Innovative Chimney-Graft Technique for Endovascular Repair of a Pararenal Abdominal Aortic Aneurysm

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After abdominal aortic aneurysm repair, progressive degeneration of the aneurysm can be challenging to treat. Multiple comorbidities and previous operations place such patients at high risk for repeat surgery. Endovascular repair is a possible alternative; however, challenging anatomy can push the limits of available technology.

We describe the case of a 71-year-old man who presented with a 5.3-cm pararenal aneurysm 4 years after undergoing open abdominal aortic aneurysm repair. To avoid reoperation, we excluded the aneurysm by endovascular means, using visceral-artery stenting, a chimney-graft technique. Low-profile balloons on a monorail system enabled the rapid exchange of coronary wires via a buddy-wire technique. This novel approach facilitated stenting and simultaneous angioplasty of multiple visceral vessels and the abdominal aorta. (Tex Heart Inst J 2015;42(1):35-9)

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Progressive aneurysmal degeneration after abdominal aortic aneurysm (AAA) repair can be challenging to treat. Multiple comorbidities, previous operations, and the need for suprarenal cross-clamping place this patient population at high risk for reoperation.¹ During a 5-year period, Conrad and co-authors² reported a 24% incidence of late aortic aneurysm proximal to the site of repair in 540 patients who had undergone elective open AAA repair.

In 2003, Greenberg and colleagues³ described an endovascular approach in which parallel visceral-artery stent-grafts were inserted and molded to the main body of the endograft after aneurysmal exclusion. Many other groups have adopted this technique, and short-term and intermediate results appear promising.⁴⁻⁶ We recently used this technique with our own novel modifications to exclude a pararenal AAA while maintaining visceral-artery perfusion.

Case Report

In 2009, a 71-year-old man had undergone open repair of an AAA with a bifurcated 16-mm × 8-cm Dacron prosthetic graft (Fig. 1A). Four years later, he presented with proximal progression of his aneurysmal disease. Abdominal computed tomographic angiography (CTA) showed a 5.3-cm pararenal aneurysm involving both renal arteries (Fig. 1B). Because the patient was at high risk for reoperation, he was referred to us for endovascular aneurysm repair (EVAR). Computed tomographic angiography with 3-dimensional reconstruction revealed no infrarenal neck, thus precluding the use of a fenestrated device. The distance from the superior mesenteric artery (SMA) to the lowest renal artery was 10 mm. The distance from the SMA to the celiac artery was 9 mm. This provided a total approximate distance from the celiac artery to the lowest renal artery of 19 mm, and the celiac artery's diameter was 24 mm, so a chimney graft to the SMA and both renal arteries was considered a viable option. The patient's common femoral arteries (CFAs) were of adequate size for total percutaneous access.

The procedure was performed in a hybrid angiography suite with a surgical team on standby. The patient was placed in a supine position, both sides of the groin were anesthetized with 2% buffered lidocaine, and moderate sedation was administered. Meticulous percutaneous access was achieved via fluoroscopic guidance of a 21G micropuncture needle. Bilateral femoral angiography was performed with use of a 3F

trocars to determine the coaxial position of the wire with respect to the CFA access site. After access was established, 2 short 5F sheaths were placed, and hydrophilic guidewires were advanced into the suprarenal aorta. An angiogram showed a large pararenal AAA proximal to the previous Dacron graft (Fig. 2A).

We used the preclose technique and a Prostar® XL 10F suture system (Abbott Vascular, part of Abbott Laboratories; Redwood City, Calif) for each groin. Once full

heparinization was achieved, we inserted an 18F sheath into the right CFA to deliver the main body of the device and an 11F sheath to deliver the contralateral limb over dual 0.035-in SS Amplatz® wires (Boston Scientific Corporation; Natick, Mass).

Through bilateral brachial-artery cutdowns, we inserted a 7F × 90-cm Flexor® Shuttle® sheath (Cook Medical, Inc.; Bloomington, Ind) into the right brachial artery and an 8F × 90-cm Flexor Shuttle sheath into the

Fig. 1 Computed tomographic angiograms (in 3-dimensional reconstruction) show the abdominal aorta. **A)** 2009: Infrarenal abdominal aortic aneurysm with a short infrarenal neck. **B)** 2013: Aneurysmal progression of the pararenal aorta proximal to the site of the aortobifiliac prosthetic graft (arrows).

Fig. 2 Digital subtraction angiograms show **A)** preoperatively, a pararenal aneurysm proximal to the site of the previous abdominal aortic aneurysm repair; and **B)** postoperatively, successful exclusion of the pararenal aneurysm and patency of all visceral-artery stent-grafts, without evidence of endoleak.

Fig. 3 Intraoperative fluoroscopic image shows multiple visceral-artery cannulations of the superior mesenteric artery (SMA) and bilateral renal arteries. The main body of an endograft is positioned within the abdominal aorta.

left brachial artery. Both sheaths were advanced into the distal descending thoracic aorta. Sequentially, 0.035-in Glidewires® (Terumo Medical, Inc.; Somerset, NJ) were exchanged for 0.014-in Spartacore® wires (Abbott Vascular) after cannulation of the right and left renal arteries in conjunction with a 5F renal double-curve catheter. The right renal artery was cannulated from the right brachial artery and the left renal artery from the left brachial artery. The 0.014-in × 300-cm Spartacore wires were advanced in their respective arteries to provide stability. The SMA was temporarily cannulated with a 5F renal double-curve catheter from the CFA access site.

A C3 Excluder® (W.L. Gore & Associates, Inc.; Flagstaff, Ariz) main body (28.5 mm × 14.5 mm × 16 cm) was advanced to the level of the renal arteries (Fig. 3). The Excluder endograft was semideployed to enable maneuverability. Both shuttle sheaths were then advanced toward their visceral target vessels to enable the progression of an iCast® balloon-expandable covered stent

Fig. 4 Intraoperative fluoroscopic images show **A**) cannulation of the superior mesenteric artery (SMA) and bilateral renal arteries. Note also the deployment of iCast stent-grafts into the **B**) left and **C**) right renal arteries, and **D**) triple kissing-balloon angioplasty to maximize wall apposition between stent-grafts for repair of the bilateral renal arteries and the aorta.

(Atrium Medical, Inc.; Hudson, NH). The stent-grafts were advanced within the renal artery for a minimum of 1 cm, followed by withdrawal of the sheath and deployment of the 6 × 59-mm iCast stent-grafts. The C3 Excluder's main body was fully deployed, and triple-kissing balloon angioplasty was performed to maximize wall apposition between the stent-grafts (Fig. 4).

Next, we cannulated the SMA through the left brachial-artery access site by using a buddy-wire technique with a 0.014-in × 300-cm Spartacore wire. A 7 × 38-mm iCast stent-graft was deployed in the SMA. A 28.5-mm × 3.3-cm aortic cuff (W.L. Gore) was then deployed at the level of the celiac artery, through the right CFA.

Two low-profile Viatrac® 6 × 30-mm percutaneous transluminal angioplasty balloons (Abbott Vascular) were then advanced into the SMA and left renal artery, over the rapid-exchange coronary 0.014-in Spartacore wires via a monorail system. The 6 × 59-mm iCast balloon was then advanced into the right renal artery, while a 32-mm Coda® balloon (Cook Medical) was positioned in the suprarenal aorta. Use of the buddy-wire technique (via dual 0.014-in rapid-exchange coronary wires) enabled our positioning of 2 low-profile balloons through a single delivery sheath for simultaneous visceral-artery angioplasty (Fig. 5).

The contralateral Gore Excluder® iliac-limb 12.5-mm × 12-cm graft was deployed via the left CFA. A Heli-FX® aortic fixation system (Aptus Endosystems; Sunnyvale, Calif) was then advanced into the suprarenal aorta through the right CFA. We secured the main body of the Excluder endograft to the aortic wall with 4 EndoAnchors (Aptus) and placed 2 additional EndoAnchors along the Gore aortic cuff (Fig. 6). At the

Fig. 5 Intraoperative fluoroscopic image shows simultaneous visceral-artery and aortic angioplasty via the "buddy-wire" technique.

end of the procedure, digital subtraction angiography showed complete exclusion of the aneurysm without evidence of endoleak (Fig. 2B). The total radiographic contrast load was 220 cc, and the radiation dose was 9,106 mGy. Estimated blood loss was less than 100 cc. No blood transfusions were given.

One month after the procedure, CTA confirmed continued patency of the visceral-artery stents and exclusion of the aneurysm without endoleak.

Fig. 6 Intraoperative fluoroscopic images show **A)** the Aptus Heli-FX aortic-fixation system, with EndoAnchors (shown within the ovals) deployed over the main body of the bifurcated Gore Excluder endograft; and **B)** use of a percutaneous transluminal angioplasty (PTA) balloon to assist in positioning of an EndoAnchor alongside the chimney stent-grafts.

SMA = superior mesenteric artery

Discussion

To exclude the aneurysm successfully, we deployed a bifurcated aortic endograft at the level of the renal arteries, completely relining the previous surgical prosthetic graft. Deployment of an aortic fixation system facilitated reinforcement of the main-body endograft at the level of the renal arteries and prevented migration.⁷ By using an aortic extension with parallel visceral-artery stent-grafts in both renal arteries and in the SMA, we extended the proximal neck toward the celiac artery to provide an adequate proximal landing zone (15 mm or more) of healthy aorta.⁸

Successful performance of the chimney-graft technique on 3 visceral vessels required that all the parallel stent-grafts be directed antegrade, despite the limitation of upper-extremity access to 2 sites. Our use of a buddy-wire technique via dual 0.014-in rapid-exchange coronary wires and low-profile balloons enabled simultaneous visceral-artery angioplasty and stent-graft placement of multiple targets via an 8F sheath advanced through the brachial artery. Furthermore, because the risk of type IA endoleaks associated with the chimney-graft technique is directly proportional to the number of chimney grafts placed, we used an aortic fixation system to minimize these “gutter leaks.”⁹

The endovascular exclusion of a pararenal aneurysm is a complex procedure involving multiple techniques that, if executed precisely, can result in successful maintenance of visceral-artery perfusion via parallel stents, with minimal risk of morbidity and death. The chimney-graft technique is a viable alternative for high-risk patients who have a pararenal AAA and few treatment options.

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