Fenestrated Endografting for the Treatment of Descending Thoracic Aneurysms

A series of custom fenestrations including an in-situ fenestration of the celiac and superior mesenteric arteries to improve distal fixation during thoracic endovascular aneurysm repair.

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As it currently stands, the mortality rate of untreated thoracic aortic aneurysms (TAAs) exceeds 80% at 5 years.[1,2] Operative repair greatly alters the natural history of the disease, and these aneurysms traditionally require open surgical repair with large thoracoabdominal incisions, aortic cross-clamping, and left heart bypass. Open surgery is therefore associated with significant morbidity (65% to 80%) and mortality (10% to 20%).[3-6]

Thoracic stent grafting, as first described by Dake et al in 1994, has been associated with less blood loss, lower morbidity rates, and shorter ICU and hospital stays. Furthermore, mortality rates after thoracic endovascular aortic aneurysm repair (TEVAR) are at least comparable to those after open surgery, despite the higher prevalence of high-risk patients in the endovascular subset.[7,8] However, this technology has been limited from widespread application by the anatomical constraints of aortic branching that can eliminate adequate proximal and distal landing zones required for graft seal and fixation.

The most complex aortic anatomy and disease are usually seen in older patients with advanced comorbidities. In an attempt to curtail the morbidity and mortality of repair in this subset of patients, hybrid thoracic aortic repair, which combines TEVAR with aortic debranching, has been promoted for high-risk patients with aneurysmal involvement of the branched aorta. However, reported results of this technique are varied, as this procedure is far from minimally invasive and requires celiotomy and long operative times.[9-11]

The advent of fenestrated and branched endografts has now shifted the focus of complex thoracoabdominal repair back toward the extension of endovascular technology in order to address these complex patients. Although the reported use of fenestrated endografts in the thoracic aorta are less extensive,[12-14] they have been applied more frequently to pararenal and juxtarenal aneurysms with good early- and midterm success.[15-24] With additional experience and expansion of this technol-

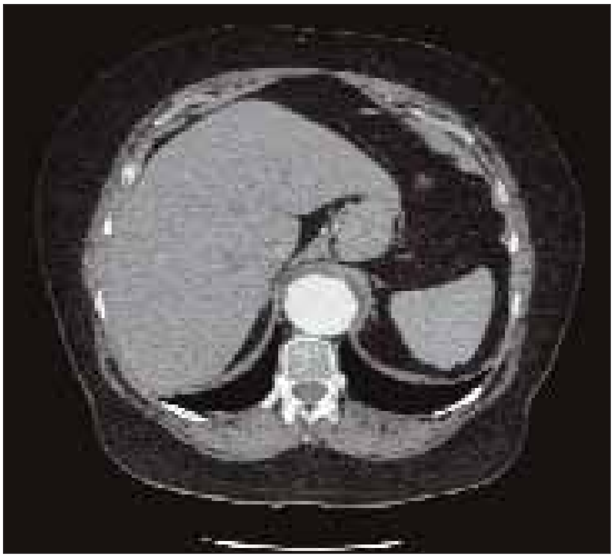

Figure 1. CT angiogram demonstrating the 62-mm descending thoracic aneurysm in the first patient treated.

ogy, it is likely that fenestrated and branched endografts will find a place in the treatment of thoracic disease. In the following case studies, we describe three patients who were treated with custom fenestrated endografts for descending TAA.

CASE 1

The first patient was an 82-year-old female with a medical history of chronic obstructive pulmonary disease (COPD), coronary artery disease (CAD), hypertension, and morbid obesity. She was referred for treatment of a 6-cm descending TAA (Figure 1). CT angiography confirmed a long proximal neck distal to the left subclavian artery that measured 24 mm in diameter. Distally, the neck length was 10 mm above the celiac artery. Rather than covering the celiac artery with the stent graft or performing an aortoceliac bypass to preserve flow, we elected to implant a custom fenestrated endograft. A thoracic aortogram was performed and confirmed the CTA findings (Figure 2). A single 36-mm Talent thoracic stent graft (Medtronic, Minneapolis, MN) was fully deployed outside of the body, and using the measurements of the angiogram and CTA, a 7-mm fenestration was created using an eye cautery, and the stent graft was reloaded into the sheath (Figure 3). Using eight markers on the stent graft to align the fenestration with the celiac artery on a lateral arteriogram, the stent graft was deployed distally to the superior mesenteric artery. A reversed curved catheter was then used to cannulate the fenestration and the celiac artery. A 7-F Pinnacle sheath (Terumo Interventional Systems, Somerset, NJ) was then passed into the celiac artery, and a 7- X 22-mm iCast covered stent (Atrium Medical Corporation, Hudson, NH) was passed into the fenestration and deployed (Figure 4). The completion angiogram demonstrated no evidence of an endoleak and showed good filling of the celiac and superior mesenteric arteries (Figure 5). The patient recovered well and was discharged from the hospital on the third postoperative day. The CT angiogram at 6 weeks confirmed patency of the fenestration and exclusion of the aneurysm (Figure 6).

Figure 2. Aortogram in lateral projection demonstrating only a 10-mm distal fixation zone for thoracic endografting to the level of the celiac artery. However, there is 20 mm to the takeoff of the superior mesenteric artery.

CASE 2

The second patient presented emergently with back pain a 7-cm descending TAA, again having no distal neck. Furthermore, she had a 4.5-cm infrarenal abdominal aortic aneurysm. She was a 79-year-old female with COPD, CAD, and severe spinal stenosis. Proximally, she had an adequate neck with an inadequate distal neck to repair the TAA. Therefore, using the techniques as described above, a 36-mm Talent thoracic stent graft was fully deployed, and a 7-mm fenestration was created in the distal end of the stent graft. A platinum-tipped .014-inch wire was sewn around the fenestration for visualization in this case (Figure 7). The thoracic components were deployed, and

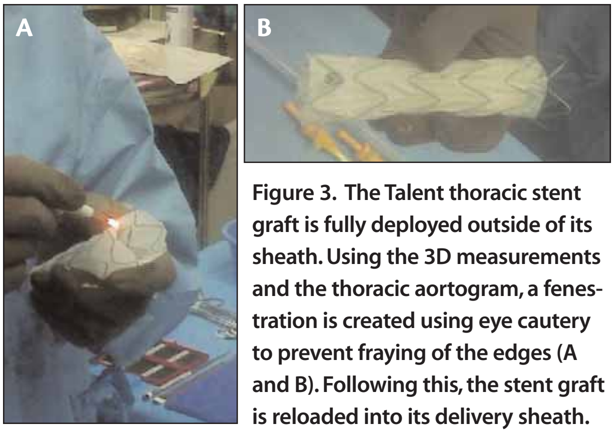

Figure 3. The Talent thoracic stent graft is fully deployed outside of its sheath. Using the 3D measurements and the thoracic aortogram, a fenestration is created using eye cautery to prevent fraying of the edges (A and B). Following this, the stent graft is reloaded into its delivery sheath.

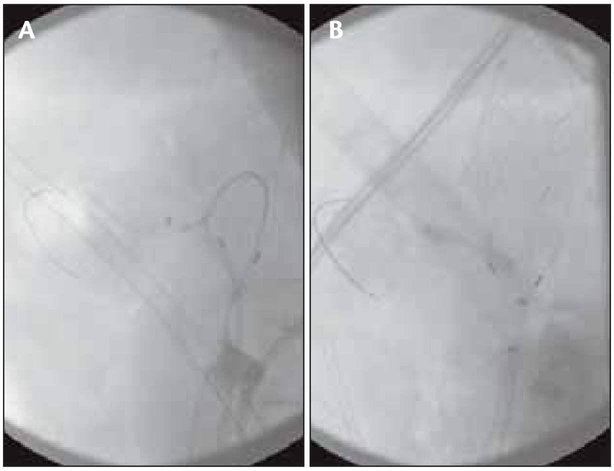

Figure 4. The stent graft is deployed, and using a reversed curved catheter, the fenestration and the celiac artery are cannulated (A); a 7-F Pinnacle sheath is used to cannulate the celiac artery, and a 7- X 22-mm iCast covered stent is placed into the celiac artery (B).

the celiac artery was cannulated through the fenestration, then a 7- X 22-mm iCast covered stent was placed. Because the patient presented with back pain, the infrarenal aneurysm was repaired with an AneuRx stent graft (Medtronic). With both the thoracic and the infrarenal aneurysms repaired, the patient required a spinal drain for right leg weakness postoperatively. She regained full strength in her leg and was discharged from the hospital on the seventh postoperative day. The CT angiogram at 4 weeks demonstrated good filling of the celiac artery with exclusion of the thoracic and infrarenal aneurysms (Figure 8).

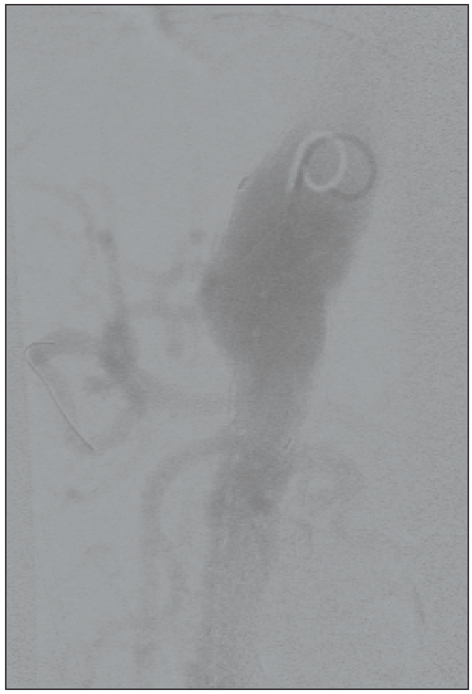

Figure 5. The stent graft covers the celiac artery and ends just above the SMA. There is complete exclusion of the aneurysm with excellent filling of the celiac artery.

Figure 6. Follow-up CTA with 3D reconstructions at 6 weeks shows the stent graft to be excluded with filling of the celiac artery through the iCast stent without evidence of an endoleak.

CASE 3

The third patient was an 80-year-old female with a contained descending TAA. On CT angiogram, the celiac artery was occluded, and the aneurysm extended to just above the superior mesenteric artery (SMA). Proximally, the aorta measured 32 mm; therefore, a 36-mm Talent thoracic stent graft was chosen. Due to external iliac arteries that measured 5 to 6 mm in diameter, we decided to use an iliac conduit. The Talent stent graft was deployed to the level of the renal arteries to exclude the aneurysm. Then, the stent graft delivery system was removed, and an 18-F sheath was placed into the conduit for hemostasis. Next, a small midline incision was made, and the SMA was dissected and encircled with vessel loops (Figure 9). A micropuncture set was used to cannulate the artery, and a 45-cm Pinnacle sheath was placed into the SMA. The 18-F sheath in the iliac conduit was then connected to the 7-F sheath in the SMA to allow flow to the SMA. Then, a transseptal needle (St. Jude Medical, Inc., St. Paul, MN) was passed over a .018-inch wire to the level of the stent graft and was used to create an in situ fenestration. An 8- X 40-mm iCast stent was placed through the fenestration and dilated. The completion angiogram showed excellent flow through the SMA, as well as exclusion of the aneurysm (Figure 10). On postoperative day 10, the patient developed ischemic colitis of the sigmoid colon, necessitating

Figure 7. CT demonstrates a short distal neck just above the celiac artery (A). Again, the Talent thoracic stent graft is deployed on the back table. A 7-mm fenestration is created, and a .014-inch platinum tip wire is sewn around the fenestration to make visualization easier (B).

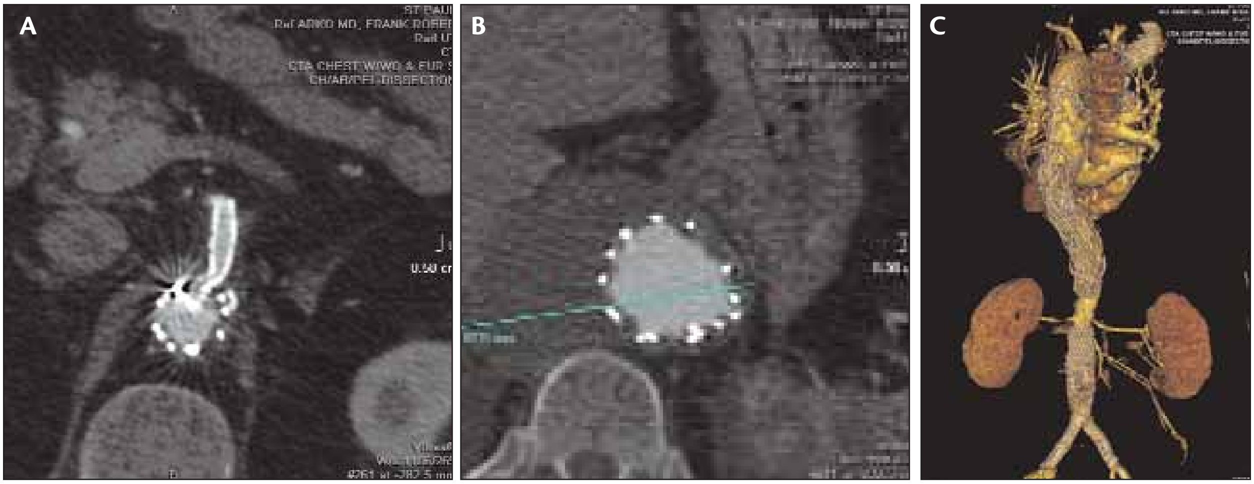

Figure 8. The iCast stent is seen within the celiac artery with mild kinking of the stent, which is not flow-limiting on duplex US (A). The aneurysm is completely excluded on axial images (B). A 3D reconstruction shows the thoracic aorta and the infrarenal aorta repaired with a Talent and an AneuRx stent graft (C).

resection. The patient went into oliguric renal failure. The family requested withdrawal of support, and the patient died on postoperative day 12.

DISCUSSION

Fenestrated endografts allow for the preservation of aortic branch vessels by incorporating them in the endovascular repair. This is accomplished by stenting open the aortic branches through adjacent fenestrations in the endograft. Fenestrations may be created by the surgeon at the time of operation, as was done in all of the patients mentioned in the preceding case studies, or the fenestrations may be premade by graft manufacturers. However, premade fenestrations are still not FDA approved in the US, and it is unknown when they will be commercially available. Either way, the side holes in the graft are created by measurements obtained from 3D CT data using orthonormal views of the aorta to determine the relationship of the side branches to each other and the new endograft.

Fenestrated endografts were first intended for use in pararenal aortic aneurysms, in which a short infrarenal neck (<15 mm) would otherwise preclude EVAR. Because an inadequate infrarenal neck is the most common contraindication for EVAR,[25] the benefit of a durable fenestrated or branched endograft has been estimated to benefit up to 20% of patients with abdominal aortic aneurysms by preventing the need for open surgical repair.[26-28] Park et al was the first to report success with this technique in 1996, when it was used to repair infrarenal aneurysms requiring preservation of the inferior mesenteric artery in the first patient, and a low renal artery in the second patient.[15] Since then, experience in the abdominal aorta has increased dramatically, demonstrating promising early[15-24] and midterm results.[17-23] Specifically, available reports show a procedural success rate of 82% to 100% and a

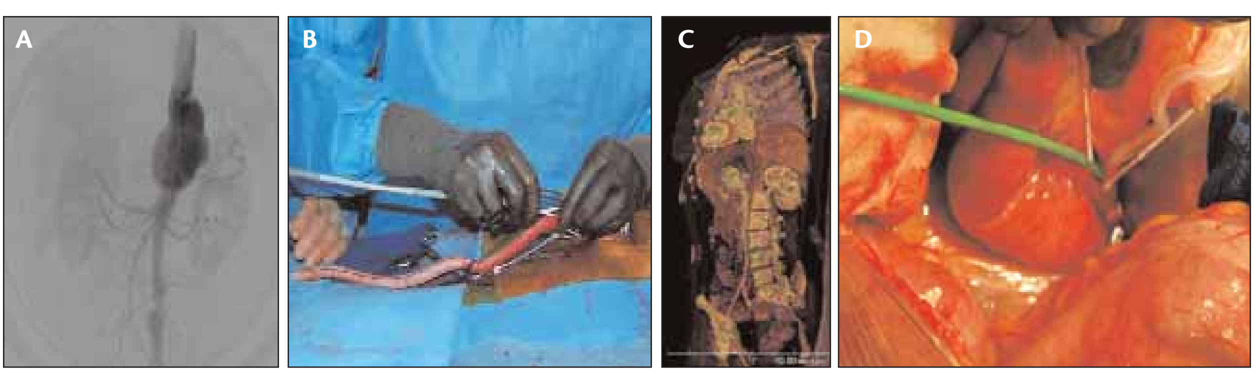

Figure 9. Aortogram (A) demonstrates the aneurysm with involvement of the celiac artery, which is occluded and ending just at the level of the SMA, as seen on the 3D reconstruction (B). A conduit was used, as the external iliac arteries were 5 to 6 mm bilaterally (C). Following deployment, a small celiotomy was made, and a 7-F Pinnacle sheath was placed into the SMA (D).

Figure 10. The 18-F sheath in the iliac conduit is connected to the 7-F sheath in the SMA to provide flow to the occluded SMA (A). Next, the transseptal needle is advanced into the 7-F sheath and used to create an in situ fenestration (B). Then, an 8- X 40-mm iCast stent is placed into the fenestration. The completion angiogram demonstrates excellent flow through the iCast stent (D).

periprocedural mortality rate of 0.8% to 4%.[15-24] With variable midterm follow-up of 2 to 7 years, the largest reports demonstrate low aneurysm-related death at 0% to 4.8%, low conversion rates of 0% to 1.6%, and a low incidence of endograft-related endoleak (type I or III) ranging from 0% to 9.2%. Stent occlusion rates, when reported, are also low (<5%).[18-24]

Fenestrated and branched endografting in the thoracic aorta may be used to distally extend the landing zone for patients with thoracic aneurysms or distal type I endoleaks. It may also be used to allow total endovascular treatment of thoracoabdominal aneurysms. However, extension of this technology to the thoracic aorta has been slower, as it is limited by more challenging anatomy and technical considerations and concern over durability and the ramifications of stent occlusion in these patients. Despite valid concerns, it should be noted that patients with thoracic aortic disease stand to gain the most benefit from this technique. The greater risks of conservative management for thoracic aneurysmal disease, as well as the risk of open TAA repair (as compared to patients with AAA), result in a greater potential for patients to benefit from this technology. In fact, by eliminating the need for aortic cross-clamping, left heart bypass, and thoracotomy/celiotomy, fenestrated endografting theoretically eliminates much of the operative risk associated with repair of TAAA.

In the case reports previously mentioned, we describe the treatment of a series of three patients, two of which were emergent procedures in patients with thoracic aneurysms and were at high risk using either open or hybrid repair. Two of the three underwent uncomplicated TEVAR procedures with distal extension of the endograft to include the celiac artery. These two patients experienced excellent short-term results that could not likely have been duplicated with other available surgical techniques. They were discharged from the hospital within 7 days, despite multiple medical comorbidities and advanced age. Unfortunately, the third patient developed ischemic colitis, and following resection, experienced acute renal failure. Upon exploration and resection of the left colon, the small bowel was well perfused with an excellent pulse in the SMA. The exact cause of the ischemic colitis is unknown, but certainly a ruptured descending TAA has a high likelihood of mortality. When the patient developed acute renal failure, withdrawal of support by the family was due to the patient's advanced age. Likewise, several investigators have now described using fenestrated and branched grafts exclusively in the thoracic aorta and have found this to be both safe and feasible.[12-14] Anderson et al first reported on four patients with TAAAs who were treated with custom-designed fenestrated and branched endografts. Although they experienced one periprocedural death, the remaining three patients were all discharged from the hospital in less than 1 week, despite significant medical comorbidities in all of the patients and ages >75 in two of the three patients. Furthermore, the 1-year follow-up showed that all of 10 treated vessels remained patent.[13] Chuter et al have recently reported 22 TAAA patients who were treated with fenestrated or branched endografts and demonstrated a periprocedural mortality rate of 9.1%, a reintervention rate of 9.1%, and a branch vessel patency rate of 98.85% at 1 month. Although they did report a high perioperative morbidity rate of 41%, this is at least equivalent to those obtained with open repair, and there were also no reports of renal failure, stroke, or myocardial infarction.[12] The largest series, reported by Roselli et al, involved 73 patients with thoracoabdominal aneurysms. They had technical success in 93% of patients, with no conversions or ruptures, a 30-day mortality rate of 5.5%, and a major morbidity rate of 14%. However, long-term follow-up is lacking.[14]

CONCLUSION

Overall, many patients with thoracoabdominal aneurysms who were once considered ineligible for endovascular repair due to complex aortic anatomy, disease, and advanced age, may in fact be candidates with the further development of fenestrated endografting. There are relative contraindications for this procedure however, as previously described by Chuter et al, including stenosis or severe angulation of branch vessels, preventing access, and severe tortuosity of the aorta or iliac arteries, preventing the free endograft movement needed to align fenestrations properly.[13] In all of the patients treated in this series, there was limited tortuosity, and the branch vessels came off relatively straight from the aorta. Currently, experiences stated in the literature are anecdotal, and without longer duration of follow-up and more substantial experiences reported, this is not the recommended operation for all patients with thoracic disease. Fenestrated or branched endografting is ideally suited for patients who desire repair, but whose comorbidities place them at significant operative risk for standard open or hybrid technique. Patients who can tolerate these other, more durable procedures should likely continue to undergo them. Until the fenestrated or branched endograft technique is more widely implemented, only experienced interventionists should perform it. ■

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