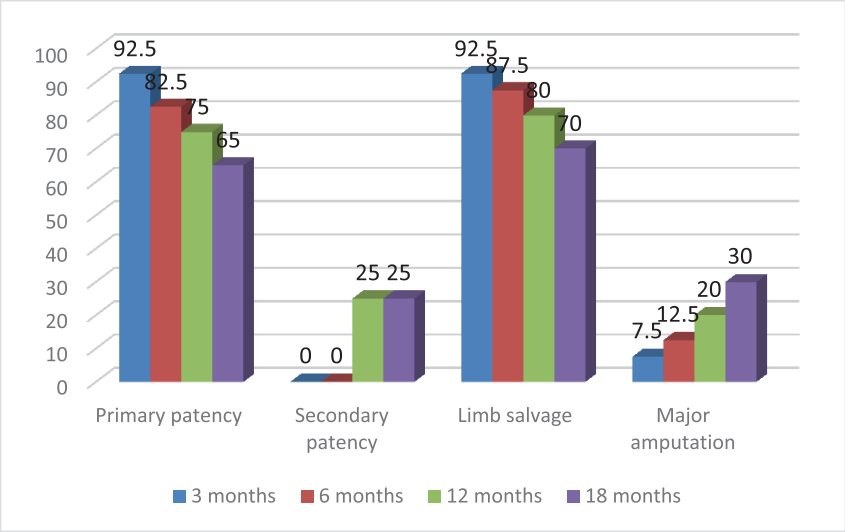

Fig. 6. Follow up data.

Table 9. The success rate.

Success rate	Months [n (%)]			
	3	6	12	18
Successful angioplasty	37 (92.5)	35 (87.5)	30 (86)	28 (70)

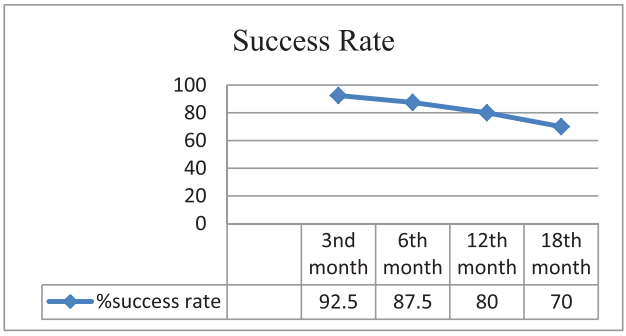

Fig. 7. The success rate.

limb ischemia. The peroneal artery is unique in that it does not connect to the larger pedal vessels at its terminus and hence only provides little angiosomes.[6] The angiosomal theory of wound healing postulates that recanalizing the artery that supplies blood to the ischemic ulcer is preferable than revascularizing adjacent arteries. However, this angiosomal technique is not always possible, and the surgeon may instead find only a single accessible vascular runoff as well as be forced to increase the foot perfusion via indirect flow. This is an unconventional strategy that may or may not work.[7]

Blood flow to the foot can be restored through either the interangiosomal choke vessel or the pedal arch, according to certain research that found no significant distinction to the angiosome idea of wound healing.[8]

Regarding demographic data, the current study showed that the mean age of the studied cases was 60.7 ± 9.70 years with male predominance (70 %).

In line with the current study, Abou Hashish et al.[9] showed that the largest percentage of CLI patients were males (77.8 %) with age ranged from 51 to 73 years old. Their mean age was 61.67 years.

Also Ghoneim *et al.*[10] revealed that CLI was more prevalent among males (55 %), individuals' ages varied widely among 42–86.

Regarding risk factor the highest risk factor was hypertension (87.5 %), then diabetic (82.5 %), while the lowest risk factor was cerebrovascular stroke (5 %).

In concordance with the current study, Abou Hashish et al.[9] revealed that all of the CLI cases

were diabetics, half of them were hypertensive. Around 66 % of them smoked regularly.

Regarding operative history among studied group there were four patients who had contralateral major amputation, two of them above knee and two below knee. There were five patients who had ipsilateral angioplasty of SFA.

Regarding indication for revascularization among studied group. There were 20 % ischemic rest pain, 17.5 % major tissue loss above transmetatarsal level, and 62.5 % gangrene of toes.

In line with the current study, Abou Hashish et al.[9] showed that rest pain was the most common presenting symptom, followed by gangrene.

Regarding site of lesion among studied group, there were 62.5 % infrapopliteal lesion, 30 % femoropopliteal and infrapopliteal lesion, and 7.5 % iliac, femoropopliteal, and infrapopliteal lesion.

In concordance with the current study, Ghoneim et al.[10] and Abdelhafez et al.[11] showed that all of the studied patients have infrapopliteal lesion.

Femoral artery access was used either ipsilateral antegrade or retrograde fashion based on the lesion site in the femoropopliteal segment from the outcome of the Duplex or diagnostic angiographic study. Ipsilateral antegrade femoral access was used in lesions involving the mid to distal femoropopliteal or infrapopliteal arteries. Contralateral retrograde femoral access was used in common femoral artery, atherosclerotic lesions of the iliac, ostial lesion of the profunda femoris or proximal superficial femoral artery, and obesity.[10]

Regarding access site among studied groups, there were 77.5 % ipsilateral, and 22.5 % contralateral. Regarding sheaths used among studied groups, there were 87.5 % 6 F sheath, and 12.5 % 8 F sheath.

However Ismail,[12] showed that in those suffering from CLI, peroneal artery endovascular revascularization was conducted as a single-vessel runoff, while all procedures were done through ipsilateral femoral access employing a 6 Fr sheath. Regarding wires used among studied group. There were 67.5 % use wire 0.35, 27.5 % use 0.35 + 0.18, and 5 % use 0.35 + 0.14.

Also, concerning methods of crossing the lesion among studied group. There were 67.5 % intraluminal, and 32.5 % subintimal. As well, regarding guiding catheters among studied group. There were 77.5 % Bern 4 F, and 22.5 % Rim catheter. Also, the most common balloon size used among patients was 3 mm (62.5 %) then 2.5 mm (37.5 %).

However Ismail,[12] in similar study used V-18 guide wire or 0.014-inch hydrophilic guide wire was able to pass through the lesion intraluminally or subintimally and then back into the real lumen with the use of a 4 Fr vertebral catheter. In certain cases, nitroglycerin (100–200 μg) proved beneficial in overcoming the vascular spasm after balloon dilatation using 2-, 2.5-, or 3-mm diameter low-profile balloons (executed for 1–2 min).

An angioplasty procedure using a balloon of the appropriate size was carried out so that it would be compatible with the healthy artery that was located next to the lesion.[13]

In the current study there were 67.5 % single runoff and 32.5 % multiple runoffs.

Regarding follow up data among studied group. The primary patency and limb salvage among patients decrease over time. While the major amputation increases over time. The primary patency rates were 37 (92.5 %), 33 (82.5 %), 30 (75 %), and 26 (65 %) at 3-, 6-, 12-, and 18-month follow-up, respectively. The limb salvage rates were 37 (92.5 %), 35 (87.5 %), 32 (80 %), and 28 (70 %) at 3-, 6-, 12-, and 18-months follow-up, respectively. The major amputation rates were three (7.5 %), five (12.5 %), eight (20 %), and 12 (30 %) at 3-, 6-, 12-, and 18-months follow-up, respectively.

In line with the current study Abdelhafez et al.[11] showed that the primary patency among patients decreases over time. The primary patency rate was 70 % after 1 and 3 months, but it dropped to 56.7 % after 6 months. As well as after a year, it had reached 40 %. After 1 year, 70 % of patients (21 total) were able to keep at least one of their limbs, while 30 % of participants (nine total) required a major amputation.

4.1. Conclusion

When compared with open lower extremity revascularization, endovascular revascularization is less invasive and causes less morbidity; as a result, it has been increasingly used to treat more complex lesions in patients who regularly present with progressing disease. Endovascular revascularization has also become increasingly popular. The peroneal artery was evaluated as a single-vessel runoff in addition demonstrated satisfactory long-term patency in addition to limb salvage rates.

Conflicts of interest

There are no conflicts of interest.

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