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CASE REPORT

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Percutaneous deep vein arterialization: An emerging technique for no-option chronic limb-threatening ischemia patients

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Abstract

Chronic limb-threatening ischemia (CLTI), with characteristic ischemic rest pain, non-healing ulcers, or gangrene attributable to arterial occlusive disease, requires successful revascularization to minimize tissue loss. End-stage CLTI in particular, with occlusion of the pedal arteries, results in a lack of suitable targets for bypass and can result in failure of endovascular revascularization procedures, leaving no option for treatment other than amputation. With limb salvage as the primary goal, non-traditional revascularization techniques such as percutaneous deep vein arterialization (pDVA) may help minimize incidence of amputation. We present a case of a patient with no-option CLTI, at high risk of amputation who failed conventional endovascular revascularization attempts facing imminent major amputation. The limb was salvaged with a successful pDVA procedure.

KEYWORDS

critical limb threatening ischemia, endovascular intervention, peripheral arterial disease

1 | INTRODUCTION

Chronic limb-threatening ischemia (CLTI) is the most severe clinical manifestation of peripheral artery disease. It is characterized by presence of persistent ulceration, gangrene or ischemic rest pain in addition to objective data of diminished peripheral arterial circulation. Prevalence of the disease is estimated at 2 million cases in the United States and has been rising significantly with ongoing increases expected.[1] Disease burden is unacceptably high in all aspects. Patients with CLTI have a high amputation rate. Moreover, mortality rate can reach up to 85% at 5 years in patients treated with major amputation.[2] Not surprisingly, the readmission rate at 6 months is 60% among CLTI patients.[1]

2 | CASE PRESENTATION

A 61-year-old female African American patient with peripheral arterial disease (PAD) initially presented with a left third toe wound (Figure 1a), Society for Vascular Surgery Wound, Ischemia, foot Infection (WIfI) Stage 4.[3] The patient had a history of coronary artery disease treated with coronary artery bypass surgery, paroxysmal atrial fibrillation on chronic anticoagulation therapy, type II diabetes mellitus, and end stage renal disease on hemodialysis. Her ankle brachial index suggested medial arterial calcinosis of infrapopliteal vessels. A peripheral arteriogram showed patent inflow arterial system with severe diffuse infra-popliteal disease particularly distally (Figure 2). An endovascular intervention to the proximal left anterior tibial artery was performed with a 3.0 mm × 12 mm drug-eluting stent. A month later the patient presented with gangrenous changes in the toe requiring amputation of the digit. Wound care follow-up showed signs of surgical site wound dehiscence (Figure 1b) with forefoot necrotic changes (Figure 1c). Two weeks later, significant worsening of the wounds were noted and a transverse metatarsal amputation was required. Three weeks later, signs of surgical wound dehiscence were noted (Figure 3). Hence, below the knee amputation

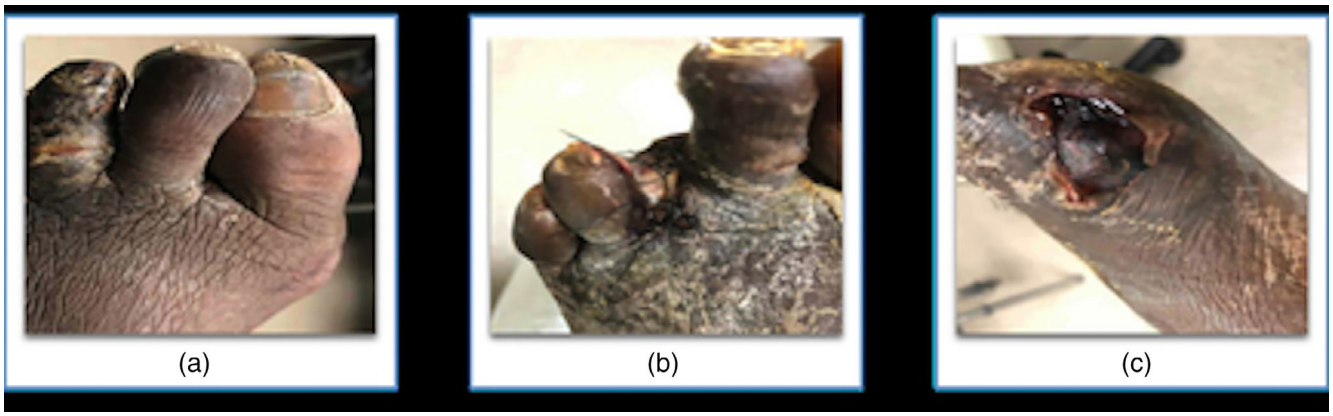

FIGURE 1 (a) Ischemic third toe wound. (b) Wound dehiscence at toe amputation site. (c) Necrotic changes at forefoot [Color figure can be viewed at wileyonlinelibrary.com]

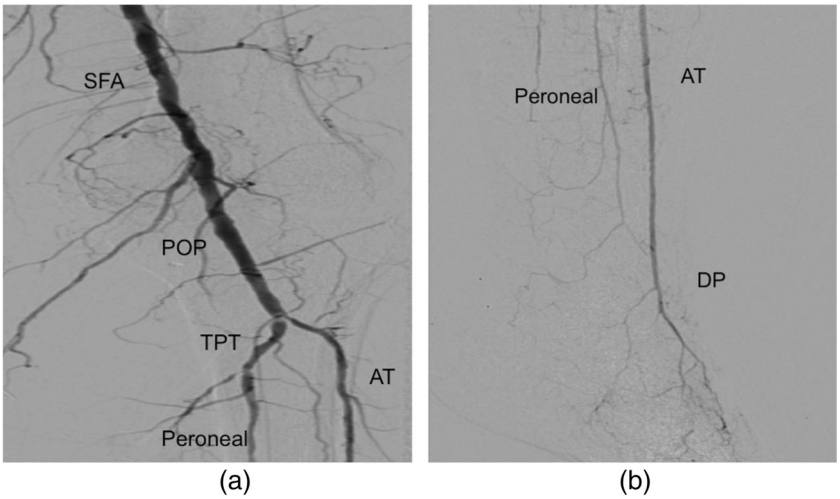

FIGURE 2 (a) Angiogram illustrating patent superficial femoral artery (SFA) and popliteal artery (POP). Severe ostial anterior tibial (AT) and tibiperoneal trunk (TPT) disease. (b) Angiogram illustrating one vessel run off anterior tibial/dorsalis pedis (DP) to the foot with severe small vessel disease

FIGURE 3 Wound dehiscence at transverse metatarsal amputation site [Color figure can be viewed at wileyonlinelibrary.com]

was discussed with the patient. The option of deep vein arterialization (DVA) was considered as a last option before the amputation.

3 | PROCEDURE TECHNIQUE

Antegrade left common femoral artery access was obtained. Angiography confirmed severe infrapoplital disease as shown in (Figure 4). A Fielder XT (Asahi Intecc USA Inc, Tustin, CA) guidewire was advanced through the previously placed anterior tibial artery stent struts into the tibioperoneal artery trunk (TPT) (Figure 5). Balloon angioplasty was performed with a 3.0×20 Ultraverse balloon (BARD, Tempe, AZ). Distal posterior tibial vein access was unsuccessful due to severe spasm. An IVUS-guided reentry catheter (Pioneer Plus, Philips Volcano, San Diego, CA) was used to cross from the TPT into the proximal peroneal vein (Figure 6). A Cougar XT guidewire (Medtronic, Santa Rosa, CA) was advanced into distal peroneal vein then crossed at ankle level to superficial dorsal vein with connection to the medial plantar vein followed by subsequent serial balloon inflations for vessel

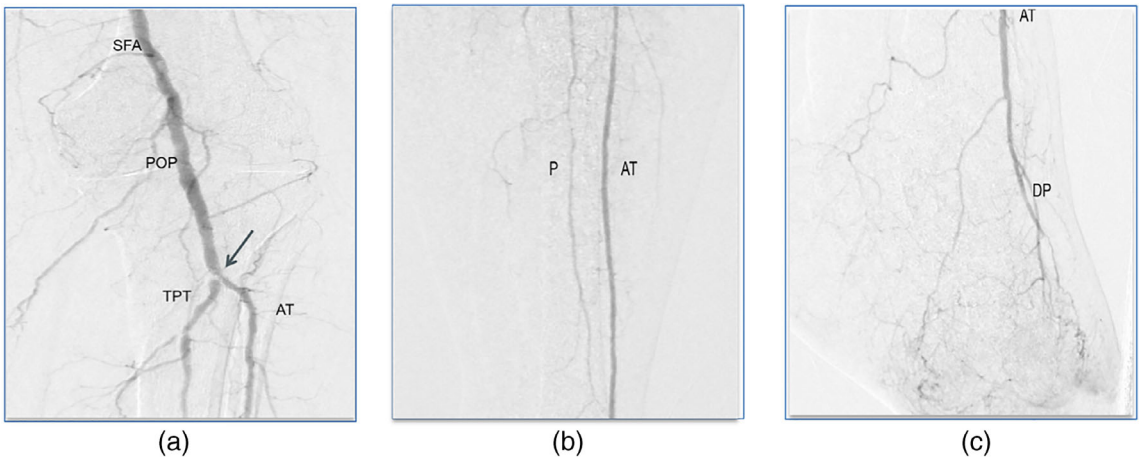

FIGURE 4 (a) Angiogram illustrating patent distal superficial femoral (SFA) and popliteal (POP) arteries with significant lesion at proximal left anterior tibial (AT) and jailing of the tibiperoneal trunk (TPT) from the prior AT stent (arrow). (b) Angiogram illustrating patent mid anterior tibial artery, severe diffuse disease in peroneal artery with occluded posterior tibial artery. (c) Angiogram illustrating one vessel run off anterior tibial/dorsalis pedis (DP) to the foot with severe small vessel disease [Color figure can be viewed at wileyonlinelibrary.com]

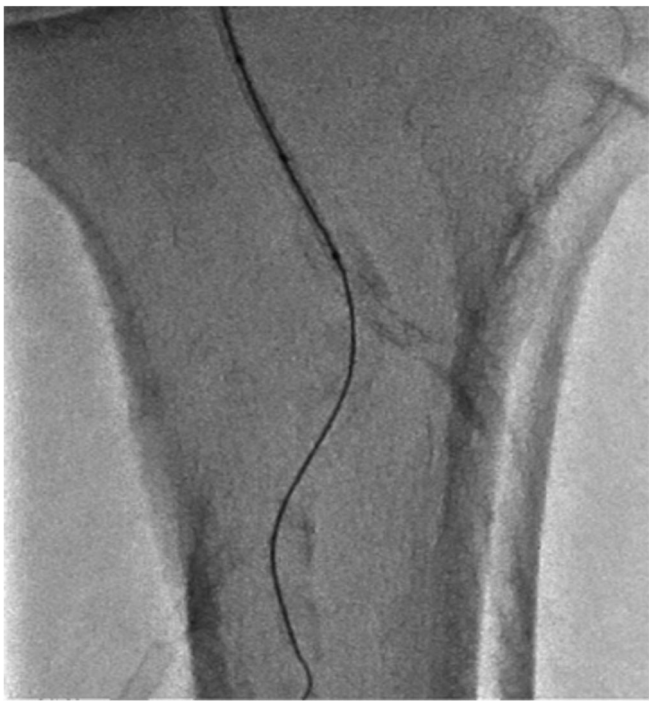

FIGURE 5 Angiogram illustrating crossing through anterior tibial artery stent struts into tibioperoneal trunk

FIGURE 6 Angiogram illustrating crossing from tibioperoneal trunk (TPT) into proximal peroneal vein with an IVUS-guided reentry catheter

preparation (Figure 7). Plantar vein valvulotomy was performed with a 3.0 × 150 mm scoring balloon (Ultrascore, BARD). Two overlapping 5.0 × 220 mm and 5.0 × 100 mm covered stents (Viabahn, GORE, Flagstaff, AZ) were deployed successfully from the distal peroneal vein to the TPT following dilatation with a 5.0 mm × 200 mm balloon. A final kissing balloon inflation of the TPT and AT was performed with 4.0 mm × 40 mm balloons. The post-intervention angiogram demonstrates establishment of good blood flow to the foot (Figures 8–10).

4 | FOLLOW-UP

Dramatic improvement in wound healing with formation of healthy granulation tissues was noted 3 weeks later. The patient underwent comprehensive multidisciplinary wound care. At 6 months follow-up the wound healed and the limb was salvaged (Figure 11).

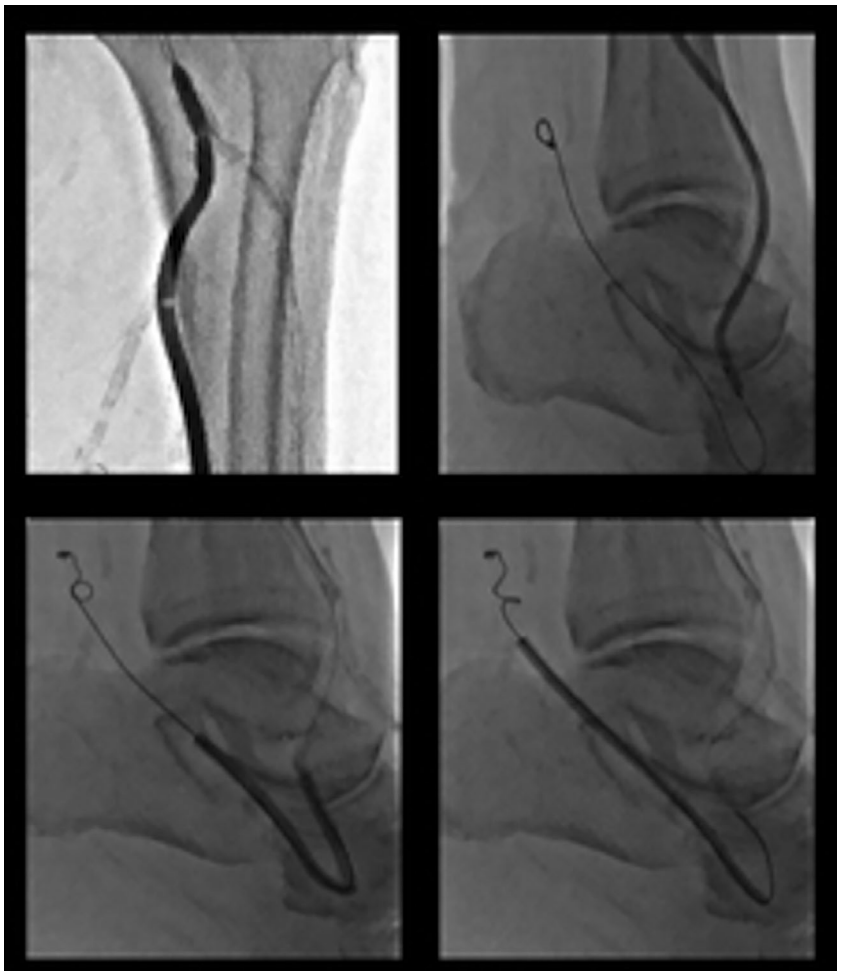

FIGURE 7 (a, b) Angiogram illustrating serial balloon dilatations of the peroneal vein. (c, d) Angiogram illustrating serial balloon dilatations of the plantar vein

5 | DISCUSSION

Approaches to PAD revascularization has expanded significantly over the last decade, with considerable advancement in procedural technique, introduction of innovative equipment, and meticulous wound care have become the cornerstone in caring for CLTI patients. Our patient was considered a no-option CLTI patient and below the knee amputation was imminent. Arterializing the patient's own deep veins was this patient's last opportunity for limb salvage.

DVA provides an additional treatment opportunity where no other options are possible. In this procedure, the flow in the distal deep veins is reversed with endovascular proximal arteriovenous fistula creation and distal valvulotomy using valvulotomes, looped wires, or balloon angioplasty with specialty balloons. Interestingly, the concept of venous arterialization was first described in early 20th century, and it has evolved since.[4] The ultimate goal is to improve wound perfusion using veins as conduits to deliver oxygenated blood to the capillary bed. In addition to the fully percutaneous approach described in this case, a hybrid approach (bypassing the greater saphenous vein to a patent popliteal or distal superficial femoral artery then performing valvulotomy in the medial marginal and forefoot veins) has been described.[5] Additionally, open surgical techniques using the greater saphenous vein, cephalic vein, and PTFE graft with vein patch in rare cases as conduits from common femoral, superficial femoral, popliteal, or proximal tibial arteries to deliver oxygenated blood to distal veins have been reported with excellent outcomes.[6,7]

Studies on surgical DVA are few with limited number of patients. The pooled limb salvage rate with DVA at 12 months has been reported at 75%.[8] Complications of DVA include excessive foot edema, venous gangrene, wound infection, and prolonged hospitalization. Long-term outcome data following DVA is sparse and larger studies are needed.[9] Of note is the LimFlow device (LimFlow, Santa Clara, CA) a purpose-built device for pDVA which has CE-mark in Europe and is under IDE investigation in the United States (PROMISE II Trial) with the indication of treating CLTI by creating an arteriovenous connection in the below-the-knee vasculature. Using the LimFlow device the ALPS (Alkmaar, Leipzig, Paris and Singapore) multicenter study of 32 Rutherford Class 5 and 6 CLTI patients reported an amputation-free-survival of 67% at 2 years accompanied by 73% complete wound healing and a median time to complete healing of 5 months.[10] Early results of another 32-patient study of the LimFlow System conducted in the United States show a trend toward similar results with a 74% amputation-free-survival rate at 6 months with 67% complete wound healing.[8] Due to the current limited availability of LimFlow device across countries other simplified approaches has

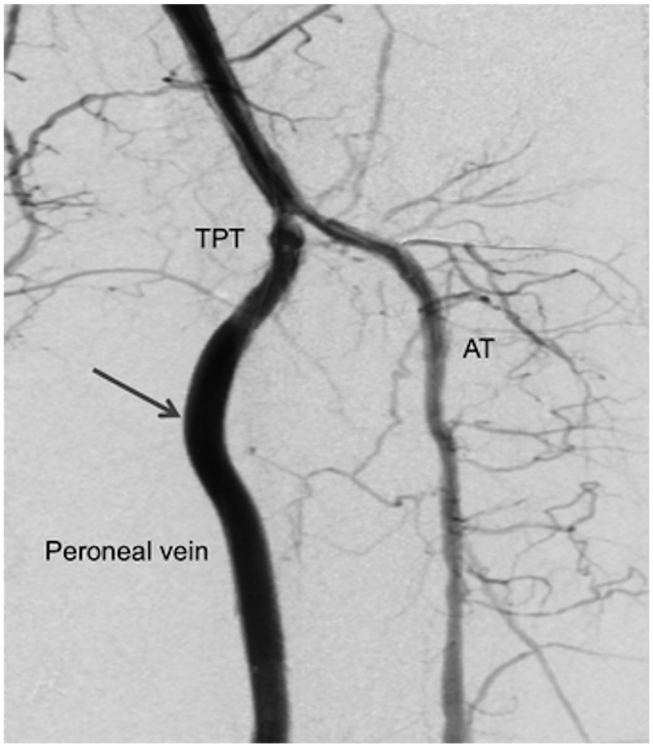

FIGURE 8 Angiogram illustrating arteriovenous fistula (arrow) after covered stent deployment

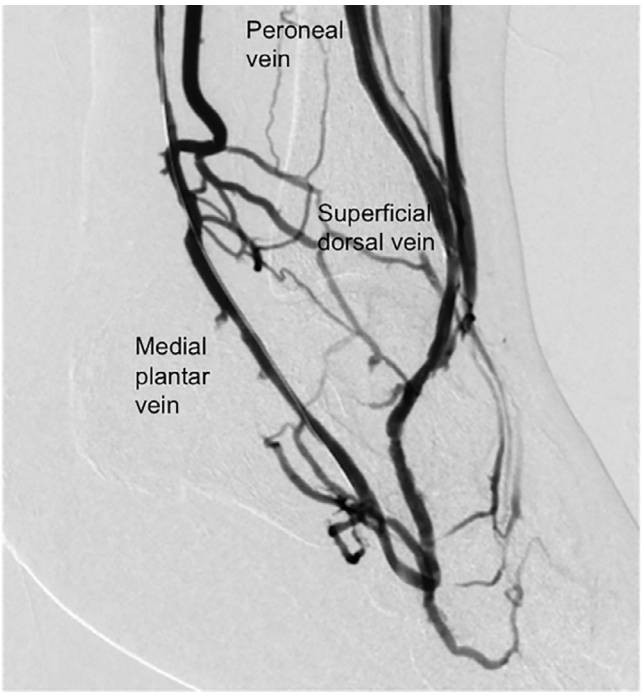

FIGURE 10 Angiogram illustrating distal deep venous system post deep vein arterialization at the ankle level crossing from peroneal vein into superficial dorsal vein then connecting with medial plantar vein

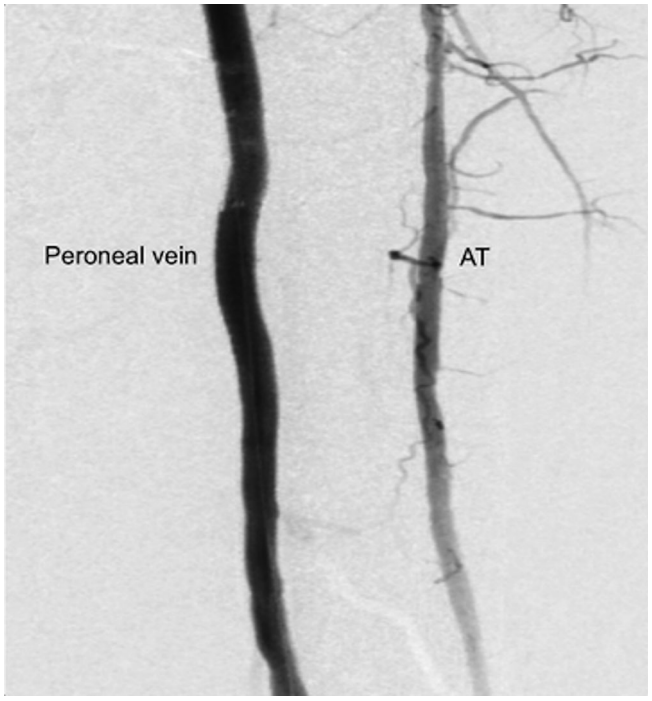

FIGURE 9 Angiogram illustrating mid arteriovenous fistula segment after covered stent deployment

FIGURE 11 Complete healing of transverse metatarsal amputation site [Color figure can be viewed at wileyonlinelibrary.com]

been developed for percutaneous arteriovenous fistula creation. One the technique is based on gunsight approach, where double snare catheters or balloon and snare catheter are advanced through tibial artery and vein then used as targets for a percutaneous needle puncture. Another technique is performed by pointing the tip of the guidewire in either the lateral or medial arterial wall and puncturing in the vein as each tibial artery is adjacent to two veins. Lastly,

arteriovenous fistula creation can be performed with re-entry catheters like Outback Elite (Cordis, Santa Clara, CA) or Pioneer Plus (Philips Volcano).[11] Since the arterio-venous connection was performed proximally in our case, long covered stents used to exclude all the proximal branches in an attempt to minimize proximal steal and maximize distal blood flow to the foot. Our post procedure medical regimen is the combination of dual antiplatelet therapy using aspirin and clopidogrel along with an oral anticoagulant such as coumadin, rivaroxaban, or apixaban at least for 6 months.

CLTI awareness, treatment, and aggressive management by a dedicated multidisciplinary team, can potentially increase amputation-free survival by twofold or higher.[12] A team of dedicated podiatrists, interventionalists, vascular and plastic surgeons, internists, endocrinologists, nephrologists, wound care experts, and infectious disease physicians in collaboration should be the standard of care.[13]

6 | CONCLUSION

DVA is a very promising treatment modality in the management of no-option CLTI patients facing imminent amputation. Further large scale and long-term trials are warranted to establish the efficacy of this technique.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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