Back Table Modification of Bifurcated Endurant Stent Graft to Aorto-Uni-Iliac Stent Graft to Treat Chronic Failure of Endovascular Abdominal Aortic Repair (EVAR) for Abdominal Aortic Aneurysm

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A patient who had previously undergone endovascular abdominal aortic repair (EVAR) of an abdominal aortic aneurysm was found to have aneurysmal growth 5 years after the initial EVAR and endovascular re-intervention was considered. However, the patient was deemed unsuitable for an ordinary bifurcated stent graft. Re-EVAR was successfully conducted with a back table modification of the Endurant bifurcated stent graft to an aorto-uni-iliac (AUI) stent graft in a setting where a manufactured AUI stent graft was not available; this procedure was followed by a crossover femoro-femoral bypass. The patient’s one-year follow-up exam revealed a marked regression of the aneurysm without any related complications. This modified technique may extend the limits of abdominal endovascular treatment for patients who are not suitable for a bifurcated stent graft and may be applicable in situations where adequate AUI devices are not available.

Key words: Abdominal aortic aneurysm, EVAR, aorto-uni-iliac stent graft, endoleak

Introduction

Endovascular abdominal aortic repair (EVAR) is now accepted as a less invasive and effective treatment of abdominal aortic aneurysms (AAA). However, previous studies have revealed a relatively higher incidence of re-intervention after EVAR than after open surgery. Re-intervention in cases of failed EVAR may be necessary to address endoleaks and require adding of another stent graft, surgical conversion or embolization. However, the effectiveness of re-EVAR has often been limited by challenging aortic neck anatomy due to the preexisting stent grafts, including the short or angulated shape necessary to achieve a sufficient seal of the aneurysm. In the case of bifurcated modular stent grafts, the short distance between the orifices of the lower renal artery and the terminal aorta or the narrow terminal aorta is an additional limiting factor. Using an aorto-uni-iliac (AUI) stent graft followed by a cross-over femoro-femoral bypass is a concrete countermeasure to overcome these anatomical challenges. However, the availability of the AUI stent graft is limited in certain locations and countries.

Here, we report a case involving chronic failure of an EVAR for an AAA that was deemed unsuitable for an ordinary bifurcated stent graft for re-EVAR. The patient was successfully treated with an AUI stent graft modified on the back table from an Endurant bifurcated stent graft (Medtronic, Santa Rosa, CA, USA) in a setting where a manufactured AUI stent graft was not available.
Case report

Institutional review board approval was not necessary at our institution for the preparation of this report. A woman in her 80s underwent EVAR for an incidentally found saccular AAA using an I-shaped handmade stent graft (MK stent graft) [1]. During the patient’s follow-up, no endoleaks were found and shrinkage of the aneurysm was noted. However, the follow-up CT obtained 5 years after the initial EVAR revealed rapid regrowth of the saccular aneurysm protruding from the lower abdominal aorta (Fig. 1a). There were no apparent endoleaks within the sac, even on the dual phase contrast-enhanced CT. We concluded that the regrowth of the sac was due to so-called endotension of an undetermined cause, and we concluded that it required re-intervention. According to the preoperative geometrical measurement obtained using a dedicated 3D workstation (AZE, Tokyo, Japan), the handmade stent graft implanted during the previous EVAR showed poor apposition with a gap between the proximal stent and neck, and the infrarenal neck length and angle were 12 mm and 58 degrees, respectively (Fig. 1b). Furthermore, the internal lumen of the lower abdominal aorta was quite small due to the preexisting stent and aortic calcification, so that it measured 10 mm in diameter. Due to these conditions, there was no adequate stent graft available at that time in Japan to accommodate the patient’s anatomy without complication; therefore, we devised a modified bifurcated device to AUI device on the back table.

Preparation of AUI device (Fig. 2)

Based on the measurement of the patient’s vascular anatomy (18 mm in proximal diameter, 13 mm in both right and left common iliac diameter, and centerline distance of 110 and 185 mm from the lower renal artery to aortic bifurcation and to the right common iliac artery, respectively), we prepared an Endurant bifurcated stent graft (23 mm in proximal diameter, 16 mm in distal diameter, 166 mm in total length) for the base stent graft. The Endurant stent graft is loaded so tightly in the original 18-F O.D system that it is challenging for physicians to resheath the modified stent graft within the original sheath once the stent graft is fully deployed. To avoid full deployment of the stent graft during the back table modification, the leading part of the Endurant delivery sheath was temporarily covered by another 18-F sheath (Medikit, Tokyo, Japan) in a top to top fashion up to the level of the graft bifurcation (Fig. 2a). The proximal stent graft was partially deployed within the 18-F sheath to the level of contralateral gate to maintain contraction of the stent graft. Only the contralateral gate was opened and exposed from the sheaths (Fig. 2b); the 3 stent struts and radiopaque markers on the contralateral gate were removed carefully by detaching the sutures on the stent and fabric us-
ing a sharp-pointed scalpel (Fig. 2c). The root of the free contralateral conduit was then tightly ligated with 3-0 multifilament polyester string (Fig. 2d). After securing the sleeve to the ipsilateral limb, the stent graft was manually reloaded into the original Endurant delivery sheath by collapsing it with 0-1 silk suture (Fig. 2e). The entire preparation process took approximately 30 minutes on the back table.

**Procedure**

Under general anesthesia, the right external iliac artery and the left common femoral artery were surgically exposed through bilateral femoral incisions and 6-F sheaths were inserted. A 4-F 7 cm sheath was also percutaneously inserted into the right brachial artery. After systemic heparinization, a 400 cm hydrophilic guidewire (Radifocus TERUMO Tokyo, Japan) and pigtail catheter were advanced from the right brachial access to the abdominal aorta, and the guidewire was pulled out from the right femoral sheath with the aid of an Amplatz Goose Neck Snare (EV3 Endovascular, Inc. Plymouth, MN, USA) to achieve the pull-through technique. The 18-F Sheath (Sentrant Introducer Sheath, Medtronic) was then inserted into the right external iliac artery. Because the preexisting stent had an inner skeleton structure, a Reliant balloon (Medtronic, Santa Rosa, CA, USA) was inserted and inflated within the preexisting stent to confirm that the wire did not thread its way through the stent’s struts.

The AUI-ized Endurant stent graft was introduced through the right femoral sheath. The stent graft was deployed from just below the left renal artery to the distal right common iliac artery, and the graft was then dilated and aligned onto the wall of the abdominal aorta with a Reliant balloon (Medtronic, Santa Rosa, CA, USA). The left common iliac artery was occluded using a 16 mm diameter Zenith iliac plug (Cook Incorporated, Bloomington, IN, USA) via the left femoral 18-F introducer sheath. The angiogram confirmed good apposition with opening of the stent graft and without a type I endoleak (Fig. 3). A femoro-femoral bypass was added after tunneling of the lower abdominal wall, using an 8-mm ringed polyester graft (Gelsoft, VASCTEK, Japan) and pigtail catheter were advanced from the right brachial access to the abdominal aorta, and the guidewire was pulled out from the right femoral sheath with the aid of another 18-F sheath (black arrow) up the level of graft bifurcation (black arrowhead). (b) The bifurcated stent graft is partially unsheathed within the 18-F sheath and contra gate fully opens out of the sheaths. (c) Three stent struts and a radiopaque marker on the contralateral sleeve are carefully detached from the fabric. (d) Root of the contralateral sleeve is ligated by 3-0 polyester strings (white arrow) and the sleeve is secured to the ipsilateral graft by additional polyester suture (white arrowhead). (e) The modified stent graft is resheathed within the original Endurant delivery system by collapsing the stent graft by tightening with 0-1 silk sutures.

**Fig. 2.** Photographs illustrating modification of the Endurant bifurcated graft to the AUI device. (a) The leading part of the Endurant delivery sheath is temporarily covered with another 18-F sheath (black arrow) up the level of graft bifurcation (black arrowhead). (b) The bifurcated stent graft is partially unsheathed within the 18-F sheath and contra gate fully opens out of the sheaths. (c) Three stent struts and a radiopaque marker on the contralateral sleeve are carefully detached from the fabric. (d) Root of the contralateral sleeve is ligated by 3-0 polyester strings (white arrow) and the sleeve is secured to the ipsilateral graft by additional polyester suture (white arrowhead). (e) The modified stent graft is resheathed within the original Endurant delivery system by collapsing the stent graft by tightening with 0-1 silk sutures.
Scotland). The wound was closed in layers.

The patient was extubated just after surgery in the operative suite without any adverse events. The patient was discharged uneventfully on postoperative day 19 and managed as an out-patient without the use of antiplatelet or anticoagulant therapy. A CT scan acquired 1 month after the operation revealed stent graft and bypass patency without any endoleaks (Fig. 4a, b). The patient continued without any complications, and the CT obtained 1 year after the procedure showed marked aneurysmal shrinkage (Fig. 4c).

**Discussion**

This report details the endovascular fixation of a failed EVAR for AAA due to endotension using a back-table modified AUI device. This modified device allowed for a safe and simple procedure even though the patient had a complicated vascular anatomy that included a narrow terminal aorta and an angulated neck. Furthermore, the AAA shrank over time without complications during the follow-up period. The treatment options for reintervention after failure of the EVAR for AAA due to endoleaks or sac expansion include open conversion and endovascular repair. Open surgical reinterventions can be challenging due to adhesions or periaortic inflammatory changes after EVAR and, in patients with a high risk background, the reported outcomes remain unsatisfactory[2]. Endovascular reinterventions are the other predictable option to treat this condition; however, anatomical issues, such as a short aortic distance between the lower renal artery and the preexisting graft bifurcation, or a small terminal aorta often preclude the application of bifurcated stent grafts. By contrast, utilizing an AUI with a crossover femoro-femoral bypass offers a wider range of options that can accommodate more anatomical situations than bifurcated stent grafts; reinterventions using AUI devices after failed EVAR have also shown better outcomes than open conversions[3]. The greater adaptability of this approach also allows for endovascular treatment of chronic pseudoaneurysms that form at proximal anastomotic sites after Y-graft repair for AAA; such pseudoaneurysms can exhibit similar anatomical challenges to failed cases after EVAR[4]. The other non-surgical options to address this rare complication of endotension include relining of the previous stent graft[5], or adding an aortic cuff to the proximal neck, performing a di-

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**Fig. 3.** Angiographic view just after the implantation of the stent graft and an iliac plug. The modified stent graft was well accommodated to the angulated infra-renal aorta in the preexisting stent graft. The left common iliac artery is occluded by an iliac plug (arrow).

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**Fig. 4.** 3D volume rendering image (a) and axial CT images (b) at the similar level with Fig. 1a obtained at 6 months after the second EVAR shows the sealed aneurysm and patency of the crossover femoro-femoral bypass. One-year nonenhanced CT (c) shows marked regression of the aneurysm (arrows in b and c).
rect sac puncture and then aspirating the aneurysm sac or injecting it with glue[6]. However, the number of reported cases using these alternatives are limited; therefore, it remains controversial whether it is better to treat endotension with surgical conversion or endovascular treatment.

One possible treatment option for this patient’s particular vascular anatomy could have been the application of a Zenith AUI device (Cook Incorporated, Bloomington, IN, USA), but a dedicated AUI device was not yet available in Japan. Another approach to address the patient’s narrow terminal aorta could have been using the kissing balloon technique with balloon expandable stents, after the application of an ordinary bifurcated stent graft or a unibody bifurcated stent graft (Powerlink system or AXF system, Endologix, Inc. Irvine, CA, USA). However, in this patient the inner diameter of the terminal aorta was only 10 mm and that precluded this approach because of the potential risk of graft collapse or limb occlusion[7].

According to the manufacturer’s instructions, the Endurant stent graft system demands at least 10 mm of sealing length with a neck angle less than 60 degrees. The utility and durability of the AUI system are similar to that of a bifurcated graft and thus the AUI device is a viable option as a tool for re-intervention[8] or in cases when there are contraindications to a bifurcated stent. While the Endurant AUI has recently become available in a number of countries, it was not approved for use in Japan at the time of this procedure, whereas the Endurant bifurcated stent graft was. Thus, given an infrarenal neck 12 mm in length that was angulated 58 degrees and associated with a misaligned preexisting stent graft, we opted to employ the Endurant stent graft for the base design of a physician-modified AUI system to achieve a secure seal.

AUI devices offer broader adaptability to various anatomical challenges, and also enable quicker implantation of the stent graft than bifurcated devices because they do not require additional cannulation of the contralateral gate. Thus, adaptation of the AUI to treat a ruptured AAA is also a good option[9]. Furthermore, to achieve a hemostatic seal, the Endurant AUI or Zenith AUI stent graft device often require two pieces to cover the distance from the aorta to the external iliac artery. Our modified AUI device requires only 30 minutes of back table modification to be ready and can potentially create a hemostatic seal with a 1 piece graft with proper selection of the length and sealing size of the base bifurcated stent graft, which may add to the benefit of this technique in emergency situations.

There are limitations of this procedure that need to be considered. Even in this technique, at least 10 mm of sealing area is needed to achieve a sufficient seal of the aneurysm. Without an adequate seal, other possible solutions are a fenestrated stent graft or a hybrid approach with debranching of the visceral arteries for an upper proximal seal. Otherwise, surgical reconstruction should be advocated. The long-term durability of this technique has not been confirmed, and thus the patient should be monitored carefully.

The manufactured, two-piece Endurant AUI device has recently become available in our district, and physicians should use this device in elective cases. Nevertheless, this technique remains useful for emergency situations or where a dedicated AUI stent graft is not available. The AUI has the inherent additional risks associated with a cross-over bypass, including graft thrombosis, infection and pseudoaneurysm formation; however, to date, the mid-term results are similar between the manufactured AUI and the bifurcated device[10].

Conclusion

An AAA after failure of EVAR was successfully treated using an AUI device that was modified from an Endurant bifurcated device, followed by a cross-over femoro-femoral bypass, despite the patient’s complicated anatomy.

Our limited experience indicates that this technique may be an option in any situation where an AUI device is necessary but not available. Thus, this technique has the potential to broaden endovascular management for the treatment of AAA.

Conflict of interest: The authors declare that they have no conflicts of interest to report.

References
