Transbrachial and Femoral Artery Approach Endovascular Therapy for Flush Infrarenal Aortic Occlusion

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WHAT THIS PAPER ADDS
Flush infrarenal aortic occlusion (FIAO) is an uncommon finding in patients presenting with arterial insufficiency of the lower limbs. Surgical repair has been considered the standard therapy for FIAO based on its long-term durability and universal applicability though it is associated with substantial morbidity rates. We have investigated transbrachial and femoral artery approach endovascular therapy with catheter-directed thrombolysis and adjunctive therapy for flush infrarenal aortic occlusion, which offers a safe and effective alternative to surgical reconstruction in selected patients.

Objective: The purpose of this study is to report the efficacy of transbrachial and femoral artery approach endovascular therapy with catheter-directed thrombolysis (CDT) and adjunctive therapy for flush infrarenal aortic occlusion (FIAO).

Materials and methods: From March 2012 to December 2013, 11 consecutive patients (9 males; mean age 68 years; range 54—80 years) were submitted to endovascular therapy for FIAO. All patients were treated with CDT initially and then adjunctive endovascular treatments were performed to correct the underlying lesions.

Results: Complete reconstruction of occluded aortoiliac arteries was successfully achieved in 81.8% (9/11) of patients. Left brachial and bilateral femoral arterial accesses were obtained in nine patients, and brachial and unilateral femoral in two patients. The residual lesions after CDT were corrected in nine patients and concomitant endovascular recanalization of superficial femoral artery was performed in two patients. Self-expandable stents were implanted in the all aortoiliac lesions with pre- and post-dilation. No renal or distal runoff embolization was seen during intraoperative angiography. Seven (7/9) patients with rest pain or tissue loss showed significant improvements in symptoms and two (2/9) patients with intermittent claudication gained an improved walking distance. The ABI rose significantly between pre- and post-procedure (0.84 ± 0.18 vs. 0.44 ± 0.13 on the right leg, p < .01; 0.89 ± 0.23 vs. 0.48 ± 0.16 on the left, p < .01).

Conclusions: Transbrachial and femoral artery approach endovascular therapy for FIAO offers an alternative to surgical reconstruction with immediate outcomes.

INTRODUCTION
Flush infrarenal aortic occlusion (FIAO) is an uncommon finding in patients presenting with arterial insufficiency of the lower limbs and it is seen in 3—5% of patients presenting with aortoiliac occlusive lesions. 1—3

Surgical bypass or endarterectomy have been considered the standard therapy for FIAO based on its long-term durability and universal applicability. 4—6 However, surgical revascularization is associated with substantial systemic or major morbidity (e.g. renal embolization), particularly in elderly high-risk patients. 7—9

Endovascular therapy has been developed as a minimally invasive alternative for infrarenal aortoiliac occlusive disease with favorable long-term results. 8,10 FIAO recanalization by endovascular techniques such as chimney grafts preserving renal flow, 11 Y-guide wire configuration, 12 and directing stenting has been reported previously. 13 However, there are severe complications of releasing embolic particles that may occlude the renal arteries during directed stenting. 11

FIAO is often caused by an initial stenosis near the aortic bifurcation, which may lead to retrograde thrombosis of the abdominal aorta. 9,11,14 Many patients may have recent deterioration of lower extremity ischemia and older organized thrombus is likely coexistent with relatively new fresh thrombus. 15 Catheter-directed thrombolysis (CDT) is useful
to dissolve clot, unmask underlying stenoses, and simplify subsequent treatment decisions.\textsuperscript{10} In previous reports, CDT has also been effective in removing partial chronic thrombus with favorable results.\textsuperscript{17,18}

The purpose of this study was to report the outcomes of an endovascular approach to FIAO with CDT and adjunctive treatments in 11 patients during last 21 months.

METHODS

From March 2012 to December 2013, 11 consecutive patients (9 males; mean 68 years; range 54–80 years) were submitted to endovascular therapy for FIAO. Takayasu disease, fibromuscular dysplasia, aortic coarctation, hypoplastic aorta syndrome, and acute FIAO (less than 14 days) were excluded from the study. None of the patients had a history of previous surgical or endovascular intervention in the aortic, iliac, or femoral arteries. Cessation of tobacco use, walking exercises, and conservative medication regimens including aspirin, cilostazol, and statin were tried but no significant clinical improvement was noted with any of them.

Pre-procedural assessment was performed in all patients with computed tomography angiography or magnetic resonance angiography to evaluate lesion site, length, and distal runoff vessels. Written informed consent was obtained from each patient after detailed explanation of the risks and benefits of the procedure and the study was approved by the local ethics committee.

Under local anesthesia, a retrograde puncture of the common femoral artery was performed initially and heparin (125 IU/kg) was administered through the sheaths to prevent development of pericatheter thrombus. The occluded aorta could not be crossed retrogradely in all patients and then access was gained via the left brachial artery. A 6F, 90 cm-long sheath (Cook, Bloomington, IN, USA) and a pigtail catheter (Cook) was advanced into the suprarenal aorta to perform the initial arteriogram. Once the guide wire (Terumo, Tokyo, Japan) and 4F, 135 cm-long catheter (Cordis, Bridgewater, NJ, USA) crossed the proximal cap, the 90 cm-long sheath was placed inside the renal artery level to obtain a more stable position and the occluded segment artery was recanalized intraluminally. After antegrade recanalization of the occlusion, the brachial guide wire was removed from the short sheath present in femoral artery, using the “crossing sheath technique”. Then a selected multi-side-hole thrombolytic catheter (AngioDynamics, Latham, NY, USA) determined by the length of the occlusion was navigated over the guide wire from the femoral artery into the occluded segment. The contralateral iliac artery was also recanalized intraluminally and another thrombolytic catheter was navigated over the guide wire from the brachial artery into the occluded segment.

Urokinase, 250,000 IU diluted in 50 mL of 0.9% NaCl, was infused at 600 IU/kg per hour through the thrombolytic catheter by microinfusion. The thrombolysis was accelerated by pulse-spray infusion five times per day (250,000 IU of urokinase diluted in 250 mL of 0.9% NaCl, and 50 mL was used each time). Concurrently, 12,500 IU of unfractionated heparin, diluted in 50 mL of 0.9% NaCl, was infused at 10 IU/kg per hour through the side arm of the sheath to prevent pericatheter thrombosis.

Laboratory monitoring including activated partial thromboplastin time (APTT), plasma fibrinogen (Fbg) and D-dimer levels was performed every 4 hours. Hemoglobin, hematocrit, platelet count, and hepatic and renal function were checked daily. The thrombolytic procedure was stopped when the Fbg level dropped to <1.0 g/L. The effect of heparin was monitored using APTT to keep it 1.5 to 2 times the control value.

Adjunctive endovascular treatments, including percutaneous transluminal angioplasty (PTA) and stenting, were performed to correct underlying lesions. Balloons (6–8 mm in diameter/60–150 mm in length; Admiral Xtreme, Invatec, Roncadelle, Italy) from the brachial and femoral arteries (or bilateral femoral arteries) simultaneously were used in kissing fashion. An extended proximal self-expandable bare stent or single bare stent for aorta (14 mm in diameter/40–60 mm in length; Smart, Cordis) was firstly deployed if the underlying lesions were close to the renal arteries. Then self-expandable stents (8 mm in diameter/60–150 mm in length; Smart, Cordis) were deployed in the distal aorta and the common iliac arteries in a kissing fashion in most patients (Fig. 1). Endovascular treatments were also performed to correct lesions of the superficial femoral artery. Completion angiography was performed to demonstrate of the final result and to screen for renal and distal runoff embolization.

Technical success was defined as restored vessel patency with a residual stenosis <30% and no evidence of embolization to the renal arteries or distal runoff. Immediate hemodynamic success was determined by an increase in ABI of >0.10 postoperatively. Clinical success was defined as a subjective perception of improved walking distance, absence of rest pain, and healing of trophic changes.

Complications included major bleeding (intracranial bleeding, bleeding that resulted in death, or bleeding that required transfusion, surgery, or cessation of thrombolytic therapy), minor bleeding (defined as less severe bleeding managed by local compression, increasing vascular sheath size, or decreasing dose of thrombolysis, anticoagulation, or antiplatelet drug), renal and distal runoff embolization, and acute renal failure.

Patients were discharged on an oral regimen of aspirin (100 mg/day), clopidogrel (75 mg/day) and statin (20 mg/day). Clinical examination and duplex ultrasonography was performed before discharge, at 1, 3, and 6 months after discharge, and every 6 months thereafter. Hemodynamic evaluation was done by measuring the ankle-brachial index (ABI) and duplex ultrasonography in all patients. Restenosis was defined as a drop in the ABI by 0.15, loss of palpable pulses, a peak systolic velocity ratio ≥2.5 by ultrasonography scan or development of ischemic symptoms. Computed tomography angiography was performed only in cases of recurrent stenosis >50% as measured on ultrasound scan. Secondary reintervention may be necessary to maintain the patency rate in the patients with severe claudication and critical limb ischemia.
Statistical analysis was performed with SPSS software (SPSS Inc., Chicago, IL, USA). The difference in ABI and Rutherford category between pre- and postoperation was analyzed with the Wilcoxon test and $p < .05$ was considered statistically significant.

**RESULTS**

All 11 consecutive patients underwent endovascular reconstruction and the clinical characteristics of the patients are shown in Table 1.

Of the 11 patients, nine had a history of claudication. Eight of the nine patients had worsening symptoms and one patient had claudication without aggravating history. The remaining two of the 11 patients were characterized by rest pain or ischemic ulcers. Concomitant unilateral superficial femoral artery occlusions were shown in three patients, with bilateral stenosis in one. According to Rutherford category, the clinical indication for endovascular therapy was severe claudication (class III, $n = 4$), rest pain (class IV, $n = 5$), and ischemic ulcers (class V, $n = 2$).

Complete reconstruction of occluded aortoiliac arteries with reestablishment of unimpeded blood flow to both legs was successfully achieved in 81.8% (9/11) patients.

Left brachial and bilateral femoral arterial accesses were obtained in nine patients, and one brachial and one
Table 1. Characteristics of patients and lesions.

<table>
<thead>
<tr>
<th>No.</th>
<th>Age (y)</th>
<th>Sex</th>
<th>Clinical symptoms</th>
<th>SFA (TASC classification)</th>
<th>Arterial access</th>
<th>Thrombolytic effect</th>
<th>Stenting for aortoiliac lesions</th>
<th>Therapy for distal runoff</th>
<th>RC</th>
<th>Pre-</th>
<th>Post-</th>
<th>Follow up</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>80</td>
<td>M</td>
<td>IC 1 y + RP 2 mo</td>
<td>Patency (−)</td>
<td>B−b-F</td>
<td>Proximal dissolution</td>
<td>Proximal + kissing</td>
<td>No</td>
<td>IV</td>
<td>I</td>
<td>6 mo</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>60</td>
<td>M</td>
<td>IC 2 y + aggravating 4 mo</td>
<td>Patency (−)</td>
<td>B−F</td>
<td>RH</td>
<td>−</td>
<td>−</td>
<td>III</td>
<td>II</td>
<td>−</td>
<td>−</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>61</td>
<td>M</td>
<td>IC 6 mo + aggravating 3 mo</td>
<td>Patency (−)</td>
<td>B−b-F</td>
<td>Proximal dissolution</td>
<td>Kissing</td>
<td>No</td>
<td>III</td>
<td>I</td>
<td>9 mo</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>78</td>
<td>M</td>
<td>IC 1 y + RP 1 mo</td>
<td>Stenosis/bilateral (A)</td>
<td>B−b-F</td>
<td>Proximal dissolution</td>
<td>Kissing</td>
<td>No</td>
<td>IV</td>
<td>II</td>
<td>21 mo</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>54</td>
<td>M</td>
<td>IC 2 y</td>
<td>Patency (−)</td>
<td>B−b-F</td>
<td>Ineffective</td>
<td>−</td>
<td>−</td>
<td>III</td>
<td>I</td>
<td>−</td>
<td>Converted to bypass</td>
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<tr>
<td>6</td>
<td>67</td>
<td>M</td>
<td>RP 1 mo</td>
<td>Occlusion/ left (C)</td>
<td>B−b-F</td>
<td>Proximal dissolution</td>
<td>Kissing</td>
<td>Stenting</td>
<td>IV</td>
<td>I</td>
<td>12 mo</td>
<td>Stenosis of SFA</td>
<td></td>
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<td>7</td>
<td>71</td>
<td>M</td>
<td>IC 6 mo + IU 1 mo</td>
<td>Occlusion/ right (B)</td>
<td>B−b-F</td>
<td>Total aortic dissolution</td>
<td>Right iliac</td>
<td>No</td>
<td>V</td>
<td>II</td>
<td>18 mo</td>
<td>No</td>
<td></td>
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<tr>
<td>8</td>
<td>69</td>
<td>M</td>
<td>IC 4 mo + RP 1 mo</td>
<td>Patency (−)</td>
<td>B−b-F</td>
<td>Proximal dissolution</td>
<td>Kissing</td>
<td>No</td>
<td>IV</td>
<td>II</td>
<td>9 mo</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>74</td>
<td>F</td>
<td>IU 2 mo</td>
<td>Occlusion/ left (C)</td>
<td>B−b-F</td>
<td>Proximal dissolution</td>
<td>Kissing</td>
<td>Stenting</td>
<td>V</td>
<td>II</td>
<td>8 mo</td>
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<td>10</td>
<td>58</td>
<td>M</td>
<td>IC 2 y + RP 1 mo</td>
<td>Patency (−)</td>
<td>B−b-F</td>
<td>Proximal dissolution</td>
<td>Kissing</td>
<td>No</td>
<td>IV</td>
<td>I</td>
<td>16 mo</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>79</td>
<td>F</td>
<td>IC 18 mo + aggravating 3 mo</td>
<td>Patency (−)</td>
<td>B−F</td>
<td>Proximal dissolution</td>
<td>Proximal</td>
<td>No</td>
<td>III</td>
<td>I</td>
<td>3 mo</td>
<td>Cerebral infarction</td>
<td></td>
</tr>
</tbody>
</table>

IC = intermittent claudication; y = years; RP = rest pain; mo = months; IU = ischemic ulcers; SFA = superficial femoral artery; B−F = brachial and femoral access; B−b-F = brachial and bifemoral access; RH = retroperitoneal hemorrhage; RC = Rutherford category.
unilateral femoral in the remaining two patients. The mean thrombolysis time was 12.5 hours (range 3–28 hours) with mean urokinase dosage at 650,000 IU (range 200,000–1,250,000 IU). Thrombolysis was effective for nine patients, in whom the proximal or total aortic thrombosis dissolved, transforming the flush renal occlusion to more distal infrarenal occlusion. Proximal thrombus dissolution after CDT was not achieved in one patient (patient 5), who had shown intermittent claudication for 2 years without aggravating history. The patient was converted to aorto-bifemoral bypass.

Residual lesions were corrected in nine patients with PTA and stents. The aortoiliac lesions were stented with self-expandable stents using the “kissing” technique in six patients. Beside distal kissing stents, a proximal bare stent was also deployed close to renal arteries in one patient (patient 1). Deployment of only one bare stent was achieved in the aorta for one patient (patient 11), and a single stent for the right iliac artery in one patient (patient 7). Superficial femoral arteries were also involved in four patients and concomitant endovascular recanalization was performed in two patients (patients 6 and 9). Concomitant renal stenting was performed in one patient (patient 1) because of stenosis of the renal artery. Self-expandable stents (1–3; mean 1.9) with pre- and post-dilation were implanted in all aortoiliac lesions.

No renal or distal runoff embolization was found during intraoperative angiography. Retroperitoneal hemorrhage occurred in one patient 3 hours after thrombolysis, with a fall in blood pressure and reduced hemoglobin. The patient recovered gradually by stopping CDT and rehydration, but refused further endovascular surgery. One patient suffered from hematoma at the brachial puncture site, but had no need of further treatment.

After a mean 11.3 months follow-up (range 3–21 months), there were no deaths and no amputations. Minor cerebral infarction occurred in one patient (patient 11) 1 month postoperatively, but the patient recovered without residual symptoms. Two (2/9) patients with severe intermittent claudication had improved walking distance and five (5/9) patients with ischemic pain showed significant improvement in symptoms 1 month after the operation. Ischemic ulcers in two (2/9) patients healed at 2 and 3 months postoperatively, and no reoccurrence of ischemic ulcers was observed. As expected, the ABI had risen significantly between pre- and post-procedure (0.84 ± 0.18 vs. 0.44 ± 0.13 on the right leg, p < .01; 0.89 ± 0.23 vs. 0.48 ± 0.16 on the left, p < .01).

In-stent restenosis of the aortoiliac artery did not occur on the basis of ultrasonography. One patient (patient 6) had restenosis of the SFA based on ultrasonography; the patient did not have lifestyle-limiting symptoms and refused reintervention.

**DISCUSSION**

FIAO is a serious condition, and thus far surgical reconstruction is considered the standard therapy. However, aorto-bifemoral bypass is associated with significant perioperative morbidity. Directed endovascular therapy for FIAO without CDT has only been reported in few cases and outcomes after endovascular treatment are less well-defined. In this study, FIAO was recanalized using transbrachial and femoral artery approach endovascular therapy, proving it to be technically feasible.

Fresh thrombus on an existing atherosclerotic stenosis is often the reason for aggravating symptoms, and eight patients showed this. The treatment of relatively fresh thrombus is important for FIAO. Ballooning or direct stenting may extrude or cut aortic thrombus and carry a risk of releasing embolic particles that may occlude renal or distal arteries. CDT therapy has been accepted as a minimally invasive method of accelerated thrombolysis by increasing the surface area available for enzymatic action. In this study, although there were always significant residual lesions that required adjunctive endovascular treatments, CDT dissolved proximal or total aortic thrombus in nine patients and transformed flush renal to focal infrarenal occlusion, which may decrease the risk of renal embolization and make treatment of the occlusion near the renal arteries safer.

In this study, besides one patient who suffered from retroperitoneal hemorrhage, CDT was not effective for proximal thrombus dissolution in only one patient, who presented chronic intermittent claudication for 2 years without aggravating history. The patient was converted to aorto-bifemoral bypass and the initial endovascular strategy did not preclude open surgical management. CDT was effective in dissolving proximal thrombus in the other nine patients with critical ischemia of less than 2 months or with an aggravating ischemia period of up to 4 months. Theoretically, organized chronic arterial thrombus (>14 days) may be relatively refractory to thrombolysis. However, there were several reports in which (partial) dissolution of chronic thrombus was achieved with CDT for peripheral arteries. In this study, the CDT was effective in dissolving thrombus in patient 2, who had the longest aggravating history of 4 months (IC 2 y and aggravating 4 m). Based on this experience and other reports, CDT may be effective in dissolving short-term thrombus (less than 6 months) and so it is important to select appropriate patients according to limb ischemic history.

Ensuring the guide wires cross the occluded lesions intraluminally is critical to successful CDT and adjunctive endovascular therapy. In this study, retrograde recanalization of aortic lesions from the femoral artery was tried in all patients, but when it failed, access was gained via the left brachial artery. Moise used the left brachial artery as a standard access point in all patients because of the ease of ensuring the guide wires cross the occluded lesions to both iliac arteries intraluminally. Subintimal angioplasty carried an additional risk of perforation during extensive attempts...
to cross the obstructed part of the aorta. The risk was minimized by crossing the occluded lesions from the brachial artery when subintimal dissection was suspected from the femoral artery.

Based on the relatively longer occlusion and the finding of non-heavily calcified lesions confirmed by predilation in this series, self-expanding stents were used in all aortoiliac lesions for their superior flexibility and ability to adapt to vessel tortuosity. In other studies, self-expanding stents were also used because they can trap atherothrombotic material more effectively owing to their smaller struts and, theoretically, reduce the likelihood of distal embolization. Stent grafts had also been deployed to decrease the need for repeat interventions and to avoid arterial rupture from balloon inflation. However, a potential disadvantage of stent grafts is the need for relatively large delivery sheaths and coverage of patent lumbar and collateral arteries.

One of the most dreaded complications of endovascular therapy for FIAO is renal embolization. Directly stenting the flush thrombosed infra renal aortic segment carries a risk of releasing embolic particles that may lead to embolization of the renal arteries. In this series, direct stenting for FIAO was avoided and the flush infrarenal occlusion was transformed to a more distal infrarenal lesion with CDT.

There are limitations to the study. It was a retrospective, nonrandomized analysis with a small group of patients with short follow-up. Thus, a further study is required to evaluate the long-term results of transbrachial and femoral artery approach endovascular therapy for more FIAO patients.

CONCLUSION
Transbrachial and femoral artery approach endovascular therapy for FIAO offers an alternative to surgical reconstruction with immediate outcomes. Extended follow-up with longer-term results and larger numbers of patients is required before this technique can be widely advocated.

CONFLICT OF INTEREST
None.

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