EJVES Vascular Forum (2023) 59, 36–40

CASE REPORT

Inferior Mesenteric Artery Snorkel for Endovascular Treatment of a Large Degenerating Saccular Aneurysm

Shin Mei Chan [a], **Julia Fayanne Chen** [b], **Ocean Setia** [c], **Naiem Nassiri** [c,*]

[a] Yale University School of Medicine, New Haven, CT, USA
[b] Division of Vascular and Endovascular Surgery, Department of Surgery, University of Toronto, Toronto, Ontario, Canada
[c] Division of Vascular Surgery and Endovascular Therapy, Department of Surgery, Yale University School of Medicine, New Haven, CT, USA

Objective: Preservation of the inferior mesenteric artery (IMA) during endovascular aortic aneurysm repair (EVAR) is necessary for prevention of mesenteric ischaemia in the case of chronically occluded coeliac and superior mesenteric arteries (SMA). This case report presents an approach in a complex patient.
Methods: A 74 year old man with hepatitis C cirrhosis and recent non-ST elevation myocardial infarction presented with an infrarenal degenerating saccular aneurysm (58 mm), chronically occluded SMA and coeliac artery, and 9 mm IMA with high grade ostial stenosis. He also had concomitant atherosclerosis of the aorta with a narrow distal aortic lumen of 14 mm, which tapered to 11 mm at the aortic bifurcation. Endovascular attempts to cross long segment occlusions of the SMA and coeliac artery were unsuccessful. Thus, EVAR was performed using the unibody AFX2 endograft and chimney revascularisation of the IMA using a VBX stent graft. One year follow up demonstrated regression of the aneurysm sac to 53 mm with patent IMA graft and no endoleak.
Conclusion: Few reports have described techniques for endovascular preservation of the IMA, which is a necessary consideration in the context of coeliac and SMA occlusion. Because open surgery was not a good option for this patient, available endovascular options had to be weighed up. An added challenge was the exceptionally narrow aortic lumen in the context of aortic and iliac atherosclerotic disease. It was decided that the anatomy was prohibitive for a fenestrated design and extensive calcification was too limiting for gate cannulation of a modular graft. Thus a bifurcated unibody aortic endograft with chimney stent grafting of the IMA was successfully used as a definitive solution.

Article history: Received 28 September 2022, Revised 24 March 2023, Accepted 15 May 2023,
Keywords: Chimney repair, Inferior mesenteric artery, Mesenteric disease, Mesenteric ischaemia, Saccular aneurysm

INTRODUCTION

In cases of concomitant infrarenal abdominal aortic aneurysm (AAA) and visceral artery occlusive disease, revascularisation of the coeliac trunk and or superior mesenteric artery (SMA) is critical prior to endovascular aortic aneurysm repair (EVAR), which inevitably results in coverage of the inferior mesenteric artery (IMA). There is scant literature on IMA preservation in the context of coeliac and SMA occlusion in endovascular infrarenal AAA repair.[1–3] This case report describes treatment of a large saccular infrarenal AAA in the setting of long segment chronic occlusion of the coeliac and SMA, with a >90% stenosed IMA and significant atherosclerosis at the ostium.

REPORT

The patient provided informed consent for publication of the details of this case and associated images. He was a 74 year old man who was an active smoker, with hepatic cirrhosis, hypertension, hyperlipidaemia, and three vessel coronary artery disease with non-ST elevation myocardial infarction two months previously (managed medically). The patient had undergone pre-operative computed tomography (CT) for liver ablation and biopsy of a hepatic lesion for malignancy, which demonstrated an infrarenal saccular aneurysm measuring up to 5.8 cm. Subsequent CT angiography (CTA) noted long segment occlusion of the coeliac trunk and SMA; circumferential calcification of the perivisceral, perirenal, and infrarenal aorta with a 14 mm lumen, which tapered to a narrow aortic bifurcation of 11 mm; near occlusive, calcified IMA ostial atherosclerosis with post-stenotic dilation to 9.3 mm and prominent 7–8 mm

* Corresponding author. Associate Professor of Surgery (Vascular), Yale School of Medicine Chief, Vascular and Endovascular Surgery, VA Connecticut Healthcare System, New Haven, CT, USA.
E-mail address: Naiem.nassiri@yale.edu (Naiem Nassiri).

https://doi.org/10.1016/j.ejvsvf.2023.05.008

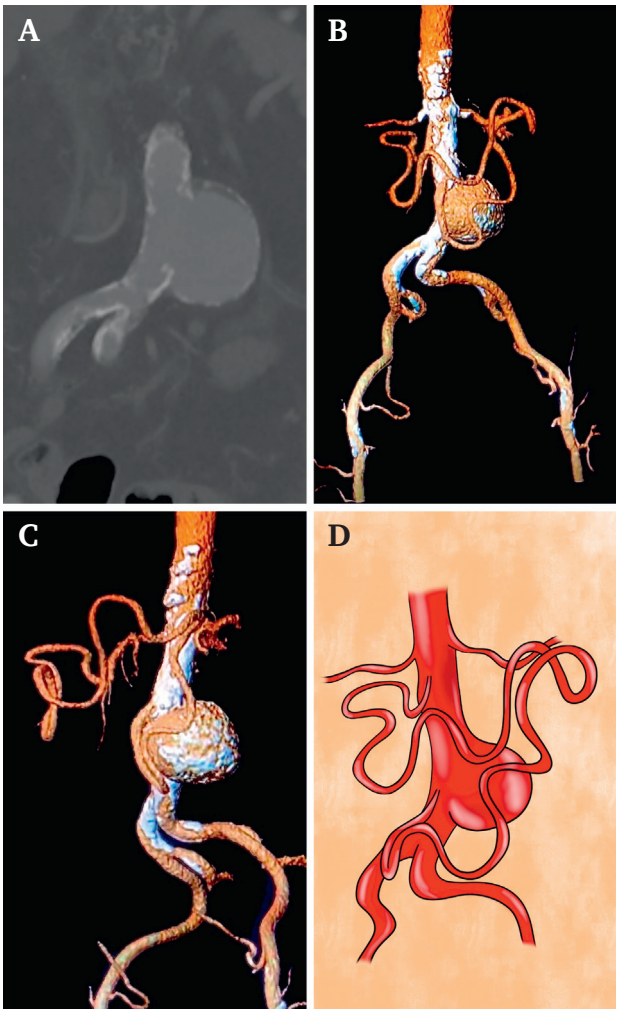

Figure 1. Coronal computed tomography angiogram (CTA) findings (A) saccular aneurysm measuring up to 5.8 cm with circumferential calcification; (B) coronal and (C) sagittal pre-operative three dimensional reconstruction computed tomography (CT); and (D) a schematic of the stenotic inferior mesenteric artery (IMA). The patient's entire gastrointestinal system was fed by a dilated IMA that was 90% stenosed at the origin with prominent collaterals (Illustration by Shin Mei Chan).

IMA for the remainder of its course; patent, mildly diseased bilateral internal iliac arteries; large mesenteric collaterals arising from the superior rectal artery; and a prominent Arc of Riolan (Fig. 1A—D).

The aneurysm neck (distance of parallel walled aorta below the renal arteries before the saccular aneurysm) was 4.6 cm. The patient did not report any post-prandial pain, unintentional weight loss, food fear, or any other concerns for chronic mesenteric ischaemia. A multidisciplinary discussion deemed it important to address the aneurysm prior to possible hepatic surgery. Given the patient's multiple comorbidities, he was a poor open surgical candidate. Infrarenal EVAR with an IMA chimney graft for preservation of mesenteric perfusion was planned. Coeliac and SMA revascularisation from a transbrachial approach was attempted prior to EVAR; however, the long segment occlusions could not be crossed in either vessel.

Surgical technique

Given the patient's extensive atherosclerosis, narrow aortic bifurcation, and the saccular nature of the aneurysm, placement of an anatomically fixated, bifurcated, unibody aortic stent graft (AFX2 22 x 90 x 16 x 30 mm; Endologix LLC, Irvine, CA, USA) was planned, which was introduced via right transfemoral access, snared, and saddled at the aortic bifurcation per usual standard protocol. Prior to this, via left axillary cutdown, an 8.5F x 90 cm TourGuide steerable sheath (Medtronic Inc., Minneapolis, MN, USA) had been advanced over a stiff guidewire down to zone 9 and used to selectively engage the severely stenotic ostium of the IMA under roadmap guidance. Selective angiography demonstrated a large Arc of Riolan providing retrograde perfusion to the SMA and the gastroduodenal arcade. The stenotic IMA ostium was serially dilated using 5 mm and 6 mm balloons (Fig. 2A) to allow advancement of an 8L x 79 mm VBX balloon expandable stent graft (W.L. Gore, Newark, DE, USA) 3 cm into the IMA. This covered stent was then insufflated and deployed immediately following deployment of the AFX2 aortic stent graft (Fig. 2B). Simultaneous balloon angioplasty of the AFX2 and the VBX was performed to allow maximum apposition and reduce the possibility of gutter leak. To secure and anchor the proximal portion of the IMA stent throughout its length, to further reduce risk of gutter leak, and to ensure adequate proximal seal above the aortic aneurysm, a 28 $\times$70 mm Endurant II cuff (Medtronic Inc., Minneapolis, MN, USA) was deployed, taking care to align the top of the cuff with the top of the VBX immediately below the lowest renal artery. Simultaneous balloon angioplasty of the cuff and the VBX stent was again performed (Fig. 2C). Completion angiography demonstrated no endoleak and brisk, unimpeded, and augmented flow into the IMA with retrograde filling of the SMA and its branches (Fig. 2D). A schematic of the stent configuration is demonstrated in Fig. 2E.

The patient was discharged on dual antiplatelet therapy after two days without complications. The patient underwent liver resection at an outside institution four months following this procedure, after which he shortly experienced sepsis but fully recovered without complications. At the six month follow up, his aspirin was discontinued and he remains on clopidogrel indefinitely. At the one year follow up, CTA demonstrated a completely thrombosed aneurysm sac with maximum diameter of 5.3 cm, widely patent IMA chimney graft and Arc of Riolan, and no evidence of endoleak (Fig. 3A and B).

DISCUSSION

In most cases of atherosclerotic mesenteric disease, emphasis is placed on reconstruction of the coeliac trunk and SMA. The IMA is seldom revascularised.[4] Notably, addressing the IMA is preferable only if the Riolan arcade is preserved to justify sole recanalisation of this vessel. Anatomy of the Arc of Riolan is highly variable; thus, sufficient imaging and patient selection is key. Branching patterns of the Arc of Riolan have been described; an anastomosis between the accessory

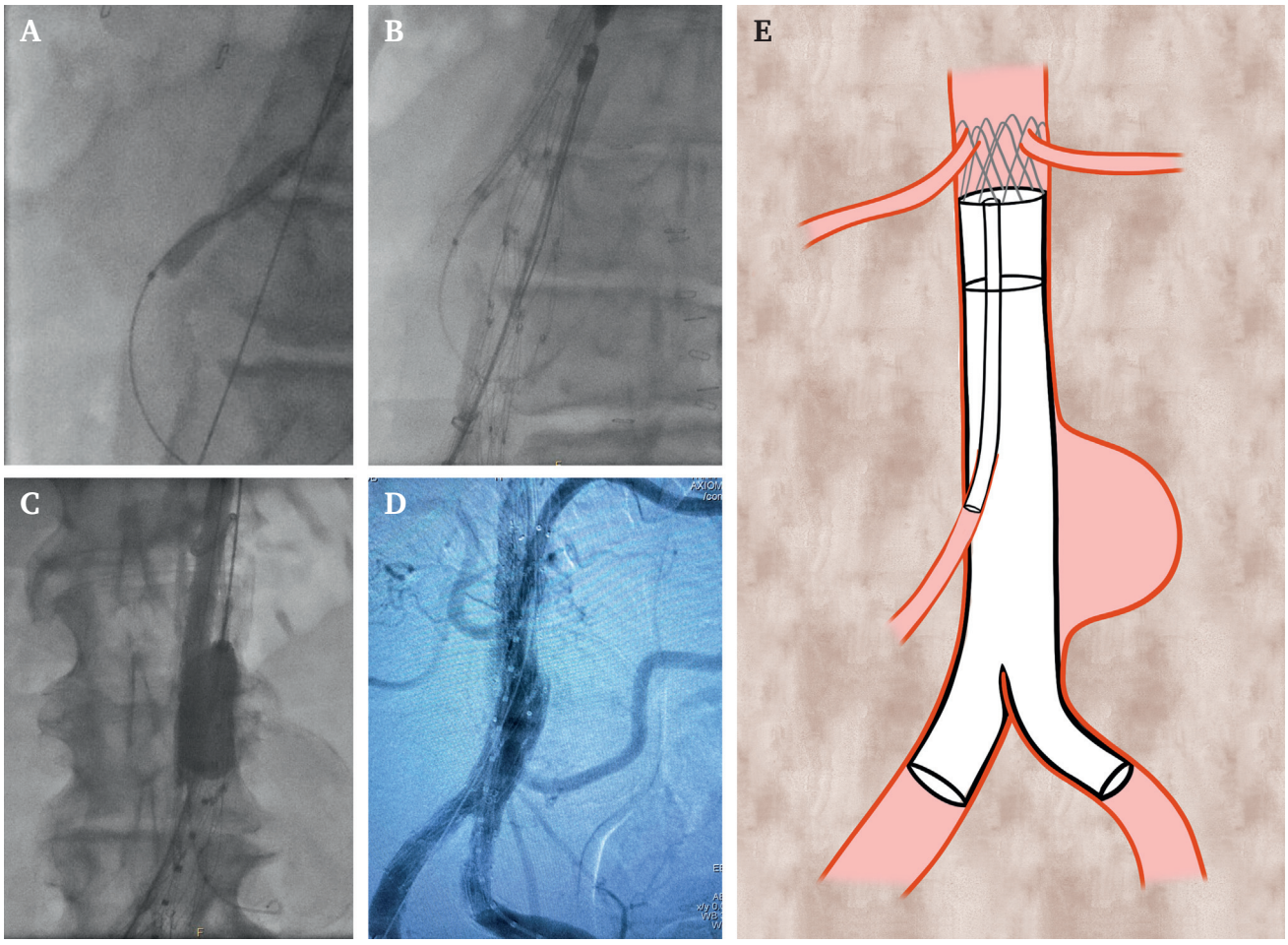

Figure 2. Surgical technique (A) Balloon angioplasty of the severely stenotic inferior mesenteric artery (IMA) in anticipation of the transaxillary snorkel. A Gore VBX (8L x 79 mm) was placed into the IMA extending proximally into the proximal aspect of zone 9 of the aorta. This was performed concomitantly with placement of an Endologix AFX2 (22 x 90 x 16 x 30 mm) (B) Endurant II cuff was placed and aligned with the top portion of the Gore VBX stent graft (C) Simultaneous balloon angioplasty of the cuff and the VBX stent was performed (D) Subsequent angiography showing complete aneurysm exclusion, as well as brisk unimpeded aorto-iliac and IMA flow. The final arteriogram demonstrated inline flow (E) Schematic demonstrating stent configuration (Illustration by Shin Mei Chan).

middle colic artery and various left colic arteries is most common, although it is critical to note that shorter anastomoses may exist on the basis of fluid mechanics.[5] It is also important to assess the marginal artery of Drummond, which also commonly serves collateral circulation to maintain perfusion of the left colic artery.[6]

This case adds to the scant body of literature describing the rare scenario in which the entire visceral circulation depends entirely on the IMA.[1–3,7–10] Commonly noted reasons for preclusion of open revascularisation of the coeliac trunk and SMA include adhesions due to prior surgery, alterations in bowel anatomy due to resections, and calcific occlusions.[7–9] Most descriptions of IMA revascularisation are open surgical cases either by bypass grafting or endarterectomy.[4,8,11] This case report highlights a technique for endovascular IMA revascularisation in the context of a saccular AAA and large vessel atherosclerosis.

Prior descriptions of isolated endovascular IMA revascularisation are rare and have only employed a single stent, including one report of using a Palmaz Genesis (Cordis, Miami Lakes, FL, USA).[7,9] The chimney or snorkel technique, whereby a covered stent extends from above the main aortic stent graft and into a branch vessel, is a complex endovascular technique initially used for ensuring blood flow to the renal arteries in EVAR. There are few reports describing this technique for the IMA.[1,2] One case detailed a man in his 70s with a 5.6 cm AAA and prominent lumbar arteries who underwent prophylactic embolisation of his lumbar arteries to prevent endoleak, and subsequent aortic reconstruction using self expanding stents in the IMA and a Gore Excluder (W.L. Gore, Phoenix, AZ. USA).[1] Kostiuk et al. described a case of a man in his 60s presenting with bilateral occlusive iliac disease and a 6.4 cm infrarenal AAA, which was successfully treated by aorto-uni-iliac endograft (Endurant II, Medtronic Cardiovascular, Santa Rosa, CA, USA) and two VBX stent grafts deployed into the IMA.[2] Notably, balloon expandable stents are preferred over self expanding stents, given increased precision in deployment; this is particularly important in the IMA as there is increased risk of dissection.[2]

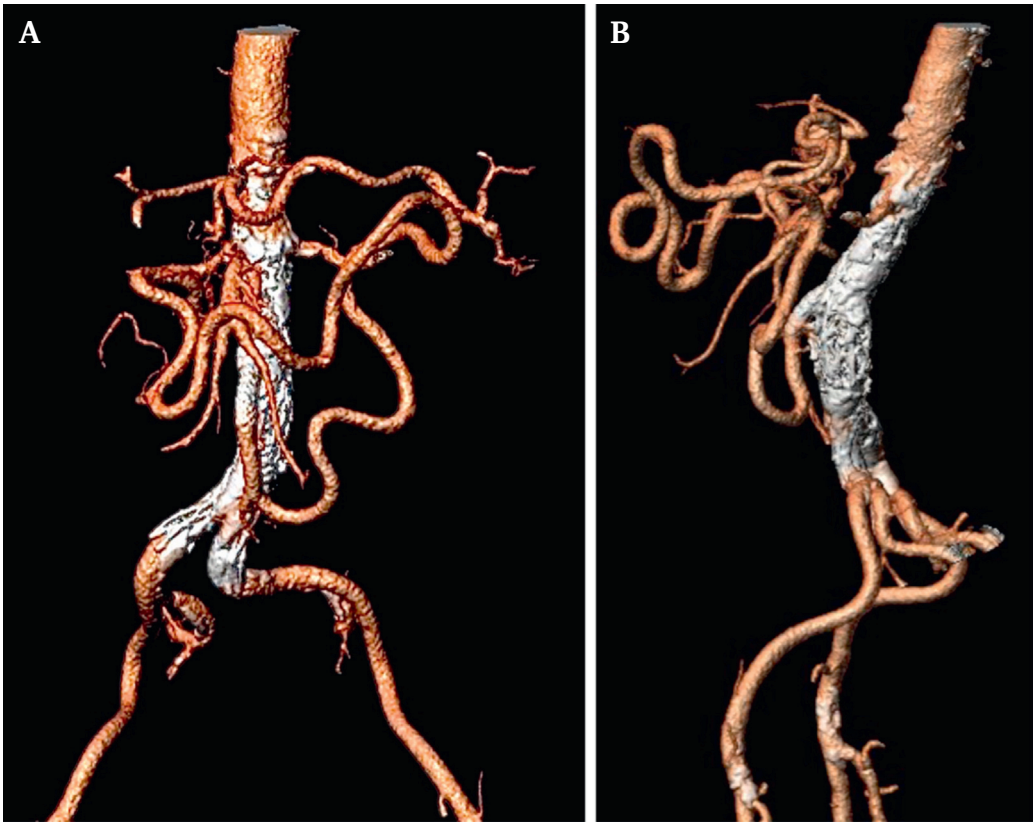

Figure 3. Three dimensional reconstruction computed tomogram at one year follow up (A) Coronal and (B) Sagittal views. There was no evidence of endoleak and the inferior mesenteric artery remained patent. At this time, the patient's aneurysm was completely thrombosed and regressed.

No prior reports have used the AFX2 body in the setting of IMA revascularisation. A separate report has previously described selective use of the AFX2.[12] This unibody bifurcated stent graft consists of a metallic endoskeleton covered by polytetrafluoroethylene fabric; it is unique in design in that it has a fixation point at the native aortic bifurcation, in contrast to most commercially available aortic stent grafts, which are modular by design with fixation only at the infrarenal neck. In this case, given the narrow aortic lumen, cannulating a contralateral gate would have been particularly challenging. Furthermore, preservation of the native aortic bifurcation decreases the risk of limb competition. This repair further added a proximal cuff to extend the proximal seal zone and decrease the potential for a gutter leak.

Other considerations in planning this case included the use of a fenestrated or physician modified stent graft. Because of the relatively low take off of the IMA in the distal aorta, in combination with the heavily calcified and narrow aortic lumen, the anatomy was prohibitive for a fenestrated design. Similar limitations have existed for construction of a modular, bifurcated physician modified graft. Modification of the AFX2 endograft is not a technique that has been described or something that the current team has previous experience with. This was an off label use of both devices, although there were limited options in this scenario. Given the unique construction of the endograft, re-sheathing the endograft would probably have been difficult. Another point of consideration was a customised aorto-uni-iliac graft with a fenestration for the IMA and a femorofemoral bypass. However, this would require an extra-anatomic bypass rather than antegrade anatomical restoration of iliofemoral flow, which is always preferable. Lastly, because of the patient's extensive comorbidities and recent myocardial infarction, open debranching and or open surgical repair were not considered to be feasible options.

Conclusion

Historically, restoration of blood supply in the mesenteric system emphasises restoration of the coeliac artery and SMA. However, in patients with extensive coeliac and SMA occlusion and favourable IMA collateralisation, endovascular stenting of the IMA is a technically feasible and effective alternative. In patients with concomitant aortic aneurysm, endovascular treatment utilising multiple graft platforms can restore in line flow throughout.

CONFLICTS OF INTEREST/FUNDING

N.N.: speaker, consultant, proctor, and Medical Advisory Board for Endologix LLC; speaker, consultant, proctor, and

medical advisory board for Medtronic Aortic, Inc.; consultant, speaker for WL, Gore, Inc.

ACKNOWLEDGEMENTS

None.

REFERENCES

1 Attisani L, Pegorer MA, Luzzani L, Cossu LG, Ferrandina C, Pucci A, et al. Inferior mesenteric artery revascularization with ChEVAR in high risk patient with bilateral occlusion of internal iliac arteries, case report and review of literature. *Ann Vasc Surg* 2022;**83**:378.
2 Kostiuk V, Mena C, Sumpio B, Guzman RJ, Ochoa Chaar CI. Endovascular aneurysm repair with inferior mesenteric artery chimney in a high-risk patient with abdominal aortic aneurysm and iliac occlusion. *J Vasc Surg Cases Innov Tech* 2022;**8**:28—31.
3 Stewart S, Tallarita T, Wendt R, Beckermann J, Swartz H, Wildenberg J. Chimney graft preservation of inferior mesenteric artery during endovascular repair of aortoiliac occlusive atherosclerotic disease. *J Vasc Interv Radiol* 2022;**33**:861—3.
4 Foley MI, Moneta GL, Abou-Zamzam Jr AM, Edwards JM, Taylor Jr LM, Yeager RA, et al. Revascularization of the superior mesenteric artery alone for treatment of intestinal ischemia. *J Vasc Surg* 2000;**32**:37—47.
5 Wang Y, Shu W, Ouyang A, Wang L, Sun Y, Liu G. The new concept of physiological "Riolan's arch" and the reconstruction mechanism of pathological Riolan's arch after high ligation of the inferior mesenteric artery by CT angiography-based small vessel imaging. *Front Physiol* 2021;**12**:641290.
6 Mann MR, Kawzowicz M, Komosa AJ, Sherer YM, Łazarz DP, Loukas M, et al. The marginal artery of Drummond revisited: a systematic review. *Transl Res Anat* 2021;**24**:10118.
7 Brandao D, Koullias GJ, Caparrelli DJ, Diethrich EB. Inferior mesenteric artery stenting: a solution for chronic mesenteric ischemia. *Perspect Vasc Surg Endovasc Ther* 2009;**21**:186—9.
8 Schneider DB, Nelken NA, Messina LM, Ehrenfeld WK. Isolated inferior mesenteric artery revascularization for chronic visceral ischemia. *J Vasc Surg* 1999;**30**:51—8.
9 Wohlauer M, Kobeiter H, Desgranges P, Becquemin JP, Cochennec F. Inferior mesenteric artery stenting as a novel treatment for chronic mesenteric ischemia in patients with an occluded superior mesenteric artery and celiac trunk. *Eur J Vasc Endovasc Surg* 2014;**27**:e21—3.
10 Chaudhuri A, Dey R. Chimney endovascular reconstruction of the aortic bifurcation (Ch-ERAB) for aorto-iliac occlusive disease allows inferior mesenteric arterial preservation. *Eur J Vasc Endovasc Surg* 2017;**54**:404.
11 Park WM, Cherry Jr KJ, Chua HK, Clark RC, Jenkins G, Harmsen WS, et al. Current results of open revascularization for chronic mesenteric ischemia: a standard for comparison. *J Vasc Surg* 2002;**35**:853—9.
12 Chen JF, Brahmandam A, Harris S, Fischer U, Nassiri N. Elucidating the role of the AFX2 endograft in endovascular treatment of aortic pathology. *Ann Vasc Surg* 2022;**86**:328—37.