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Original Article

Vascular

Vascular
2021, Vol. 0(0) 1–9
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DOI: 10.1177/17085381211023229
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Transbrachial and transfemoral approaches combined with visceral protection for the treatment of juxtarenal aortoiliac occlusive disease: Technical issues and clinical outcomes

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Abstract

Purpose: To evaluate the safety and efficacy of transbrachial and transfemoral approaches combined with visceral protection for the endovascular treatment of juxtarenal aortoiliac occlusive disease (AIOD) over an average 19-month follow-up period.

Methods: In this retrospective analysis, all patients with juxtarenal AIOD at a single institution were reviewed from June 2015 to January 2020. Patient characteristics, angiographic results, and follow-up outcomes were retrospectively recorded. The indications for treatment were critical limb threatening ischemia in 12 patients and bilateral claudication in five patients. Percutaneous access via the left brachial artery was first obtained to recanalize the infrarenal occluded lesions. After that, femoral accesses were achieved. A 4-Fr catheter, a 4 mm balloon, or a 6-Fr 90-cm-long sheath was used to complete visceral artery protection.

Results: A total of 17 juxtarenal AIOD patients (14 males; mean age, 63.4 ± 8.1 years) underwent endovascular treatment. The technical success rate was 100%. Complete reconstruction was achieved in 15 (88.2%) patients. The infrarenal aorta was reconstructed with kissing covered stent grafts (n = 7), kissing bare-metal stents (n = 2), covered stent grafts (n = 2), bare-metal stents (n = 1), or the off-label use of iliac limb stent grafts (n = 5). Renal embolization was found in 3 (17.6%) patients during intraoperative angiography. There was 1 (5.9%) case of distal runoff embolization after CDT and 1 (5.9%) case of left iliac artery rupture. One (5.9%) death occurred due to acute myocardial infarction 20 days after the operation. The average follow-up period was 19.3 ± 16.7 months (range, 1–54 months) in the remaining 16 cases. The renal artery patency rate was 100%. The estimated cumulative primary patency rates were 92.3% at 12 months and 59.3% at 36 months according to the Kaplan–Meier method.

Conclusions: Transbrachial and transfemoral approaches combined with visceral protection offer a safe and effective alternative to open revascularization for the endovascular treatment of juxtarenal AIOD.

Keywords

Juxtarenal aortoiliac occlusive disease, endovascular treatment, transbrachial, transfemoral, visceral protection

Introduction

Aortoiliac occlusive disease (AIOD) is defined as a chronic atherosclerotic occlusive disease and usually presents with intermittent claudication, resting pain, tissue loss, and erectile dysfunction in men.[1–3] Juxtarenal AIOD, which accounts for only approximately 3–8.5% of AIOD cases, is considered the most complex type of TransAtlantic Inter-Society Consensus (TASC) type D lesion.[3] Aortobifemoral bypass is recommended as the first-line treatment for extensive aortoiliac occlusive lesions due to its long-term

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patency rate.[4,5] Open surgical revascularization, however, is technically challenging because of the proximal involvement of renal and visceral arteries, and it is associated with a high periprocedural mortality rate, delayed postoperative recovery, and a long hospital stay, especially in the developing countries.[2,5,6] Suprarenal aortic cross-clamping above the visceral arteries is frequently associated with ischemic injury or thrombosis of the kidney or other visceral organs, mainly owing to ischemia/reperfusion injury and visceral atheroembolization from dislodged aortic thrombus.[7] Moreover, patients with serious preoperative comorbidities are usually considered high risk for open surgery.[1]

Endovascular repair is preferred for the treatment of short lesions.[8] With the development of endovascular skills and new devices in recent years, endovascular therapy has emerged as an alternative management option for the treatment of extensive and complex AIOD cases because of its good perioperative and long-term clinical outcomes.[2,9–16] However, limited studies have focused on the clinical outcomes of endovascular treatment for juxtarenal AIOD.[6,13,17,18]

This study aimed to evaluate the midterm safety and efficacy of transbrachial and transfemoral approaches combined with visceral protection for the endovascular treatment of juxtarenal aortoiliac occlusions over an average 19-month follow-up period.

Methods

This retrospective observational study was approved by the institutional review board, and informed consent was obtained from all the participants included in the study. 17 consecutive patients with juxtarenal AIOD underwent endovascular treatment and were reviewed retrospectively at the study hospital, Shandong Provincial Hospital Affiliated with Shandong First Medical University, between June 2015 and January 2020. Juxtarenal AIOD was diagnosed as total occlusion of the abdominal artery adjacent to the origin of the visceral arteries by Doppler ultrasound (DUS) and computed tomography contrast angiography (CTA). Patients with Takayasu disease, fibromuscular dysplasia, aortic coarctation, or acute abdominal artery embolism were excluded from this study.

Patient characteristics, including clinical features, risk factors, angiographic results, and follow-up outcomes, were retrospectively recorded. The indications for treatment were critical bilateral lower limb ischemia in 12 patients and bilateral claudication in five patients. Renovascular hypertension for renal stenosis was also present in six patients.

Operative technique

All procedures were performed under local anesthesia ($n = 9$), general anesthesia ($n = 6$), or nerve block anesthesia ($n = 2$). In all cases, access was first gained percutaneously from the left brachial approach, and a 6-Fr, 90-cm-long sheath (Flexor RB-RAABE, Cook Medical Inc., Bloomington, IN, USA) was introduced in the suprarenal aorta. A bolus of heparin was administered intravenously to achieve an activated coagulation time >250 s. An initial angiogram was performed by a 5-Fr pigtail catheter to evaluate the lesion extension, the involvement of the renal arteries, and the iliac and infrainguinal arteries. The occluded lesion was recanalized using a 0.035″ hydrophilic guidewire (Terumo Corp., Tokyo, Japan) and a 5-Fr 125-cm-long multipurpose catheter (Cordis Corporation, Miami, Florida) via brachial access to avoid unintentional subintimal dissection of the aorta at the level of the visceral arteries. After successful antegrade recanalization of the occluded segment, each femoral artery was punctured under fluoroscopy. The Terumo wires were captured and pulled out by using the antegrade–retrograde intervention technique and were exchanged for 0.035″ stiff guidewires (Terumo stiff flex L, or Hi-Torque SupraCore guidewire). A Perclose ProGlide vascular device (Abbott Vascular, Redwood City, CA, USA) was deployed prior to cannulation. In patients planning Fogarty catheter embolectomy or femoral artery endarterectomy, femoral cutdown was performed, and the introducer was inserted in the common femoral artery after completing the patch suture.

A multimodal approach was applied to visceral protection. Briefly, one or two V18 wires (0.018″ Boston Scientific, MA, USA) or 0.014″ PT2 wires (0.014″ Boston Scientific, MA, USA) were placed in the visceral arteries which might be involved in the endovascular interventions as a rescue from the right and/or left brachial approach. A 4-Fr catheter, a 4 mm balloon, or a 6-Fr 90-cm-long sheath was left in the visceral artery during the adjacent endovascular management, including percutaneous transluminal angiography (PTA) and stenting. With the use of the femoral approach, balloons (6–8 mm in diameter/100–150 mm in length) were simultaneously used in a kissing fashion. The juxtarenal aorta and iliac arteries were revascularized by using bare-metal stents, covered stents, or iliac limb stent grafts. The stents or stent grafts were chosen by operators based on the lesion characteristics (length, morphology, grade of stenosis, and calcification), as shown in Table 1. In cases of occlusion of the renal artery ostium or renal artery stenosis, renal artery stenting was performed using a chimney technique. Completion angiography was performed to verify the patency of the aorta and the visceral arteries.

Patients without atrial fibrillation were discharged with oral antiplatelet therapy (100 mg/day aspirin indefinitely and 75 mg/day clopidogrel for at least 3 months) and statins (20 mg/day). Patients with atrial fibrillation or aortic valve replacement received conventional warfarin treatment (INR 2.0–3.0). Clinical examination and DUS were performed

Table 1. Characteristics of patients with juxtarenal aortic occlusive disease.

Characteristics	*N* (%) or mean ± SD (*n* = 17)
Age, years	63.4 ± 8.1
Males	14 (82.4)
Comorbidities	
Current smoking	13 (76.5)
Hypertension	11 (64.7)
Cerebrovascular disease	6 (35.3)
Atrial fibrillation	3 (17.6)
Diabetes mellitus	3 (17.6)
Coronary artery disease	4 (23.5)
COPD	1 (5.9)
Level of distal aortic occlusion	
Infrarenal abdominal aorta	1 (5.9)
Common iliac artery right/left	5 (29.4)/4 (23.5)
External iliac artery right/left	9 (52.9)/11 (64.7)
Common femoral artery right/left	2 (11.8)/1 (5.9)
Runoff vessel	
SFA + PFA right/left	14 (82.4)/12 (70.6)
PFA right/left	3 (17.6)/5 (29.4)
Rutherford category	
Preoperative	
3	4 (23.5)
4	12 (70.6)
6	1 (5.9)
Postoperative	
0	10 (58.8)
1	5 (29.4)
2	2 (11.8)
ABI	
Preoperative	
Right	0.27 ± 0.23
Left	0.20 ± 0.21
Postoperative	
Right	0.84 ± 0.17
Left	0.76 ± 0.26

SD: standard devations; COPD: chronic occlusive pulmonary disease; SFA: superficial femoral artery; PFA: profunda femoris artery; ABI: ankle–brachial index.

1, 3, and 6 months after discharge and yearly thereafter. Computed tomography contrast angiography was used when clinical suspicion or symptom recurrence was indicated.

Statistical analysis

Technical success was defined as the successful restoration of blood flow, with residual stenosis <30% and no evidence of embolization to the distal runoff. Clinical success was defined as symptomatic improvement, including improved walking distance, absence of resting pain, and healing of ischemic ulcers. Restenosis referred to a peak systolic ratio >2.5 measured by DUS or an angiographic diameter reduction >50%.

All statistical analyses were performed using SPSS 25.0 statistical software (SPSS Inc., Chicago, IL, USA). Categorical variables are described using frequencies and percentages, and continuous data are presented as the mean ± standard deviation (SD). Comparisons of ankle–brachial index (ABI) values and Rutherford classification before and after treatment were conducted with the nonparametric test. A p value <0.05 indicated statistical significance.

Results

All 17 patients had juxtarenal complete aortoiliac occlusion lesions. The average age was 63.4 ± 8.1 years (range, 48–82 years). Six (35.3%) patients had coexisting severe renal artery stenosis, of whom two had bilateral stenosis and four had unilateral stenosis. One (5.9%) patient had left renal artery occlusion and left kidney atrophy. Another patient had superior mesenteric artery occlusion without any symptoms of mesenteric ischemia. Open surgery was not strongly recommended for these patients due to their medical comorbidities, as shown in Table 1. The indication upon clinical presentation was claudication in 5 (29.4%) patients, resting pain in 11 (64.7%) patients, and tissue loss in one (5.9%) patient. Concomitant unilateral common femoral artery (CFA) occlusions were observed in 3 (17.6%) patients, unilateral superficial femoral artery (SFA) occlusions in 3 (17.6%) patients, and bilateral SFA occlusions in 2 (11.8%) patients.

Technical success was achieved in all patients. Complete reconstruction of the occluded aortoiliac arteries with re-establishment of uninterrupted blood flow to both limbs was successfully achieved in 15 (88.2%) patients, and re-establishment of uninterrupted blood flow to the symptomatic leg but not both legs was successfully achieved in the remaining 2 (11.8%) patients due to the failure of distal runoff re-entry. The operative data are summarized in Table 2.

Bilateral brachial and bilateral femoral arterial accesses were obtained in 5 (29.4%) patients, and left brachial and bilateral femoral arterial accesses were obtained in 4 (23.5%) patients. Left brachial arterial access and unilateral or bilateral femoral cutdown were performed in the remaining 8 (47.1%) patients; in addition, Fogarty catheter embolectomy was performed in 5 (29.4%) patients, and femoral artery endarterectomy with bovine pericardium patch plasty (Balmedic Company, Beijing, China) was performed in 3 (17.6%) patients. Catheter-directed thrombolysis (CDT) was performed in 2 (11.8%) patients, but successful proximal thrombus dissolution was not achieved (see Figure 1 for preoperative computed tomography angiography).

Table 2. Summary of data for endovascular treatment.

Characteristics	*N* (%) or mean ± SD (*n* = 17)
Route	
b-B-b-F	5 (29.4)
B-b-F	4 (23.5)
B-b-FC	5 (29.4)
B-FC	3 (17.6)
CDT first	2 (11.8)
Construction of infrarenal aorta	
Kissing covered stent grafts	7 (41.2)
Kissing bare-metal stents	2 (11.8)
Covered stents	2 (11.8)
Off-label use of iliac limb endograft	5 (29.4)
Bare-metal stent	1 (5.9)
Associated procedures	
Iliac artery stenting	14 (82.4)
Embolectomy with Fogarty catheter	5 (29.4)
Endarterectomy with bovine pericardium patch plasty of CFA	3 (17.6)
Renal artery stenting	9 (52.9)
Bilateral	3 (17.6)
Unilateral	6 (35.3)
Inferior mesenteric artery stenting	1 (5.9)

b-B-b-F: bibrachial and bifemoral access; B-b-F: brachial and bifemoral access; B-b-FC: brachial and bifemoral cutdown; B-FC: brachial-unilateral femoral cutdown; CDT: catheter-directed thrombolysis; CFA: common femoral artery; SD: standard deviations.

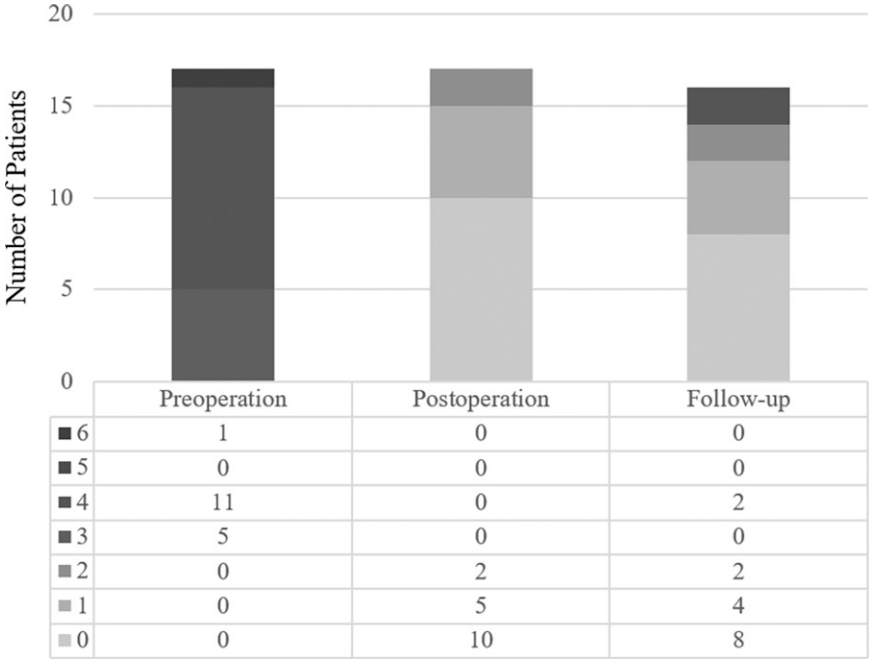
Figure 1. Preoperative computed tomography angiography of a 58-year-old male patient showed juxtarenal aortoiliac occlusion extending distally to the common femoral artery and occlusion of the left renal artery.

The average number of stents was 4.4 ± 1.6 (range 1–7). An infrarenal aorta was reconstructed with kissing covered stent grafts ($n = 7$), kissing bare-metal stents ($n = 2$), covered stent grafts ($n = 2$), bare-metal stents ($n = 1$), or the off-label use of iliac limb stent grafts ($n = 5$). Renal artery stenting was performed using the chimney technique in 9 (52.9%) patients, with the use of a 6 mm covered stent graft (Viabahn Stent Grafts, W.L. Gore and Associates Inc.) in one patient. Renal embolization was found in 3 (17.6%) patients during intraoperative angiography after angioplasty of the aortoiliac arteries, and the placement of protective renal artery stents was required (Figure 2). In 1 (5.9%) patient, inferior mesenteric artery (IMA) stenting was performed using the chimney technique.

One (5.9%) patient suffered from acute limb ischemia due to distal runoff embolization after CDT and was treated immediately with surgery. There was one (5.9%) case of left iliac artery rupture, which was immediately repaired using a covered stent graft (Viabahn Stent Grafts, W.L. Gore and Associates Inc.). One (5.9%) patient suffered from a left brachial arterial access site hematoma but had no need for further repair. There was one death (5.9%) from acute myocardial infarction 20 days after the operation. No impaired renal function or retroperitoneal hemorrhage was found in this study. The medial Rutherford category changed from 4 (0–6) preoperatively to a median of 0 (0–2) postoperatively ($p < 0.001$). The ABI improved significantly from 0.27 ± 0.23 on the right and 0.20 ± 0.21 on the left to 0.84 ± 0.17 on the right and 0.76 ± 0.26 on the left after the operation in all patients ($p < 0.001$) (Table 1). The Rutherford category improved after the procedure and at follow-up compared with at baseline (Figure 3).

The average follow-up period was 19.3 ± 16.7 months (range, 1–54 months) for the remaining 16 patients. The renal artery patency rate was 100%. One male patient with preoperative Rutherford category six experienced below-knee amputation of the left leg due to dry gangrene 3 months after the primary operation, and he eventually received femoral–femoral bypass 15 months after the operation because of resting pain in the right leg. One female patient developed total thrombotic occlusion of the right external iliac artery stent 3 months after the initial treatment, and she received successful drug therapy with Rutherford category 2. Another patient suffered from symptomatic reoccurrence due to iliac in-stent occlusion 6 months after the initial treatment and was treated conservatively. The estimated

Figure 2. Renal embolization in the treatment of juxtarenal aortoiliac occlusive disease. Digital subtraction angiography of a 68-year-old male patient demonstrated proximal juxtarenal aortoiliac occlusion at the level of the left renal artery and occlusion of the left renal artery (a). Embolectomy with Fogarty catheter was performed with the protection of a 4-Fr catheter in the left renal artery (b). The long-segment aortoiliac occlusion was recanalized (c). Left renal artery embolization was found after stenting of the infrarenal abdominal aorta (d). A renal artery stenting was placed in a chimney technique (e). Completion angiography showed patency of the infrarenal aorta and the left renal artery.



	Preoperation	Postoperation	Follow-up
6	1	0	0
5	0	0	0
4	11	0	2
3	5	0	0
2	0	2	2
1	0	5	4
0	0	10	8

Figure 3. The Rutherford categories improved after the procedure and at follow-up compared with at baseline.

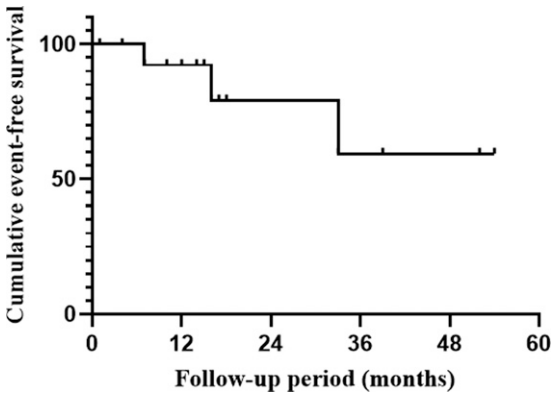


Figure 4. Kaplan-Meier estimates of cumulative primary patency.

cumulative primary patency rate was 92.3% at 12 months and 59.3% at 36 months according to the Kaplan–Meier method (Figure 4).

Discussion

The choice of optimal management for the treatment of juxtarenal aortoiliac occlusive lesions is still under debate. In the current study, endovascular therapy with renal protection was performed in 17 patients with juxtarenal AIOD. The results demonstrate that the endovascular strategy is an attractive alternative for these complex diseases. The cumulative primary patency rate was 92.3% at 12 months and 59.3% at 36 months after treatment. The interventional strategy was associated with high technical success, low morbidity and mortality, and satisfactory midterm clinical results in the treatment of juxtarenal aortoiliac occlusive lesions (see Figure 5 for digital subtraction angiography).

Open revascularization treatment has been traditionally regarded as the gold-standard treatment for TASC D aortoiliac occlusions.[2,3,19] Anatomic reconstruction of aortobifemoral bypass (AFB) provides good survival and long-term patency rates in low risk patients with appropriate anatomy, with a 5-year primary patency rate of 86–92%.[4,5,19,20] However, juxtarenal AIOD lesions are different pathological conditions with distinct anatomies, for which the choice of revascularization is often influenced by the anatomical and technical complexity of the disease and the patients' comorbidities.[4,7] Open surgery requires more extensive surgical exposure or laparotomy, suprarenal aortic cross-clamping, reconstruction of visceral arteries if necessary, and an increased physiological impact.[19] Suprarenal aortic cross-clamping is documented to be associated with increased rates of postoperative acute kidney injury, up to 14% reported in open repair of juxtarenal aortic aneurysm.[7,21] Moreover, open reconstruction therapy is associated with high cardiac and respiratory complication rates, a burden of a 1.6–6% periprocedural mortality rate, a high morbidity rate up to 8.5–28.6%, and a long hospital stay.[2,5,6,10] Extra-anatomical bypasses of axillary-femoral bypass (AFB) might also serve as an alternative choice in high risk patients and can result in lower morbidity and mortality rates.[4,20] But, unsatisfactory long-term patency rates and higher complications rates hinder the wide use of this surgical approach, especially in elderly patients with extensive comorbidities.[10]

Endovascular treatment has been demonstrated to be the first-line therapy for focal or short TASC A or B lesions.[8,9] Recently, endovascular treatment has also emerged as a safe and effective alternative for the treatment of TASC D lesions, including juxtarenal AIOD, because of its good perioperative and long-term clinical outcomes.[6,10–14,16,18,22] Bin Jabr et al.[18] performed endovascular repair with chimney grafts to preserve visceral flow in 10 patients with juxtarenal aortic stenosis or occlusion. Successful revascularization was achieved in all patients. One death (10%) occurred in the hospital. Mangialardi et al.[6] reported endovascular treatment in 13 patients with total juxtarenal AIOD. They reported a technical success rate of 100% and a complication rate of 38.5%. During a mean follow-up of 18 months, the primary and secondary patency rates were 92.3% and 100%, respectively. In the current study, the patients were considered to be at high risk for open surgery, as shown in Table 1. The technical success rate was 100%, the complete revascularization rate was 88.2%, and the in-hospital mortality rate was 5.9% (1/17), which was comparable with previous reports.[6,18]

Recanalization of complex and long-segment lesions is a critical issue in juxtarenal AIOD.[6] In this study, antegrade recanalization through left brachial access was achieved in all patients. No retrograde approach was attempted to reduce the risk of perforation and subsequent subintimal dissection during attempts to cross the occluded lesions.[23,24] Unilateral or bilateral femoral access facilitates further PTA and implantation of stents or stent grafts. This approach seems to be safe and efficient for the treatment of complex juxtarenal AIOD by using initial recanalization via left brachial access and subsequent endovascular procedures via femoral access (see Figure 6 for postoperative computed tomography angiography).

Fresh thrombi often exhibit stenosis or occluded lesions, which can aggravate lower extremity ischemia symptoms. Catheter-directed thrombolysis therapy is preferred as a minimally invasive method and can dissolve proximal or total aortic thrombi in flush infrarenal aortic occlusion.[23] However, the development of distal embolism, thrombolysis-related bleeding, and catheter-related infection is always a concern in CDT therapy. In this study, juxtarenal AIOD complicated by fresh thrombi occurred in seven patients. Nevertheless, CDT therapy was only performed as the initial therapy in two patients. Distal runoff embolization occurred in one patient after CDT. Surgical embolectomy

with a Fogarty catheter was applied in the remaining five patients. Surgical embolectomy seems to be more effective than CDT when a large number of fresh thrombi exist in the infrarenal abdominal aorta.[25]

Self-expanding stents are preferred in all these types of juxtarenal AIOD due to their flexibility and ability to adjust to vessel tortuosity.[18,23] No balloon-expanded stents were used in this study due to their rigidity. In the BOLSTER study, covered balloon-expandable stents can offer several potential advantages of a covering with the radial outward strength and accuracy of placement over bare-metal stents or self-expandable covered stents.[26] However, Humphries et al. found that bare-metal stents showed improved primary and secondary patency compared with covered balloon-expandable stents.[27] These might attribute to the rigid end of the covered stents, which could result in the compliance mismatch at the end of the stent or outside the stent. The covered endovascular repair of the aortic bifurcation (CERAB) technique, which was first introduced in 2013 by Goverde et al., is believed to be a promising technique for extensive AIOD.[11,28–31] The new technique uses three balloon-expandable covered stents to create an aortic neo-bifurcation. It was reported to be able to offer superior flow geometry, additional physiologic flow patterns in vitro, and superior 3-year patency rates and clinical improvements in vivo.[11,29–31] However, the devices are not commercially applied in our institution. As a result, the kissing stent technique with bare-metal stents or covered stent grafts was performed in 9 (52.9%) patients in this study. To reduce the need for reinterventions and decrease the risk of arterial rupture after angioplasty, the off-label use of iliac limb endografts was also conducted in 5 (29.4%) patients. Compared with other endoprostheses, Medtronic Endurant II iliac limb endografts (16-16-83/95 mm) seem to be more reasonable due to the consistency with the diameter of the infrarenal aorta. Attention should be paid to the need for large delivery sheaths in iliac limb endografts.

Renal embolization is one of the most severe complications.[18,23] In this study, three patients suffered from renal embolization. Protection of visceral flow was performed by placing balloons or sheaths in the visceral arteries through brachial access in all patients.[31] The flush infrarenal aortic occlusion could also be transformed to a distal aortic lesion with CDT therapy.[23]

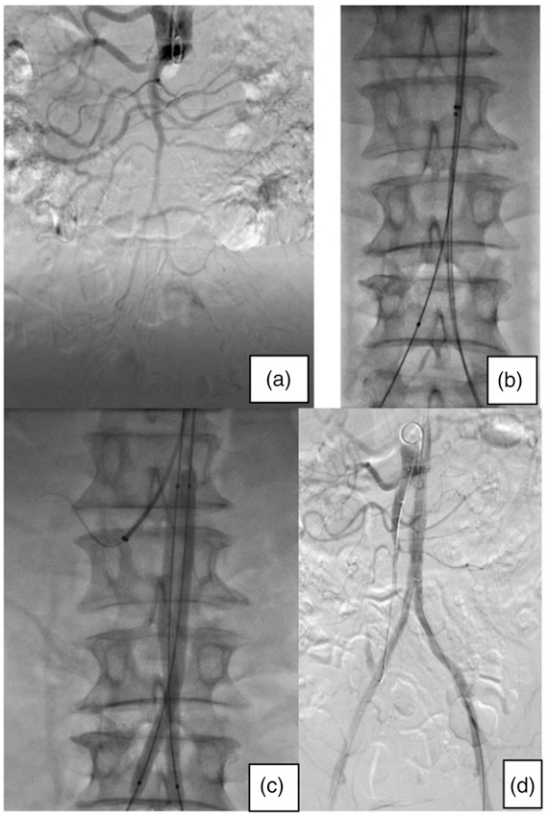


Figure 5. The Rutherford categories improved after the procedure and at follow-up compared with at baseline.

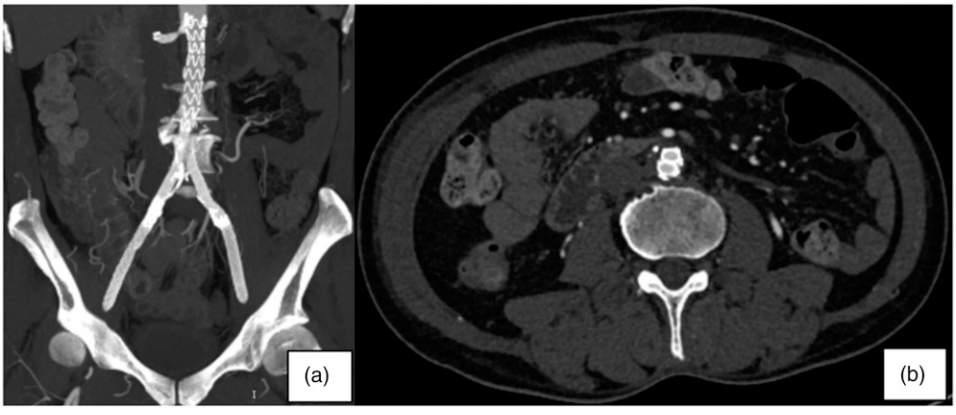


Figure 6. Postoperative computed tomography angiography of a 58-year-old male patient demonstrated complete revascularization of the juxtarenal aortoiliac occlusion.

This study has several limitations. First, it was a retrospective analysis with a small number of patients enrolled and a short follow-up time. A series of different adjunctive therapies were also performed in the endovascular treatment of juxtarenal AIOD. Moreover, DUS but not CTA was the most frequently used investigation to evaluate the patency of the stents during follow-up. Further studies with large sample sizes and longer follow-up periods are needed to demonstrate long-term durability.

Conclusions

Transbrachial and transfemoral approaches combined with visceral protection offer a safe and effective alternative to open revascularization for the endovascular treatment of juxtarenal AIOD. Further studies with a larger number of patients and longer follow-up durations are warranted to confirm these findings.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study is supported by Medicine and Health Science Technology Development Program of Shandong Province (2017WS093) and Shandong Key Research and Development Program (2017GSF18176, 2019GSF108098).

Ethical Approval

The acquisitions were performed with the approval of the Human Research Ethics Committee of Shandong Provincial Hospital Affiliated to Shandong First Medical University.

Informed Consent

Written informed consent was obtained from all participants for their clinical records to be used in this study.

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