Editorial

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Totally Percutaneous Deep Foot Vein Arterialization in No-option CLTI Patients Anatomical and Technical Key Points

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Editorial

The new term chronic limb-threatening ischemia (CLTI) represents the clinical end stage of peripheral artery disease (PAD).

Global Vascular Guidelines on CLTI management recommend the use of this term, instead of critical limb ischemia (CLI), because this includes a broader and more heterogeneous group of patients with varying degrees of ischemia that can often delay wound healing and increase amputation risk [1].

It is estimated that up to 10% of patients with PAD will progress to CLTI, that is associated with increased cardiovascular morbidity and mortality and high risk of limb loss (about 25% at 1 year).

Despite the improvements in surgical and endovascular techniques, unfortunately about 14-20% of patients with CLTI are defined as "no-option" [2], because in these patients arterial revascularization is not possible or not effective due to the absence of distal target vessels, severe calcification or small artery disease (SAD) [3,4]. The risk of major amputation is significantly higher in this cohort of patients than in others with CLTI.

For no-option CLTI patients non-revascularization treatments are still widely used in clinical practice despite the lack of evidence to support these. Only spinal cord stimulation and intermittent pneumatic compression seem to reduce the risk of major amputation in a selected group of patients with rest pain and minor tissue loss [1].

So, the optimal treatment of CLTI is undoubtedly revascularization. Therefore, in case of no-option patients, when arteries are too damaged and unusable, it is possible to use healthy veins to deliver blood flow into the foot by performing foot vein arterialization.

This idea is not new, indeed in 1912 Halsted and Bernheim [5,6] published the first series of patients treated with arterial-venous (AV) flow reversal. Yet, the procedure did not have great success and did not spread, probably, due to the complexity, the lack of standardization and the presence of many technical issues, like: the right site to create AV fistula, the way to treat distal competent valves, a high risk of distal anastomosis infection, etc.

However, during the last 3 years, some Authors [7-9] showed that deep foot vein arterialization can be performed with a totally percutaneous approach with acceptable results (1-year limb salvage rate more than 70%), being less invasive, reducing the risk of distal anastomosis infection and with a better treatment of distal competent valves compared to open surgery.

Total percutaneous deep foot vein arterialization is still at the beginning and so it has a lot of controversial and unsolved issues.

In 2018, we published [10] our paper on the PiPeR (Pioneer Peschiera Revascularization) technique, an alternative percutaneous technique to create AV flow reversal, using an IVUS-guided needle catheter (Pioneer Plus, Philips). The advantages of using this catheter are: firstly, to perform the whole procedure with only one antegrade 6F sheath, in order to avoid the distal tibial vein puncture in an infected and ischemic area; secondly, to have a direct ultrasound view of tibial vessels, in order to choose the best site to create the AV connection and to evaluate the best vein to arterialize.

We have now standardized this technique and have identified some main anatomical and technical key points.

First of all, considering the anatomical issues, the network of foot veins is completely different from that of the arteries. Indeed, we know that there are 2 levels of arteries, the dorsal (dorsalis pedis artery) and the plantar (medial and lateral plantar arch), usually connected through the pedal-plantar loop and the tarsal arteries, conversely in the venous network there are 4 levels: 2 dorsal veins, superficial (medial and lateral marginal veins) and deep (dorsalis pedis vein) and 2 plantar veins, superficial (Lajars' plantar venous sole) and deep (medial and lateral plantar vein). Of these 4 levels the most developed are the superficial dorsal and the deep plantar veins, connected through different perforator veins. The most important connection is the perforator vein located in the first metatarsal interosseous space that is usually avalvulated. This knowledge helps understand why the best way to obtain an effective arterialization is to create the AV connection at the level of the tibio-peroneal trunk, proximal peroneal or proximal posterior tibial arteries; because the venous network around the dorsalis pedis artery is not well developed.

Another anatomical issue is that the most important way out of our arterialization is the 1° toe main dorsal vein, this usually has 2-3 competent valves. So during p-DVA the valves in the 1° toe main dorsal vein need to be crossed and devalvulated in order to deliver blood flow into the forefoot, usually at this level an adequate venoplasty is enough.

As to the technical key points, the first one is to create the AV connection at the proximal level of tibial vessels, in order to have sufficient blood flow through the arterialization, not less than 300 ml/min, and to reduce the calibre gap between the donor artery and the venous stent. This gap induces turbulent flow, rapid donor artery restenosis and DVA occlusion.

The second key technical aspect is the placement of a coronary covered stent across the AV connection in order to direct the flow downward and to place a long covered stent along all arterialized veins in order to open all competent valves and to close all collaterals.

In our experience, it's also mandatory to extend the covered stent up to the common plantar venous arch because in this way it's possible to cross the Laciniatum ligament (flexors' retinaculum), which goes from the medial malleolus to the calcaneus. In many cases this ligament causes compression and occlusion of our DVA.

The key concept is that the AV fistula is anatomically at the level of the proximal tract of the tibial vessels, but functionally it is distal at the level of the foot, as proposed by Lengua [11].

In every p-DVA, during the first weeks, we have a "typical storm" with different degrees of cyanosis, swelling, pain and superficial necrosis due to the reverse flow in the venous system with venous hypertension. This period is important to open all hibernated capillaries and to improve tissue nutrition and oxygenation.

So, 4-6 weeks after the first p-DVA, we do another angiography in order to fix any eventual restenosis at the level of the donor artery and, above all, to focalize the arterial flow into the venous system, using surgical ligation or coil embolization of collaterals, based on the venosome concept and wound lesion localization.

Finally, after p-DVA, foot surgery is completely different compared to that after usual PTA, avoiding suture and primary intention wound closure, but pursuing a secondary intention closure using multimodal therapies and tension-free surgery.

In conclusion, totally percutaneous deep foot vein arterialization is an exciting alternative technique to treat no-option CLTI patients, facing major amputation. Now, after technical approach standardization, more clinical study is needed in order to better clarify the effectiveness of p-DVA.

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