Tibio-Pedal Arterial Minimally Invasive Retrograde Revascularization in Patients with Advanced Peripheral Vascular Disease: The TAMI Technique, Original Case Series

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Background: A tibial-pedal access method is needed for patients with advanced peripheral artery disease (PAD) unable to tolerate common femoral artery (CFA) access and intervention due to body habitus or comorbidities. This is the first case series reporting an alternative technique to revascularize such patients. Using ultrasound (US) and the tibio-pedal arterial minimally invasive retrograde revascularization (TAMI) technique, operators accessed, and revascularized the lower extremity completely via tibial-pedal arterial access.

Methods: This retrospective, single-center, case series recorded on 23 patients who underwent TAMI revascularization during a seven-month period in 2012, demonstrating the feasibility and safety of the TAMI technique. Eighty-three percent had Rutherford Classification IV–VI. Ultrasound guidance aided all tibial access. Demographics, vascular symptoms, disease characteristics, success, procedure length, time to discharge, immediate and 30-day complications were collected. Comparison was sought with 201 unmatched patients treated via traditional CFA access over a similar period.

Results: Arterial access was successful in all patients. Thirty-six lesions were treated. Lesion success (ability to cross lesion and achieve post treatment stenosis <30%) was achieved in 95% of patients. 25% of lesions were above the knee. Average prestenosis was 92.5%; average poststenosis 12%. No major complications were noted. Two patients presented within 30 days with access site pain. Access site peroneal artery pseudo-aneurysms were diagnosed and treated percutaneously with covered stents. Both recovered with no sequelae.

Conclusion: Retrograde tibio-pedal intervention appears to be safe and effective. The TAMI technique offers an alternate revascularization method for critically ill advanced PAD patients.

Key words: critical limb ischemia; endovascular; tibial access; ultrasound
INTRODUCTION

Advanced peripheral artery disease (PAD) is a term used by the authors to describe patients with Rutherford Classification III disease with complex anatomy, and critical limb ischemia (CLI) patients with Rutherford Classification IV–VI. Endovascular revascularization of patients with advanced PAD has evolved dramatically over the past decade due to a better understanding of the atherosclerotic process. Treatment modalities are broad, and include balloon angioplasty, bare metal stents, drug eluting stents, atherectomy, and distal tibial bypass surgery. However, the delivery of therapy has traditionally been through major arterial conduits including the common femoral artery (CFA). Patients lacking good CFA conduits for antegrade access have failed antegrade access, are morbidly obese, or are unable to lie flat, may not be able to tolerate traditional CFA access leaving a void in the treatment of advanced PAD patients.

The combination of high-risk patients with advanced PAD requiring revascularization treatment, the availability of new lower profile peripheral vascular (PV) devices, and the need to revascularize lesions (that were previously unsuccessfully treated from an antegrade approach), resulted in the development of the Tibio-pedal Arterial Minimally Invasive (TAMI) retrograde revascularization technique. The TAMI technique is achieved by using single or dual retrograde tibial-pedal access, with the aid of ultrasound (US) guidance, to perform diagnostic and interventional procedures in patients that are poor candidates to receive the same therapy from CFA access.

METHODS

This retrospective case series was performed at a single center on patients who underwent revascularization for advanced PAD during a 7-month period in 2012. Patients were chosen by the operators based on previous failed antegrade access, the lack of good CFA conduits, obesity, or inability to lie flat. The Institutional Review Board (IRB) approved the study protocol. Four operators performed cases. Eighty-three percent of patients had Rutherford Classification IV–VI. Ultrasound guidance was used to access 100% of the tibial-pedal vessels. Variables collected include demographics, vascular symptoms, disease characteristics, success rate, procedure length of time, time to discharge, and immediate and 30-day complications. All patients were consented for the invasive procedure.

A comparison was sought between the TAMI technique population and the hospital’s peripheral vascular population treated via traditional CFA access. A total of 201 patients with advanced PAD were treated at our institution over a similar 6-month period in 2011.

STEP-WISE TAMI INTERVENTION PROCEDURE DESCRIPTION

Please refer to the online case study video, as the step-wise approach is highlighted throughout an example of a full TAMI procedure.

A key component for revascularization utilizing the TAMI technique is a baseline-selective angiographic evaluation. Selective angiography will uncover vascular conduits that are not identified during nonselective angiography. The chronic total occlusion (CTO) segment identified by retrograde selective angiography is often found to be shorter than what is visualized via nonselective angiography and/or antegrade angiography.

The video shows an example of a TAMI procedure performed on a 69-year-old female CLI patient. The patient presented with ongoing rest pain and a nonhealing ulcer involving the plantar medial aspect of her right foot. The patient was classified as Rutherford Class V. Magnetic resonance imaging of her foot revealed osteomyelitis of the first metatarsal. Her vascular exam was abnormal with absent bilateral pedal pulses. The baseline ankle brachial index was measured at 0.36 on the right and 0.56 on the left.

The patient’s initial peripheral angiogram was performed via conventional left CFA retrograde access. Multiple images were obtained during the procedure showing severe right SFA and popliteal artery disease, including total occlusion of the right mid-popliteal artery that reconstituted in the distal segment of the popliteal artery below the knee. The tibial runoff was poor and not well visualized via the antegrade contrast injection, and good tibial reconstitution proximally was not evident. There was evidence of reconstitution of the posterior tibial and anterior tibial arteries above the ankle on the right. During the procedure, the patient developed hypertensive urgency and the case was stopped early. She also developed a large, right groin hematoma prior to discharge.

Based on arterial disease identified in the diagnostic angiogram, and the patient’s cutaneous ischemic breakdown, femoral versus brachial versus retrograde tibial access were considered for the revascularization approach. Femoral access was not tried again due to the patient’s previous complications and inability to lie flat. A brachial approach may have been feasible, but would have limited potential treatment of below the knee vessels due to limitation of device lengths. A decision was made to proceed with retrograde tibial access, with the TAMI technique.

Step 1: Patient Placement

The patient is typically placed in the reverse manner with the patient’s head to the right of the operator and
the lower extremities to the left. This allows imaging modalities to reach to the foot. Traditionally, the patient lies flat on their back with bilateral groins prepped for emergency access if necessary. However, in several TAMI cases, the procedure was performed with the patient lying at a 45-degree angle, due to the patient’s inability to lie flat.

The target limb should be prepped and draped separately. The orientation of the foot is adjusted depending on the target tibial vessel. In cases of dorsalis pedis or distal anterior tibial artery access, the foot is maintained in a natural orientation with the heel of the foot on the mattress with slight dorsiflexion as shown in the video. To access the posterior tibial artery, the foot is rotated laterally and the leg is bent slightly at knee level for patient comfort. To access the peroneal artery, the foot needs to be rotated more laterally to separate the fibula and tibia. This maneuver will facilitate direct cannulation of the artery.

In the video, the patient was placed on the angio suite table with a supporting mattress that allowed her to sit at a 45-degree angle. The patient was prepped with the target limb, the right lower extremity, exposed from the groin to the toes. Sterile towels were then placed over the leg so that it could be exposed or covered as needed during the procedure. Keeping the target limb fully exposed and sterile allows operators to obtain multiple access sites as needed and to use US-guided access and intervention without limitations.

**Step 2: Access**

Using a hockey stick US probe and Site-Rite Vision Ultrasound System (Bard Peripheral Vascular, Inc, Tempe, AZ) the RVT uses the US probe to visualize the tibial artery above the ankle in both short- and long-axis views. The healthiest patent segment is identified as the target access point for sheath placement. Once a target segment is selected, US guidance is used to advance the access needle (21 gauge, Cook Medical, Bloomington, IN). The needle can be visualized directly as it enters the anterior wall while carefully avoiding the posterior wall and tibial veins surrounding the arteries. The RVT is present for the entire TAMI procedure. In the video, the posterior tibial artery was chosen as the major access site for revascularization due to its mostly straight nature from the retrograde approach.

**Step 3: Successful Arterial Cannulation**

With direct visualization of the access needle entering the tibial artery, successful arterial cannulation will result in bright red blood return. Depending on the degree of disease, pulsatile blood flow may not be present. Also, on rare occasion, visual confirmation of arterial access by US imaging of the access needle and wire within the target tibial artery may be necessary.

**Step 4: Access Wire Introduction**

After arterial cannulation, the operator advances the 0.021 access wire provided with the micro-sheath (Cook Medical or Terumo Interventional Systems). Typically, while the operator is advancing the wire through the access needle, the RVT visualizes the wire within the tibial vessel under US. The operator depends on tactile sensation from the wire and direct visualization of the wire being advanced within the vessel.

Utilization of US guided wire advancement during the initial phase of sheath placement has been adopted. This achieves two purposes, maintaining the wire tip in the true lumen away from the subintimal space and real-time visualization, allowing maneuvering of the wire across plaques and high-grade stenosis. Fluoroscopy is not routinely used during access or to watch the wire advance.

**Step 5: Sheath Insertion**

After successful wire introduction, the operator advances the microsheath into the tibial vessel. In many diseased tibial arteries, a regular 4F sheath may potentially occlude the artery completely, and create blood flow stagnation, associated with increased risk of acute thrombosis. The technique of placing a 4F micropuncture sheath or dilator, which has a significantly smaller outer diameter, allowing blood flow around the sheath despite presence of vasospasm or plaque, has been adopted. If a dilator is used, it is secured to the leg with a Sheath Anchor (Lakeshore Medical Innovations, Byron Center, MI).

Both the Cook and the Terumo micropuncture wires have a smooth wire transitional zone in their tips. The transition is short, allowing for the stiff wire portion to support the advancement of the sheath.

In elderly patients with advanced PAD and venous disease, the skin tends to be thick and advancing the sheath may be difficult. In these cases, the operator can create a small incision to facilitate advancing the sheath while avoiding injury to the vessel.

**Step 6: Intraarterial Sheath Confirmation and Medications**

The operator may choose to confirm the position of the sheath via two modalities, US or fluoroscopy. Ultrasound allows for visualization of the tip of the microsheath within the tibial vessel. Under fluoroscopy, contrast injection confirms the intraluminal
position of the sheath. Usually, the operator injects 5–10 mL of diluted contrast (50% contrast, 50% saline). Full anticoagulation is started once sheath insertion is confirmed.

The operator gives intraarterial nitroglycerin (400 μg) and heparin (80 units/kg—our institutional protocol for tibial-pedal interventions) and performs the initial diagnostic images. Unfortunately, there has been no adequate body of evidence to state the ideal Activated Clotting Time (ACT) for tibial vessels. Our institution maintains an ACT between 200 and 250 sec. The ACT is checked at 20-min intervals to maintain a higher ACT while working in the tibial vessels, avoiding risk of thrombosis. Also, a 10-min interval time is initiated after the first nitroglycerine dose. Typically an intratibial nitroglycerine injection of 200–400 μg based on blood pressure tolerance is used.

In the case of bolus injections, both heparin and nitroglycerine create a transient burning sensation in the ankle and foot area. Patients should be warned about the sensation before administration of these medications.

Another option is to create, as described, a TAMI Solution. The TAMI Solution is composed of 500 cc of heparinized saline mixed with 1,600 μg of nitroglycerine and 5 mg of verapamil (calcium channel blocker). The solution is infused via the side port of the microsheath at a rate of 6–7 cc/min. This allows for continuous flushing of the tibial vessels and a constant level of vasodilation. When equipment is present in the Terumo 4 Fr microsheath and a 0.035 catheter (Terumo Interventional Systems), the solution can still continually flush.

### Step 7: Revascularization Strategy

Choosing the modality of therapy depends on the lesion to be treated. In CTOs, different crossing modalities may be used, such as a wire and catheter technique or devices for crossing CTOs that fit through 4F sheaths. The Crosser (Bard Peripheral Vascular) and TruePath (Boston Scientific) crossing devices may be used. Atherectomy was performed on a significant number of the patients (52%). The device commonly used in the TAMI cohort was orbital atherectomy. A 1.25 micro crown orbital atherectomy device (Cardiovascular Systems, Inc., Minneapolis, MN) can be inserted through a 4F Precision sheath (Terumo Interventional Systems).

Balloon angioplasty can also be performed through the 4F Precision sheath. In our cohort, Ultraverse peripheral balloons (Bard Peripheral Vascular) were utilized. Stenting, if needed, can be performed with the insertion of the stent in a sheathless fashion. Currently, the stents available on the market do not fit through a 4F sheath. Many devices on the market today have an IFU description of 5–6 Fr compatibility. In the experience of the authors, most of these devices are also compatible with a 4 Fr sheath. Table I shows a list of devices that can be utilized with TAMI.

In the video, a 0.018-inch CXI catheter (Cook Medical) and a 0.014-inch Runthrough wire (Terumo Interventional Systems) were employed.

Once the lesion was crossed, the operator chose to use a 1.25 microcrown orbital atherectomy device (CSI, Minneapolis, MN) through a 4Fr Precision sheath with success. Balloon angioplasty using an Ultraverse low-profile balloon (Bard Peripheral Vascular) that fit through the 4-Fr Precision sheath was employed.

### Step 8: Angiographic Assessment

Post retrograde tibial revascularization, distal runoff is performed to rule out distal embolization, spasm, and acute thrombosis. Ideally, the operator maintains wire access, for example, a 0.014-inch wire is kept inside the vessel. A 0.018-inch or a 0.035-inch catheter can be advanced over the wire. The COPILOT system (Abbott Vascular, Abbott Park, IL) can be used to inject through the catheter around the wire. The evaluation of angiographic results is performed in a stepwise fashion from supratibial to infratibial vessels. Final angiogram injection is through the tibial sheath while maintaining wire access. In this case series, the dilator of the 4Fr micropuncture sheath (Cook Medical) was chosen, which allows distal flow to the access site post intervention. This allows adequate visualization of the accessed tibial vessel. If spasm is visualized intra-arterial vasodilators are given. If distal embolization is visualized, transial...
access and treatment of the embolized arterial segment would follow. If this is not possible, another option would be antegrade target artery access and treatment of the target embolized artery. If a flow-limiting dissection is found through angiographic assessment, balloon angioplasty should be attempted. If this is not successful, the authors have found that utilizing a 5 Fr Precision sheath allows for the delivery of a Zilver stent (Terumo Interventional Systems, Cook Medical).

Step 9: Hemostasis
At the end of the procedure, ACT is obtained and the sheath is removed immediately, regardless of ACT result. Hemostasis can be achieved via manual compression or via a hemostasis device. Manual compression is typically utilized for 10 min. Compression duration does not vary by tibial-pedal access site. When no evidence of bleeding is visualized, manual compression is stopped. Many of the hemostasis devices used for radial access have been tried with variable success. Currently, our site utilizes Rad-Band (Vascular Solutions, Minneapolis, MN). Once the hemostasis device is applied, the site is checked every 15 min for hemostasis. The device is removed once no bleeding is observed. Doppler pulses are documented immediately after the removal of the hemostasis device. After hemostasis is achieved, the site is checked every 15 min for bleeding and Doppler pulse is assessed. Following a TAMI procedure, patients may ambulate 30 min after hemostasis is achieved and patients may be discharged same day.

In the video, the patient’s osteomyelitis and wound healed following limited wound debridement. The patient was followed at regular intervals in our clinic and wound care center. The patient’s wound was healed completely at 5 months post procedure.

DATA ANALYSIS
Descriptive analysis was documented using means and standard deviations. Patients in the TAMI technique cohort were compared to the traditional CFA PV cohort. These cohorts were not matched. Statistical comparison between the TAMI technique cohort and the CFA PV cohort was not performed due to the relatively small TAMI cohort size.

RESULTS
A total of 27 patients were enrolled in the TAMI technique cohort and revascularization was successful in 23 patients. Table II highlights the clinical variables related to the TAMI procedure. The average procedure time was 76.7 min. Average time to access was 171.6 sec from local anesthetic delivery to sheath placement. Intraluminal tibial-pedal access was achieved in 100% of patients. In four patients (15%), the wire was unable to be advanced through the access needle because of significant plaque and calcification. The 23 patients, with successful wire advancement, underwent the TAMI technique procedure with no immediate in-hospital sequelae.

The TAMI technique cohort was compared to the traditional CFA PV group. The TAMI patients had a higher incidence of chronic kidney disease (CKD), anemia, and had more CLI features of rest pain and ischemic skin breakdown. A total of 36 lesions were treated via the TAMI technique. Sixty-five percent of the lesions were CTOs of the tibial vessels. Procedure success, defined as residual stenosis, by visual estimate, <30%, was achieved in 95% of patients. The average prestenosis was 92% and the average poststenosis was 12%. TAMI patients were able to sit up immediately postprocedure and two patients received their TAMI revascularization while sitting at a 45 degree angle. Despite the high-risk profile, the TAMI patients suffered no major complications. Table III documents immediate outcomes at hospital discharge for the TAMI and CFA cohorts.

There were no major amputations, above the ankle, in the TAMI technique population. At 30 days, the rate of limb salvage was 100%.

Two patients did present within 30 days of the index procedure, in the outpatient setting, with complaints of access site discomfort. They were discovered to have pseudoaneurysms at the access site. In both patients,

## Table II. TAMI Technique Procedure Variables

<table>
<thead>
<tr>
<th>Procedure variables</th>
<th>TAMI technique</th>
<th>Traditional CFA PV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average duration of procedure</td>
<td>76.7 min</td>
<td>171.6 sec</td>
</tr>
<tr>
<td>Average time to obtain access</td>
<td>171.6 sec</td>
<td>450.3 sec</td>
</tr>
<tr>
<td>Average number of attempts to obtain access</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Average time to ambulation</td>
<td>80 min</td>
<td>120 min</td>
</tr>
<tr>
<td>Average ACT</td>
<td>196.7 sec</td>
<td>200 sec</td>
</tr>
<tr>
<td>Anterior tibial access</td>
<td>52%</td>
<td>52%</td>
</tr>
<tr>
<td>Posterior tibial access</td>
<td>34%</td>
<td>34%</td>
</tr>
<tr>
<td>Peroneal access</td>
<td>14%</td>
<td>14%</td>
</tr>
<tr>
<td>Average heparin dose</td>
<td>9069 units</td>
<td>9069 units</td>
</tr>
</tbody>
</table>

## Table III. Immediate In-Hospital Outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>TAMI technique</th>
<th>Traditional CFA PV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death/MI</td>
<td>0/23</td>
<td>0/195</td>
</tr>
<tr>
<td>Access site complication</td>
<td>0/23</td>
<td>6/195 (3%)</td>
</tr>
<tr>
<td>Major amputation</td>
<td>0/23</td>
<td>4/195 (2%)</td>
</tr>
<tr>
<td>Emergency vascular surgery</td>
<td>0/23</td>
<td>1/195 (0.5%)</td>
</tr>
<tr>
<td>Blood transfusion</td>
<td>0/23</td>
<td>8/195 (4%)</td>
</tr>
<tr>
<td>Vessel perforation</td>
<td>0/23</td>
<td>14/195 (7%)</td>
</tr>
<tr>
<td>Vessel embolization</td>
<td>0/23</td>
<td>1/195 (0.5%)</td>
</tr>
<tr>
<td>Vessel thrombosis</td>
<td>0/23</td>
<td>1/195 (0.5%)</td>
</tr>
</tbody>
</table>
the peroneal artery had been accessed. The pseudoaneurysms were treated with the placement of a covered Jostent GraftMaster, sealing the access site to the pseudoaneurysm (Abbott Vascular, Abbott Park, IL).

DISCUSSION

The challenges of arterial access, and limitations placed by the multiple comorbidities of advanced PAD patients, led to the adoption of the TAMI technique as a modality of revascularization for this high-risk cohort. Accessing major vascular conduits through the CFA has long been the practice for delivering endovascular therapy. Traditionally, practitioners use the femoral head as a bony landmark to localize the CFA in order to avoid high or low arterial access. Despite extreme attentiveness to utilizing the bony landmark, the most common complication types of all endovascular procedures are related to access. Fluoroscopic evaluation of peripheral access has shown to benefit the reduction of access complications; however, anatomical variations that contribute to complications are often not recognized by fluoroscopic visualization alone [1–6].

The TAMI technique is unique in that it allows operators to selectively engage the target tibial vessel and completely treat it from retrograde tibial access, thus completely eliminating the potential for antegrade and retrograde femoral groin site complications. CFA complications are frequently seen in elderly patients with calcified vessels, obese patients with a large pannus, and patients unable to lie flat due to low back disease and sleep apnea. These patients are ideal candidates for the TAMI procedure as patients are able to lie at a 45-degree angle and ambulate quickly post procedure. The technique also has the benefit of using US for access and visualization during the procedure. Utilizing US seems to be an appropriate skill that can improve accuracy and avoid complications [7]. US was used to gain access in 100% of the TAMI technique patients. Access was obtained in the cross-sectional view and wire advancement was viewed in the longitudinal view. Sheath placement, after wire access, was also US guided. This adds significant value in this patient population by allowing practitioners to visualize direct entry into the target artery, minimize the use of contrast and radiation, increase access success, and expedite time to tibial-pedal access. Historically, non-US guided tibial-pedal access is cumbersome because access is obtained via blind technique using calcified tibial-pedal arteries as landmarks. This can lead to increased contrast and radiation exposure and the inability to demonstrate venous and arterial conduits during access. A higher incidence of venous cannulation may result or multiple attempts may be needed. Multiple attempts can lead to arterial spasm and failed cannulation of the tibial-pedal arteries. Additional antegrade CFA access would then be required, which may not be desirable in this patient population.

Following US guided tibial-pedal retrograde access, the majority of the tibial CTO lesions were crossed under US guidance. US allowed the operators to visualize the CTO cap and the length of the CTO segment. The crossing device was monitored with US, expediting the crossing time, and facilitating safe crossing. Since US was used to interrogate the tibial artery, minimal contrast was needed. Radiation was also reduced as US was utilized for interventional device delivery and activation, including balloon inflation, atherectomy, and stent placement.

Revascularizations performed entirely from retrograde tibial-pedal access were performed on all 23 of the patients in this series. For many of these advanced PAD patients with complex tibial disease, the retrograde access provided an alternative option for revascularization after the conventional antegrade method failed. The retrograde access and approach, along with US guidance, increased the success rate of the revascularization for the following reason—the lesion is closer to the access site. A closer lesion allows for ease of torque delivery, device push-ability, forward force transmission of CTO crossing tools, expedited device transit time, less chance of loss of wire control, and better local drug delivery. CTO cap crossing may also be easier to perform from the retrograde approach. In addition to the issues stated previously, patients with advanced PAD are often not healthy and have multiple commodities that can impact the length of a procedure. Or, it is very common for PAD patients to undergo staged interventions. Patients in the BASIL trial underwent on average 1.9 procedures per patient [8]. Multiple lengthy procedures increase the amount of radiation and contrast exposure and increase the likelihood for complication. The ability to limit the amount of contrast, while regaining vessel patency, adds to the appeal of the TAMI technique. This is especially important when treating patients with CKD. Patients with CKD and CLI gain a survival advantage with revascularization [9].

Additionally, the TAMI patients were able to ambulate within 80 min. This is in contrast to the traditional CFA postprocedure bed rest times lasting anywhere from 2 to 6 hr, assuming no groin complications. And, all patients were able to sit up immediately following the procedure; or in some cases, patients were able to sit at a 45-degree angle during the entire procedure. While not measured, patient comfort and satisfaction were clearly evident to the operators in comparison to patients undergoing a traditional revascularization procedure.

Therapy was successfully delivered whenever a TAMI approach was attempted with the exception of
It was learned from these patients that the TAMI approach should not be attempted in patients without adequate lumen visualization for tibial vessel cannulation. The inadequate tibial-pedal vessels have a typical appearance under US. The vessel will appear as a white calcified dot in a short axis view (Fig. 1), or a long white string in a long-axis view (Fig. 2). This vessel appearance is being referred to as the “White Stop Sign.” As experience improved with the TAMI technique, the “White Stop Sign” was identified as an US image that should prohibit utilizing tibial-pedal vessels for access or delivering therapy. The TAMI approach was aborted in all four patients who demonstrated the “White Stop Sign.”

Two patients returned with pseudo-aneurysms within 30 days of their TAMI procedure. In both cases the peroneal artery had been accessed and a regular 5Fr sheath had been used. It is the opinion of the operators that the transition between the dilator and the shaft of the utilized 5Fr sheath was too abrupt leaving no smooth transitional zone from the tip of the dilator to the tip of the sheath. The abrupt step-up from the dilator to sheath may have contributed to the pseudoaneurysms. Inadequate hemostasis may have also played a role. Pseudoaneurysms were not noted in the patients where 4 Fr sheaths were utilized. These events led to a change in protocol. All peroneal sheaths are now pulled under US guidance and manual pressure is applied until hemostasis is achieved.

**STUDY LIMITATIONS**

This is a small single-center case series with four operators performing TAMI procedures. The sample is biased because the patient population size is limited. The operators sought to compare the CFA and TAMI patient population cohorts for comorbidities, degree of illness, and complication rate. This comparison will need to be tested on a wider scale to confirm the feasibility and safety of the TAMI technique against the traditional PV approach. As experience with the technique increases, patient selection will also become more refined. A limitation to the TAMI technique is that there may be poor visualization distal to the access site. Peripheral embolizations may be difficult to diagnose and treat. As more safety data are obtained, better recommendations can be proposed. Some institutions may view the need for the presence of a trained registered vascular technologist (RVT) as a limiting factor. The technicians at this institution do not undergo specialized training for this procedure. Also, the TAMI technique cannot be universally applied to all advanced PAD patients.

**CONCLUSION**

In conclusion, TAMI is an additional approach to the revascularization of patients with whom a traditional revascularization approach is a poor option. Currently, many endovascular devices are shifting toward a lower-compatibility profile, allowing the vascular specialist to deliver a broad spectrum of revascularization devices through a microsheath via retrograde tibial-pedal access. The increased use of US has the potential for improving patient safety and decreasing the amount of contrast and radiation, which is very beneficial to both the patient and the operator. It is believed that the TAMI technique, when chosen in the right subset of patients, will have a positive impact on patient outcomes.
REFERENCES