Transpedal Balloon Angioplasty

Using interventional techniques and devices to successfully restore inflow and outflow in patients with CLI.

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Critical limb ischemia (CLI) occurs as an arterial stenosis approaches a critical point, compromising blood flow to the distal extremity and thus falling short of the basal tissue oxygen demand.[1,2] As a result, patients present with rest pain and/or nonhealing ulceration and comprise approximately 1% to 2% of the peripheral arterial disease (PAD) population.[3] Nearly 40% of patients with CLI require amputation, and roughly 150,000 amputations occur annually.[4,5]

CLI wounds typically demand multilevel arterial occlusive treatment. Below-the-knee endovascular intervention has characteristically been reserved for cases of threatened CLI limb loss. The size and nature of the lower extremity vessels, along with the fear of potential limb loss, can add to the technical difficulty of using conventional peripheral angioplasty equipment if a complication occurs. However, trials have shown the competence and attractiveness of an initial percutaneous approach for a selected group of patients with CLI and infrapopliteal vascular disease.[6,7] After 2 to 5 years, the limb salvage rate in the patients who were treated with percutaneous transluminal angioplasty ranged from 85% to 91%. These data therefore contend with previous thought and indicate that angioplasty of the tibioperoneal vessels should not necessarily be reserved for limb salvage situations. Yet, if angioplasty fails, the surgical options are limited, and hence, caution is still advised in patient selection.

In 1987, Taylor and Palmer described the angiosome concept that separated the body into three-dimensional vascular regions supplied by specific source arteries and drained by specific veins.[8] Five angiosomes comprise the lower leg, and six angiosomes cover the foot and ankle.[9] The medial sural artery, lateral sural artery, posterior tibial artery, anterior tibial artery, and peroneal artery supply blood to the angiosomes of the lower leg; the posterior tibial artery, anterior tibial, and peroneal arteries distribute the blood supply to the angiosomes of the foot and ankle.

Noninvasive diagnostic tools, such as angiosome mapping, are imperative in determining the ischemic vessel(s) associated with a located CLI wound.[10,11] The angiosome method is especially necessary when there are multiple occluded tibial arteries, and thus revascularization is applied to the artery supplying the wound.

The following case illustrates the use of the angiosome concept to direct tibiopedal endovascular treatment and prevent lower extremity amputation in a CLI patient.

CASE REPORT

A 68-year-old woman with a history of insulin-dependent diabetes mellitus, hypertension, and hyperlipidemia was referred for a nonhealing right great toe ulcer. She stated that 6 months earlier, she had an ingrown toenail removed. However, the great toe failed to heal after nail removal, even with aggressive wound care. She had a 2+ palpable right femoral pulse, 1+ palpable right popliteal pulse, and nonpalpable right dorsalis pedis and posterior tibial pulses. Considering the location of the wound on the right great toe, compromised blood flow to the anterior tibial artery was suspected.

Angiographically, her right iliac and femoral arteries had no significant stenosis. Her popliteal artery displayed a 50% mid-stenosis supplying a patent proximal anterior tibial artery and diseased tibioperoneal trunk that provided flow to a severely diseased peroneal artery that occluded in its midsegment and a posterior tibial artery that occluded proximally (Figure 1). The anterior tibial artery provided the dominant flow to the foot; however, it was occluded above the ankle, with two islands of reconstitution at the level of the dorsalis pedis (Figure 2). There was no obvious reconstitution of flow for either the peroneal or posterior tibial arteries distally.

To improve inline flow to the great toe, an antegrade approach was attempted. An 0.018-inch Quick-Cross catheter (Spectranetics Corporation) was placed at the proximal cap of the anterior tibial occlusion, and a series of CTO wires were used in an attempt to cross into the

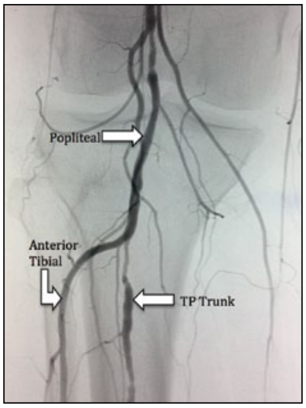

Figure 1. The proximal tibial anatomy.

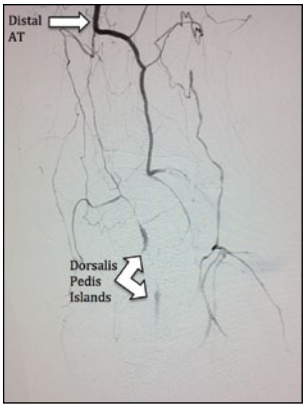

Figure 2. The pedal vasculature.

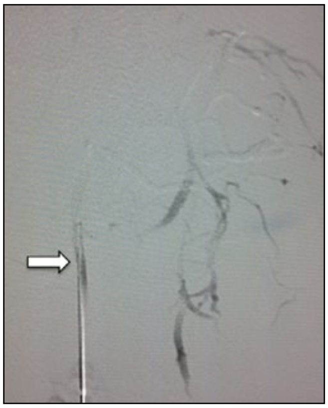

Figure 3. The micropuncture needle accessing the dorsalis pedis island.

Figure 4. Retrograde subintimal wire placement at the level of the distal anterior tibial artery.

dorsalis pedis. However, the wire entered a subintimal space and could not reenter the true lumen. Therefore, a micropuncture needle was used to access the dorsalis pedis island and placement of a 2.9-F Micropuncture pedal access sheath (Cook Medical) (Figure 3). An 18-g Approach CTO microwire guide (Cook Medical) was used to traverse to the proximal cap of the anterior tibial artery, but once again, the wire was in a subintimal space and could not reenter the distal anterior tibial lumen (Figure 4).

Leaving this wire and the antegrade wire in place, a 2.5- X 20-mm NC Trek coronary dilatation catheter (Abbott Vascular) was placed over the retrograde wire, and a 2-mm X 4-cm Advance 14LP low-profile balloon (Cook Medical) was placed over the antegrade wire, so that the ends of each balloon were abutting. Simultaneously, the balloons were inflated (double-balloon technique), resulting in communication between the two subintimal planes (Figure 5). As a result, the retrograde wire was able to advance across into the true lumen of the distal anterior tibial and up to the popliteal artery, where it traversed through a DAV catheter (Cook Medical) and was externalized out the left common femoral artery (Figure 6). The proximal end of the wire was outside the left common femoral artery, and the distal end of the wire was outside the right dorsalis pedis (flossing technique).

A 2-mm X 4-cm Advance 14LP balloon was then placed over the wire from the left common femoral artery and taken to the dorsalis pedis, where several nominal balloon inflations were performed through the dorsalis pedis to the distal anterior tibial chronic total occlusion. This resulted in a < 30% residual stenosis throughout the dorsalis pedis, but an obvious flow-limiting dissection was present at the level of the distal anterior tibial artery. The 2.9-F pedal sheath was occlusive, such that the distal pedal arcade could not be visualized (Figure 7). A 0.018-inch Quick-Cross catheter was then advanced to the level of the 2.9-F sheath. The sheath was removed, and external pressure was applied over the insertion site. As pressure was applied, an Asahi Prowater wire (Abbott Vascular) was extended to the distal pedal arcade, distal to the access site, and the 2-mm X 4-cm Advance 14LP balloon was reinserted and inflated to nominal pressure over the puncture site for 2 minutes, providing internal hemostasis. This resulted in hemostasis with inline flow to the toe. However, a flow-limiting dissection remained at the level of the distal anterior tibial artery, impeding inline flow to the foot. A 2.25- X 12-mm Ion coronary drug-eluting stent (Boston Scientific Corporation) was placed, successfully tacking the dissection and providing brisk inline flow to the toe wound (Figure 8). The patient noticed an immediate improvement in the cramping of her foot the next day, and the wound healed in approximately 3 weeks.

CONCLUSION

CLI is linked to morbidity and mortality, and it requires either a surgical or endovascular procedure to promote limb viability.[12] Within 1 year of the onset of CLI, nearly 25% of patients will die, with another 25% of patients undergoing amputation.[13,14] Of the amputees, approximately 40% of patients will be deceased within 2 years of the procedure.[13,14] In today's era, an endovascular approach has become the favored form of therapy for these patients.[12] However, there are numerous challenges that increase risk during an endovascular procedure. Angiographically, these patients typically have chronic total occlusions, calcified vessels, and the involvement of the tibial vessels and/or multilevel disease.[12,15-17] CLI populations, typically having multilevel disease of the arteries, commonly affect the inflow (thigh) and runoff (below-the-knee) vasculature. These statistics directly correlate to inflow and its dependency on outflow.

In a study conducted by Davies et al, naturally occurring outflow predicted the patency of femoropopliteal percutaneous transluminal angioplasty procedures.[18,19] In patients

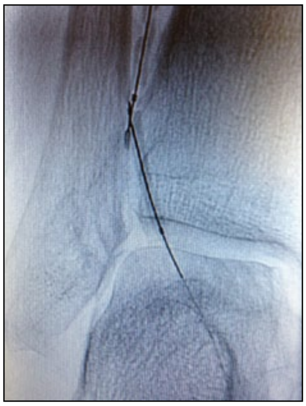

Figure 5. The double-balloon technique.

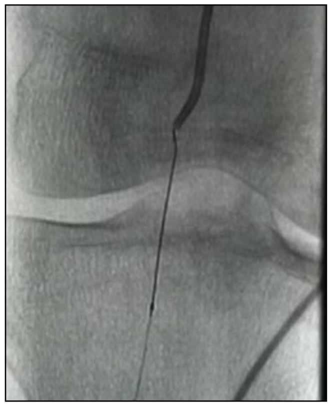

Figure 6. A retrograde wire advancing into the antegrade DAV catheter.

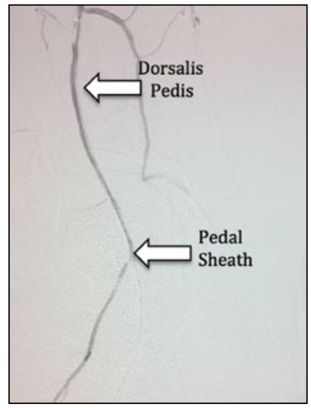

Figure 7. Imaging of balloon angioplasty showing flow occlusion with the pedal sheath.

Figure 8. Imaging after sheath removal, balloon angioplasty, and stent placement in the distal anterior tibial artery.

with one or less patent calf arteries, only 37% showed patency at 2 years. Comparing this with patients having more than one patent calf artery, 71% showed patency at 2 years. Upon further investigation in a 5-year post–endovascular intervention study, it was determined that limb salvage and mortality is directly related to the level of outflow.[18,19] Patients with good outflow after endovascular intervention had a survival rate of 82%, whereas patients with compromised or poor outflow had a 59% survival rate.[19]

The treatment for PAD has evolved from a surgical to an endovascular approach, resulting in a significant reduction in amputations.[20] Balar et al displayed this observation at the Westchester Square Medical Center; in 1999, all PAD patients were treated with open revascularization, resulting in a 32% amputation rate compared to 2010, when 89% of patients were treated endovascularly and 11% by open revascularization, resulting in a 5.2% amputation rate.[20] As such, endovascular specialists who treat complex CLI patients must become well-versed with novel techniques and devices to successfully restore inflow and outflow to prevent amputation and ultimately lower mortality rates. ■

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