Retrograde pedal access for patients with critical limb ischemia

Hernan A. Bazan, MD, Linda Le, MD, Melissa Donovan, MD, Tara Sidhom, RN, Taylor A. Smith, MD, and W. Charles Sternbergh III, MD, New Orleans, La

Objective: Retrograde pedal access may allow the treatment of tibial occlusive lesions when standard endovascular techniques fail. We aimed to analyze the outcomes in patients with chronic limb ischemia (Rutherford class IV and V) who were not surgical candidates for a tibial bypass and had undergone an unsuccessful attempt at revascularization through an antegrade access.

Methods: During a 3-year period, a retrograde pedal access was selectively chosen when a popliteal or tibial lesion could not be crossed through an antegrade approach. Retrograde pedal access was performed under ultrasound guidance using a 4F micropuncture coaxial sheath. All interventions were performed in a sheathless fashion using a 0.014- or 0.018-inch “bareback” wire as support for a 2- or 2.5-mm balloon angioplasty catheter to cross and treat tibial chronic total occlusions that could not be treated through an antegrade approach. Routine anticoagulation and dual-antiplatelet therapy were used periprocedurally. Antegrade access was used to treat any lesion that required a stent placement after the retrograde wire was snared and brought through the antegrade guidecatheter. Patient indications and comorbidities were recorded. Outcomes analyzed were limb salvage rate, periprocedural complications, and mortality. Mean and standard deviations were calculated. The Kaplan-Meier method was used to calculate limb salvage rates.

Results: A review of the 681 lower extremity angiograms in which a patient had an intervention from July 2010 through December 2013 identified 13 patients (nine men) in whom a retrograde pedal access was performed (mean age, 71.4 ± 12.4 years). Among these, diabetes was present in 10 of 13 (77%) and chronic renal insufficiency (stages II-V) in nine (69%). Five (38%) had undergone contralateral amputation. Indications for a retrograde pedal revascularization were Rutherford chronic limb ischemia class IV in two (15%) and class V in 11 (85%). Technical success rate was 69% (nine of 13). A variety of popliteal (two of 13) and tibial (13 of 13) vessels were treated with angioplasty alone (10 of 13) or angioplasty/stent placement (three of 13) through a retrograde approach. The technical failures were due to inability to cross the occlusion(s). Periprocedurally, there was one myocardial infarction but no local complications, worsening renal insufficiency, or deaths. At a mean follow-up of 17.1 ± 10.3 months, the limb salvage rate was 77% (10 of 13). There was a high mortality rate of 23% (three of 13) on follow-up in this cohort, occurring at median 6 ± 4 months.

Conclusions: Retrograde pedal access for limb salvage in high-risk patients is feasible and safe, with acceptable limb salvage rates at intermediate follow-up. Appropriate candidates are those who have failed an antegrade intervention and are poor candidates for a tibial bypass. Future studies should test whether this mode of revascularization has favorable limb salvage rates in larger patient populations and seek to identify specific patient populations who will benefit from this technique. (J Vasc Surg 2014;60:375-82.)

Patients with critical limb ischemia (CLI) require in-line revascularization in addition to optimal medical therapy for limb salvage in cases of tissue loss. Generally, patients with CLI have a poor survival compared with those with intermittent claudication; at 1 year after presentation, there is a 20% mortality, 30% undergo major amputation, and only 45% are alive with both limbs.1-6 Infrainguinal bypass remains the gold standard for treatment of CLI; to date, no other mode of revascularization is comparable to the excellent 5-year patency rates of popliteal-to-distal bypass, particularly patients on dialysis. Out of this need, endovascular revascularization has been used with increasing prevalence.4 Antegrade endovascular revascularization can oftentimes be accomplished; however, a subset of these patients with difficult popliteal or tibial occlusive lesions cannot be revascularized in an antegrade fashion, even with the skills of an experienced interventionalist. In these patients, a retrograde pedal access to establish in-line flow to the foot may be considered as an adjunctive endovascular approach for revascularization in cases of limb salvage.

Since its initial description in 2003 by Botti et al5 and Spinosa et al,8 several case reports9-19 and, more recently, single-center series20-24 have described various aspects of this technique. Intermediate follow-up and limb salvage rates, however, are lacking in the literature. We describe our experience with this technique during a 3-year period in 13 patients with mean follow-up of 17.1 months.

METHODS

This was a retrospective case series performed with Institutional Review Board approval at our institution.
Data were collected retrospectively (2010 to 2011) by querying our institution’s procedural database for all lower extremity angiograms with interventions and through a prospectively maintained database (2012 to 2013; our institution’s Society for Vascular Surgery Vascular Quality Initiative). Patient indications and comorbidities were recorded. Outcomes analyzed were limb salvage rate, peri-procedural complications (myocardial infarction, renal failure, bleeding), and mortality. Continuous variables are expressed as mean ± standard deviation. Kaplan-Meier was used to calculate limb salvage rates using GraphPad Prism software (GraphPad Software Inc, La Jolla, Calif).

**Technique.** Retrograde pedal access is obtained under ultrasound guidance, using an S Series 7.5-MHz linear probe (SonoSite Inc, Bothell, Wash), looking for a “calciﬁed halo,” which is the heavily calcified pedal artery, usually accompanied by two pedal veins (Fig 1, A). The use of larger probes may not be feasible. Light pressure applied with the ultrasound transducer will compress the pedal veins and reveal some pulsation in the target pedal artery, even in patients with ankle-brachial indices <0.4 and proximal popliteal and tibial occlusions. Color flow may be used to conﬁrm the pedal artery, although it is not necessary.

After local anesthesia is established with 1% lidocaine, a 21-gauge needle with an echogenic tip is entered into the pedal artery under ultrasound guidance. The pedal artery is often heavily calcified in patients with diabetes mellitus or chronic renal insufﬁciency, and hence, the operator can often feel entry of the needle tip across the anterior wall of the artery. Achieving entry in the ﬁrst try through a single anterior wall access is important to avoid pedal artery thrombosis.

Next, a 4F 15-cm micropuncture coaxial introducer catheter (Cook Medical, Bloomington, Ind) is used to obtain a sheathless access, minimizing trauma to the pedal vessel. As discussed earlier, a key potential disadvantage of the retrograde pedal access is potential obliteration of the runoff to the foot. To avoid this, a sheathless access is used by next attaching a copilot bleed-back control valve (Abbott, Santa Clara, Calif) to the 4F microcatheter with an exchange-length 0.014-inch or 0.018-inch extra support hydrophilic-coated nitinol wire (Fig 1, B). The patient is anticoagulated with heparin (80-100 U/kg), and an activated clotting time of 250 to 300 seconds is maintained throughout the procedure.

Through the side arm of the copilot bleed-back control valve, a retrograde angiogram is easily obtained and one can get a road map of the lesion(s) to treat. To avoid vaso-spasm, a solution of nitroglycerin and verapamil in heparinized saline is used to ﬂush the sheathless microcatheter access every 10 to 15 minutes. The components of this mixture are verapamil hydrochloride, 2.5 mg; nitroglycerin, 100 µg; and heparin, 2500 U in 50 mL 0.9% normal saline. If the patient is hypotensive (systolic blood pressure <90 mm Hg), verapamil may be omitted from the mixture.

In our experience, open tibial access has not been needed. Once the lesion(s) are identiﬁed, the microcatheter sheathless access is removed, and a low-proﬁle over-the-wire small diameter (2- to 2.5-mm) Coyote ES balloon (Boston Scientiﬁc, Natick, Mass) is used in a “bareback” fashion as a support catheter (Fig 1, C). Under road map ﬂuoroscopy, tibial lesion(s) are crossed in this retrograde fashion and treated with balloon angioplasty. Should a stent be necessary, traditional antegrade access is gained,
if not already present, and the retrograde wire is manipulated inside of an antegrade catheter or may be snared through the antegrade approach (Fig 2). Any lesion requiring stent placement is treated from the antegrade access.

After the intervention, gentle manual compression with D-stat dry silver topical hemostat (Vascular Solutions, Minneapolis, Minn) is used for pedal access hemostasis, taking care not to obliterate the runoff. We have found that 5 to 10 minutes is sufficient.

In some instances, retrograde wire passage through the chronic total occlusion (CTO) into the true lumen may not be possible and may result in placement of the hydrophilic wire in a subintimal space. If not already established, traditional antegrade access is gained, and the antegrade wire is brought into the subintimal space at the level of the occlusion. A “double-balloon” technique to disrupt the dissection membrane with abutting balloons delivered from both access sites can then be used to gain retrograde access into the true lumen. Larger-diameter balloons are used

Fig 2. Representative transpedal angiogram shows a heavily diseased right anterior tibial (AT) artery that cannot be accessed through a traditional antegrade approach in a patient with ischemic cardiomyopathy (10% ejection fraction and a nonhealing right first digit ulcer). A, A 5F angled glide catheter is placed in the below-knee popliteal artery through antegrade access and a retrograde 0.014-inch hydrophilic wire in the proximal AT. B, Angiogram through the antegrade catheter demonstrates a heavily calcified AT origin, which could not be crossed by antegrade access. C, Through the retrograde access, the hydrophilic wire 0.014-inch wire easily crosses into the popliteal artery and is navigated into the antegrade catheter. D, Angiogram demonstrates the near-occlusion in the AT origin and mid-AT disease, which is predilated, (F) revealing the stenotic origin disease, (G) followed by placement of a drug-eluting balloon-expandable stent. Completion angiogram demonstrates (H) resolution of the AT origin disease, (I) in-line flow to the foot, and a patent dorsalis pedis artery access and filling of the pedal artery without any distal defects. Note the hydrophilic wire exiting from the dorsalis pedis in the foot, denoting the percutaneous access (arrows).
proximally and a smaller balloon distally in tibial disease. Inflation times of 1 minute at half nominal pressures may be needed in these instances to seal the disrupted membrane and avoid the need for stent placement. When a stent is needed for flow-limiting dissection or significant (>30% residual stenosis after angioplasty) disease, a drug-eluting balloon-expandable stent is placed in the tibial vessel. All patients undergoing pedal interventions (angioplasty alone or with stent placements) are loaded with clopidogrel (300 mg) postprocedure and maintained on dual antiplatelet (aspirin, 81 mg) and statin therapy.

Patency of the revascularization was documented in the initial of face postprocedure visit by pulse volume recordings or arterial ultrasound, or both, for the nine patients who were revascularized through a retrograde pedal access. On long-term follow-up, however, the main outcome measure was limb salvage rate.

RESULTS

From July 1, 2010, through December 1, 2013, there were 681 infrainguinal angiograms in which a patient had an intervention performed by our group at our institution; of these, 13 patients (nine men, four women) underwent a retrograde pedal access. Demographics, indications, and comorbidities are outlined in the Table. The 13 patients in this cohort were a mean age of 71.4 ± 12.4 years, and diabetes was present in 10 (77%) and stages III to V chronic renal insufficiency in nine (69%). Five patients (38%) had undergone contralateral amputations: one patient had a previous contralateral transmetatarsal, three a below-knee, and one an above-knee amputation. All patients undergoing pedal interventions (angioplasty alone or with stent placements) are loaded with clopidogrel (300 mg) postprocedure and maintained on dual antiplatelet (aspirin, 81 mg) and statin therapy.

Patency of the revascularization was documented in the initial office postprocedure visit by pulse volume recordings or arterial ultrasound, or both, for the nine patients who were revascularized through a retrograde pedal access. On long-term follow-up, however, the main outcome measure was limb salvage rate.

The technical success rate was 69% (nine of 13). The four technical failures were due to inability to cross the CTO(s). A double-balloon technique was attempted in four of the 13 patients and was successful in two of the four attempts. Tibial vessels (nine of 13) were intervened on in this cohort, and two patients had concomitant popliteal interventions. There were six occlusions (two in the popliteal artery and four in tibial vessels) and seven of 13 tibial stenoses. The mean lesion length was 6 cm (range, 2-12 cm). Interventions consisted of angioplasty alone (six of nine), or angioplasty, followed by placement of a balloon-expandable drug-coated stent (three of nine) for residual disease after angioplasty or flow-limiting dissections.

One myocardial infarction occurred perioperatively. There were no local access complications or pedal vessel thrombosis, worsening renal insufficiency, or deaths. At a mean follow-up of 17.1 ± 10.3 months, the limb salvage rate was 77% (10 of 13; Fig 3). These patients had resolution of rest pain (one of 13) and healing of ulceration (nine of 13). Of the four technical failures, there were three patients with tissue loss and one with rest pain. Two of the

Table. Demographic characteristics, procedural details, and outcomes of the retrograde pedal cohort

<table>
<thead>
<tr>
<th>Pt</th>
<th>Age, years</th>
<th>Sex</th>
<th>DM</th>
<th>Stage V</th>
<th>Contralateral amputation</th>
<th>Indication</th>
<th>Pedal access</th>
<th>Technically successful?</th>
<th>Modality</th>
<th>Limb salvage</th>
<th>Follow-up, months</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>82</td>
<td>F</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Tissue loss</td>
<td>DP</td>
<td>Yes</td>
<td>PTAS</td>
<td>Yes</td>
<td>24</td>
</tr>
<tr>
<td>2</td>
<td>53</td>
<td>M</td>
<td>Yes</td>
<td>Yes</td>
<td>BKA</td>
<td>Tissue loss</td>
<td>PT</td>
<td>Yes</td>
<td>PTA</td>
<td>Yes</td>
<td>35</td>
</tr>
<tr>
<td>3</td>
<td>57</td>
<td>M</td>
<td>Yes</td>
<td>Yes</td>
<td>BKA</td>
<td>Tissue loss</td>
<td>PT</td>
<td>Yes</td>
<td>PTAS</td>
<td>No</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>88</td>
<td>F</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Tissue loss</td>
<td>DP</td>
<td>Yes</td>
<td>PTA</td>
<td>Yes</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>59</td>
<td>M</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Tissue loss</td>
<td>PT</td>
<td>No</td>
<td>...</td>
<td>Yes</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>84</td>
<td>M</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Tissue loss</td>
<td>PT</td>
<td>No</td>
<td>...</td>
<td>Yes</td>
<td>30</td>
</tr>
<tr>
<td>7</td>
<td>67</td>
<td>M</td>
<td>Yes</td>
<td>No</td>
<td>TMA</td>
<td>Tissue loss</td>
<td>PT</td>
<td>Yes</td>
<td>PTA</td>
<td>Yes</td>
<td>26</td>
</tr>
<tr>
<td>8</td>
<td>72</td>
<td>M</td>
<td>Yes</td>
<td>No</td>
<td>BKA</td>
<td>Tissue loss</td>
<td>DP</td>
<td>Yes</td>
<td>PTA</td>
<td>Yes</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>64</td>
<td>M</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Tissue loss</td>
<td>DP</td>
<td>Yes</td>
<td>PTA</td>
<td>Yes</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>87</td>
<td>M</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Rest pain</td>
<td>DP</td>
<td>Yes</td>
<td>PTA</td>
<td>Yes</td>
<td>8</td>
</tr>
<tr>
<td>11</td>
<td>89</td>
<td>F</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Tissue loss</td>
<td>PT</td>
<td>No</td>
<td>...</td>
<td>Yes</td>
<td>7</td>
</tr>
<tr>
<td>12</td>
<td>79</td>
<td>F</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>BKA</td>
<td>Tissue loss</td>
<td>PT</td>
<td>Yes</td>
<td>PTA</td>
<td>Yes</td>
</tr>
<tr>
<td>13</td>
<td>48</td>
<td>M</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Rest pain</td>
<td>PT</td>
<td>No</td>
<td>...</td>
<td>Yes</td>
<td>6</td>
</tr>
</tbody>
</table>

AKA, Above-knee amputation; BKA, below-knee amputation; CKD/HD, chronic kidney disease with hemodialysis; DM, diabetes mellitus; DP, dorsalis pedis artery; F, female; M, male; Pt, patient; PT, posterior tibial artery; PTA, percutaneous angioplasty; PTAS, percutaneous angioplasty, followed by drug-eluting stent placement; TMA, transmetatarsal.

*Underwent pedal bypass for limb salvage.

Fig 3. Kaplan-Meier survival with standard error (dashed lines) demonstrates avoidance of an ipsilateral below-knee or above-knee amputation after retrograde pedal access.
three other technical failures with tissue loss later required below-knee amputation, and in one patient, a small toe ulceration healed at 7 months with aggressive local wound care. The fourth patient with ischemic rest pain subsequently underwent a popliteal-to-tibial bypass for symptom resolution. Overall, there was a high mortality rate on follow-up in this cohort of 23% (three of 13) occurring at median 6 ± 4 months.

DISCUSSION

Treatment of tibial occlusive disease for patients with limb-threatening ischemia (Rutherford chronic limb ischemia class IV and V) remains a challenge in the high-risk patient, particularly patients on dialysis and long history of diabetes, as in our series. Patients with peripheral arterial disease confined to the tibial vessels have a higher incidence of limb loss, presumably due to more extensive distal disease with poor runoff to the foot and severe comorbidities precluding surgical bypass.25 Endovascular treatment of patients with CLI who are poor bypass candidates and who cannot be revascularized through an antegrade approach may be salvaged through a retrograde pedal access, recanalization of the tibial or popliteal occlusion(s), and definitive angioplasty, with or without stent placement. Although no specific patient comorbidity criteria were used, reasons for deeming a patient to not be a bypass candidate were a failed chemical cardiac stress test, history of ischemic cardiomyopathy with ejection fractions of <20%, and patients on hemodialysis deemed to have poor functional status. One of 13 patients in our series subsequently underwent a popliteal-to-tibial bypass for symptom resolution; in this individual, further cardiac work-up after the failed retrograde pedal attempt demonstrated he was a moderate risk for bypass.

There are certain advantages to the retrograde pedal access:

1. The small diameter of tibial vessels (2-3 mm) may help to increase the pushability of the wire and microcatheter through the infrapopliteal occlusion.
2. Because collateral vessels usually arise in a caudal angle, there is less likelihood of entering these side branches through a retrograde approach.
3. Frequently, the most difficult portion of an infrapopliteal CTO is the proximal cap/segment. In contrast, the distal portion is often softer, and gaining access through it is often easier.
4. Finally, this approach may have a safety advantage in morbidly obese patients or patients with a hostile or infected groin, in whom an antegrade femoral approach may not be technically feasible.

Similarly, there are potential disadvantages to a retrograde pedal approach to consider:

1. The small diameter of the tibial vessels, particularly in women, could make them particularly prone to vasospasm and possible thrombus formation.
2. Multiple sticks should be avoided because this could result in vessel spasm, thrombosis, and risk obliteration of the runoff to the foot and worsening of the presenting symptomatology.
3. Finally, this is not a routinely use approach, and the unfamiliarity by operating room or catheterization technicians may make this approach especially challenging in already difficult cases.

Taken together, in specific cases of patients with CLI who are not tibial bypass candidates and who cannot be revascularized through an antegrade approach, selective use of a retrograde approach is safe, technically feasible at re-establishing in-line flow to the foot, and can achieve acceptable limb salvage rates.

Another advantage of this approach is that it uses basic tools available in the endovascular suite, is less costly than routine use of CTO and re-entry devices, and can be achieved with local anesthesia and minimal sedation. Indeed, re-entry devices were designed to assist in situations where the antegrade guidewire passes beyond the CTO but is not able to re-enter the true lumen distal to the occlusion. Besides cost, a limitation to wide application of re-entry device use is that they may fail up to 35% of the time26 in the femoropopliteal location due to inability to penetrate the occlusion proximally with the antegrade guidewire or due to perforation. Despite these unique advantages to the retrograde pedal access, we strongly believe this type of extreme revascularization technique should be reserved for patients with CLI, Rutherford chronic limb ischemia class IV and V, who are otherwise poor candidates for a tibial bypass. Although we did not note this complication in our series, given the possibility of obliteration of the runoff vessel(s) to the foot, a retrograde pedal access should not be extended into patients with Rutherford chronic limb ischemia class III/disabling claudication.

CTOs arise from thrombotic occlusion of a high-grade stenosis; in the coronary artery, histology of an occlusion has demonstrated a dense concentration of collagen-rich fibrous tissue proximally and markedly less dense tissue distally.27 Tibial CTOs likely have less calcified tissue in the distal segment of the CTO; this is thought to be the basis for the technical success with retrograde pedal access, as has also been documented in coronary CTOs.24,28 Another reason that retrograde access may have an advantage over antegrade access is that the CTO lesion is closer to the access site, which allows for ease of pushability, forward force through the CTO, and ease of torque delivery. The dorsalis pedis and posterior tibialis arteries in the foot are ideal access arteries for retrograde access. These vessels are superficial even in morbidly obese patients and are readily visualized by ultrasound guidance, allowing their precise cannulation. When deciding on which pedal artery to access for retrograde recanalization, we favor following the angiosome concept and selecting the tibial vessel that results in in-line flow to the tissue loss, because this has been demonstrated to positively affect limb salvage in patients with direct compared with indirect flow (86% vs
69%).²⁹,³⁰ We have not attempted peroneal access, although it is described in the literature,³¹ because its anatomical location in the deep posterior compartment may result in difficulty with postprocedural hemostasis, increasing the likelihood of hematoma formation and possible compartment syndrome.

There are some technical aspects that are worth discussing further. First, the retrograde wire should ideally be an extra support wire that is exchange length (260 cm), allowing ease of treatment with various retrograde balloons or should snaring of the retrograde wire be required through an antegrade approach.

Second, sometimes the retrograde wire enters a subintimal plane that is in a different subintimal space than the antegrade wire. In these instances, the dissection membrane that separates both subintimal wires can be disrupted by a “double-balloon” technique.¹² In this technique, a larger-diameter balloon is used from above and a smaller balloon distally; both diameters should equal the approximate size of the vessel being treated. These abutting balloons will disrupt the dissection membrane and allow the retrograde wire to re-enter the true lumen. Balloon angioplasty inflation times of 1 minute may be used at half nominal pressures to seal the disrupted membrane and avoid the need for stent placement.

Third, should a stent be necessary, particularly in a tibial artery, traditional antegrade access is gained, and the retrograde wire is brought inside of an antegrade catheter or may be snared through the antegrade approach. A sirolimus-eluting balloon-expandable stent is used given preliminary data demonstrating increased efficacy with sirolimus over paclitaxel.³²

Fourth, the pedal access is associated with a learning curve. It is important for the operator to be comfortable cannulating a 1- to 2-mm vessel with a single puncture of the anterior wall of the vessel. Multiple attempts may lead to vasospasm and potential thrombotic occlusion. Periodic flushing of the pedal target vessel with a calcium channel inhibitor and a direct vasodilator may aid in decreasing the risk of vasospasm and thrombotic occlusion.

Fifth, as described in the Methods section, it is imperative that the retrograde be performed in a sheathless fashion and that any balloon catheter brought retrograde be done so in a “bareback” fashion to avoid pedal vessel trauma and risk of thrombosis. We have not found the need to insert a sheath in any of the 13 patients in our series.

Sixth, routine dual-antiplatelet therapy is used in these popliteal/tibial interventions as well as statin therapy to help maintain vessel patency and reduce cardiac morbidity periprocedurally.³³

Lastly, when routine subintimal angioplasty fails during recanalization attempts of CTOs, a subintimal arterial blossing with antegrade-retrograde intervention (SAFARI technique) has been described as a mode of re-entering the true lumen.⁶,³¹ In this technique, retrograde and pedal accesses are obtained, and retrograde subintimal recanalization is done until the antegrade subintimal space is reached. The retrograde wire is then snared or manipulated into an antegrade catheter, creating a “blossing-type” wire access. This facilitates tracking of an angioplasty balloon catheter across the CTO and treatment.

This is a unique study compared with the case reports and series that have been reported by nonsurgical groups. We present patients who were deemed by vascular surgeons to be poor surgical candidates and report safety and intermediate limb salvage data with a mean follow-up of 17.1 months, longer than what has previously been reported.

A main limitation of this study is that it is a retrospective, nonrandomized report from a single institution. The sample is biased, because this is a small patient population that was selected to undergo a retrograde pedal access based on the judgment of one of three vascular surgeons. Another limitation is that there is no comparison to a group of patients with Rutherford chronic limb ischemia class IV or V who were not revascularized through an antegrade or retrograde approach. Such a future study would address the effect of aggressive local wound care on healing such lesions that cannot be revascularized.

Of the 13 patients in our study, 11 were Rutherford chronic limb ischemia class V patients. We did not attempt the retrograde pedal approach on patients with Rutherford class VI (major tissue loss). Traditionally, we have treated these patients with a pedal bypass and rotational or free myocutaneous flaps. Future studies could address the utility of this technique in this and other patient populations. Larger scale, multi-institutional studies will need to confirm the safety, efficacy, and limb salvage rates we have observed.

CONCLUSIONS

Inability to enter the true lumen during an endovascular intervention involving a popliteal or tibial CTO, or both, was estimated to occur as high as 20% of the time,⁶,²¹ although this may be lower in more contemporary practice. Nonetheless, a retrograde pedal approach is another option for patients with CLI who cannot be revascularized through an antegrade approach and are not tibial bypass candidates. It can be achieved with minimal morbidity, avoiding the use of more expensive re-entry devices, and our single-institutional series did not note any local complications, an understandable fear of using a retrograde pedal access. More experience with this technique and further refinement are required for further improvements in the treatment of popliteal and tibial CTO lesions in patients with CLI who are not tibial bypass candidates and who cannot be revascularized in an antegrade manner.

AUTHOR CONTRIBUTIONS

Conception and design: HB
Analysis and interpretation: HB, LL, MD, TAS, WS
Data collection: HB, LL, TS
Writing the article: HB
Critical revision of the article: HB, LL, MD, TAS, WS
DISCUSSION

Dr Cynthia K. Shortell (Durham, NC). Congratulations to the authors on this excellent paper about a challenging clinical and technical problem; namely critical limb ischemia due to tibial disease in patients who are poor surgical risk.

As vascular surgeons, we are increasingly called upon to achieve limb salvage in more and more difficult situations, be it unfavorable patient anatomy, patient physiology, or patient psyche, and we need ever-greater numbers of tools in our toolbox in order

Final approval of the article: HB
Statistical analysis: HB
Obtained funding: HB, WS
Overall responsibility: HB

REFERENCES


to accomplish this. This paper describes the Ochsner group’s experience with just such a tool; namely, retrograde pedal access for patients with tibial artery occlusive disease. While this technique has been described previously, midterm results have not been reported previously. The authors describe the use of this technique in patients in whom a standard antegrade approach had been tried and had failed, and report favorable technical and clinical success rates.

I thoroughly enjoyed reading this well-written manuscript and appreciate receiving it from the authors well in advance of the meeting. I would also like to thank the authors for providing me with a copy of the manuscript in a very timely manner. I have several questions for the authors:

First, can you be more specific about the unsuitability for surgery? Were there medical comorbidities or patient-related issues such as obesity? How was this determined? Were there specific criteria or was it surgeon-specific?

Your manuscript suggests that all patients had an initial attempt at traditional antegrade access. Was this indeed the case, and if so, was the pedal access attempted at the same or a later setting?

In four patients, the procedure was technically unsuccessful. What happened to these patients?

You had a limb salvage rate of 77% at 17 months. Did you assess patency of the revascularization, and if so, what was it?

Given the results of this study will you change your practice to offer pedal access as the initial procedure in some cases now?

Dr Hernan Bazan. Thank you, Dr Shortell, for the nice summary and the very insightful questions. The first question you asked is about the unsuitability of the patients. We did not do any standardized risk stratification. Patient suitability was left to one of the three board-certified vascular surgeons who deemed whether or not the patient was a bypass candidate. Patient factors, such as ischemic cardiomyopathy with a severely depressed ejection fraction or dialysis-dependence with a poor functional status, are some examples. In terms of whether or not we brought the patients back for a retrograde pedal access during the initial angiogram, I can only recall one or two instances where the patient was brought back after a failed antegrade access. This does bring up another point, which we were discussing earlier: in these cases that involve a retrograde pedal access after a failed antegrade approach, what we have found is that after one attempt to revascularized via an antegrade approach for an hour or one hour and a half, the techs in the endovascular suite are then told “okay, let’s prep the foot,” and everybody in the endo suite has to be prepared to work an additional hour or so. Hence, it certainly does add more time, but I can recall one or two patients where they were brought back. These were primarily cases in which we were trying to avoid a large contrast exposure in patients with compromised renal function.

You also asked a question about the four patients we were not able to revascularized; there was major limb loss in three of them. The fourth patient had rest pain, and he subsequently underwent a successful revascularization through a pedal bypass. He was the only one out of the 13 that had a bypass, as none of the other patients were bypass candidates.

The last question you asked: Would this change our practice? I think, as it was mentioned earlier and mentioned on the first day of our conference, we always teach our trainees to individualize treatment to the patient. I believe we should optimize our attempt to do a tibial bypass when we can because it is a great operation, very durable, and to date, nothing else has similar long-term patency. Although we do in fact attempt an endovascular approach first in the majority of patients, there are some who are clearly good bypass candidates and no endoluminal attempt at revascularization is made; they go on to a tibial bypass.