

Commentary

Commentary on Pedal Revascularization: Extending the Limits of Endovascular or Surgical Means to Prevent Amputation

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Abstract

Critical limb ischemia carries risk of significant morbidity and mortality and revascularization is particularly challenging in patients with tibial and pedal arterial disease. Recent advances in both endovascular therapies and open revascularization techniques have expanded our ability to treat patients with below the knee disease who may otherwise be subject to amputation. This commentary briefly reflects on emerging endovascular and open revascularization techniques for limb salvage in complex below knee arterial disease in order to raise awareness and minimize primary amputation without attempts at these “state of the art” modalities.

Keywords: Limb salvage; Peripheral arterial disease; Pedal disease; Pedal revascularization

Introduction

Critical Limb Ischemia (CLI) affects between 1-3% of patients with Peripheral Arterial Disease (PAD), which in turn affects over 10% of the United States population [1,2]. Due to the severity of underlying systemic and peripheral vascular disease, nearly 1 in 5 patients with CLI progress to limb loss or mortality within 1 year [3]. Diabetic patients represent a complex subset of CLI patients as they frequently present with arterial disease that is localized to the tibial and pedal vasculature which can be more challenging to treat. In recent years, new techniques have been developed for limb salvage in patients with severe below the knee (BTK) disease where distal targets are limited and in patients with “desert foot” where distal targets

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Citation: Lauria AL, Ronaldi AE, Neville RF (2021) Commentary on Pedal Revascularization: Extending the Limits of Endovascular or Surgical Means to Prevent Amputation. J Angiol Vasc Surg 6: 071.

Received: July 21, 2021; **Accepted:** July 23, 2021; **Published:** July 30, 2021

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are non-existent. In parallel to the implementation of these advanced procedures, outcomes in patients with CLI have shown improvement [3,4].

Our institution has performed an increasing number of pedal revascularization cases, both through open and endovascular techniques for limb preservation. Most recently, we described a single case report in which a diabetic patient presenting with tissue loss from CLI involving the pedal arteries was successfully treated with thrombo-endarterectomy and long segment patch angioplasty to allow for bypass at the dorsalis pedis level [5]. The objective of this commentary is to raise awareness of pedal revascularization for amputation prevention and briefly discuss emerging techniques for pedal revascularization in the context of our institution’s recent experiences.

Endovascular Approaches

Multiple catheter-based techniques have emerged to recanalize the pedal and tibial vasculature with encouraging outcomes. These approaches may be favored particularly in patients with comorbidities that limit tolerance of open revascularization procedures. A retrograde approach via pedal access allows for treatment of tibial vessels when antegrade approaches fail. Antegrade access can be utilized simultaneously with a wire left as a target for re-entry from the retrograde access [6]. Improved rates of wound healing have been demonstrated in patients who undergo pedal artery revascularization with both antegrade and retrograde endovascular approaches [7]. The pedal-plantar loop technique, which involves creating a track through the plantar arch to revascularize the dorsal and plantar circulations is another valuable adjunct to tibial and pedal revascularization. This is useful in scenarios where only one tibial vessel is present or can be revascularized to provide outflow to the foot [8]. In these cases, it is important to create an intact pedal loop connecting the tibial anatomy.

Subintimal Arterial Flossing with Antegrade-Retrograde Intervention (SAFARI) is an established endovascular approach to achieve pedal revascularization. This technique involves antegrade access proximal to the occlusion, followed by retrograde access to the true lumen of the artery. Retrograde subintimal recanalization is performed until the retrograde wire meets the antegrade catheter or sheath, allowing for a ‘flossing’ technique in which angioplasty can then be performed from the antegrade approach. This dual access approach allows for recanalization of tibial vessels that cannot be accessed through an antegrade approach, while minimizing the size of the distal arterial puncture. Results with this approach, including applications for tibial disease, have been encouraging with 6-month limb salvage rate of 90% reported [9].

Percutaneous based deep venous arterialization (DVA) represents an innovation adding to the armamentarium of complex BTK revascularization. In patients with no suitable target artery for alternative revascularization options, venous arterialization is performed by creation of an arteriovenous fistulous connection and destruction of venous valves to establish tissue perfusion in a retrograde manner to the capillary bed. This technique relies on the concept that oxygenated blood can be supplied to the limb through the deep venous system

when arterial outflow is not suitable. The LimFlow (LimFlow, Inc. San Jose, CA) percutaneous deep vein arterialization system is utilized for DVA via an endovascular approach. The technique involves antegrade femoral arterial access and retrograde tibial venous access with arteriovenous crossover proximal to the arterial occlusion. Catheters are aligned with ultrasound guidance and a crossing needle is extended from the arterial catheter to the vein, effectively creating an arteriovenous fistula. This pathway undergoes balloon angioplasty followed by distal venous valve removal with an endovascular valvulotome. Lastly, covered stents are deployed to maintain patency of the connection [10]. Early results in this technique have been promising, and a large multicenter trial is ongoing to further characterize outcomes [11]. Attempts have been made to achieve similar results with other available endovascular equipment pending results of the LimFlow trial.

Open Approaches

Open surgical revascularization continues to be appropriate for approximately 25% of our CLI patients. Patients expected to live greater than 2 years are considered for operative bypass given the improved durability and reduced re-intervention rate of surgery. Bypass also remains a consideration for patients with long, complex tibial artery occlusive disease, and after failed endovascular therapy. These decisions demand close communication between vascular surgeons and endovascular specialists if they are not one and the same, as failed endovascular intervention can alter bypass options and lead to greater chance of amputation.

In addition to unique reconstructive techniques such as that described in our original case report [5], tibial bypasses with distal vein patch and open deep vein arterialization represent novel approaches for revascularization in complex tibial and pedal disease. For patients requiring tibial bypass who lack autologous vein, the distal vein patch technique has shown promise in improving patency of PTFE based tibial bypasses. This technique involves use of autologous vein to create a patch or venous interface between the target tibial vessel and PTFE conduit. The venous patch acts as a “biologic buffer” between the native tibial artery and prosthetic conduit material, with biologic and mechanical characteristics that support the durability and patency of the bypass. Primary patency rates of nearly 80% at one year and over 50% at four years have been achieved with this strategy known as the Distal Vein Patch (DVP) technique [12,13]. For patients with disadvantaged arterial runoff, a technique similar to the DVP is utilized while adding a common ostium arteriovenous fistula created between the target artery and its associated tibial vein. This strategy has resulted in limb salvage rates of 57% at 24 months in this challenging patient population [14].

In order to surgically revascularize patients without a distal target artery for bypass, known as the “desert foot”, the concept of deep venous arterialization has been adapted to the DVP bypass technique. This technique is only used for those patients with CLI and a threatened limb and without adequate outflow targets for standard bypass. Open DVA involves creation of a surgical bypass originating from a lower extremity artery serving as an inflow source which is most commonly the common femoral artery. The distal anastomosis uses the fistula technique previously described with destruction of venous valves in the recipient tibial vein to allow for reversed flow to the capillary bed of the lower leg and foot.

Conclusion

New and innovative strategies for tibial and pedal revascularization have emerged both through endovascular and open surgical techniques. A recent review of reported cases of open and percutaneous DVA demonstrated primary patency between 44.4% and 87.5% at 1 year with limb salvage rates between 25% and 100% [15]. Our institution has performed over ten open surgical DVA procedures with early technical success; long term outcomes will be followed and subsequently reported. We have found techniques such as complex tibial and pedal reconstruction and open surgical DVA to be strong and effective additions to our armamentarium for pedal revascularization.

Conflicts of Interest

AL, AR- none

RN- WL Gore, Scientific Advisory Board

Disclosure

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