*Case Series*

# EndoAnchors Minimize Endoleaks in Chimney-Graft Endovascular Repair

## of Juxtarenal Abdominal Aortic Aneurysms

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*Juxtarenal abdominal aortic aneurysms (AAAs) are difficult to treat because they often have little or no proximal aortic neck. Patients with this complex anatomy are not usually candidates for an endovascular aneurysm repair (EVAR). Chimney-graft EVAR has been introduced, but type Ia endoleak is a typical risk. We have begun using EndoAnchors to determine whether this risk can be reduced.*

*From July 2013 through July 2014, we used the chimney-graft EVAR technique in 5 patients whose juxtarenal AAAs had a short or no proximal aortic neck. During the procedure, we implanted EndoAnchors as needed. Postprocedurally, at 30 days, and through end of follow-up (duration, 11–18 mo), all patients had patent endografts without type Ia endoleak (our primary endpoint), visceral stent-graft thrombosis, or renal complications. One patient who received 4 chimney grafts had a postprocedural type II endoleak, which was treated with embolization.*

*We found it feasible to use EndoAnchors with the chimney-graft technique to prevent type Ia endoleaks in the treatment of juxtarenal AAAs. Further studies are needed to validate this adjunctive technique and to determine its durability.* ***(Tex Heart Inst J 2019;46(3):183-8)***

***Key words:*** *Aortic aneurysm, abdominal/pathology; blood vessel prosthesis implantation/instrumentation/methods; endoleak/etiology/prevention & control/therapy; endovascular procedures/instrumentation/methods; prosthesis design; stents; surgical stapling/instrumentation; treatment outcome*

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Juxtarenal abdominal aortic aneurysm (AAA) is present in 15% to 20% of patients who are considered for endovascular aneurysm repair (EVAR).[1] Juxtarenal AAAs are difficult to treat because they often have a short proximal aortic neck (<15 mm from the lowest renal artery) or no neck (Fig. 1A–B). Patients with this complex aortic anatomy are typically poor candidates for EVAR.

In attempting endovascular treatment of these complex aneurysms, clinicians have worked to innovate stent-graft (SG) techniques and devices. Fenestrated EVAR stent-grafts are promising; however, not all the visceral vessels can be cannulated during their placement, and a minimal proximal neck (length, 4 mm) is necessary for fixation.[2] The standard effectiveness of the chimney-graft technique (Ch-EVAR) has been limited by endoleaks, which are directly proportional to the number of visceral chimney grafts (CGs). The endoleaks are caused by persistent gaps (gutters) between the aortic stent and aortic wall, created by tenting of the aortic stent by the visceral stent chimney.[3]

When used in Ch-EVAR procedures, EndoAnchors (Aptus™ EndoAnchor™, now Medtronic) have been shown to reduce early and late endoleaks by affixing the aortic SGs firmly to the native aortic wall (Fig. 2).[4-6] We report our experience with using this adjunctive step during Ch-EVAR.[6]

## Patients and Methods

From July 2013 through July 2014, we performed Ch-EVAR in 5 patients whose AAAs had short or absent proximal infrarenal aortic necks (length, 0–3 mm) (Table I). All procedures were performed at the discretion of the interventionist, without standardization or randomization. The patients provided written informed consent. Four patients were sedated and given local anesthesia; one patient was placed under general anesthesia.

In brief, the Ch-EVAR procedure involves extending the aortic SG above the aneurysmal neck, into the narrowed portion of the aorta, to create an adequate seal (Fig. 1C). Chimney grafts were created by deploying a covered stent into the affected visceral vessels (celiac, superior mesenteric, or renal artery), then extending the proximal end

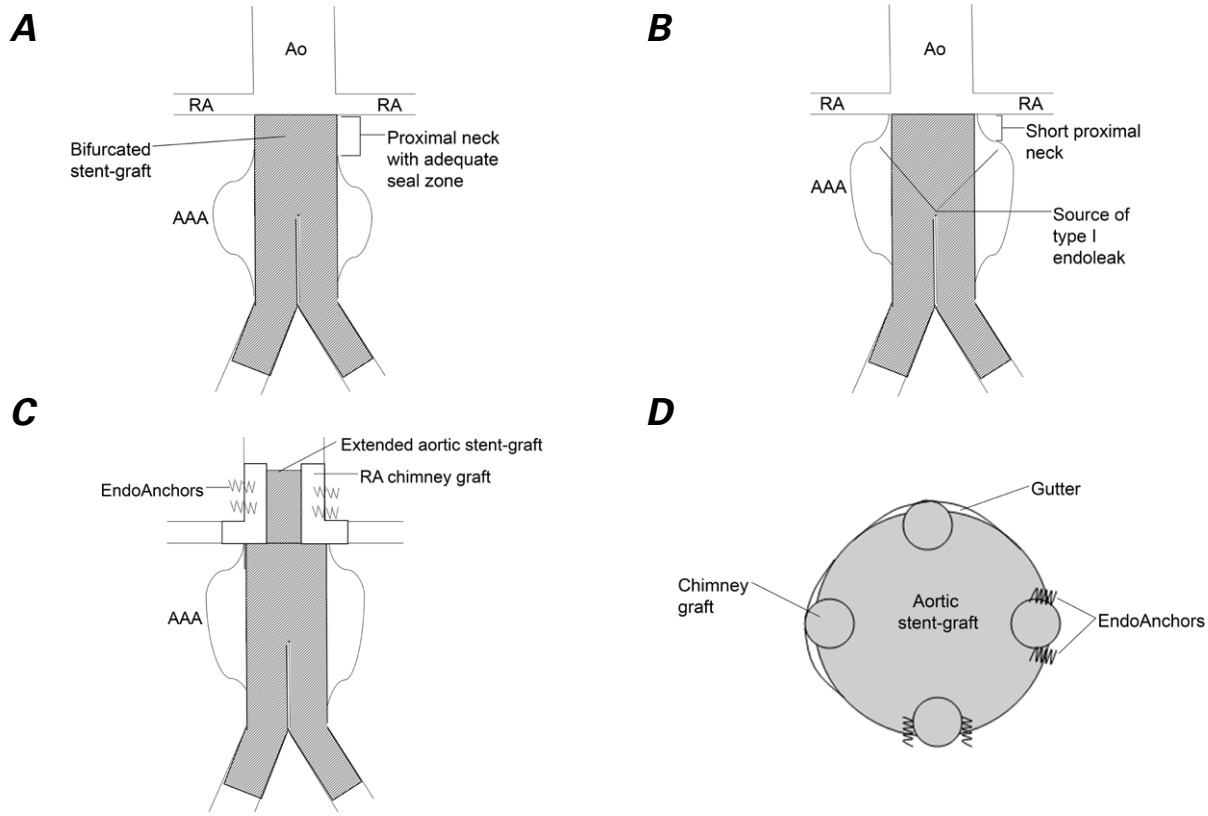


***Fig. 1*** *Schematic drawings show coronal views of **A**) an ideal infrarenal neck length and adequate seal zone, compared with **B**) a short proximal neck and an inadequate seal zone, which creates a high risk for type Ia endoleak. **C**) An extended aortic stent-graft, chimney grafts, and EndoAnchors securely seal the aneurysm. **D**) The transverse view shows EndoAnchors at the 3 and 6 o'clock positions alongside the chimney graft. Gutters at 9 and 12 o'clock may allow persistent flow into the aneurysmal sac.*

*AAA = abdominal aortic aneurysm; Ao = aorta; RA = renal artery*


***Fig. 2*** *The Heli-FX™ EndoAnchor™ System. The EndoAnchors are used to fixate and thus seal the endovascular aortic graft to the aortic wall. This system is used in patients with stents that are at risk for or have exhibited migration or endoleak that compromises adequate aneurysm exclusion. (Image and text reproduced with permission from Medtronic.)*

of the stent above the seal zone of the aortic SG. Thus, the aortic SG covered the origin of the visceral vessel, while flow was maintained through the CGs. Gutters were then closed with use of EndoAnchors (Fig. 1D).

The procedures were performed in a cardiac catheterization laboratory endovascular suite. We achieved percutaneous access by using the preclose technique and commercially available suture-mediated closure devices for all femoral access sites. When brachial artery access was needed, open exposure was achieved, to minimize risks of bleeding and pseudoaneurysm. Arterial access was achieved with use of fluoroscopic guidance. All procedures began with an angiogram acquired through a 5F flush catheter at the level of the renal arteries. Intravascular ultrasonography enabled adequate sizing and good views of the visceral vessel ostia.

We placed a Lunderquist® Extra-Stiff Guide Wire (Cook Medical Inc.) within the aorta from the femoral artery access sheath for delivery of the aortic SG. The SG was oversized by approximately 20% to enable adequate wall apposition and to accommodate the visceral CGs. When more than 2 visceral CGs were needed, we sized the aortic SG to accommodate them and to ensure maximal apposition of the fabric to the contour of the grafts. We then deployed the aortic SG over the Lunderquist wire, below the level of the visceral vessel that was to be stented. If an aortic cuff or extension was to be used, we deployed the SG above the level of that vessel.

We routinely precannulated all visceral vessels, positioning the CGs antegrade or retrograde at the interventionist's discretion. Retrograde access was often achieved by deploying (from the groin) a large access

**TABLE I.** Procedural Details for Patients with Juxtarenal Abdominal Aortic Aneurysms

| Pt. | Proximal Aneurysm Neck Length (mm) | Proximal Aortic Diameter (mm) | Aortic Stent-Graft Model, Diameter (mm) | Proximal Cuff Model, Diameter (mm) | No. of CGs | CG Model, Diameter (mm) | No. of Endo-Anchors | Anesthesia |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 26 | Gore Excluder, 28 | — | 3 | iCAST, 6 | 9 | Local |
| 2 | 0 | 31 | Endologix, 28 | Gore TAG, 34 | 4 | iCAST, 7; and Viabahn, 6 | 10 | General |
| 3 | 0 | 25 | Gore TAG, 28 | — | 3 | iCAST, 6 and 7 | 10 | Local |
| 4 | 0 | 23 | Gore TAG, 26 | — | 1 | iCAST, 7 | 5 | Local |
| 5 | 3 | 27 | Gore Excluder, 30 | Gore, 32 | 1 | iCAST, 5; and Viabahn, 6 | 6 | Local |

CG = chimney graft; Pt. = patient

sheath along with a separate 7F sheath. Cannulation was often achieved with use of a 0.035-in Glidewire and a 5F renal double catheter (Merit Medical Systems, Inc.).

Antegrade access was preferentially obtained from the left brachial artery and sometimes from the right. We inserted a single 7F or 8F shuttle sheath (Cook Medical) from the brachial artery to support visceral artery cannulation. Using a buddy-wire technique, we cannulated the visceral arteries with 5F renal double catheters and a 0.014-in Spartacore wire (Abbott Vascular).

Sequentially, we withdrew each sheath and deployed the CG. At least 10 mm of the CG was landed within the visceral vessel, with the proximal end adequately raised above the fabric of the proximal aortic SG. When an aortic cuff was required, we chose a longer CG or extended it with 2 to 3 cm of overlap between segments.

The iCAST SG provided more support and fixation; the Viabahn was more flexible and moldable. If only 1 or 2 CGs were needed without extension, an iCAST alone was sufficient. If we anticipated using more than 2 grafts, we used the Viabahn because of its conformability against the aortic graft. When extension above the aortic SG or below it into the flow channel was needed, we used both devices. The iCAST enabled fixation at the ostia, and the Viabahn enabled extension into the aortic lumen or flow channel.

We then advanced a compliant molding balloon to the top of the aortic SG. Balloon angioplasty was performed simultaneously in that graft and the CGs, in either a triple or quadruple kissing fashion, to enable maximal apposition to the aortic wall and to minimize gutter leaks around the CGs.

Through a femoral artery sheath, we advanced a low-profile 16F™ Heli-FX™ EndoAnchor System over a Lunderquist wire, to the level of the aortic SG. Under fluoroscopy, the Heli-FX delivery device can be angulated by up to 90°, which creates a deflection force by using the opposing endograft wall, further supporting the EndoAnchor for implantation.

We placed EndoAnchors along the proximal fabric of the aortic SG to secure it to the aortic wall (Fig. 3A). EndoAnchors were positioned clockwise, usually commencing in the 3 and 9 o'clock positions (Fig. 3B). For further fixation, additional EndoAnchors may be placed at other positions as needed. A previously described technique,[7] involving a contrast-filled angioplasty balloon within the CG, enabled us to view the CG and to prevent accidentally placing an EndoAnchor through it.

When a CG is deployed between the aortic SG and the aortic wall, a residual geometric space—predisposed to endoleaks—is formed alongside the graft. EndoAnchors can be placed along a longitudinal axis on either side of the CGs to eliminate this space (Fig. 3C).

When an AFX® Endovascular AAA System (Endologix, Inc.) was the aortic SG, we placed EndoAnchors only along the fabric of the proximal extension or cuff. The Heli-FX system cannot be used with the AFX system because of the known incompatibility of the unique fabric type and the risk of tearing.

We acquired completion angiograms after each procedure, to verify exclusion of the aneurysm and to look for type Ia endoleaks. All patients were prescribed aspirin and clopidogrel postprocedurally.

## Results

All 5 patients' completion angiograms indicated technical success (Table II): exclusion of the AAA and no type Ia endoleaks. In 3 patients, a single modulated aortic SG sufficiently excluded the aneurysm (Table I). In 2 patients, we used additional aortic cuffs to form a sufficient seal above the affected visceral vessels. One to 4 arteries per patient needed CGs. The iCAST™ balloon-expandable covered stent (Atrium Medical) was used in all 5 patients; in 2, the Gore® Viabahn® Endoprosthesis (W.L. Gore & Associates, Inc.) was placed for additional extension of the CG. Five to 10 EndoAnchors were used per patient.

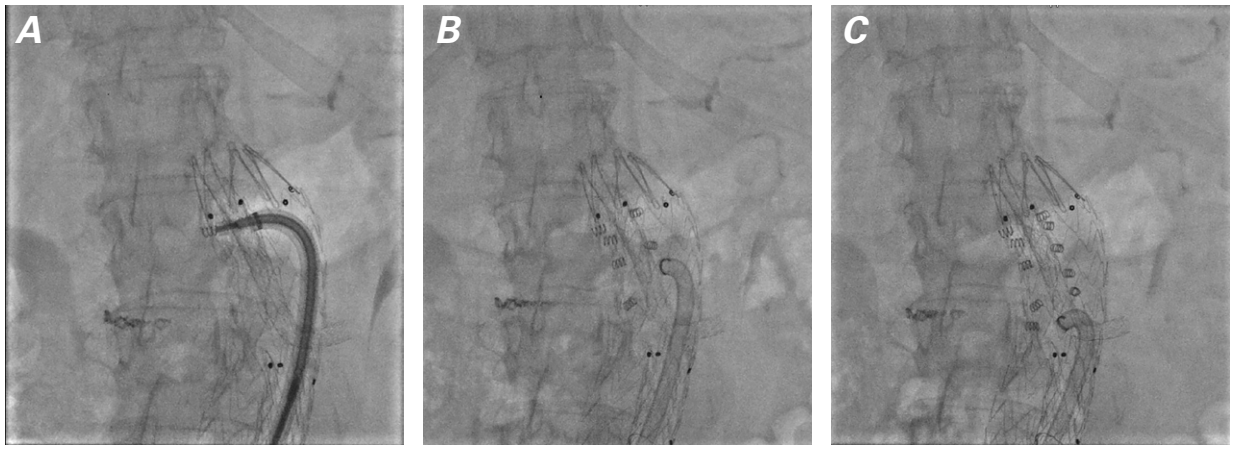


***Fig. 3*** ***A****) Angiogram shows EndoAnchor deployment adjacent to a chimney graft. Note support of the catheter from the contralateral wall.* ***B****) EndoAnchors have been deployed at the 3 and 9 o'clock positions along the length of the chimney graft.* ***C****) EndoAnchors have been deployed along the entire length of a chimney graft to minimize the risk of type Ia endoleak (gutter leak).*

The average follow-up time was 13.6 months (range, 11–18 mo). We used 3-dimensional reformatted computed tomographic angiograms (CTA) to look for endoleaks at follow-up (Fig. 4). Postprocedurally, a patient in whom 4 visceral vessels were stented had a type II endoleak, which we embolized by using Onyx glue, a low-risk procedure.[8] No CTA showed any type Ia endoleak in any patient, and all CGs remained patent. No deaths or cardiac, respiratory, or renal adverse events were reported.

## Discussion

Patients with juxtarenal AAA usually have complex aortic anatomy that limits their treatment options and contraindicates EVAR or fenestrated EVAR. Moreover, many of these patients are poor candidates for extensive surgical repair, which poses risks for morbidity and death.

Lee and colleagues[9] reported technical success when using Ch-EVAR in 28 patients with juxtarenal AAAs. Performing Ch-EVAR involves extending the proximal landing zone by stenting the visceral arteries above the level of the aortic SG or aortic cuff, but with an increased risk of type Ia endoleak.[10]

Moulakakis and co-authors[3] reviewed the literature on Ch-EVAR and found a 7% incidence of type Ia endoleak among patients who received a single visceral CG, compared with 15.6% for those who received 2 visceral CGs. These results suggest that the incidence of endoleak is directly proportional to the number of CGs.[3]

The endoleak phenomenon appears to relate directly to the space that the CG creates between the aortic wall and aortic SG. This triangular space, called a gutter leak, appears to be a less severe type of Ia endoleak.[10] It is associated with the snorkeling of visceral vessels arising from the space created between the aortic endograft and the visceral CG.[11] These endoleaks may be prone to thrombosis because of high resistance within these spaces; indeed, thrombosis has been reported within 6 months postoperatively.[6,10,11] Of note, as the number of CGs increases, the size of this space increases, theoretically worsening the severity and size of the type Ia endoleak.

Niepoth and colleagues[6] showed in vitro that placing EndoAnchors seems to decrease the volume of gutter-leak channels associated with CGs. In silicone pararenal aortic aneurysm models, CG configurations were constructed by using balloon-expandable SGs with and without EndoAnchors. EndoAnchor use led to a significantly lower gutter volume than did unanchored configurations. Our findings agree with theirs and suggest applicability in patients. Indeed, 3 of our patients had 3 or more CGs secured with EndoAnchors, and none had type Ia endoleak postprocedurally.

EndoAnchors are compatible with most commercially available aortic SGs, but not the Endologix AFX (because of its exoskeleton) or the Ovation system (because of its polymer rings). In our experience, the EndoAnchor system is otherwise dependable. Endograft selection should depend on the patient's anatomy and the interventionist's preference.

Detractors of Ch-EVAR have concerns about adverse renal events, including renal graft thrombosis.[10] Our patients took aspirin and clopidogrel immediately after the procedure and regularly thereafter. Their creatinine levels were monitored, and no clinically significant changes occurred. All CGs remained patent during follow-up, consistent with data from Donas and associates[12] in support of Ch-EVAR.

An additional concern is patients' exposure to radiation. In our patient with 4 CGs, radiation exposure ex-

**TABLE II.** Procedural Results after Chimney-Graft Endovascular Repair of Juxtarenal Abdominal Aortic Aneurysms

| Patient | Estimated Blood Loss (mL) | Total Radiation (mGy) | Total Contrast Medium (mL) | Fluoroscopy Time (min) | Endoleak | Follow-Up Duration (mo) |
|---|---|---|---|---|---|---|
| 1 | <100 | 9,105 | 200 | 80.9 | None | 18 |
| 2 | 500 | 19,205 | 250 | 289 | Type II | 17 |
| 3 | 200 | 6,540 | 180 | 56.3 | None | 11 |
| 4 | 50 | 1,673 | 35 | 28.9 | None | 11 |
| 5 | 50 | 1,124 | 100 | 37.9 | None | 11 |

No chimney-graft thrombosis or adverse renal events were detected during follow-up.

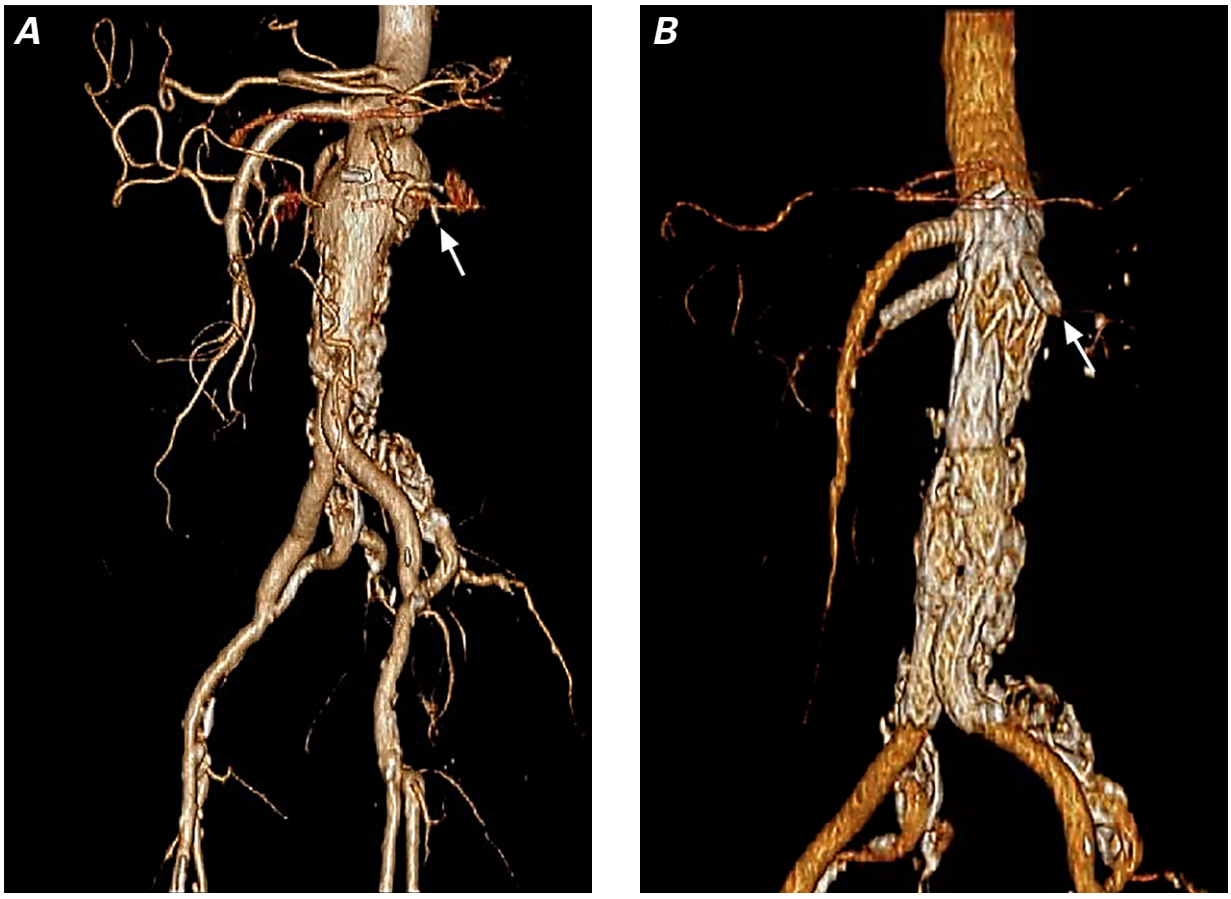


***Fig. 4*** *Computed tomograms (3-dimensional reconstruction) show* ***A****) a juxtarenal aneurysm (arrow) that formed many years after an aortobiliac bypass, and* ***B****) stent-graft exclusion of the aneurysm, as well as stenting of the bilateral renal arteries and the superior mesenteric artery with use of EndoAnchors.*

ceeded the recommended maximum. None of our 5 patients had complications from radiation. As our experience with similar cases has grown, radiation exposure has decreased.

Our results are from a small series of nonstandardized procedures performed at the interventionists' discretion. Multiple biases and confounding factors may have influenced our results. Regardless, our series shows the feasibility of using EndoAnchors in Ch-EVAR procedures to prevent type Ia endoleak in the treatment of juxtarenal AAA. Larger, prospective studies are needed to validate this technique and determine its durability.

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