Comparison of the endovascular revascularization outcomes of Anterior Tibial versus Posterior Tibial angioplasty
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Abstract

Objective: Due to the long healing period of diabetic foot ulcers, approaches are required to recognize ways to accelerate the ulcer process of healing. The concept of the angiosome divides the body into three-dimensional tissue blocks supplied by particular source arteries. The objective of this research was to assess the value of endovascular infra-popliteal revascularization in patients with single vessel runoff taking in consideration the angiosome model of perfusion in the healing process of diabetic foot ulcers.

Methods: In total, 106 patients with critical limb ischemia and single vessel runoff who had undergone endovascular revascularization were evaluated. Patient records and periprocedural leg angiograms have been reviewed. The legs were divided into two groups posterior tibial artery and anterior tibial artery single runoff, they were also divided into two groups as per to whether or not direct arterial flow to the foot ulcer site was achieved depending on the concept of angiosome (direct group) or not (indirect group). Patency rates and limb salvage rates were compared between the two groups.

Results: Our results show that PTA as a single runoff showed significantly higher primary patency (p value= 0.04) and limb salvage rates (p value= 0.01) at 3 and 6 months than the ATA as single runoff vessel. Direct flow to the angiosome going to feed ulcer region has been achieved in (51%)of patients compared with indirect revascularization in (49%) of patients. Patients treated with angiosome-targeted angioplasty had better limb salvage rates. DR limb salvage was (98%) while IR was(92%) at 6 months.(P value = 0.04)

Conclusions: Posterior tibial artery shows better limb salvage rates as a single vessel runoff and as well, direct revascularization shows better limb salvage rates than indirect revascularization

Keywords: Angiosome, Foot Ulcers, Distal Runoff

INTRODUCTION

For CLI patients, particular factors apply. CLI is characterized by multi-level disease and a high impact of comorbidities. Therefore, decision-making in CLI revascularization approaches varies greatly from those in patients with claudication, as the main concern in CLI is to ensure that ulcer recovery, limb rescue and maintained ambulation are various therapeutic objectives than enhanced walking capacity. Long-term patency as such is probably a second priority.

An increased incidence of major amputation of up to eight folds per obstructed crural artery has been reported in studies, with a significantly high incidence of occlusion of all three crural arteries during procedures. [1] Other studies, nevertheless, have concluded that clinical
reperfusion outcomes are dictated by the restoration of blood flow to the ischemic region instead of the number of tibial runoff vessels reached to the foot, and have shown that better limb rescue rates reported in their angiosome-oriented endovascular group are independent of the number of runoff vessels.[2, 3].

As well as being connected by medium and large sized collateral vessels, like the pedal arch and peroneal distal branches, pedal angiosomes are also connected by collateral of small sized vessels called “choke-vessels” which can mainly maintain ischemic tissue circulation in healthy people. [10].

The arterial lesions that lead to CLI usually are long lesions or part of extensive disease.[4, 5] However, it was reported that TASC A & B can cause CLI in diabetics given the presence of microangiopathy that hinder the flow of blood through arterio-venous fistulae to the microvascular bed, which can produce symptomatic disease with less progressed femoro-poplitieal disease,[3, 6] several studies reported success rates of PTA up to 84% in CLI patients who have been TASC C or D with primary patency rates up to 88%. [7] However, It is now accepted that mere patency seems to be not as important as limb rescue evidenced by presence of asymptomatic sufferers with subclinical lower limb ischemia and low perfusion pressure who develop symptoms only following foot ulceration as they lack the circulatory reserve to promote healing except after improving the local arterial perfusion even transiently.

Ischemic ulcers can show delayed or failed healing process due to lack of ties among the reperfused tibial artery and the local ischemic territory. The theoretical foundation for studying the impact of this possible factor on ulcer healing is offered by the angiosome anatomical concept. In CLI cases, this anatomical model is implemented for revascularization planning, and promising outcomes were reported showing that achieving direct arterial blood flow via the tibial artery which selectively feeds the compromised foot angiosome may result in better ulcer healing and limb preservation results.[8, 9]

**METHODS**

This is a prospective research carried out over the period from 4/2013 to 4/2014 on patients submitted to our Department of Vascular and Endovascular Surgery, Kasr Al Ainy Hospital, Cairo University.

Out of 450 patients with chronic lower limb ischemia presented to our hospital during the last year, 106 who underwent endovascular management with single vessel runoff. According to the TASC guidance, we defined chronic critical lower extremity ischemia as: lower extremity with rest pain for more than two weeks, ulcers, or tissue loss due to arterial occlusive disease.

In patients with non-salvageable limbs that require major primary amputation, acute thrombotic or embolic ischemia, aneurysms, trauma, arteritis or connective tissue disorders, were removed from this research. All sufferers underwent history taking, proper clinical review and radiological imaging.
Ipsilateral antegrade puncture of the common femoral artery was the first preference technique for lower extremity intervention. Anatomical and fluoroscopic localization of the common femoral artery was done. If the duplex scan showed iliac or common femoral artery stenosis > 50% proximal SFA lesion, extreme obesity, increased femoral bifurcation, prior stenting of the common femoral artery, recent hematoma, or suspected skin infection at the target groin, the contralateral femoral method was selected.

A bolus of 5000 IU of non-fractionated heparin was then given. An initial angiogram was done to confirm the pre-procedure duplex and to determine the morphology of the lesion and the plan of treatment.

For the dilatation of arteries, a guide wire was inserted over arterial obstructions and balloon catheters. Over dilatation of vessels especially tibials was avoided to avoid intimal hyperplasia. Tridil 5 mg/ml (1 ml diluted into 10 ml saline) was administered intra-arterially in cases of vessel spasm.

Stents were used selectively in cases of: Flow limiting dissection, residual stenosis >30% or occluding intimal flap. When direct flow was angiographically obtained in the treated vessel with or without distal pulsation retrieval, vessel recanalization was deemed efficient.

Figure 1 Angiography of a patient presented with ulcer on the plantar aspect of the forefoot and posterior tibial artery as single vessel runoff that was successfully recanalized using 2.5mm x 120mm balloon

Figure 2 Angiography of a patient who presented with toe gangrene and occluded anterior tibial artery and DPA that was treated using 3mm x 200mm paclitaxil drug eluting balloon after pre-dilatation by 3mm x 150mm balloon
The following data were recorded for every patient:

- Lesions were categorized into stenosis or occlusion or both which in all cases applied to the TASC classification.
- Crossing the diseased segment in terms of wire type, either intraluminal or subintimal crossing modality, and whether or not the crossing was successful till the foot level was registered.
- Intra-procedure complications like recoil and spasm of the vessel, dissecting whether or not the flow is limited and the necessity for therapy.

Procedure outcome:
Clinical evaluation (pulse, capillary refill, and warmth) and angiography were the basis for the immediate assessment. The outcome was evaluated for every case immediately post-procedure, 3 months and 6 months later. Follow up was according to clinical re-assessment, duplex findings, ABI or PSV.

The success of the procedure has been defined by the following:

Technical success:
Angiographic immediate success is characterized as good flow at the narrowest point of the arterial lumen with less than 30% residual stenosis.

Clinical success, that may include:
final success in the form of pulse recovery, clinical progress (good capillary circulation, warmth, rest pain relief and good ulcer healing or slight amputation which is up to forefoot amputation) and improvement of preprocedural ABI and or PSV.

- Primary patency.
- Secondary patency.
- Limb Salvage.

Early debridement, abscess drainage, slight amputations, and wet dressings are the local treatment of the foot. In line with our general protocol, serious infections have received broad spectrum antibiotic treatment. The process of healing was tracked at periods of 1 to 2 weeks. All written documents and digital photographs taken during the follow-up have been assessed. As the time required for the full epithelialization of the ischemic ulcer, we described “healing time”. “Major amputation” has been identified as an amputation above the ankle.

Data was statistically defined in terms of frequency (number of cases) and percentages, where applicable. The Chi square ($\chi^2$) test was utilized to compare the study groups. Instead, the exact test was utilized when the predicted frequency was less than 5. The p values of less than 0.05 were deemed statistically significant.

RESULTS

This study was conducted on 106 patients with critical lower limb ischemia in a period of 12 months and the following results were obtained.

The number of female patients was 60 (56.61% of the cases), while there were only 46 male (43.49%) patients. The age group of the study population varied from 42 to 82 years with an average age of 60.3 years. The comorbidities were diabetes, hypertension, smoking, cardiac
diseases, COPD and stroke. With diabetes and hypertension being the most prevalent (98.22% and 75.48% respectively)

Thirty five percent (34.53%) of the patients presented with rest pain, while (64.16%) presented with tissue losses in the form of non-healing ulcers in (26.42%), gangrenous toes(37.74%) and forefoot gangrene in (22.65) and heel lesions in two patients (1.88%).(Table 1)  

Table 1: Different presentations of the patients

<table>
<thead>
<tr>
<th>Presentations</th>
<th>frequency</th>
<th>Percent</th>
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</thead>
<tbody>
<tr>
<td>Rest pain</td>
<td>26</td>
<td>34.53%</td>
</tr>
<tr>
<td>Non-healing ulcer</td>
<td>28</td>
<td>26.42%</td>
</tr>
<tr>
<td>Toe gangrene</td>
<td>40</td>
<td>37.74%</td>
</tr>
<tr>
<td>Forefoot gangrene</td>
<td>24</td>
<td>22.65%</td>
</tr>
<tr>
<td>Heel lesion (ulcer/gangrene)</td>
<td>2</td>
<td>1.88%</td>
</tr>
</tbody>
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The length of lesion was <5cms in (15.9 %), from 5 to 10 cms in (28.3%) and >10 cms in (56.6%). Sites of lesions were SFA ,popliteal artery, tibioperoneal tunk(TPT) ,Anterior tibial artery(ATA) and posterior tibial artery(PTA).

Seventy seven and a half percent (77.5%) of patients had lesions in the angiosome supplied by PTA, while 22.5% of patients had lesions in the angiosome supplied by ATA. Fifty percent (50%) of patients had revascularization of the affected angiosome, while 50% had indirect revascularization. Eighty five percent 85% of those who undergone direct revascularization had PTA as single vessel runoff, and 15% had ATA as single vessel runoff. (Table2)

Table 2 Direct vs indirect revascularization

<table>
<thead>
<tr>
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<th>PTA</th>
<th></th>
<th>ATA</th>
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<tbody>
<tr>
<td></td>
<td>Direct</td>
<td>Indirect</td>
<td>Direct</td>
<td>Indirect</td>
</tr>
<tr>
<td>Frequency</td>
<td>34</td>
<td>28</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Percent</td>
<td>85% of total direct</td>
<td>70% of total indirect</td>
<td>15% of total direct</td>
<td>30% of total indirect</td>
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</tbody>
</table>

Post procedure, dorsalis pedal pulse was restored in (45.28%), posterior tibial pulse was restored in(45.28%) ,popliteal pulse was restored in (2%) , failed angioplasty in(7.45%) due to either failure to cross the lesion ,failure of reentry or myocardial infarction and ICU transfer.

Primary patency at 3 months in patients with ATA as single vessel runoff was 88% ,PTA was 100%. Primary patency at 6 months in patients with ATA as single vessel runoff was 84% , PTA was 92%. Primary patency of posterior tibial was significantly higher than that of ATA at 3 and 6 months ( P value = 0.01),( P value = 0.04) respectively.

There was no secondary patency as none of the cases needed reintervention within the 6 months follow up period.

Limb salvage at 3 months with ATA patients was 88%, PTA was 100% Limb salvage at 6 months with ATA patients was 84%, PTA was 96%. Limb salvage of posterior tibial was
significantly higher than that of ATA at 3 and 6 months (P value = 0.01), (P value = 0.04) respectively.

Total number of sufferers underwent amputation was 10(10%), 6 of them below knee (BKA) (60%) and the rest (40%) above knee amputation (AKA).

Among these, four BKA, two AKA were done after 3 months due to presence of non-salvageable lesions of the heel or life threatening infection, two BKA, two AKA were done after 6 months due to the same reasons. All of patients who had BKA had ATA as single vessel runoff. Two of the patients who had AKA had ATA as single vessel runoff, two of them had PTA as single vessel runoff.

**DISCUSSION**

The existence of substantial tissue loss (forefoot or beyond) has shown a limb salvage rate of 72.7 %, 63.6 % at 3 and 6 months in the present research. In a study by Taylor et al [11], it was argued that clinical success for ischemic tissue loss following lower limb revascularization was defined by intrinsic patient variables and not by revascularization methods.

TASC II D infrainguinal lesions were found in 46 cases (52.83%). This indicates that CLI includes extensive illness and long occlusion, not just short stenosis or occlusion, and this was compatible with other research [4, 5, 12]. Nevertheless, as diabetic patients often had microvascular deficiency (microangiopathy), TASC A & B could induce CLI since the existence of DM tends to decrease blood flow through arterio-venous fistulae to the microvascular bed, contributing to symptomatic disease with less progressive femoro-popliteal disease.[6, 13].

In the current study, lesions more than 10 cm were present in 56.60% of cases and SFA segment was the highest segment affected, and our results were almost similar to those mentioned in other studies. In the study by Taneja et al,[14] similar limb salvage rates were observed in CLI patients with long-segment occlusions treated with bare nitinol stents like in our study; and primary patency rates were relatively low at 61.5% and 27% following 6 - 12 months, respectively.

In the current study; primary patency rate was 94%, 90% at 3 and 6 months follow-up respectively. The limb salvage rate after 3 and 6 months were 94%, 90% respectively. Our results were relatively consistent with other studies.[15, 16] (P value=0.04-0.01) respectively.

Primary patency for ATA cases was (88%) and (84%) for 3 and 6 months follow up respectively. Primary patency for PTA cases was significantly higher (100%) and (96%) for 3 and 6 months follow up respectively. (P value=0.04-0.01) respectively.

There was no secondary patency rates because none of the patients needed reintervention within the 6 months follow up period. Our primary patency was the same as our limb salvage rates.

This can be proposed that revascularization of the feeding artery to the angiosome can lead to better ulcer recovery and limb rescue rates, given that in nearly 86.5 % of instances ischemic heel ulcers perfused by the dorsalis pedis can heal [17]. This indicates there are intra-arterial
links among the dorsalis pedis, the peroneal artery, and the common plantar artery's medial and lateral plantar branches. Consequently, direct revascularization (DR) of arteries feeding the compromised angiosome target may be more effective in regards of ulcer healing than indirect revascularization (IR) [25].

In the current study, all patients (106) had single vessel runoff. Forty nine percent (49.06%) of cases had ATA as runoff and (50.94%) had PTA. DR was achieved in (51%) of cases while IR was (49%). Most of DR followed the PTA angiosome (85%), while ATA angiosome represented only (15%) of DR.

DR limb salvage was significantly high (98%) while IR was (92%) at 6 months (P value=0.04). Limb salvage rate of (100%) and (96%) at 3 months and 6 months respectively in patients with PTA as single runoff, (85%) of which undergone revascularization of the injured angiosome. While (88%) and (84%) in patients with CLI, who underwent endovascular revascularization at 3 months and 6 months respectively, with ATA as single runoff, (15.3%) of which undergone revascularization of the injured angiosome.

Similarly in patients with diabetes with tissue loss who undergone endovascular lower extremity procedures wherein the specific revascularization of the damaged angiosome was regarded, Alexandrescu et al. registered a limb rescue rate of 84 % and an ischemic ulcer recovery rate of 73 % at 36 months [8]. When using the angiosome concept, Attinger et al also reported a 9% recovery fail rate opposed to a 38% fail rate when wounds were indirectly revascularized [26]. In line with this disparity in wound healing, when DR was not feasible, they were able to demonstrate a worse limb salvage rate [3].

In a broader cohort study of 203 successively treated limbs, the rate of limb salvage was 86% with DR contrasted to 69% with IR, the conclusions that other researchers have confirmed in high-quality case series [9, 25].

61 % was conducted in a prospective trial of 64 patients with CLI and single-vessel runoff to the foot DR, and 39 % was conducted with IR. In 39.1%, the process of revascularization versus open surgery in 60.9 % was the endovascular procedure. Regarding patients’ presentations: 81.2% had ischemia of the forefoot, 17.2% had ischaemic heel, and 1.6% had ischemic ulcers that were not healing. The leading artery to the foot was ATA in (42.2%), PTA in (34.4%) and the peroneal artery in (23.4%). Follow up at 1, and months showed that ulcer healing was superior with DR than with IR. In terms of limb salvage, no statistically significant differences could be observed, even though there was a benefit trend for DR. In direct comparison this research indicates that DR contributes to better healing of the ulcer, that was statistically significant (P= 0.021), while there was no statistically significant improvement in the limb salvage rate.

In this context, we argue that the discrepancy of findings among publications focusing on foot outflow vessels may be partly explained in some studies by the lack of a classification of foot anatomical ulcer and the lack of data on foot and ankle collateral patency. The theoretical basis for exploring the impact of distal collateral vessels on distal revascularization of ischemic ulcer healing and limb rescue may be the angiosome classification of foot tissue loss.
CONCLUSION

Based on our results, achieving perfusion through a direct line to the foot following endovascular interventions in diabetics with CLI and tissue loss is of utmost importance in regards of ulcer healing and limb preservation.

Clinical improvement is dependent on restoration of blood flow to the local ischemic territory regardless the number of patent tibials following revascularization. This can be achieved through either medium or large collateral vessel or the specific tibial artery. Consequently, careful planning and knowledge of the foot collateral circulation anatomy is mandatory before attempting endovascular interventions.

REFERENCES


