Retrograde Pedal Access for the Superficial Femoral Artery Recanalization in Critical Limb Ischemia

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Abstract

OBJECTIVE: Retrograde pedal access may allow the treatment of superficial femoral artery (SFA) occlusive lesions when standard endovascular techniques fail. Here, we aimed to analyze the outcomes of this approach in patients with chronic limb ischemia who had undergone an unsuccessful attempt at revascularization through antegrade access.

MATERIALS AND METHODS: Here we present our experience of transpedal approaches in 60 surgical interventions in 60 patients during January 2020 to May 2022. A transpedal approach was performed either as second access after unsuccessful antegrade recanalization or primarily when antegrade access was not possible. For occlusions of the SFA from the ostium, 2 accesses are usually used: proximal and distal. Retrograde recanalization was performed with 0.018/0.035 hydrophilic guidewires. If the follow-up angiography showed no extravasation, residual stenoses, or signs of dissection, the procedure was completed; in case of dissections, the stent was inserted. Postoperatively, ankle-brachial index was controlled.

RESULTS: For all 60 patients enrolled in the study, the puncture was performed under ultrasound guidance. The posterior tibial artery was used for puncture in 35 cases (58%), and the anterior tibial artery in 25 cases (42%). Recanalization was technically successful in 59 interventions (98.3%) and failed when accessed through the pedal arteries in 1 intervention (1.7%). The ankle-brachial index postoperatively was 0.86 ± 0.13 points. Local complications during early postoperative period included 5 (8.3%) patients with non-tense, non-pulsatile hematoma in the puncture area without communication with the punctured artery. Long-term results were followed up to 1 year, with a patency of 85% of the arteries. After 1 year, the limb was preserved in 59 patients (98.3%). Cumulative survival rate at 1 year was 98.3%.

CONCLUSIONS: Our study showed the retrograde transpedal approach to be safe and effective for mechanical recanalization of femoral-popliteal and tibial segment occlusions in patients with complex femoral-popliteal segment lesions.

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Key words: Critical lower limb ischemia, atherosclerosis, occlusion, superficial femoral artery, transpedal approach, endovascular intervention, “no option” patient.

Introduction

The treatment of critical lower extremity ischemia is primarily surgical. Depending on the volume and extent of the lesion, the severity of arterial wall calcinosis, and availability of veins suitable for shunting, the patient can be offered both open and endovascular intervention, as well as a hybrid approach.[1]

In recent years, vascular surgeons increasingly prefer endovascular revascularization, especially when open surgery is not possible. The number of endovascular surgeries for occlusions in the femoral-iliac and tibial segments increased significantly.[2,3]

Usually, either antegrade ipsilateral access through the common femoral artery (CFA) or retrograde contralateral access through the CFA is used for such interventions. These recanalization accesses are not always technically possible, since the proximal portion of the occlusion may be too stiff for recanalization. The absence of a superficial femoral artery (SFA) stump can prevent the correct guidewire direction. Subintimal recanalization can

TABLE 1. PATIENT CHARACTERISTICS.	
Demographics	
Total number of patients	60
Mean age, years ±	65.3 ± 8.2
Patient's gender (male/female)	43 (71.6%)/17 (28.4%)
Major Diseases	
Atherosclerosis	60 (100%)
Pelvic limbs chronic ischemia, grade 3	34 (56.6%)
Pelvic limbs chronic ischemia, grade 4	26 (44.4%)
SFA lesion	45 (75%)
SFA+ PoA lesion	15 (25%)
Mean extent of occlusion, cm ±	17 ± 2
TASC II Classification	
Class C	50 (83.3%)
Class D	10 (16.7%)
Concomitant Diseases	
Essential hypertension	58 (96.6%)
Ischemic heart disease	32 (53%)
Type 2 diabetes mellitus	17 (28.3%)
Cardiac rhythm disorders, including atrial fibrillation	16 (26.6%)

Data are presented as n (%) or mean ± . Abbreviations: SFA, superficial femoral artery; PoA, popliteal artery; TASC, Trans-Atlantic Inter-Society Consensus.

fail the reach of the true lumen. In such situations, transpedal approach might become a "lifeline."[4,5]

The advantages of the transpedal approach are: (1) the distal occlusion might be softer than the proximal one; and (2) the distal occlusion might be more convenient for recanalization (CTOP occlusion types 2-4).[6] The main requirement for the transpedal approach is the available distal flow.

The indications for transpedal approach include: (1) inability of SFA antegrade recanalization; (2) SFA occlusion from the ostium; (3) tortuous iliac arteries make it impossible to pass; (4) severe obesity and risk of local puncture complications; (5) scarring is evident in the proposed puncture site; and (6) subintimal antegrade recanalization, unsuccessful attempts to exit to the true lumen.

Here we present our experience with the transpedal approach for critical limb ischemia (CLI) in patients with critical occlusion of the femoral artery.

Materials and Methods

Patient characteristics and indications of transpedal approach

The Vascular Surgery Department of the F.I. Inozemtsev City Clinical Hospital has accumulated experience of transpedal approaches in 60 surgical interventions in 60 patients during January 2020 to May 2022. **Table 1** presents the detailed characteristics of the patients. The transpedal approach was performed either as second access after unsuccessful antegrade recanalization or primarily when an antegrade access was not possible. The indications for the access are described above in the Introduction and are shown are shown in **Table 2**. Punctures were always performed under ultrasound guidance. A 4/5/6F sheath (Terumo Corporation) was placed. Recanalization was done with a 0.018/0.035 hydrophilic guidewire (Terumo Corporation).

TABLE 2. INDICATIONS FOR TRANSPEDAL APPROACH	
Obesity	2 (3.3%)
Tortuosity of iliac arteries	3 (5%)
SFA occlusion from the ostium	45 (75%)
Unsuccessful antegrade recanalization	5 (8.3%)
Subintimal recanalization, inability to exit into the true lumen	5 (8.3%)

For occlusions of the SFA from the ostium, 2 accesses are usually used: proximal and distal. For the proximal access, the radial, brachial, femoral contralateral, and ipsilateral arteries are used. If the patient has severe obesity or tortuosity of the iliac arteries, the arteries of the upper limbs are punctured. Next, antegrade recanalization of the SFA is attempted. With multiple unsuccessful attempts to recanalize the artery and exit to the true lumen, many surgeons prefer to finish the surgery and label the patient as a "no option" patient. In fact, retrograde puncture of the tibial arteries under ultrasound guidance is the last option. In severe calcification of tibial arteries and when the ultrasound machine is not available, one can puncture under fluoroscopic control, but this technique has many more disadvantages in comparison with ultrasound: less accuracy and irradiation of the surgeon's hands.

The technique of the transpedal approach to critical ischemia in patients with occlusion of the superficial femoral artery from the ostium

Before the surgery, all patients underwent multi-spiral computed tomography (MSCT) of the abdominal aorta and arteries of the lower limbs with intravenous contrast to determine the exact topology, volume, and nature of the lesion for prediction of difficulties and volume of the surgical intervention. Immediately prior to surgery, the surgeon performed an ultrasound duplex scan of the lower limb arteries to assess the distal flow for possible pedal puncture. The posterior tibial artery (PTA) or the anterior tibial artery (ATA) were usually used for transpedal approach. For insertion into the tibial arteries, 4F and 5F, and rarely, 6F, introducers were used. To prevent angiospasm, bolus

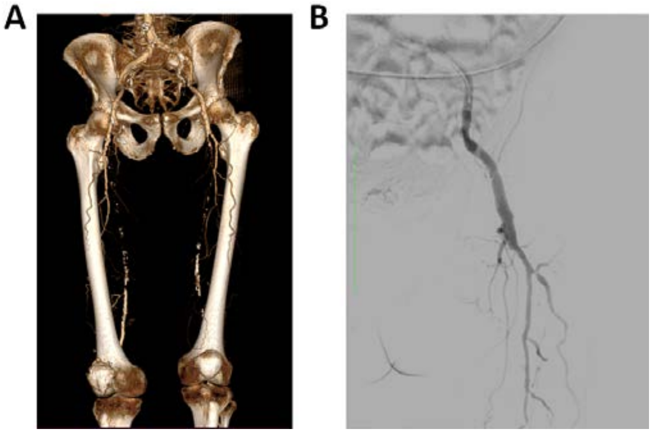

FIGURE 1. An example case of superficial femoral artery (SFA) occlusion from the ostium. **A**. Multi-spiral computed tomography of the lower limb arteries with intravenous contrast: bilateral SFA occlusion and left-sided popliteal artery occlusion; **B**. The angiography of SFA occlusion left from the ostium.

0.1% nitroglycerin solution was injected through the introducer into the tibial artery. Retrograde recanalization was performed with 0.018″/0.035″ hydrophilic guidewires (Terumo Corporation). The guidewire is withdrawn beyond the occlusion into the true lumen of the CFA. Then, transluminal balloon angioplasty with low-profile balloons (Medtronic) was performed. That provided the lumen for the antegrade guidewire insertion and SFA stenting; a 6F introducer allows stenting via distal access. If the follow-up angiography showed no extravasation, residual stenoses, or signs of dissection, the procedure was completed; in case of dissections, the stent was inserted. The instruments were removed, and manual hemostasis was performed within 10 to 15 minutes. The permeability of the puncture area was monitored by ultrasonography. Pressure dressings were applied to the puncture area. Postoperatively, ankle-brachial index was controlled. All the angioplasty/stenting patients received dual antiplatelet therapy: acetylsalicylic acid 100 mg lifelong plus clopidogrel 75 mg for at least 1 month postop, then clopidogrel was replaced by rivaroxaban 2.5 mg twice per day orally lifelong. If the patient had atrial fibrillation as a comorbidy, acetylsalicylic acid 100 mg plus rivaroxaban 20 mg were prescribed once a day continuously.

Results

An example of transpedal approach application

To demonstrate the technique of transpedal approach, we describe a clinical case.

Patient A, a 73-year-old man, was admitted electively to the Department of Vascular Surgery with complaints of pain in the lower limbs with minimal exertion and trophic ulcer in the left foot area. The complaints had been bothering him for a year. History of chronic diseases included hypertension, grade 3, stage III, high risk of complications, grade 3 obesity (body mass index 43, severe abdominal obesity). On examination, the left leg was cold and pale but with preserved motion and sensitivity. A trophic ulcer was noted on the back of the left foot, 3*4 cm in size, under a dry scab, without discharge. Pulsation was distinct in the femoral triangle on both sides, with no distal pulsation.

MSCT of the lower limb arteries with intravenous contrast was performed, which allowed a diagnosis of bilateral SFA occlusion and left-sided popliteal artery occlusion (PoA) **(Figure 1A)**.

The resulting diagnosis was atherosclerosis of the lower limb arteries, bilateral occlusion of the SFA, and grade 4 critical left lower limb ischemia. A decision was made to perform the following elective surgery: Recanalization, balloon dilation angioplasty, and stenting of the SFA and left PoA.

The right brachial artery was punctured retrogradely under local anaesthesia. A 6F introducer was inserted and 5000 U systemic heparinization was performed. Then, a diagnostic catheter was inserted into the left CFA via a guidewire. Angiography found extended total-length SFA occlusion from the ostium, without a stump, and PoA occlusion to the knee joint cleft **(Figure 1B)**.

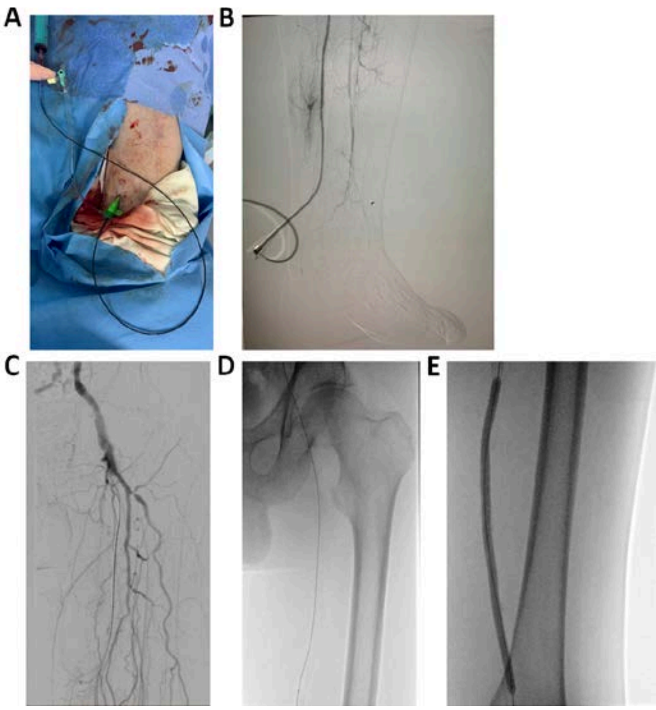

FIGURE 2. An example case of transpedal approach for critical ischemia in patients with occlusion of the superficial femoral artery (SFA) from the ostium. **A, B.** A photograph (**A**) and an angiography (**B**) of the placement of the introducer into posterior tibial artery; **C-E**. Angiographies, showing (**C**) retrograde SFA recanalization, (**D**) the placement of the guidewire into the true lumen of the common femoral artery and (**E**) post dilation of the stents installed in the SFA and popliteal artery.

The tibial arteries (ATA and PTA) contrast showed the signs of diffuse stenosis along the entire length. The transpedal approach and retrograde recanalization through the PTA was performed.

The left PTA was punctured under ultrasound guidance in the medial ankle. A 6F transradial introducer was inserted **(Figure 2A, Figure 2B)**. Retrograde recanalization of the occluded SFA and PoA was performed with a 0.018 hydrophilic guidewire supported by a vertebral catheter **(Figure 2C)**. The catheter and guidewire were placed into the true lumen of the CFA **(Figure 2D)**.

Consecutive angioplasty was performed in the recanalized areas of the PoA and SFA via 4*200 mm and 5*200 mm balloons. The control angiography showed an extended dissection and rigid calcified stenosis in the distal portion of the SFA. We performed SFA and PoA stenting. The 7*150 and 6*150 mm stents were positioned and opened successively. The post dilation of the stents is shown in **Figure 2E**.

The control angiography showed the optimal angiographic result: SFA, PoA, tibioperoneal trunk (TPT), ATA, and PTA were passable throughout **(Figure 3A, Figure 3B)**. The early postoperative period passed without any complications. After the surgery, a distinct pulsation was noted in the popliteal and posterior tibial arteries. The patient was discharged on the second postoperative day. The hospital stay was 3 days.

Overall results

For all 60 patients enrolled in the study, the puncture was performed under ultrasound guidance. The PTA was used for puncture in 35 cases (58%), and the ATA in 25 cases (42%). Recanalization was technically successful in 59 interventions (98.3%) and failed when accessed through the pedal arteries in 1 intervention (1.7%). The puncture site in the tibial artery was passable in all patients. The ankle-brachial index postoperatively was 0.86 ± 0.13 points. No systemic complications were noted. Local complications in the early postoperative period included 5 (8.3%) patients with non-tense, non-pulsatile hematoma in the puncture area without communication with the punctured artery. Long-term results were followed up to 1 year, with a patency of 85% of the arteries. After 1 year, the limb was preserved in 59 patients (98.3%). Cumulative survival rate at 1 year was 98.3%.

Discussion

Critical lower limb ischemia is accompanied by a high risk of amputation. The only option to save the limb is a surgical intervention.[1] The fundamental question is whether to perform open surgery using femoral-iliac or femoral-tibial shunts, use endovascular methods to restore blood flow in the affected limb, or to prefer hybrid technologies? In the recommendations, critical lower limb ischemia can be treated by bypass surgery using an autogenous vein (class I recommendation, level A of evidence) or by endovascular revascularization (class IIa, level B). Critical

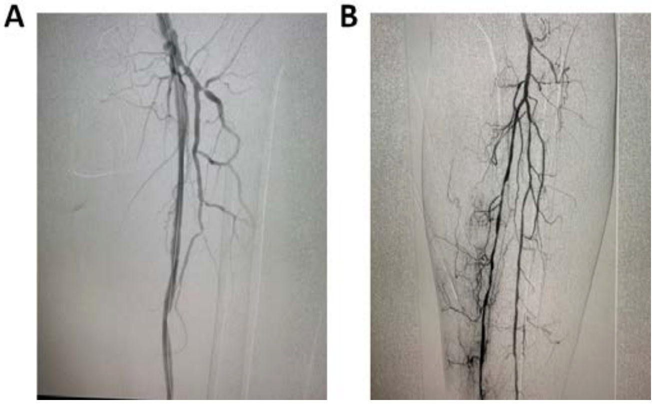

FIGURE 3. Angiographies showing the results of superficial femoral artery (SFA) occlusion addressment via transpedal approach. **A.** Reconstructed superficial femoral artery lumen. **B.** The tibial arteries were contrasted without hemodynamically significant stenoses. SFA, popliteal artery, tibioperoneal trunk, anterior and posterior tibial arteries are passable throughout.

ischemia is clearly postulated to be an absolute indication for lower limb revascularization.[3]

However, the intended vein is not always suitable for bypass (because of the great saphenous vein system varices, condition after thrombophlebitis, or venous angiodysplasia). In addition, the trophic disorders in the lower limb increase the risk of surgical area infection. Therefore, in such patients, an endovascular intervention comes to the fore.[2,6]

The Bypass vs Angioplasty in Severe Ischaemia of the Leg (BASIL) trial showed equivalent results of surgical bypass and endovascular interventions for recanalization of the arterial lesion below the inguinal fold. In a meta-analysis by Romiti et al, the 2-year limb salvage rates after bypass and angioplasty were 85% and 82%, respectively. Soderstrom et al showed similar results when comparing angioplasty and bypass for popliteal artery lesions. Both groups achieved similar results: The 5-year limb survival (75.3% vs 76%), survival rate (47.5% vs 43.3%), and amputation-free survival (37.7% vs 37.3%)[7].

Antegrade recanalization is not technically workable in all cases, especially if it was preceded by open surgical intervention on the affected arteries with arterial desobliteration. In most patients, the proximal occlusion is more rigid and more difficult to recanalize. With antegrade recanalization, it may be more difficult to pass to the true lumen of the artery. Based on the C-TOP classification, types 2 to 4 occlusions are easier to retrograde recanalization. In such cases, retrograde puncture via transpedal approach can save the patient.[8-11]

PTA or ATA are the most frequent arteries used for puncture. The small tibial artery is used less frequently because of its poor accessibility. However, the possibility of puncturing the small tibial artery through the interosseous ligament is discussed. Adequate access requires a control, ultrasound, or fluoroscopy.

Several authors use angiography for retrograde puncture of tibial arteries: contrast agent is injected through the proximal arteries and "RoadMap" mode is set. Alas, this method has 2 important drawbacks: 1) RoadMap mode requires a stationary position of the patient's limb, which cannot always be achieved; and 2) the X-ray exposure of the patient and medical staff is significantly increased. We use ultrasound control for transpedal approaches. It is relatively easy to perform, allows real-time control of the puncture, and poses no threat to the patient and physician.[10]

After the puncture, 4F, 5F, and 6F introducers were placed. Several authors recommend inserting introducers of only 4F into the tibial arteries.[10] Even the insertion of larger introducers did not result in any complications, but this observation requires further study and additional procedures.

After puncture, mechanical recanalization was performed of the affected segment, followed by angioplasty and/or stenting. The instruments were removed after the operation; an aseptic pressure dressing applied to the puncture area for only 2 hours.

Conclusions

Our study showed the retrograde transpedal approach to be safe and effective for mechanical recanalization of femoral-popliteal and tibial segment occlusions in patients with complex femoral-popliteal segment lesions. We emphasize this technique as the last option in this group of patients only, when antegrade recanalization of the rigid occlusion fails. But the technique increases the efficiency of the surgery and preserves the affected limb, therefore, improving the patient's quality of life and lifespan.

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