Insights Into Endovascular Revascularization in Limb Salvage Procedures: "Antegrade-Retrograde" Technique in Chronic Total Occlusion

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Significant occlusions of the peripheral arterial circulation, responsible for chronic limb ischemia (CLI), are a serious cause of morbidity, mortality, and poor quality of life. The currently available treatment options for patients with severely symptomatic CLI include bypass surgery and arterial revascularization. Percutaneous transluminal angioplasty for CLI is shown to be as effective as bypass surgery at high-volume centers, and it also offers a less invasive alternative, leading to quicker patient recovery times and lower short-term costs. This case report reviews the current techniques available and discusses an "antegrade-retrograde" angioplasty approach to successfully recanalize such challenging obstructions.
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Key words: Percutaneous transluminal angioplasty • Chronic limb ischemia • Peripheral arterial disease

Significant occlusions of the peripheral arterial circulation, responsible for chronic limb ischemia (CLI), are a major cause of morbidity, mortality, and poor quality of life. This includes pain with ambulation, at rest, or at night, leading to severe ulcerations and gangrene due to tissue necrosis. The currently available treatment options for patients with lifestyle-limiting CLI who have failed aggressive medical intervention include bypass surgery and arterial revascularization by means of percutaneous transluminal angioplasty (PTA). In fact, data from a recently published multicenter, randomized, controlled trial have shown that the two techniques "are associated with broadly similar outcomes in terms of amputation-free survival."[1]

PTA for CLI has been shown to be as effective as bypass surgery at high-volume centers; it also offers a less invasive alternative, leading to quicker patient recovery times and lower short-term costs. However, it poses new challenges to the interventionalist, such as difficulty with reentry into the true lumen or post-procedure flow-limiting dissections.[2] The procedure can be complicated in cases in which the peripheral obstructions are long, end in large proximal collaterals, or the vessels are narrow with diffuse intimal disease. Herein we report an approach to recanalize such challenging obstructions using an "antegrade-retrograde" angioplasty technique.

Presentation

A 76-year-old woman presented with severe, critical left lower limb ischemia, documented by ultrasound and angiographic study. She had multiple risk factors for peripheral vascular disease, and presented with severe intermittent claudication, numbness, tingling, decreased physical activity, and abnormally low ankle:brachial indices (ABIs; 0.5 on the right and 0.4 on the left). Staged angioplasty was planned to address the suspected occlusion on the left side during this hospitalization and the probable lesion on the right side at a later time. The right femoral artery was cannulated with a short 6 French Avanti® + sheath introducer (Cordis Corp., New Brunswick, NJ) and angiography performed via the sheath-side port.

Selective diagnostic angiogram with distal runoff revealed a total chronic occlusion of the left superficial femoral artery (Figure 1). A 0.035 Quick-Cross® wire (Spectranetrics, Colorado Springs, CO) and a stiff-angled Glidecath® (Terumo, Somerset, NJ) were advanced beyond the point of total occlusion but could not reenter the true lumen from the subintimal space (Figure 2). Therefore, the left dorsalis pedis artery was cannulated under fluoroscopic guidance using contrast injection from the level of the left common femoral artery entry (Figure 3). The subintimal track and reentry technique was used, employing a 4 French Micropuncture® kit (Cook Medical, Bloomington, IN) was used and a 0.018 Quick-Cross and a gold-tipped Glidecath wire were advanced from the dorsalis pedis artery in a retrograde fashion crossing the lesion point of total occlusion.

This approach facilitated the snaring of the gold-tipped Glidewire that was advanced from below the lesion into the previously anterogradely placed long Pinnacle® sheath (Terumo) (Figure 4). The wire created a rail, which was used to anterogradely advance a Quick-Cross from the right groin, across the lesion, and into the true lumen distally. Atherectomy was performed successfully at the site of the proximal portion of the superficial femoral artery (SFA) lesion using a 2.0 Diamondback 360® PAD System (Cardiovascular Systems Inc., St. Paul, MN) in the calcified portion of the lesion. Finally, angioplasty with prolonged inflation using a 4.0 × 120 mm Amphirion

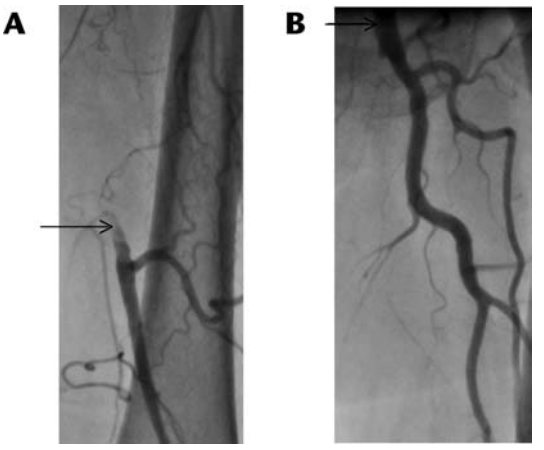

Figure 1. *Angiograms demonstrating the extent of the chronic occlusion. A)* Arrow *points to the distal margin of the superficial femoral artery (SFA) occlusion. B)* Arrow *points to the common femoral artery and proximal margin of the SFA occlusion.*

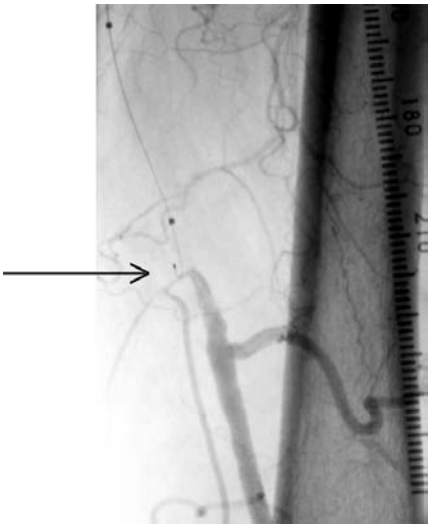

Figure 2. *The true lumen of the superficial femoral artery (SFA) could not be reentered* (arrow) *from the intima once the left SFA lesion was crossed.*

Figure 3. *Angiographic image of dorsalis pedis access site* (arrow).

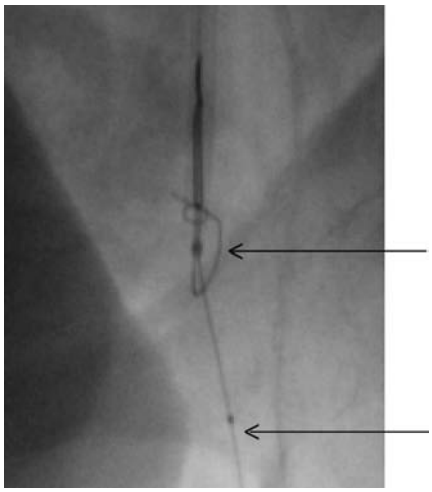

Figure 4. *Angiographic image documenting the snaring of the glide wire above the lesion* (top arrow) *and the wire advanced from below the lesion* (bottom arrow).

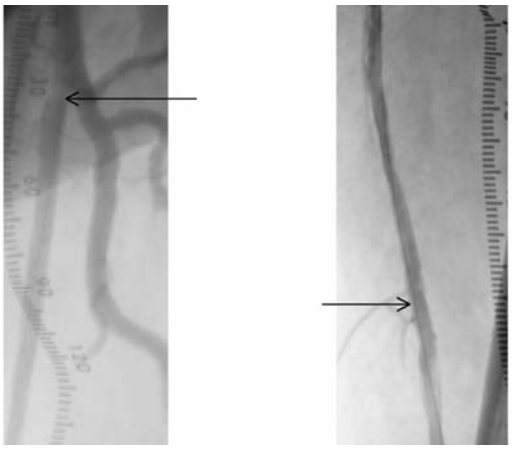

Figure 5. *Angiograms of the proximal* (left) *and mid* (right) *superficial femoral artery following angioplasty of the chronic occlusion.*

DEEP balloon (Invatec, Roncadelle, Italy) followed by an upgrade to a 5.0 × 100 Sterling® SL balloon (Boston Scientific, Natick, MA) resulted in excellent results with lesion reduction from 100% to 0% (Figure 5). After revascularization the Thrombolysis In Myocardial Infarction (TIMI) flow was improved from 0 to 3, and the gradient was reduced from > 60 to < 5 mm Hg. Femoral and dorsalis pedis arterial hemostasis was achieved using manual pressure after removal of the respective sheaths. The patient tolerated the procedure well and the subsequent hospital stay was uneventful. After a follow-up period of 2 months she remained pain free, her ABIs normalized, and the patency of the SFA was documented by ultrasound. Even after 18 months her ABI was 0.72 on the left side.

Discussion

Bolia and colleagues[3] were credited with first using subintimal recanalization for long chronic total occlusions of the superficial femoral artery in 1989. This particular approach, also known as percutaneous intentional extraluminal revascularization (PIER), involves intentionally creating a false lumen between the tunica intima and the tunica media of the vessel chosen for revascularization. The guide wire is inserted into the subintimal space just proximal to the occlusion, tunneled through to a level just distal to the occlusion, and subsequently reintroduced into the true lumen. Balloon angioplasty is then performed. Since then, this technique has received increasing interest and scrutiny as a useful alternative to bypass surgery in patients with CLI.[4-12] Subintimal recanalization was found to have similar limb salvage success when compared with the surgical approach, with the advantage of fewer complications. Reentry of the true lumen is the most important and most difficult technical aspect, limiting the overall success; it is considered the "Achilles' heel" of this technique. Initially, the rate of failure to reenter the true lumen was as high as 25% (Table 1).[2] The more recent introduction of true lumen reentry devices, such as the fluoroscopically guided OUTBACK® LTD® catheter (Cordis Corp.) and ultrasound-guided Pioneer catheter (Medtronic, Minneapolis, MN), has dramatically improved success rates.[13,14]

The Bypass Versus Angioplasty in Severe Ischaemia of the Leg (BASIL) study[1] is the most in-depth study to date that compares the outcome of balloon angioplasty with bypass surgery in patients with CLI.[1] This multicenter, randomized, controlled study enrolled 452 patients at 27 different hospitals in the United Kingdom; they were randomly assigned to receive an angioplasty-first (n = 224) or a surgery-first (n = 228) strategy. The primary endpoint was amputation-free survival, and throughout the 2-year follow-up the hazard ratios (HRs) of surgery relative to angioplasty did not provide strong evidence of a difference between the 2 treatments (adjusted HR 0.72; 95% confidence interval [CI], 0.49-1.07). However, in the short term the angioplasty-first strategy was associated with a lower rate of mortality (HR 0.34; 95% CI, 0.17-0.71), shorter length of hospital stay (36.35 vs 46.14 days), and a lesser use of the intensive therapy unit (0.04 vs 0.13 days), leading to lower hospital costs at 12-month follow-up (£17,419 vs £23,322).

Since the publication of that study, several case reports and case series have documented new alternative approaches to overcome the problem of reentry into the true lumen.[13,15-21] These new tools in the interventionalist's armamentarium include an antegrade-retrograde and a transcollateral angioplasty approach. The

Table 1
Summary of Case Series Reporting Technical Success Following Subintimal Angioplasty in Chronic Limb Ischemia

Study	Patients (n)	Location	Success Rate (%)
Bolia A et al[2]	71	SFA/Popliteal	76
Berengoltz-Zlochin SN et al[4]	20	SFA/Popliteal	85
McCarthy RJ et al[8]	66	SFA/Popliteal	74
Vraux H et al[11]	36	Tibial	78
Ingle H et al[6]	67	Popliteal/Tibial/Peroneal	86
Lipsitz EC et al[7]	39	SFA/Popliteal	87
Yilmaz S et al[12]	61	SFA	88
Jacobs DL et al[13]	87	Iliac/SFA	100

SFA, superficial femoral artery.

Subintimal Arterial Flossing with Antegrade–Retrograde Intervention (SAFARI) method can be used when attempts at subintimal recanalization and reentry into the distal true lumen of the vessel have been unsuccessful. In such an instance a subintimal tract can be created by engaging the desired vessel in a retrograde manner. The antegrade and retrograde tracts can then be connected with the use of a guidewire.

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The transcollateral technique centers on tracking a guidewire to create a loop between different tibial arteries via collateral arteries. The loop can be then used directly, where the vessel is engaged and subsequently opened in a retrograde manner, or indirectly, as a guide to attempt reopening of the vessel in an antegrade manner. Although the antegrade-retrograde approach is feasible in patients with distal arterial access, the latter approach could be attractive in patients in whom pedal artery access is not practical. Here we describe obtaining retrograde access via the dorsalis pedis artery; an alternative approach would be to place the patient in a prone position and engage the popliteal artery ("flip-and-stick" method).

Patient selection is a critical factor for the success rates of either the surgical or percutaneous interventions. These treatment modalities are not mutually exclusive, and in fact they have even been used in a hybrid fashion to improve clinical outcomes.[22] Based on our experience, when femoral bypass surgery fails, there is often an endovascular solution (and vice-versa). It comes as no surprise then that both treatment options have very similar failure (restenosis) rates, requiring 20% to 30% reintervention at 2 years. Selecting one procedure over the other can generally be guided by the following findings: 1) smoking correlates with proximal disease, whereas diabetes and more advanced age correlate with distal disease; 2) proximal artery stenoses are treated with endovascular techniques, whereas diffuse disease, or occlusions of the popliteal and tibial arteries, require surgical techniques or more challenging endovascular procedures; 3) a majority of diabetic and end-stage renal disease (ESRD) patients with CLI and foot ulcers demonstrate proximal occlusions that are associated with diffuse disease in the distal arteries (> 10 cm occlusions) as well—such patients are more amenable to surgery; and 4) ultimately, patients with proximal, very extensive, and diffuse occlusive disease may end up with amputations or in hospice care.

The occurrence of CLI in patients with ESRD forewarns a high rate of subsequent morbidity and mortality, despite revascularization of the affected limb. Whether surgical or endovascular, outcomes after revascularization for peripheral vascular disease in dialysis patients are inferior when compared with outcomes in the general population. The problems with revascularization in this group of patients include decreased wound healing, prolonged hospital stay, poor rehabilitation, and loss of limb despite a patent graft. The only absolute predictor of limb loss despite a patent graft is the presence of a heel ulcer more than 4 cm in diameter.[23] Unfavorable anatomy findings, such as extensive diffuse disease or long distal lesions, remain a marker for

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subsequent limb loss in the chronically ischemic leg in patients with ESRD.[24]

Conclusions

Patients presenting with CLI have worse angiographic outcomes, and subsequently shorter symptom-free survival and increased revascularization rates, when compared with revascularization rates of other peripheral lesions. This is in part due to the fact that the true lumen is more difficult to reenter in patients with CLI. The use of bare metal and drug-eluting stents to prevent leg amputations in critical limb ischemia is currently under study, with initial reports showing similar revascularization rates (repeat angiography in 35% of patients). To date, our experience with the antegrade-retrograde technique amounts to a dozen CLI cases, with no complications or failures. The limitations to this novel technique include lack of distal arterial access, increased contrast exposure, and longer procedure duration due to the additional access site. On the other hand, time can be saved crossing the fibrous cap retrogradely. We consider this technique a feasible, realistic approach that would increase amputation-free survival and preserve the native vessel in such difficult CLI instances in which intraluminal reentry cannot be achieved by the usual interventional techniques. ■

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Main Points

- Significant occlusions of the peripheral arterial circulation, responsible for chronic limb ischemia (CLI), are a serious cause of morbidity, mortality, and poor quality of life.
- The currently available treatment options for patients with severely symptomatic CLI include bypass surgery and arterial revascularization.
- Percutaneous transluminal angioplasty (PTA) for CLI has been shown to be as effective as bypass surgery and offers a less invasive alternative, leading to quicker patient recovery times and lower short-term costs. However, it poses challenges to the interventionalist, such as difficulty with reentry into the true lumen or postprocedure flow-limiting dissections.
- Newer, alternative approaches, including the antegrade-retrograde and transcollateral angioplasty approaches, overcome the problem of reentry into the true lumen.

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