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Technical Note

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Technical Approach to Rescuing a Previous Physician-Modified Endovascular Graft with a New Physician-Modified Endovascular Graft

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Abstract

Purpose: To demonstrate the feasibility of the physician-modified endovascular graft (PMEG) technique in acute aorta disease, even in cases with a previous PMEG requiring a new repair. **Technique:** A 77-year-old man presented with an infectious native aortic aneurysm (INAA), which was treated with a PMEG containing fenestrations for the renal arteries and superior mesenteric artery (SMA). After 4 months, a new infectious aneurysm developed at the right renal hilum, which was treated by occluding the right renal artery with a vascular plug. At the 1-year follow-up, computerized tomography angiography (CTA) demonstrated a new suspected INAA at the level of the celiac trunk, just proximal to the previous PMEG. A new PMEG with fenestrations for the left renal artery and SMA was deployed within the previous PMEG, followed by a proximal extension of the PMEG with a thoracic stent graft. Completion angiography and CTA follow-up at 1 month showed successful exclusion of the aneurysm. **Conclusion:** Treatment with a PMEG may provide an endovascular solution for patients requiring urgent aneurysm repair even after a previous PMEG. This case also highlights the importance of anticipating a future proximal extension when planning a PMEG

Clinical Impact

This article demonstrates the use of a physician-modified endovascular graft (PMEG) to reline and proximally extend a previously implanted PMEG requiring urgent repair. Although technically challenging, this approach provides a safe and effective endovascular solution for patients with a previous fenestrated endograft requiring urgent repair, thereby avoiding the need for open surgery. This case underscores the benefit of PMEGs to the vascular surgeon's armamentarium and emphasizes the importance of anticipating future reinterventions during primary procedures

Keywords

abdominal aortic aneurysm, endovascular aneurysm repair, fenestrated stent graft, mycotic aneurysm, off-label use, emergent procedure

Introduction

Endovascular aortic repair (EVAR) is the primary treatment option for infrarenal abdominal aortic aneurysms (AAAs).[1] For complex AAAs that involve the visceral arteries, fenestrations or branches are necessary for the graft design.[2] The position of the fenestrations in the endograft depends on the patient-specific anatomy. The waiting time for custom-made fenestrated endografts is usually several weeks to months, limiting their use in urgent settings. Alternatively, a physician-modified endovascular graft (PMEG) can be used, where the surgeon manually modifies an existing

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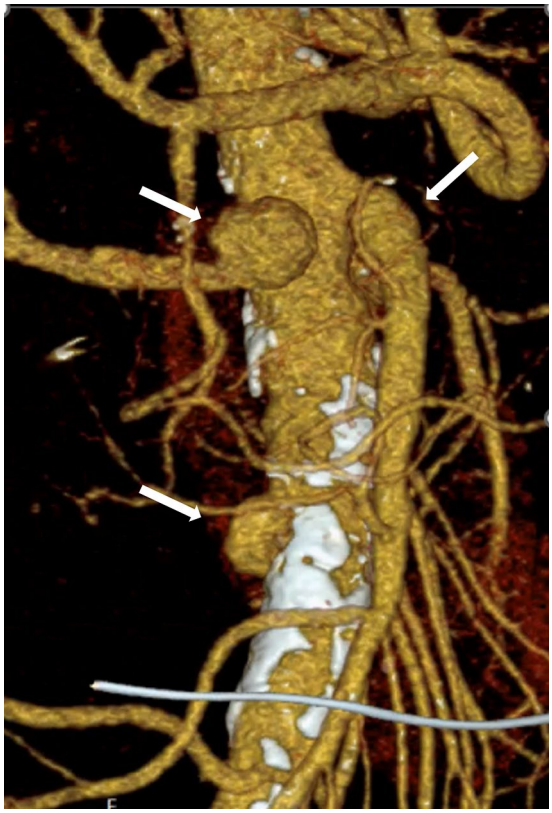

Figure 1. Three-dimensional reconstruction of preoperative computerized tomography angiography showing suspected infectious native aortic aneurysms at the right renal artery, the origin of the superior mesenteric artery, and the dorsal aspect of the infrarenal aortic wall (white arrows).

endograft to a fenestrated design. Current literature indicates that PMEG can be a safe and effective treatment option in selected cases, with stent-graft outcomes comparable to those of custom-made endograft.[3–5] This report describes the use of a PMEG for the treatment of a previous PMEG requiring urgent repair.

Technique

The patient, a 77-year-old man with a history of monoclonal gammopathy of unknown significance, hemolytic anemia, and liver cirrhosis with esophageal varices, presented with abdominal pain, an elevated erythrocyte sedimentation rate >100 mm/h, and a C-reactive protein level of 16 mg/L. Computerized tomography angiography (CTA) revealed 3 suspected infectious native aortic aneurysms (INAAs) at the dorsal infrarenal aortic wall, the right renal artery (RRA) origin, and the superior mesenteric artery (SMA) origin, respectively (Figure 1). The case was discussed by a multidisciplinary team (consisting of a vascular surgeon, anaesthesiologist, radiologist, and infectious disease specialist), and aortic repair to exclude the INAAs was recommended. Open surgical repair was considered high risk due to the combination of the patient's comorbidities and the INAA location at the level of the visceral arteries, which would require extensive open surgery with renovisceral revascularization. Therefore, it was decided to treat the aneurysms by endovascular means using a PMEG based on the Zenith Flex® (Cook Medical, Bloomington, IN, USA) platform.

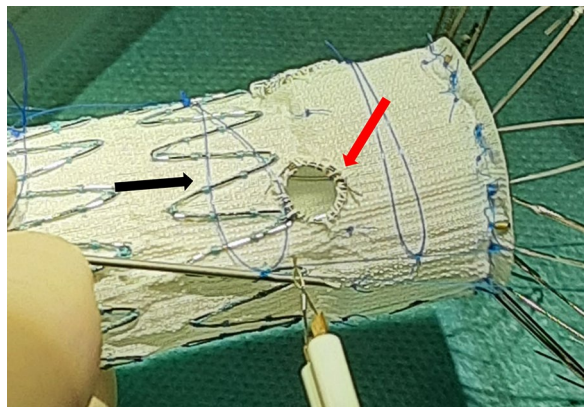

Figure 2. Zenith Flex® bifurcated stent graft with a fenestration for the left renal artery reinforced by attaching a snare around the fenestration with Gore-Tex® CV-7 (red arrow) and application of the diameter-reducing ties (black arrow).

A detailed description of constructing a PMEG has been published previously.[6] In short, constructing the PMEG involved desheathing the endograft under sterile conditions. Using a sterile 3D template, 3 fenestrations were created using a high cautery pen in the endograft for the SMA, left renal artery (LRA), and RRA. The fenestrations were reinforced with a radiopaque wire loop obtained from a snare (Multi-Snare®; Gothia Medical, Billdal, Sweden) attached around the fenestration with Gore-Tex® CV-6 suture (W.L. Gore & Associates, Flagstaff, AZ, USA) in a 720° running fashion (Figure 2). The top stent trigger wire was repositioned externally along the posterior border of the device. Circular diameter-reducing ties were then added to each Z stent, using the repositioned top stent trigger wire to hold the diameter-reducing ties constrained (Figure 3). Lastly, the device was carefully resheathed into the delivery system. Femoral access was gained bilaterally. An 8 × 50 mm Viabahn® stent graft (W.L. Gore & Associates) was then deployed in the diseased RRA to create a safe landing zone for the bridging stent past the aneurysm in the origin of the artery. After angiography, the PMEG was deployed with the proximal landing zone just distal to the celiac trunk. Following catheterization of the target vessels and full deployment of the device, all target vessels were stented

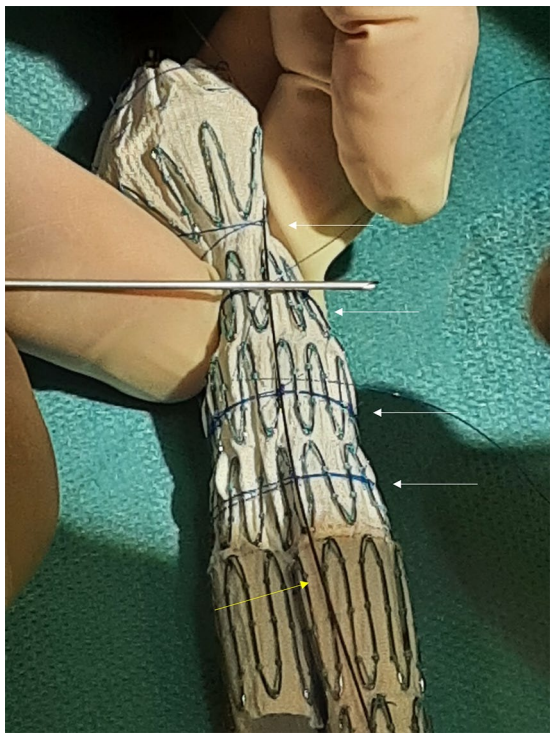

Figure 3. The top stent trigger wire (yellow arrow) is repositioned externally along the posterior border of the bifurcated stent graft to hold the diameter-reducing ties constrained (white arrows).

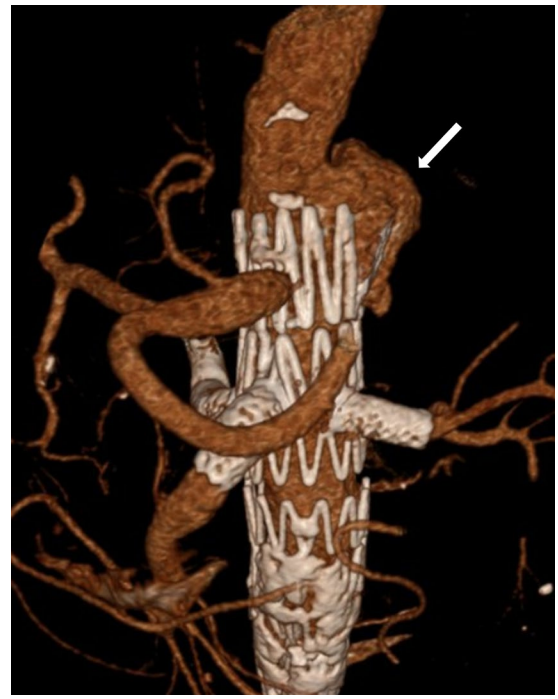

Figure 4. Computerized tomography angiography after 1 year showing a new suspected infectious native aortic aneurysm (white arrow) at the level of the celiac trunk on the dorsolateral aspect of the aortic wall. The suprarenal fixation stent of the PMEG is projecting into the aneurysm. PMEG, physician-modified endovascular graft.

with BeGraft® Peripheral balloon expandable covered stents (Bentley InnoMed, Hechingen, Germany). The limbs were extended to the common iliac artery bilaterally using standard Zenith Alpha® Spiral-Z® (Cook Medical) EVAR limbs. Due to a narrow segment in the distal aorta, both limbs required reinforcement with Lifestream™ (Bard Peripheral Vascular, Tempe, AZ, USA) balloon expandable covered stents. Completion angiography and cone beam computerized tomography (CBCT) revealed technical success without endoleak and patent target vessels.

Unfortunately, the follow-up was not uneventful. After 4 months, abdominal pain recurred, and subsequent CTA showed a new INAA in the hilum of the right kidney. Prompt reintervention was carried out by successful occlusion of the RRA with an Amplatzer® Vascular Plug (Abbott Vascular, Redwood City, CA, USA). Furthermore, the CTA at 1-year follow-up revealed a new suspected INAA aneurysmal formation at the level of the celiac trunk and the bare proximal stent of the previous PMEG (Figure 4). Due to the lack of available adequate sealing length in the PMEG for a proximal extension using a standard thoracic endograft, it was decided to perform a complete relining with proximal extension. For this purpose, a second PMEG was constructed from a Zenith Flex, this time with fenestrations for both SMA and LRA. The fenestrations were placed at least 2 Z stents below the proximal edge of the stent graft, allowing for enough length for a proximal extension. No fenestration for the celiac trunk was made. As the proximal struts of the previous Zenith Flex PMEG were judged to hinder access to the celiac trunk with a bridging stent graft, and sufficient collateral circulation via the SMA was observed on the preoperative CTA, it was decided to occlude the celiac trunk.

The second PMEG procedure was done through a bilateral femoral approach. First, the celiac trunk was occluded using an Amplatzer vascular plug. Access to the in-situ bridging stents for the SMA and LRA was then gained, and the bridging stents were flared to a larger diameter to facilitate access during the placement of the new PMEG. The new PMEG was introduced and deployed to the diameter-reducing ties. After careful orientation and catheterization of the SMA and LRA, the diameter-reducing ties were released (Figure 5A and B). The PMEG was then extended proximally with a Conformable TAG® thoracic endograft (W.L. Gore & Associates). Expansion and apposition of the stent grafts were achieved using a molding balloon (TriLobe; W.L. Gore & Associates, Figure 5C). Subsequently,

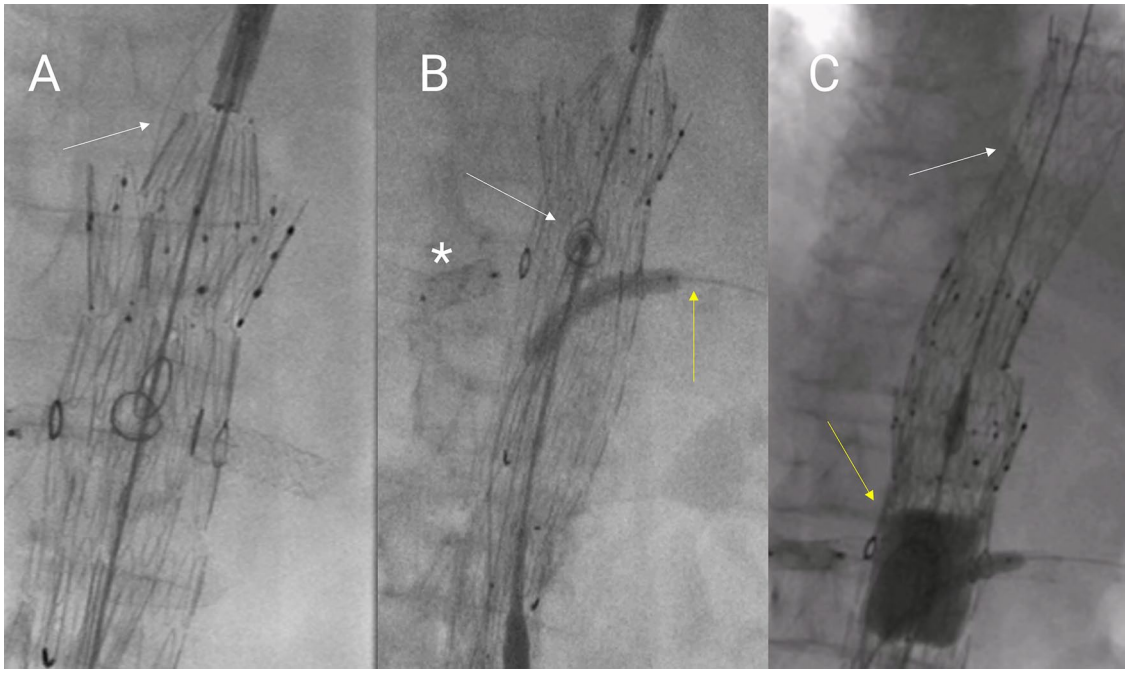

Figure 5. (A) The new PMEG is positioned and deployed to the reduced diameter inside the previous PMEG. The diameter-reducing ties trigger wire is still in place (white arrow) constraining the stent graft to allow adjustment of the positioning. (B) The target vessels (SMA white arrow; LRA yellow arrow) are catharized and the diameter-reducing ties released. The previously placed plug in the RRA is also visible (asterisk). (C) The new PMEG is extended proximally with a standard thoracic endograft (white arrow) and all overlap zones are remodeled using a Tri-lobe balloon while protecting the target vessels with PTA balloons (yellow arrow). LRA, left renal artery; PMEG, physician-modified endovascular graft; RRA, right renal artery; SMA, superior mesenteric artery.

the previous SMA stent was completely relined with a 10×37 mm BeGraft Peripheral covered stent, which was extended centrally with a 10×27 mm BeGraft Peripheral covered stent to achieve sufficient protrusion through the fenestration into the second PMEG lumen. The LRA was relined with an 8×27 mm BeGraft Peripheral covered stent (Figure 6). The ipsilateral and contralateral limbs were extended with a 12×39 mm BeGraft Aortic® and a 12×59 mm BeGraft aortic-covered stent, respectively, to achieve a seal within the reinforced previous PMEG limbs. BeGraft aortic-covered stents were used as bridging limbs to reduce the risk of compression of one of the limbs due to limited space. Completion angiography and intraoperative CBCT showed no endoleak and patent target vessels. Total procedure time was 241 minutes (excluding the modification of the graft), fluoroscopy time was 93 minutes, and 130 mL of contrast agent was used. The postoperative CTA at 1- and 6-month follow-up showed a patent SMA and LRA, and no signs of endoleak (Figure 7). Lifelong antibiotic therapy was initiated for the patient. Prior to the first PMEG, the patient was put on single antiplatelet therapy (aspirin 80 mg daily), which was left unaltered after both procedures. The patient died 7 months after the second PMEG procedure due to cerebral hemorrhage.

Discussion

Current European Society of Vascular Surgery (ESVS) guidelines recommend that proximal failure of a standard EVAR should preferably be addressed by endovascular means.[7] In fenestrated devices, proximal failure is an uncommon event that poses a significant challenge to manage, especially in the absence of a landing zone for proximal extension with a standard TEVAR.[8] Successful treatment of a failed custom-made fenestrated endograft with another custom-made fenestrated endograft has been previously described.[9,10] Although technically challenging, this procedure has shown promising results in multiple aortic centers.[11,12] However, these reports focus exclusively on custom-made endografts, the use of which is limited in urgent cases due to the construction time. In this report, the successful use of a second PMEG to treat a recurrent INAA in a patient with a previous PMEG is described for the first time, extending the range of

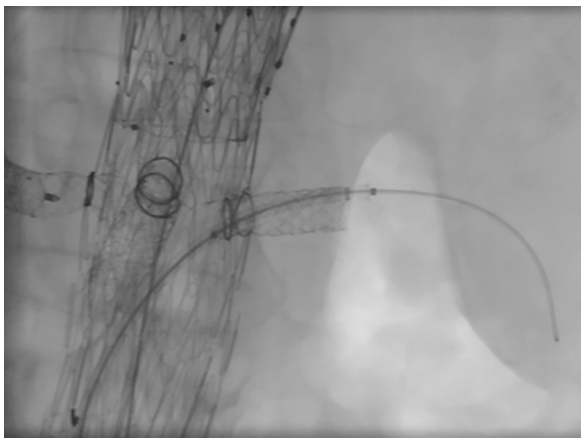

Figure 6. Intraoperative image after placement of the new PMEG in a previous PMEG and deploying bridging stent graft into the SMA and LRA. LRA, left renal artery; PMEG, physician-modified endovascular graft; SMA, superior mesenteric artery.

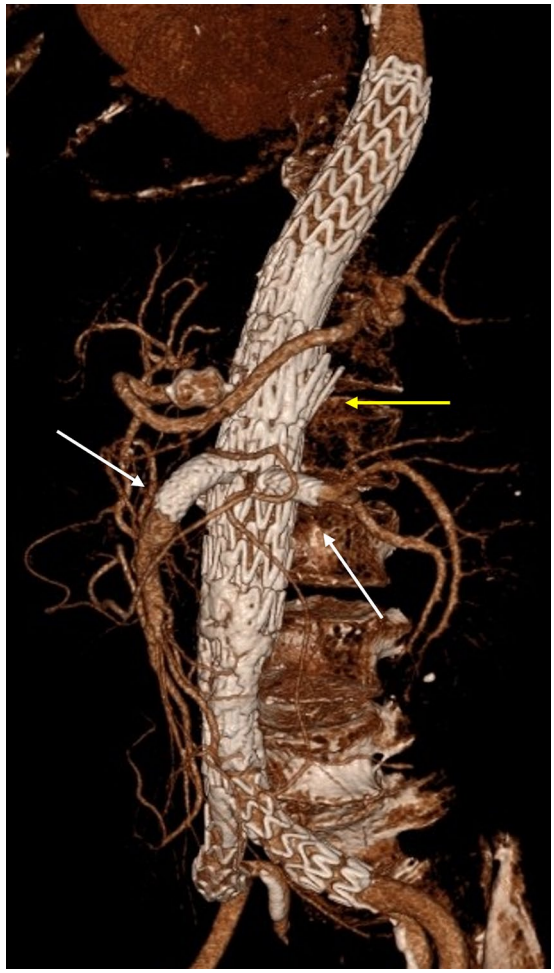

Figure 7. Three-dimensional reconstruction of postoperative computerized tomography angiography after the PMEG in PMEG procedure showing successful exclusion of the new aneurysm (yellow arrow) and patent target vessels (white arrows). PMEG, physician-modified endovascular graft.

patients who can potentially benefit from endovascular surgery.

For INAAs, the choice between open surgery and endovascular repair is usually made on a patient-specific basis.[13] Current ESVS guidelines also recommend an individualized approach to INAA treatment and suggest that endovascular repair is an acceptable alternative the open repair.[7] Open surgery was deemed high risk for this patient, given the comorbidities and the location of the INAA at the level of the visceral arteries; additionally, there would have been the need to explant the fenestrated device for the recurrent INAA. Due to the generally acute nature of INAAs, the use of custom-made endografts is often not feasible given the required waiting time of several weeks. For complex aneurysms at risk for rupture, chimney grafts can be considered to incorporate the visceral arteries but carry the drawback of potential gutter endoleaks.[14] Ultimately, a relining with a new fenestrated PMEG was performed to circumvent these drawbacks.

The Zenith Flex was used for its relative ease of deployment, modification, and resheathing with the proximal barbs still attached, unlike, for instance, the Zenith Alpha (Cook Medical), which requires the removal of the proximal barbs to resheath the endograft. Following the initial PMEG, the distance from the lowest fenestration to the flow divider was measured at 6.7 cm. This distance would have allowed sufficient sealing of a physician-modified straight endograft in the previous PMEG. However, there is a risk of a subsequent type 3a endoleak necessitating the placement of an inverted limb device due to inadequate space for a standard bifurcated device. To mitigate this risk and draw on the extensive experience with PMEGs constructed on a bifurcated platform at the treatment center, a complete relining with the Zenith Flex was performed.

INAAs are at risk for infection-related complications, including recurrent INAAs.[13] In retrospect, the PMEG from the primary procedure should have included a fenestration for the celiac trunk. Extending the sealing zone to above the celiac trunk level would have reduced the risk of proximal failure. Moreover, by positioning the sealing zone 1.5 to 2 stent lengths above the celiac trunk, a subsequent proximal failure could have been addressed with a standard thoracic endograft. Therefore, anticipating the potential need for reintervention during the initial PMEG procedure and leaving sufficient length for a proximal extension could have averted the need for more extensive surgery. Alternatively, a PMEG using a standard thoracic endograft [eg, Zenith®

TX2® Dissection stent graft (Cook Medical) or Relay Plus® (Terumo Aortic; Vascutek Ltd, Inchinnan, UK)] could have been used in the primary procedure to achieve a longer proximal sealing zone. However, increasing the length of aortic coverage should be balanced against the potential increased risk of spinal cord injury.

Fenestrated/branched off-the-shelf devices provide a prefabricated alternative to PMEGs in urgent cases. However, not every patient's anatomy is eligible for these devices.[15] In this case, the narrow diameter of the renovisceral segment was not suitable for the off-the-shelf options available at the treatment center. Therefore, PMEGs remain a valuable addition to the vascular surgeon's armamentarium for managing complex AAA cases.

Conclusion

A PMEG may be used safely and effectively to manage a previous PMEG in select urgent cases. This approach extends the range of patients who may benefit from endovascular surgery, particularly when dealing with AAAs requiring imminent repair. During primary PMEG procedures, emphasis should be placed on selecting a sealing zone that minimizes the risk of failure and allows for easy proximal extension to anticipate potential future reinterventions.

Declaration of Conflicting Interests

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