

Novel Technique for the Treatment of Type Ia Endoleak After Endovascular Abdominal Aortic Aneurysm Repair

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Abstract

Purpose: Open surgical repair of type Ia endoleak after endovascular aortic aneurysm repair/sealing (EVAR/EVAS) is associated with significant perioperative mortality and morbidity. Current endovascular redo techniques face limitations, especially when the infrarenal landing zone is inadequate and the previous endograft is rigid and features a short or no main body. We present a novel concept for the treatment of type Ia endoleak using a custom-made branched device. **Technique:** The 5-branch-device (Cook Medical, Bloomington, IN, USA) consists of a nitinol skeleton with branches, covered with a low-profile polyester fabric loaded in an 18F sheath. The device features a minimum of 2 proximal sealing stents and includes branches for renovisceral vessels as well as an additional 8 mm branch for the contralateral iliac limb. Implantation and sealing in the renovisceral vessels is carried out in standard fashion, using transfemoral and transaxillary access. Distal sealing is achieved by tapering the branched component into the ipsilateral iliac limb and using a bridging balloon-expandable or self-expandable stent-graft through the additional branch to the preexisting contralateral iliac limb. **Conclusion:** Treatment of type Ia endoleak with a new custom-made device enables sufficient proximal seal while minimizing suprarenal aortic coverage and facilitates adequate component overlap. The low profile branched design accommodates implantation through the preexisting endograft and catheterization of target vessels.

Keywords

type Ia endoleak, bEVAR, EVAR, EVAS, additional branch, custom-made device

Introduction

Treatment of type Ia endoleak after endovascular aneurysm repair/sealing (EVAR/EVAS) constitutes a challenging clinical scenario. Open surgical repair generally requires suprarenal clamping, may be technically challenging and associated with significant morbidity and mortality rates, especially in patients primarily deemed unfit for conventional open repair.^{1,2} Alternatively, a number of endovascular techniques have been reported, including balloon angioplasty, implantation of bare metal stents in the proximal sealing zone or deployment of covered extension cuffs and application of endoanchors.^{3,4} A frequent problem encountered during these procedures, however, is the insufficient proximal sealing zone.³ Other endovascular options for management of type Ia endoleaks, with still uncertain long-term durability include embolization using coils, glue (*n*-butyl cyanoacrylate), or liquid embolic agents such as Onyx.^{5–7} Further endovascular methods include chimney grafts and fenestrated or branched endografting (fEVAR/

bEVAR).^{8,9} Chimney grafts may lead to gutter-related endoleaks.¹⁰ A frequent technical problem encountered during fEVAR is the insufficient seal in the previous stent-graft and the lack of working length required for complete relining with a fenestrated cuff and bifurcation device especially with devices featuring a short or no main body.¹¹ On the other hand, branched stent-grafts usually require extensive coverage of the thoracic aorta, increasing the risk of spinal cord ischemia.¹²

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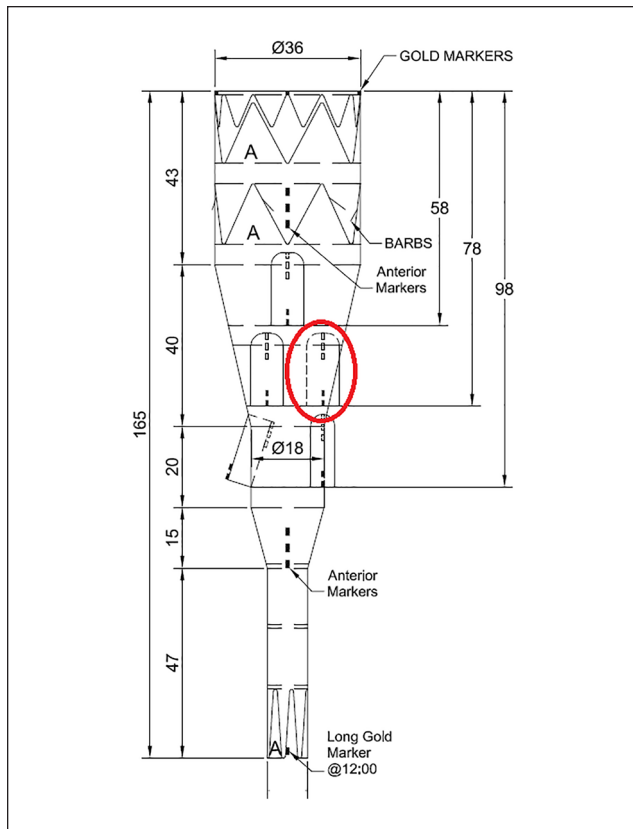


Figure 1. Plan of a tapered, custom-made, low-profile branched device featuring an additional posterior branch (red marking) used for sealing in the contralateral iliac limb.

Technique

Aim

The goal of endovascular treatment of type Ia endoleak following standard EVAR is to achieve a secure seal both proximally in the native aorta as well as distally in the pre-existing endograft. When an extension of the landing zone suprarenally is required, the aim should be to seal in a healthy aortic segment while preserving renomesenterial perfusion and as many intercostal arteries as possible, and distally achieve an adequate overlap to the preexisting device. Further challenging aspects include access problems through the usually rigid previous endograft as well as the limited maneuverability during deployment.

Device Design

To address these issues in endovascular type Ia endoleak repair we present a custom-made device (Cook Medical, Bloomington, IN, USA), featuring an additional 8 mm branch for the preexisting contralateral iliac limb and loaded

in an 18F introduction system (Figure 1). The device consists of a nitinol skeleton with branches covered with a low-profile polyester fabric. It features a maximal proximal diameter of 38 mm, can be tapered down to 16 to 20 mm at the level of the renal arteries and additionally down to a minimum of 10 mm at the level of the ipsilateral iliac limb. Length of tapering below the renal arteries (RAs) does not exceed 20 mm. Because of manufacturing constraints, a stainless steel internal stent is incorporated at the distal end of the endograft in case of distal tapering to ≤ 16 mm. The device features a minimum of 2 proximal sealing stents with a total length of 58 mm to the caudal end of the first branch. Branch design includes 8 mm branches for the celiac artery (CA) and superior mesenteric artery (SMA) and 6 mm branches for the RAs (Figure 1, 2). An additional 8 mm branch for the contralateral iliac limb is incorporated usually at the level of the SMA branch, with an angle span of 150° (Figure 2, 3). The endograft is delivered in an 18F internal diameter sheath and features single diameter reducing ties. The average time required for device planning and construction is approximately 6 weeks.

The device can be applied for the treatment of proximal type I endoleaks or progression of disease after EVAS or EVAR with a short main body, as well as for proximal para-anastomotic aneurysms after open surgical repair. Minimum requirements are an iliac diameter >7 mm and an aortic diameter ≥ 26 mm at the renovisceral level to facilitate device introduction and proper branch deployment.

Vascular Access

Vascular access for branched devices has been described in previous studies.¹³ A unilateral percutaneous femoral access and an axillary access is required. A 12F transaxillary sheath is introduced over the through-and-through wire into the descending thoracic aorta. We strongly suggest introduction of the device transfemorally directly over a through-and-through wire as an alternative to the introduction over a transfemoral super-stiff wire, in order to overcome possible friction issues in the previous aortic stent-graft. A percutaneous contralateral femoral access with a small diameter sheath can be used for angiographic purposes.

Deployment

Device deployment is carried out in standard fashion, following angiographic control of the renovisceral segment and in correct orientation to the target vessels. The proximal end of the branched endograft is deployed in the supraceliac aorta while the distal end is usually deployed into the pre-existing ipsilateral iliac limb. A further distal extension may be carried out in cases long iliac relining is required.

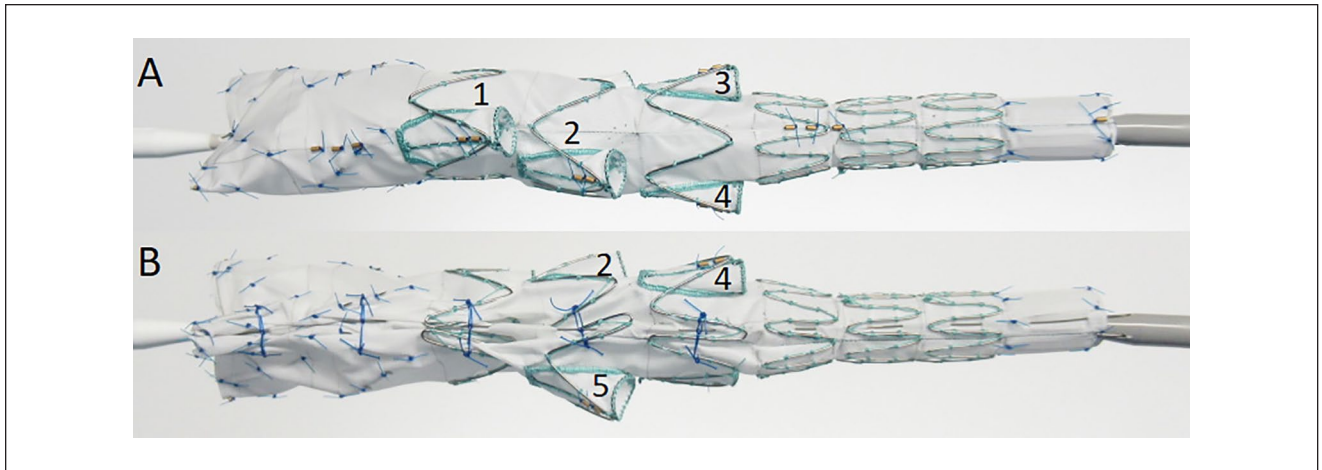


Figure 2. Anterior (A) and posterior (B) view of the custom-made device featuring a branch for the celiac artery (1), a branch for the superior mesenteric artery (2), a branch for the left (3) and right (4) renal artery and a branch for the contralateral iliac limb (5).

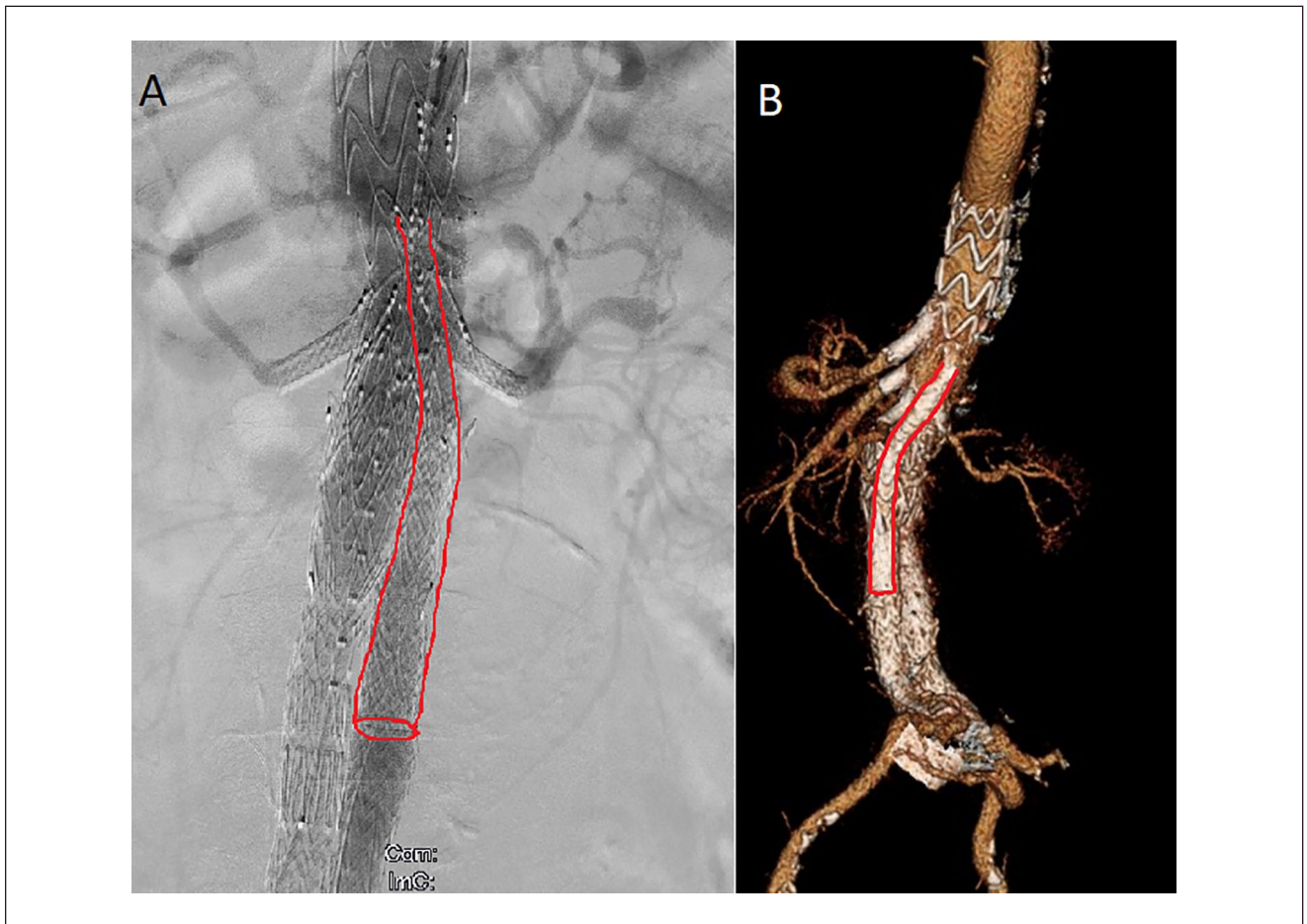


Figure 3. Intraoperative angiography in anterior view (A) and 3-dimensional reconstruction of a postoperative computed tomography angiography in posterior view (B) of a patient treated with a device featuring an additional iliac limb branch (red marking).

Branch Cannulation and Choice of Bridging Stent-Grafts

Subsequently the through-and-through wire is retracted from the ipsilateral limb, the additional branch is cannulated and the wire is snared over the contralateral side. The sheath of the main device is removed from the ipsilateral side and blood flow is completely restored, while maintaining vascular access. All branches are sequentially catheterized in standard technique from the transaxillary access using 12F and 8F sheaths and secured using balloon- or self-expandable bridging stent-grafts. A consideration with this device design is sealing in the contralateral limb, which usually requires a large diameter distal bridging stent-graft. The 8 mm branch provides adequate blood flow to the contralateral side; however, the diameter mismatch between the branch and the distal landing zone limits choice of the respective bridging component. A solution is the use of latest generation balloon-expandable stent-grafts with the option to overdilate from 8 mm up to 16 mm (VBX, WL Gore and Associates, Flagstaff, AZ, USA). In this way, proximal landing in the 8 mm branch and simultaneous distal sealing in the previous iliac limb can be achieved with a single bridging stent-graft, avoiding the use of additional components with possible overlap and mismatch issues. When a complete relining or extension of the previous iliac limbs is required (eg, in the case of suspected additional type III or type Ib endoleak) then a further distal extension using a self-expandable stent-graft is carried out.

Discussion

This novel device design addresses several technical issues that are associated with the endovascular repair of EVAR failure due to type Ia endoleak. One of the most problematic aspects when designing an endograft for redo endovascular repair is the limited working length below the renal arteries in cases of endografts with short main body or following EVAS. This issue is also encountered in patients with proximal para-anastomotic aneurysms following open repair with a bifurcated graft featuring a short main body. This limitation may compromise distal sealing in the previous endograft. To address this issue several options have been proposed, including treatment with fenestrated cuffs sealing in the preexisting main body, which may however lead to type III endoleaks or complete relining of the previous endograft with use of a bifurcated distal component featuring an inner limb.¹⁴ The latter option minimizes the overlap of the bifurcated to the fenestrated component as well as to the contralateral iliac limb also potentially leading to type III endoleaks. One advantage of this branched design is that distal landing is achieved on the ipsilateral side with the tapered main body and on the contralateral side with a bridging stent-graft to the respective limb through the

additional branch. In this way, a complete relining of the previous endograft can be achieved, without compromising component overlap even in cases of short working length.

A potential disadvantage of branched devices for failed EVAR is the extension of the sealing zone significantly above the supraceliac level and the long renovisceral bridging stent-grafts required in case an infrarenal component is used for relining. The goal should be to achieve an adequate proximal seal but at the same time preserve as many intercostal arteries as possible, in order to minimize the risk of spinal cord ischemia.¹² This disadvantage of branched devices has been addressed by using only 2 proximal sealing stents. In this way the device length can be reduced to a minimum of 58 mm proximal to the end of the first branch and therefore intercostal artery coverage is minimized. Positioning of the additional branch at the level of the SMA is deliberately carried out to enable deployment of renovisceral branches as close as possible to the target vessel ostia while facilitating catheterization of the preexisting contralateral limb. Even in cases of EVAS the short tapering length below the renal branches allows precise deployment of the device near the renal artery ostium. Because of this custom-made design, bridging stent-graft length to the renovisceral vessels usually does not exceed 60 mm and supraceliac intercostal artery coverage is kept at a minimum.

Further advantages of this device are associated with the reduced interference with the preexisting endograft. Intraoperative technical challenges usually arise due to the rigid and often narrow previous endograft, as well as due to the existence of stent-struts at the level of the target vessels in case of devices featuring suprarenal fixation. Exact deployment of any device may be tedious due to the limited maneuverability in the preexisting stent-graft that hinders correct introduction as well as orientational adjustments during deployment. This is especially critical for the alignment of fenestrations to target vessels in fEVAR. Catheterization of target vessels and introduction of the bridging stent-grafts is possible, but it may however require additional maneuvers such as ballooning of the suprarenal stent struts in case of previous endografts or cuffs featuring suprarenal fixation.¹⁵ Additionally, interference with the suprarenal fixation may compromise sealing of the fenestrated main body at the pararenal level. Catheterization and sheath introduction into three or more target vessels prior to full device deployment may be very difficult due to interference with the components of the previous device. The 18F design of this device facilitates introduction through the rigid preexisting endograft as well as slight adjustments during deployment. The branched design enables target vessel catheterization, even in case of slight deviation from the optimal device orientation. Target vessels catheterization takes place sequentially, thus minimizing component interference.

The main limitation of this technique is the minimal aortic diameter required for a branched device. An aortic diameter of <26 mm at the level of branches is problematic since it may lead to compression of the bridging stent-grafts and possibly bridging stent-graft occlusion. Another disadvantage in comparison to fEVAR is the fact that the proximal landing zone is extended 4 to 5 cm into the thoracic aorta compared with a 4-fold fenestrated device. Finally, an upper access is generally required in order to correctly position the device and facilitate target vessel and contralateral limb catheterization. Bridging stent-graft implantation through a transfemoral access may also be feasible¹⁶; however, we advise use of an upper access in order to increase maneuverability and avoid friction with preexisting components.

Conclusion

Treatment of type Ia endoleak with a new custom-made device design enables sufficient proximal seal while minimizing suprarenal aortic coverage and facilitates adequate component overlap even in cases of previous EVAR with a short main body or EVAS. The 18F branched design accommodates implantation through the preexisting endograft and catheterization of target vessels.

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Declaration of Conflicting Interests

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