Treatment of recurrent iliac branch occlusion after endovascular repair of abdominal aortic aneurysm diagnosed by contrast-enhanced ultrasound combined with computed tomography angiography: a case report

Lei Wang[1#], Xiao Feng[2#], Ze Song[1], Xu Xie[1], Zhen Zhang[1], Ming Qi[1]

[1]Division of Vascular surgery, First Affiliated Hospital of Dalian Medical University, Dalian, China; [2]Division of Ultrasound, First Affiliated Hospital of Dalian Medical University, Dalian, China

[#]These authors contributed equally to this work.

Correspondence to: Ming Qi. Department of Vascular Surgery, First Affiliated Hospital of DMU, 193, Lianhe Road, Shahekou County, Dalian 116021, China. Email: qiming@dmu.edu.cn.

Background: Endovascular treatment of abdominal aortic aneurysm (AAA) has been in use for several decades and has become the main treatment for this disease. Iliac branch occlusion (IBO) is a common complication after endovascular treatment. The diagnosis and guidance of contrast-enhanced ultrasound (CEUS) combined with computed tomography angiography (CTA) in the treatment of recurrent IBO after endovascular aneurysm repair (EVAR) are rarely reported. In this case, CEUS gave important hints on the cause of IBO.

Case Description: We present a 67-year-old male patient who was diagnosed with AAA in 2020 and underwent endovascular treatment in the same period. There was no family history of AAA. The operation process was successful. The CTA re-examination one month after operation showed that the aneurysm was well isolated without obvious endoleak. However, the patient developed intermittent claudication of both lower limbs after operation, but did not receive relevant diagnosis and treatment. Four months after surgery, the patient's claudication symptoms of the left lower limb were significantly worse than before, and CTA review revealed left IBO. The left ankle brachial index (ABI) was too low to detect the value. A femoral artery thrombectomy was performed and a stent was extended distal to the left iliac stent. The claudication symptoms improved after surgery. Unfortunately, only two months later, the patient developed rest pain in the left lower limb. CTA examination showed that the left iliac branch was occluded again. The problem in the proximal end of the left iliac branch was observed by CEUS before re-operation, which was also confirmed by digital subtraction angiography (DSA) after thrombectomy. The blood flow was significantly improved after the angle of the proximal iliac branch was adjusted by stent placement. The patient did not show claudication symptoms again during follow-up. Through CEUS, we identified the pathogenic causes which could not be reflected in CTA and formulated the correct treatment plan.

Conclusions: The risk factors of IBO after EVAR are mostly hidden in the process of the initial operation. CEUS can provide more information about postoperative hemodynamics than CTA. The role of CEUS in postoperative follow-up of endovascular treatment of AAA needs to be further explored.

Keywords: Abdominal aortic aneurysm (AAA); endovascular aneurysm repair (EVAR); Iliac branch occlusion (IBO); contrast-enhanced ultrasound (CEUS); case report

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Introduction

In the last three decades, the endovascular repair of abdominal aortic aneurysm (EVAR) has been extensively promoted and applied (1,2). Compared with open aneurysm repair, the application of this technology has rapidly and effectively treated abdominal aortic aneurysm (AAA) which seriously threatens human life. At pace with the development of technology and devices, we have expanded our capability and indications to treat complex AAA, even ruptured aneurysms. Although patients with AAA obtain the greatest benefit from EVAR, problems have increasingly been exposed in the wake of time, such as rupture post-implantation, endoleak, graft migration, graft infection, limb thrombosis, and so on (3,4). Complex anatomical conditions are usually the main cause of related complications, and are associated with a higher rate of surgical revision (5,6). Iliac branch occlusion (IBO) is a common issue post EVAR, with a reported incidence of approximately 1–8% (5,7-9). Either unilateral or bilateral sides can be involved in IBO, and the causes are usually complex, including anatomy, equipment, operator factors, and so on. Emergency endovascular or surgical intervention is generally required. Computed tomography angiography (CTA) is the most commonly used effective means of postoperative examination and follow-up and can be used to conduct further intervention (10,11). However, we found that in some cases, CTA does not readily identify the intrinsic cause of IBO. The extrusion deformation between stents could be very hidden. In recent years, contrast-enhanced ultrasound (CEUS) has been increasingly widely used in the follow-up of EVAR (12,13). However, there are few reports on the diagnosis of IBO by CEUS. In this report, we described a patient with recurrent IBO after EVAR. We applied CEUS to explore the cause of IBO which had not been made apparent by CTA or digital subtraction angiography (DSA). This case suggests that more attention should be paid to the angulation of the proximal iliac branch in EVAR. We present the following article in accordance with the CARE reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-22-4498/rc).

Case presentation

A 67-year-old male patient had been diagnosed with AAA at another hospital during a routine physical examination. The patient had no obvious abdominal pain or other positive symptoms. Soon after the diagnosis was confirmed, he was admitted to hospital for follow-up treatment. The patient had a history of hypertension for more than 20 years, and the rest of his medical history was unremarkable. There was no family history of AAA in the immediate family. According to the systematic inspection and imaging analysis, he received EVAR treatment in December 2020, which was an implanted Medtronic (USA) 23 mm × 13 mm × 170 mm main stent graft. The right iliac artery was spliced with a 16 mm × 10 mm × 95 mm stent, and the left iliac artery was connected with a 16 mm × 16 mm × 120 mm stent and subsequently a 16 mm × 10 mm × 120 mm stent. The distal end of both iliac branch stents extended to the external iliac artery. To reduce the risk of endoleak, preventive coil embolization was performed on the right internal iliac artery. The preoperative CTA images and intraoperative DSA images are shown in *Figure 1A-1C*. One month after the operation, follow-up CTA showed that the aneurysm was well isolated without obvious internal leakage, but it could be seen that the bilateral iliac branches were anchored in the external iliac artery, and the blood vessels at the distal end of the stent were tortuous (*Figure 1D*).

The patient had intermittent claudication symptoms of both lower limbs after the surgery; walking on the flat ground was acceptable, but the limbs became swollen and uncomfortable when climbing, and the claudication distance was less than 30 meters. In March 2021, the patient suddenly experienced motor dysfunction of the left lower limb. The CTA showed that the left iliac artery stent was occluded (*Figure 2A*), and the left ankle brachial index (ABI) could not be measured. The patient underwent left femoral artery incision and thrombectomy. Intraoperative DSA indicated that the blood flow at the distal end of the left iliac stent was limited. A Fluency 10 mm × 60 mm stent (Bard, USA) was placed at the distal end of the iliac stent. The motor function of the left lower limb recovered well after surgery (*Figure 2B*). The patient were treated with aspirin and clopidogrel after operation.

In May 2021, the patient was hospitalized again because of pain and numbness of the left lower limb, and the limping distance was <20 m. The right ABI was 0.58, and the left ABI was 0.36. The CTA showed that the left iliac branch was occluded again (*Figure 3A*). At the same time, we performed an abdominal aorta CEUS on the patient (*Figure 3B*). The examination revealed no evidence of a restricted connection between the main stent and the proximal stent of the left iliac branch. On the contrary, the right iliac branch was slightly narrow, but the blood flow was unobstructed (*Figure 3C*). This problem was not

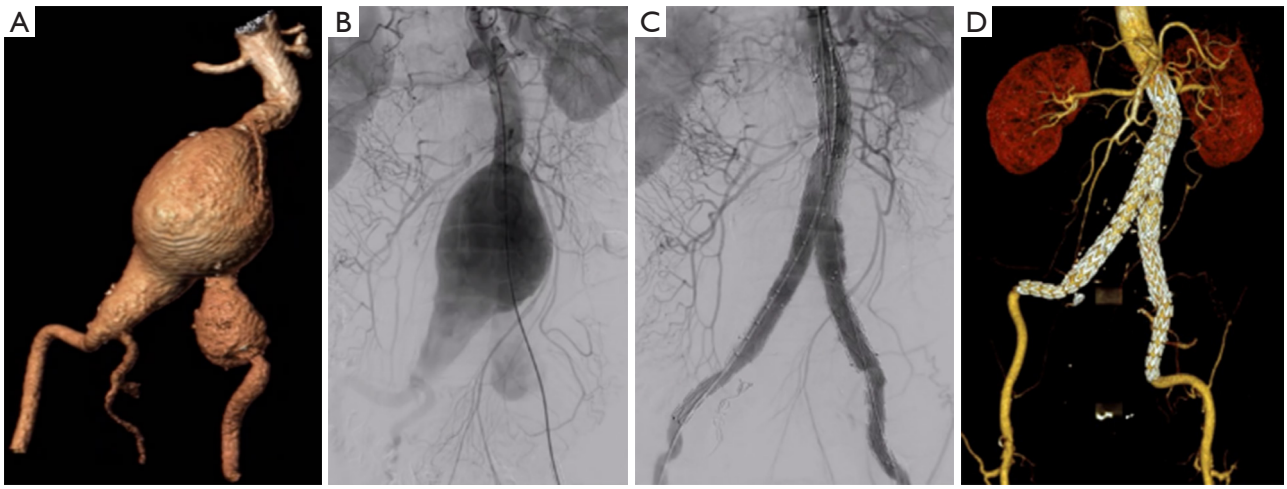

Figure 1 Perioperative CTA and DSA images of the first EVAR operation. In December 2020, preoperative CTA (A) and intraoperative DSA (B,C) images of the patient at the first surgery. CTA follow-up one month after the operation showed that the aneurysm was well isolated without endoleak or iliac branch occlusion (D). CTA, computed tomography angiography; DSA, digital subtraction angiography; EVAR, endovascular repair of abdominal aortic aneurysm.

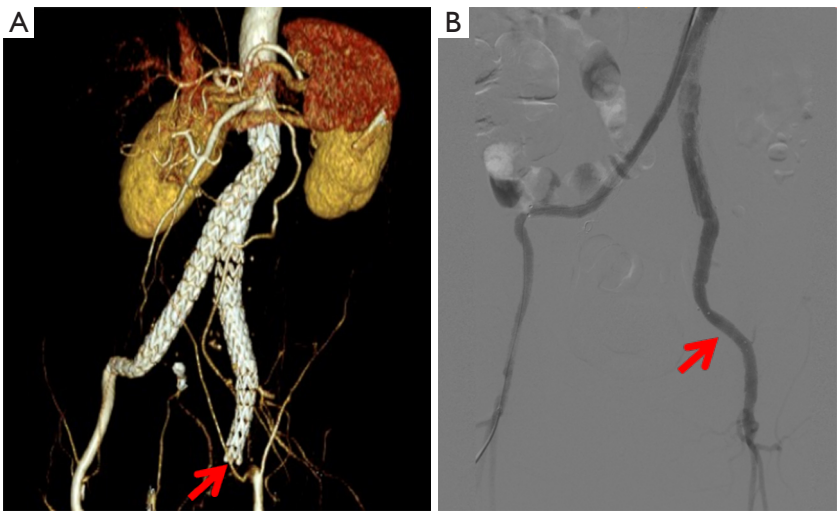

Figure 2 Preoperative CTA and intraoperative DSA images of the first IBO operation after EVAR. In March 2021, three months after EVAR surgery, the patient developed a significant exacerbation of left limb claudication. CTA showed occlusion of the left iliac branch, and the distal end of bilateral iliac branch stents twisted into angles with the iliac artery (A). The patient extended stent. After operation, DSA showed that the blood flow of iliac branch was unobstructed (B). CTA, computed tomography angiography; DSA, digital subtraction angiography; IBO, iliac branch occlusion; EVAR, endovascular repair of abdominal aortic aneurysm.

clearly reflected on the CTA (*Figure 3D*). We performed a repeat thrombectomy of the left femoral artery. Next, we performed right femoral arteriography, which showed severe stenosis at the distal end of the right iliac stent. After balloon pre-expansion, an Absolute-Pro 10 mm × 60 mm stent (Abbott, USA) was placed. Angiography at the proximal end of the main stent showed that the blood flow in the stent of the left iliac artery was stagnant. The pulse of the left common femoral artery was weakened. Through DSA, we found that there was marginal laminar flow at the proximal end of the left iliac branch, and the blood flow velocity significantly decreased. We implanted

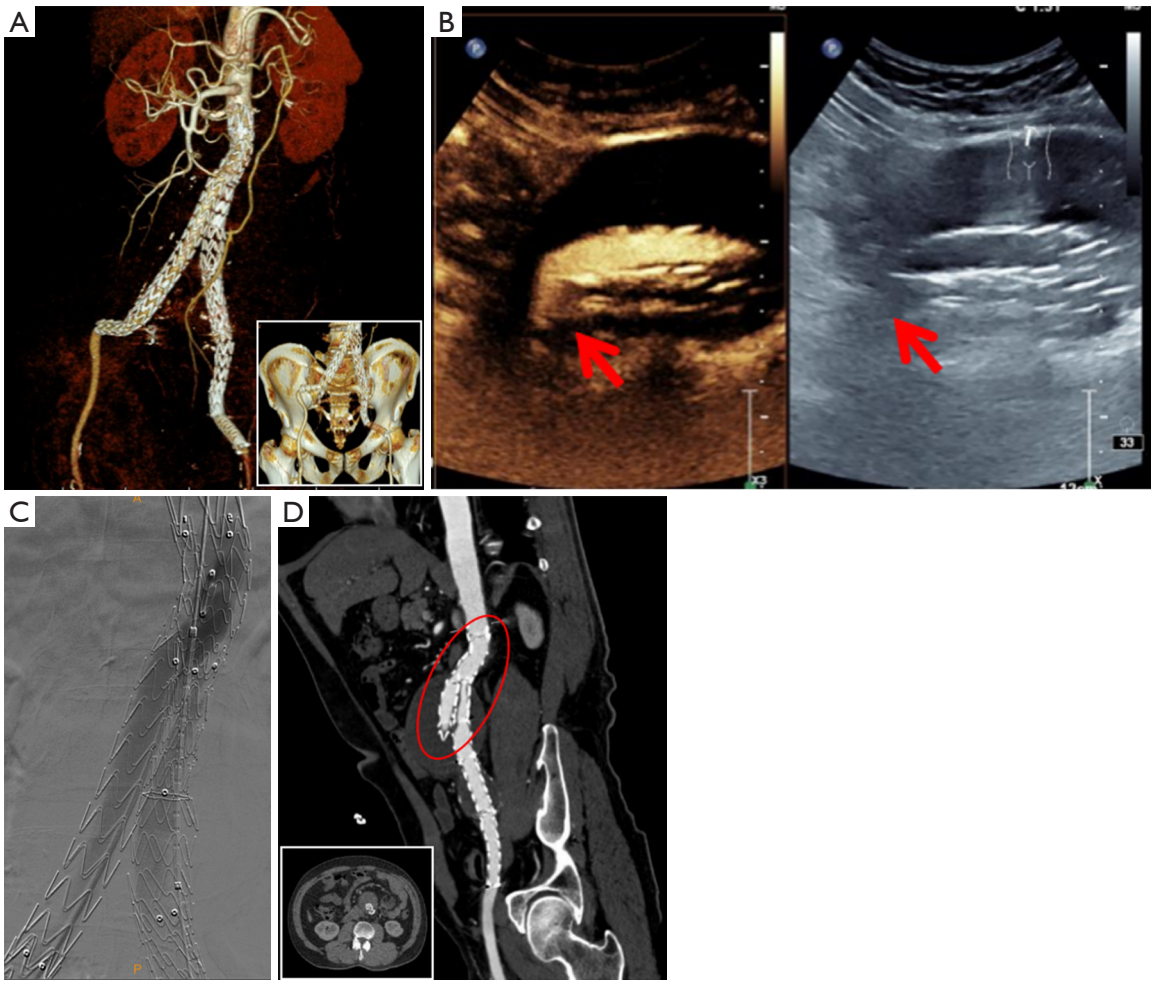

Figure 3 CTA and CEUS images before the second IBO operation and DSA images during the operation. In March 2021, CTA after symptom recurrence indicated that the left iliac branch was occluded again (A). Preoperative CEUS showed that there was no obvious stenosis in the proximal end of the left iliac branch as shown by the arrow (B). DSA showed that there was obvious marginal laminar flow in the left iliac branch and the blood flow velocity decreased (C). This phenomenon could also be observed indirectly through the reconstructed images of CTA (D). Mural thrombus can be seen in the stent of the proximal iliac branch as shown in the circle. CTA, computed tomography angiography; CEUS, contrast-enhanced ultrasound; IBO, iliac branch occlusion; DSA, digital subtraction angiography.

an E-luminexx 12 mm × 60 mm stent (Bard) at the proximal junction of the left iliac branch, and the proximal end slightly exceeded the left iliac branch stent. The angle of the proximal end of the left iliac branch was improved through this stent. Armada 14 mm × 60 mm balloon (Abbott) was introduced into the stent and expanded. Angiography showed that the blood flow of the left iliac artery was significantly improved. After this operation, the claudication symptoms of both lower limbs were significantly relieved. In August 2021, CTA and CEUS follow-up showed that the blood flow of bilateral iliac branches was smooth, and no obvious stent stenosis was present (*Figure 4A-4C*). The CEUS results also showed that the marginal laminar flow at the proximal end of the left iliac branch disappeared. There was no significant difference in blood flow velocity of the bilateral iliac branches (*Figure 4D*). The patient had no recurrence of intermittent claudication symptoms. The timeline of the patient's entire diagnosis and treatment process is shown in *Figure 5*. All procedures performed in this study were in accordance with the ethical standards

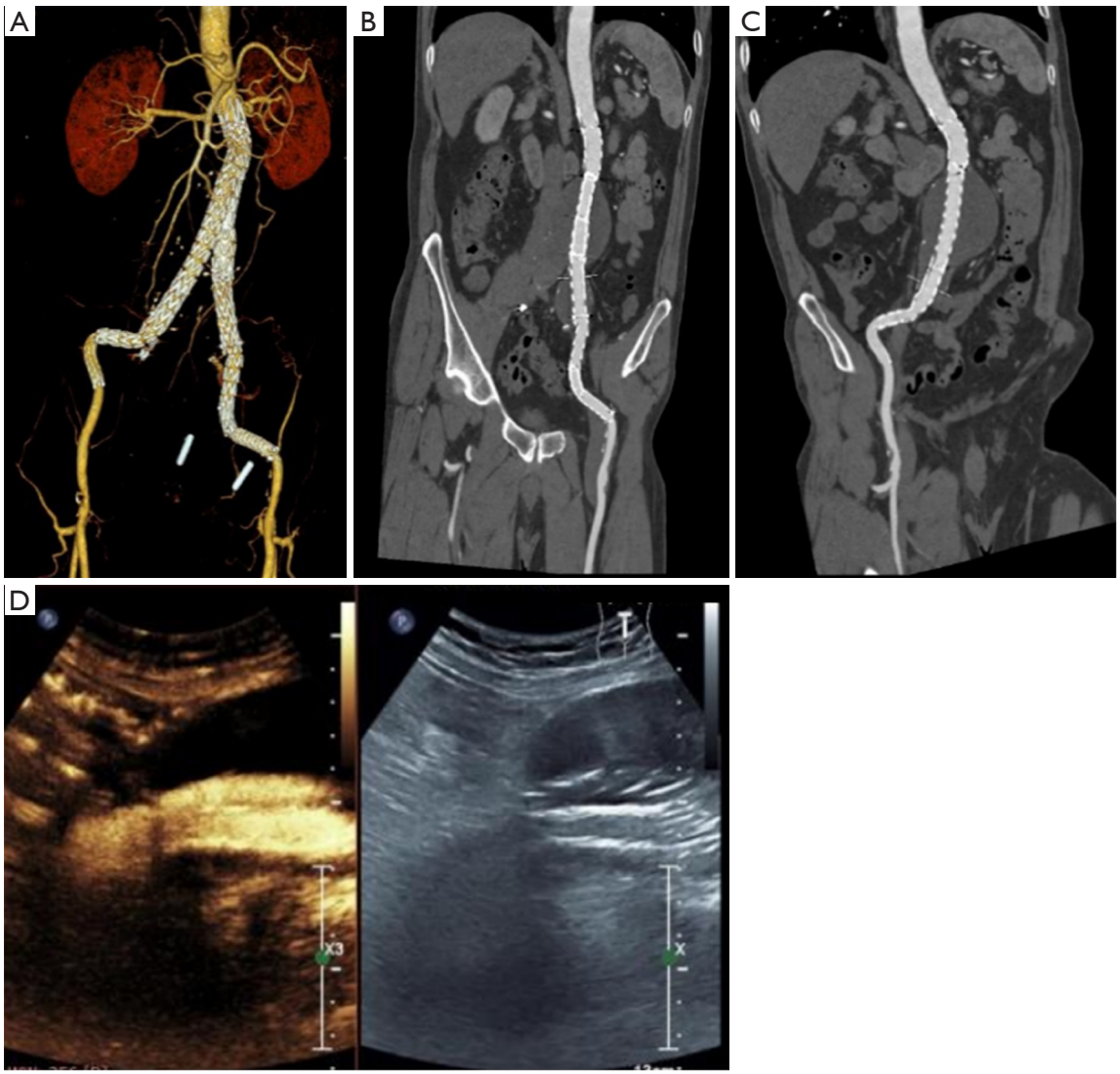

Figure 4 Follow-up results of CTA and CEUS after the second IBO operation. In August 2021, CTA follow-up results 2 months after the last operation (A-C). The CEUS results after stent implantation showed that the marginal laminar flow disappeared after the improvement of the angle of the proximal end of the left iliac branch (D). CTA, computed tomography angiography; CEUS, contrast-enhanced ultrasound; IBO, iliac branch occlusion.

of the institutional and/or national research committee(s) and with the Declaration of Helsinki (as revised in 2013). Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

Discussion

With the maturity of technology and the accumulation of experience, vascular surgeons have used endovascular treatment techniques to challenge the treatment of more patients with complex AAA. After the technical carnival, we became aware of a series of problems brought by this operation. As the main complication after EVAR, IBO brings serious clinical symptoms to patients and requires surgical revision. There are many possible causes of IBO, such as twisted neck of the aneurysm, calcification, distortion, and stenosis of iliac artery (14,15). Bogdanovic *et al.* recently reported a multicenter retrospective cohort

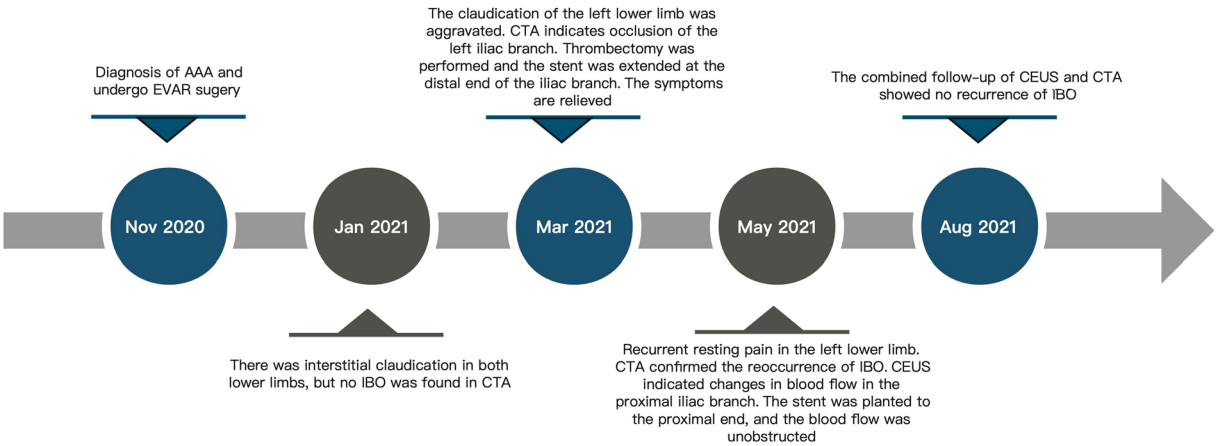

Figure 5 Treatment summary of the patient from diagnosis to last follow-up. AAA, abdominal aortic aneurysm; EVAR, endovascular repair of abdominal aortic aneurysm; IBO, iliac branch occlusion; CTA, computed tomography angiography; CEUS, contrast-enhanced ultrasound.

study that reconfirmed that anchoring in the external iliac artery and narrowed external iliac diameter were risk factors for IBO after EVAR. Their study also revealed that the Zenith Alpha covered stent system is an independent risk factor for IBO (9). Poor proximal anchoring zone-inflicted IBO is rarely reported. Through a retrospective study, Ge *et al.* found that in patients with infrarenal aneurysm neck with an angle of more than 60°, the stent bifurcation was just at the angle of the aneurysm neck, and the opening of one iliac branch was squeezed by the contralateral iliac branch, which led to iliac branch thrombosis. They named it the "capping" effect (16). The patient we reported reflects both the adverse factors leading to IBO. It is difficult to correct the defects such as large angle and narrow neck with EVAR. Before the completion of the final DSA, the hard guide wire should be removed to allow observation of the vascular morphology of the proximal and distal anchoring areas after stent implantation and to ascertain whether there are risk factors for IBO.

Stent-related complications occur in 6–27% of patients after EVAR (17). The current guidelines recommend CTA as the first choice for monitoring after EVAR (10). It was used to observe the main related complications after EVAR, such as endoleak and IBO. However, CTA ultimately presents static images, so there are some limitations in tracing the cause of endoleak. In order to evaluate the complications after EVAR in "four dimensions", many researchers try to apply CEUS for follow-up observation (18,19). Many studies have shown that CEUS is more sensitive than CTA in detecting internal leakage compared with CTA, especially in the case of low flow rate and low blood flow. However, there are few reports on the application of CEUS to observe IBO. In this case, we reported that we used CEUS to detect occult causes that were not clearly indicated on CTA. When the vascular angle increases, the blood flow changed from laminar flow to non-laminar flow. The blood flow velocity profile at the bend of the vessel was asymmetric, the curved lateral side was faster and that of the medial side was relatively low. After this patient was hospitalized for the second time because of IBO, we reviewed the CEUS result from March and found that the proximal end of the left iliac stent was angled, resulting in a decrease in blood flow velocity due to non-laminar flow. To explain this phenomenon, we introduced the concept of "edge laminar flow separation". The velocity profile of laminar flow changes at the point where the vessel bends, forks, or strictures, and continues for some distance. In some cases, there is both forward and backward flow in the artery. This zone of zero flow velocity is called "edge laminar flow separation", and this can lead to thrombosis. After we placed a stent with stronger support at the proximal end during reoperation, the angle of the original stent disappeared. By reviewing the DSA of two operations, we could find this previously neglected problem (*Figures 2A*,*3C*). We observed again through CEUS that this non-laminar flow state also disappeared. The non-lamellar bleeding disappeared, and thrombus were no longer formed. This case reveals that CEUS has instructive significance for treatment of IBO. The surgeon can make an accurate plan before operation by interpreting the results of CEUS, so as to reduce the re-

intervention of target vessels.

Conclusions

IBO is a common complication following EVAR for a variety of reasons. We believe that the best method to deal with it is to thoroughly analyze all important elements during the first operation and avoid the occurrence. Unfortunately, we are unable to thoroughly investigate the questions and responses at this time. As a result, more systematic postoperative follow-up and a more complete examination are still required to assess changes in the patient's health. Our research has just begun to employ both CTA and CEUS to assess the therapeutic efficacy of EVAR. We anticipate that CEUS will compensate for CTA's shortcomings in certain ways and assist us in dealing with difficulties following EVAR.

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Footnote

Reporting Checklist: The authors have completed the CARE reporting checklist. Available at https://atm.amegroups.com/article/view/10.21037/atm-22-4498/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-4498/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Declaration of Helsinki (as revised in 2013). Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

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