

# Technique of partial open surgical stent graft explantation with preservation of fenestrated stent graft component to treat recalcitrant type II endoleak

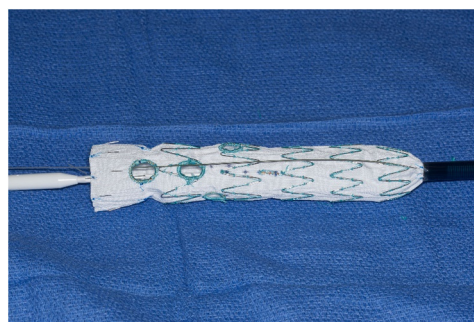
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## ABSTRACT

Fenestrated and branched stent grafts have been used with increasing frequency for endovascular repair of complex aortic aneurysms. Endoleaks are frequently encountered after endovascular aortic aneurysm repair, with treatment indicated when associated with an enlarging aneurysm sac. When endovascular treatment fails, complex open surgical explantation will become necessary. We have reported the technique of partial graft explantation in a patient with a recalcitrant type II endoleak. Both the proximal fenestrated segment and the distal iliac limbs were preserved, and aortic control was obtained by clamping the infrarenal stent graft. This method allowed for more distal aortic cross-clamping and negated the need for visceral branch reimplantation. (*J Vasc Surg Cases Innov Tech* 2022;8:500-4.)

**Keywords:** Abdominal aortic aneurysm; Endoleak; FB-EVAR; Graft explant

Endovascular repair of complex aortic aneurysms using fenestrated and branched stent grafts (FB-EVAR) has been established as a safe alternative to open repair.<sup>1,2</sup> Despite advances in device design and technology, the incidence of endoleaks still warrants long-term surveillance and has continued to be a frequent indication for secondary intervention.<sup>3,4</sup> With appropriate patient and device selection, type I or III endoleaks will be infrequent; however, type II endoleaks (T2ELs) will occur in  $\leq 40\%$  of patients.<sup>5</sup> The clinical practice guidelines have recommended treatment for patients with 5-mm aneurysm sac enlargement, symptoms, or rupture.<sup>3</sup> Although endovascular approaches with sac embolization are used as first-line treatment, disappointing results have often been achieved for patients with diffuse T2ELs.<sup>6-8</sup> In these patients, partial or complete endograft explantation can be recommended.<sup>9-11</sup> We have reported a technique of partial graft explantation with preservation of the fenestrated segment for a patient with a recalcitrant, diffuse T2EL after multiple endovascular embolization



**Fig 1.** Physician-modified endograft (PMEG) with celiac artery, superior mesenteric artery (SMA), and bilateral renal artery fenestrations.

procedures. The patient provided written informed consent for the report of his case details and imaging studies.

## CASE REPORT

A 77-year-old man had been treated for a 6.2-cm pararenal abdominal aortic aneurysm with a physician-modified endovascular graft (PMEG; Fig 1) 5 years before presentation. The PMEG was designed with four fenestrations for the celiac artery, superior mesenteric artery (SMA), and bilateral renal arteries, as previously reported.<sup>12-15</sup> At 16 months of follow-up, computed tomography angiography (CTA) demonstrated a type IIb endoleak emanating from a lumbar artery with progressive sac enlargement to 7.2 cm (Fig 2, A). A first reintervention had involved right transfemoral arterial access into the right L4 lumbar artery via internal iliac collateral arteries. Contrast-enhanced imaging demonstrated a large T2EL communicating with both right and left L4 lumbar arteries. No type I or III leaks were identified. The perigraft flow channel was then filled with Onyx 18 (Medtronic, Dublin, Ireland), with extrusion into the

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Author conflict of interest: none.

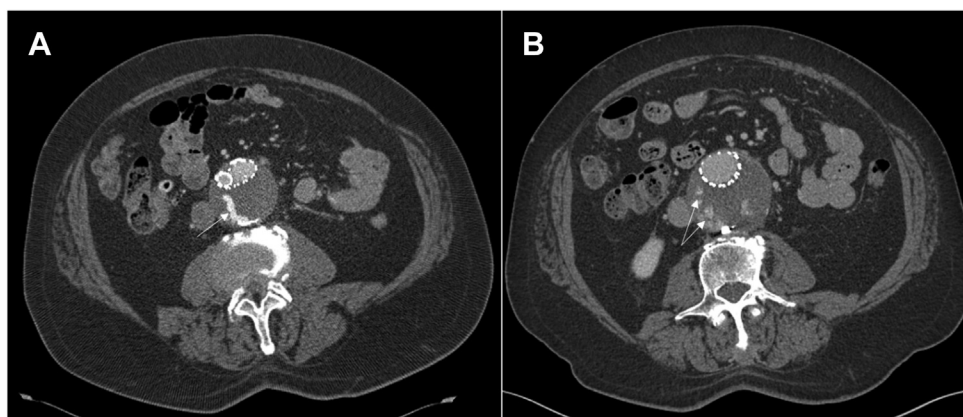
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2468-4287

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<https://doi.org/10.1016/j.jvscit.2022.05.020>



**Fig 2.** Computed tomography angiography (CTA) demonstrating an endoleak. **A**, Delayed phase showing a visible type IIb endoleak emanating from lumbar arteries identified 16 months after index PMEG (arrow). Note the enlarged aneurysm sac diameter. **B**, Follow-up CTA after initial transarterial lumbar artery embolization demonstrating a persistent “Swiss-cheese” type IIb endoleak morphology with continued aneurysm sac expansion to 8.2 cm (arrows).

lumbar arcade and middle sacral artery. Completion imaging showing no further opacification of the T2EL.

Repeat CTA at 5 months after the reintervention demonstrated continued aneurysm growth to 8.2 cm, with the T2EL assuming a more diffuse, “Swiss-cheese” morphology (Fig 2, B). A second reintervention with translumbar embolization was performed using *n*-butyl cyanoacrylate glue mixed with ethiodized oil. However, within 6 months, the aneurysm had again enlarged to 8.7 cm, and translumbar embolization was repeated. The aneurysm sac had expanded again to 9.7 cm at 22 months of follow-up. Multiple CTAs had documented the absence of a type I endoleak. However, given the recalcitrant nature of the T2EL and complexity of the endoleak anatomy, it was decided to proceed with realignment of the entire infrarenal aortic component and iliac limbs of the stent graft to exclude a contributing occult type III endoleak or endotension. Abdominal aortography revealed no obvious endoleaks. Redo infrarenal endovascular repair was performed using 30- × 58-mm aortic cuff extensions (Cook Medical, Bloomington, IN) for the infrarenal aorta and 13-mm bilateral iliac limb extensions (Cook Medical).

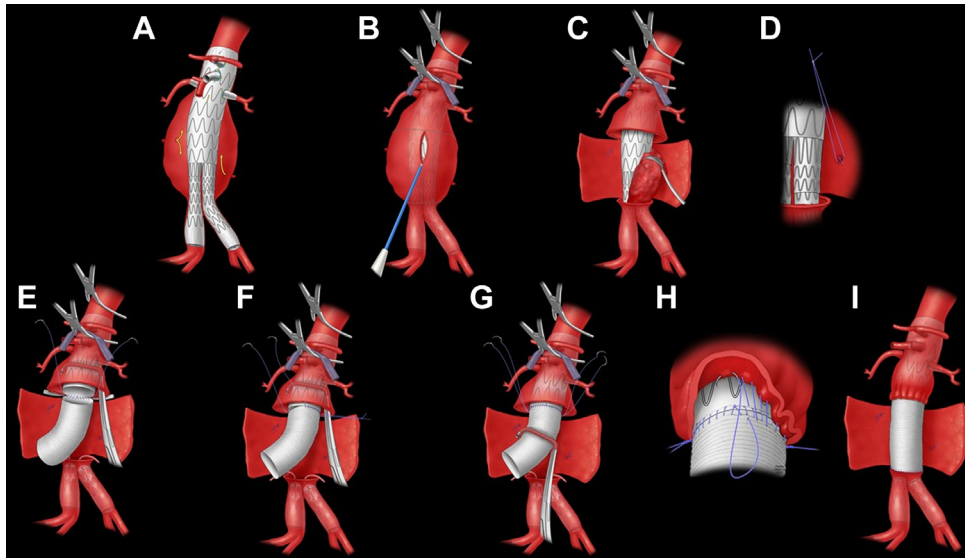
However, no resolution of the T2EL had occurred and persistent aneurysm sac enlargement to 10 cm was present at 50 months after the initial repair. No evidence was found of a type I or III endoleak using CTA in multiple phases, duplex ultrasound, and arteriography. Partial stent graft explantation with preservation of the fenestrated stent graft component and infrarenal aneurysm repair was recommended.

## PROCEDURE

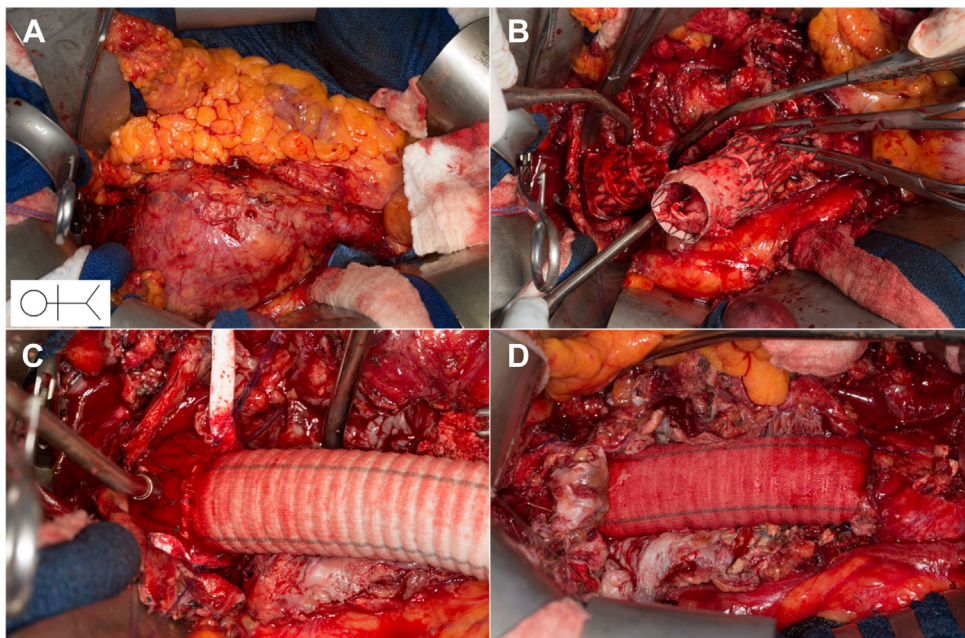
The technical steps of the procedure have been summarized in the [Supplementary Video](#). A midline transperitoneal laparotomy was performed, and the supraceliac aorta, renal arteries, and SMA were exposed and prepared for clamping. The clamps were positioned on the supraceliac aorta but not applied (Figs 3, B and 4,

A). The infrarenal aneurysm sac was opened longitudinally without aortic cross-clamping, confirming the absence of a type I or III endoleak. With the sac open, the stent graft was skeletonized, removing the aortic thrombus and embolic material (Fig 3, C). Diffuse oozing from the aneurysm wall was noted that was emanating from at least one pair of lumbar arteries. These were identified and ligated with 4-0 polypropylene suture (Fig 3, D). The infrarenal aorta immediately below the renal arteries was mobilized circumferentially for ~4 cm. A padded C-shape clamp was applied to the infrarenal portion of the fenestrated graft without dislodging the renal stents. The distal infrarenal stent graft component was divided and explanted (Fig 4, B), preserving the iliac limbs, which were controlled with Fogarty balloon occlusion catheters. A 24-mm polyester graft was anastomosed end to end to the proximal fenestrated component, incorporating the remnant of the posterior infrarenal aortic wall and a felt strip from the 3- and 9-o'clock positions (Fig 3, E). Anteriorly, the first suture line included the stent graft and the polyester graft. The clamp was subsequently transferred to the polyester graft (Figs 3, F and G, and 4, C). A second anterior suture line was then completed to incorporate the anterior aortic wall into the stent graft and polyester graft (Fig 3, H). The distal repair was completed in an aortic–aortic fashion, preserving the iliac limbs of the stent graft (Figs 3, I, 4, D, and 5).

On completion of the anastomosis, the small bowel and sigmoid colon appeared ischemic. A Doppler signal in the SMA was present but suboptimal. Thus, the SMA was dissected out and retrograde access obtained, and a 45-mm, 7F sheath was advanced into the vessel. The PMEG SMA stent had been compressed by the retractor paddles. The SMA compression was restented with a 7 × 22 covered stent. A completion angiogram



**Fig 3.** Schematic diagram illustrating steps to endograft explantation. **A**, Configuration of fenestrated-branched (FB) endograft with type IIb endoleaks emanating from lumbar arteries. **B**, Supraceliac and suprarenal aortic clamps were positioned but not applied, and the aneurysm sac was opened sharply with electrocautery. **C**, Removal of aortic thrombus and skeletonization of the infrarenal stent graft. **D**, Ligation of lumbar artery feeding the type IIb endoleak. **E**, End of the remnant of the posterior infrarenal aortic wall and a felt strip from the 3- and 9-o'clock positions. **F**, Completion of first suture line of the anterior part of the anastomosis. **G**, Completed posterior and first suture line of the anterior layers of the proximal anastomosis. **H**, Second anterior suture line completed incorporating the anterior aortic wall into the stent graft and polyester graft layer. **I**, New polyester graft position after completion of proximal and distal anastomoses. The visceral fenestrated branches and bilateral iliac branches of the stent graft were preserved.



**Fig 4.** Intraoperative photographs, with patient's head to the left. **A**, Exposed, unopened aneurysm sac, with suprarenal aortic clamp positioned but not applied. **B**, C-shape clamp applied to infrarenal portion of fenestrated graft, with distal infrarenal stent graft divided. **C**, First layer of anterior suture line completed, anastomosing the stent graft and new polyester graft. **D**, Completed proximal and distal anastomoses with preservation of bilateral common iliac limbs of stent graft.



**Fig 5.** Reconstructed computed tomography angiogram demonstrating completed repair with proximal and distal endograft in situ.

confirmed resolution of the SMA compression and good distal flow. Temporary abdominal closure was performed, with an overnight intensive care unit admission because of temporary mesenteric ischemia. On postoperative day 1, the patient returned to the operating room. The bowel was well perfused; thus, definitive closure was performed. The patient was discharged home on postoperative day 6. At 4 years after the partial graft explant, the patient was alive without any aortic-related complications. His most recent imaging studies demonstrated the infrarenal aortic graft was well incorporated, with no evidence of aneurysm or sac enlargement.

## DISCUSSION

T2ELs are often identified after EVAR and will develop in 15% to 40% of patients.<sup>16,17</sup> The treatment of T2ELs has remained controversial because of the relative benign course. Nonetheless, continued aneurysm sac expansion has been recognized as an indication for intervention owing to the theoretical increased risk of aneurysm rupture and the potential compromise in the aneurysm seal with progressive enlargement of the aneurysm sac and device migration.<sup>16,18-20</sup> Treatment will usually be performed endovascularly using transfemoral, translumbar, or transcaval embolization.<sup>7,21</sup> Conversion to an open procedure will be reserved for cases

recalcitrant to endovascular modalities.<sup>22</sup> The proposed mechanisms of endovascular treatment failure include persistent flow through the embolization coils, the development of a complex endoleak with both inflow and outflow channels forming a retiform “Swiss-cheese” endoleak, and new endoleak development.<sup>6,23</sup> Graft explantation has been performed, on average, 30 to 40 months after EVAR, with an endoleak the most common indication, present in  $\leq 30\%$  of explantations.<sup>10,11</sup> Graft explantation is not a benign undertaking. A 30-day mortality rate of 17% has been reported for elective explantation, increasing to 37% and 56% for emergent and ruptured cases, respectively.<sup>11</sup> Even in the setting of infrarenal EVAR, supraceliac or suprarenal clamping will usually be necessary for control above the proximal fixation site of the graft,<sup>24,25</sup> and grafts with more extensive suprarenal fixation will require longer aortic cross-clamp times.<sup>25</sup> Open conversion in the setting of FB-EVAR will add a layer of complexity owing to the extensive graft coverage, because supraceliac clamping, visceral branch reimplantation, and bilateral iliac artery anastomoses will usually be required.

Several techniques for complete or partial EVAR graft preservation have been described.<sup>26</sup> One option for a well-defined T2EL is opening the aneurysm sac and oversewing the feeding lumbar arteries, followed by sac closure over the preserved endograft.<sup>26</sup> The benefits of such a technique are that the graft is left undisturbed and avoids the morbidity of aortic cross-clamping, dissecting out the partially incorporated graft from the aneurysm sac, and performing two or more anastomoses. For our patient, this approach was not pursued owing to the complex morphology of the T2EL, the size of the aneurysm sac, the repeated failure of the endovascular interventions, and in accordance with patient preference. The decision was made to perform a more aggressive resection of the entire infrarenal aortic stent graft segment to ensure a higher likelihood of definitive therapy.

Partial endograft preservation in the setting of aortobiiliac grafts with anastomosis to the proximal aortic stent graft and distal iliac stent branches has been reported.<sup>27,28</sup> The technique we have described uses a similar approach in the setting of a more complex aneurysm and endograft. A fundamental requirement for using the technique we have described is stability of the fenestrated segment, without the presence of a type I or III endoleak, and with a minimally enlarged aorta around the renal and mesenteric vessels. Although this approach will not always be feasible, it offers several advantages compared with total FB-EVAR explantation or conversion to open thoracoabdominal aortic aneurysm repair. First, with the open exposure, the presence of a type I endoleak can be excluded, which will justify the decision to preserve the proximal graft in the setting of an intact graft to a native aorta seal. Preserving the

proximal graft enabled us to use it as a clamp site and avoid supraceliac and suprarenal clamping, which are independent risk factors for mortality.<sup>29</sup> Second, preserving both the proximal and the distal portions of the FB-EVAR reduced the number of anastomoses and branch reimplantation required during open repair, shortening the operative time. It is important to consider the retractor placement in patients undergoing FB-EVAR owing to the risk of branch stent compression and subsequent distal ischemia. Prompt recognition of this is important to avoid potentially devastating mesenteric or renal ischemia.

## CONCLUSIONS

The presence of a persistent T2EL with concomitant aneurysm sac enlargement justifies the use of aggressive treatment. In the setting of multiple failed endovascular treatments, an open approach is acceptable. In the absence of a type Ia endoleak, preservation of the proximal endograft in the setting of FB-EVAR will allow for more distal aortic cross-clamping and negate need for visceral branch reimplantation.

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Submitted Jan 21, 2022; accepted May 9, 2022.