◆ CASE REPORT ◆

Hybrid Open-Endoluminal Technique for Repair of Thoracoabdominal Aneurysm Involving the Celiac Axis

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Purpose: To describe a technique combining endoluminal and open approaches for the repair of thoracoabdominal aneurysms involving the celiac axis.

Case Report: Two patients with type I thoracoabdominal aneurysm and suboptimal cardiac reserve underwent transluminal stent-graft implantation. To achieve satisfactory distal seal, the caudal end of the endograft was circumscribed with a Dacron band that was sutured to the aorta and endograft through a midline incision. The patent celiac artery in both patients was ligated to stop retrograde filling of the aneurysm sac. The patients developed no problems perioperatively, and exclusion of the aneurysms was confirmed by follow-up imaging. Three years after endografting, both patients had excluded aneurysms without evidence of endoleak or device migration.

Conclusions: This combined approach is another treatment option for thoracic aneurysms that have an anatomically suitable proximal attachment zone with a compromised distal neck.

J Endovasc Ther 2000;7:513–519

Key words: thoracic aorta, endograft, endoleak, Z-stent, Dacron

Thoracic aortic aneurysm is a life-threatening condition, in which rupture is nearly always fatal. In untreated patients, the 5-year survival rate is only about 20%.[1] Elective surgery is indicated if the aneurysm is >6 cm in diameter, rapidly enlarging, or impinging on adjacent structures. However, the surgical mortality rate is significant (10%–15%), even when the procedure is performed by experienced surgeons in patients with good cardiac and respiratory reserve.[2] Moreover, the mortality increases in patients with comorbidities such as advanced age (>80 years), chronic obstructive pulmonary disease, and coronary heart disease.[3]

Standard surgical technique requires resection of the aneurysmal segment and replacement with a synthetic graft via a left thora-

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cotomy, frequently using cardiopulmonary bypass for organ protection. However, despite surgical advancements and varied approaches to spinal cord preservation,[4] paraplegia continues to occur in up to 21% of conventional thoracic aortic aneurysm repairs.[5]

Endovascular stent-grafting has evolved as a relatively safe and effective technique for minimally invasive repair of abdominal aortic aneurysms.[6] Experience with endografting in the thoracic aorta is more limited.[7–10] Although the transluminal approach obviates the need for aortic cross-clamping, which causes spinal ischemia in conventionally treated patients, blood supply to the spinal cord can still be jeopardized by occlusion of the intercostal arteries with the endograft. To date, most anecdotal reports of thoracic aortic stent-grafting involve aneurysms distal to the left subclavian artery and proximal to the celiac axis, where the risk of occluding intercostal arteries is less.[9] However, sporadic cases of paraplegia are not unknown in lengthier thoracic aneurysms.[8,11]

When treating 2 patients with type I thoracoabdominal aneurysms involving the celiac axis, we evolved a hybrid technique combining a custom-made endoluminal graft with open ligation of the patent celiac artery and external banding of the distal endograft fixation site to ensure satisfactory aneurysm exclusion.

CASE REPORTS

An 80-year-old woman being investigated for exertional shortness of breath was found to have a thoracoabdominal aneurysm. She had had a right subclavian artery aneurysm repaired 14 years previously and had medically treated cardiac disease and hypertension. A spiral computed tomographic (CT) scan (Fig. 1) of the chest and upper abdomen showed a 6-cm aneurysm extending from the midthoracic aorta to the level of the celiac axis; no other aneurysmal disease was found in the abdominal aorta or periphery. Because of her age and cardiac disease, she was considered for endoluminal repair. A thoracoabdominal angiogram in combination with the spiral CT scan suggested that a combined endoluminal/open repair would be feasible.

Figure 1 ◆ Contrast computed tomography scan from the female patient showing the distal extent of the thoracoabdominal aneurysm on the left side; the celiac artery (arrow) is visible anteriorly.

In the other case, a 73-year-old man with multiple comorbidities (myocardial infarct, peptic ulcer, chronic renal failure, hypertension, and hyperlipidemia) presented with upper abdominal pain. An initial CT scan revealed an aneurysm involving the upper abdominal aorta. A thoracoabdominal CT scan showed a 6-cm thoracoabdominal aneurysm involving the celiac axis; the mesenteric vessels were patent on arteriography, and the aneurysm appeared suitable for the combined repair technique.

In both cases, the endografts were constructed from self-expanding stainless steel Z-stents (Cook Inc., Bloomington, IN, USA) covered with Cooley Verisoft woven Dacron fabric (Boston Scientific, Natick, MA, USA) and sized according to measurements from CTs and angiograms. Each operation was performed under general anesthesia, with arterial and central venous pressure monitoring and urinary catheter in situ. After the abdomen and groin were prepared and draped, the common femoral artery was exposed via an incision in the right groin. An angiogram (Fig. 2) was performed to localize the celiac and superior mesenteric artery (SMA) orifices; an external marker was placed at the level of the SMA origin. An angiography catheter was delivered to the SMA, where it remained

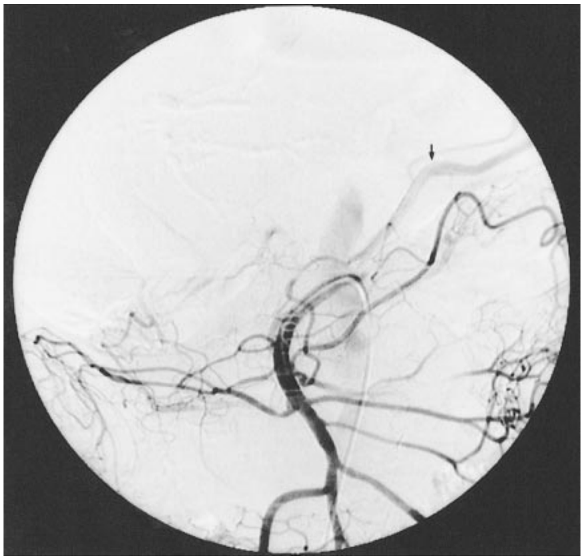

Figure 2 ◆ Selective intraprocedural angiogram via the SMA shows flow in the splenic artery (arrow) fed by collateral vessels.

throughout the procedure to further delineate the SMA origin.

A stiff exchange guidewire was then passed up to the distal aortic arch, and a 22-F sheath was advanced over the wire until it reached above the aneurysm. A straight endograft was inserted into the sheath and passed cephalad until the distal end was at the level of the SMA marker. As the sheath was retracted, the stent-graft expanded to anchor proximally to the aorta above the aneurysm and between the celiac and superior mesenteric arteries distally. An angiogram was performed to ensure that there was no proximal endoleak, but backfilling from the hepatic and splenic arteries via the celiac artery was seen in both cases and a distal endoleak in one (Fig. 3).

A midline abdominal incision was made to expose the celiac and superior mesenteric origins via the gastrocolic mesentery and the lesser sac. The median arcuate ligament was divided, and the branches of the celiac artery were isolated; the segment of aorta between the celiac artery and SMA was cleared. The celiac artery was then clamped, and the pressure in the artery was measured to determine whether there was adequate flow in the hepatic and splenic arteries (approximately 70 to 80 mm Hg in both cases). The celiac artery was divided and the ends oversewn with 5-0 Prolene, thus improving access to the exposed normal aorta above the SMA. Three 3-0 Prolene sutures were placed over Dacron pledgets at the 3, 9, and 12 o'clock positions through the aorta and the internal stent-graft to anchor the device inside the lumen of the aorta (Fig. 4).

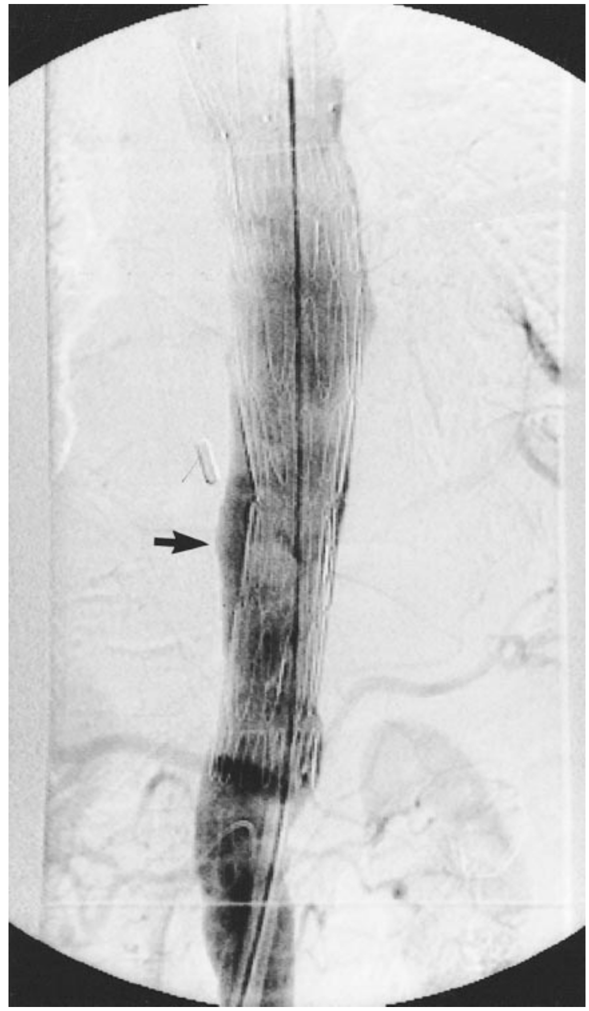

Figure 3 ◆ Control angiogram before the abdominal phase, showing an endoleak (arrow) around the distal end of the stent-graft. Retrograde filling of the hepatic and splenic arteries is also seen.

A 15-mm-wide Dacron band was then passed around the normal aorta distal to the aneurysm. (The length of Dacron needed to comfortably circumscribe the aorta was previously determined from CT scans and

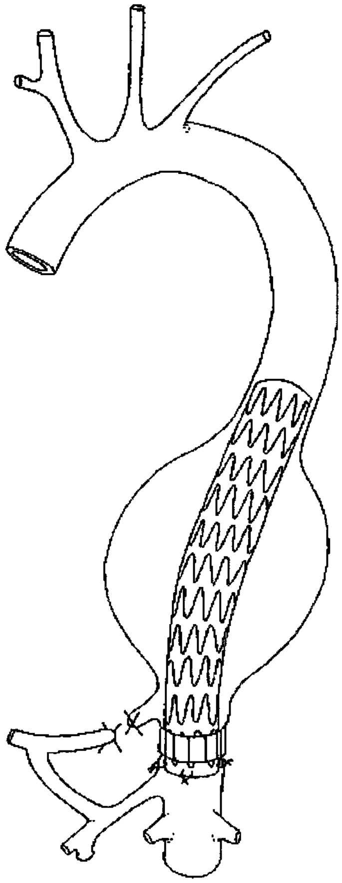

Figure 4 ◆ Illustration of the endoluminal thoracic aortic aneurysm repair, including transaortic suture (5 sutures) fixation of the graft and a reinforced circumferential Dacron band.

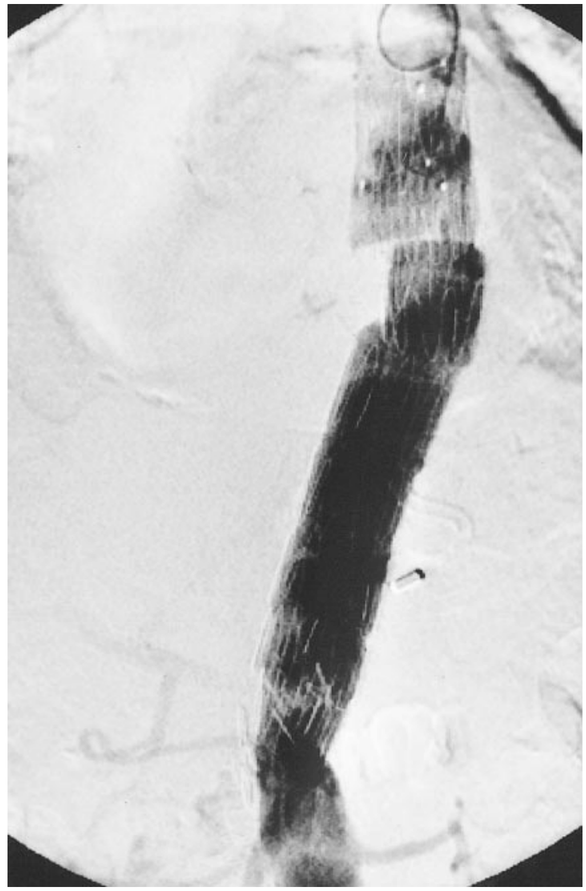

Figure 5 ◆ Control angiogram after the abdominal phase, showing no leak around the distal end of the graft.

marked on the Dacron band.) The band was improved by the transverse placement of large surgical Ligaclips. The excess fabric was excised and the ends sutured together (with 3-0 Prolene), forming a continuous ring around the aorta. The Dacron ring was then sutured to the aorta and stent-graft with interrupted 3-0 Prolene; there was minimal bleeding while suturing the pulsatile aorta. The abdominal incision was closed, and aortography and selective angiography (Fig. 5) were performed via the SMA catheter to identify any endoleaks and filling of the hepatic and celiac arteries via collaterals.

The procedures required 6 and 5 hours, respectively, and each required 130 mL of contrast. Both patients were admitted to the intensive care unit. The woman was extubated after 4 hours and moved to the ward the next day, but the man required a 3-day stay in the intensive care unit owing to poor respiratory function and onset of acute renal failure (serum creatinine peaked at 450 μmol/L). Both patients developed atrial fibrillation on the third postoperative day, which was controlled with amiodarone and then digoxin. The woman became ambulatory on day 3, resumed a normal diet on day 5, and was discharged 8 days after surgery. Predischarge imaging studies (Fig. 6) showed no endoleak and a satisfactory contour to the stent-graft. That patient remains well at 3 years, and the aneurysm has reduced in size.

The man's progress was slower, but by discharge on the 13th postoperative day, his creatinine level had returned to 140 μmol/L. Because of his renal dysfunction, contrast CT

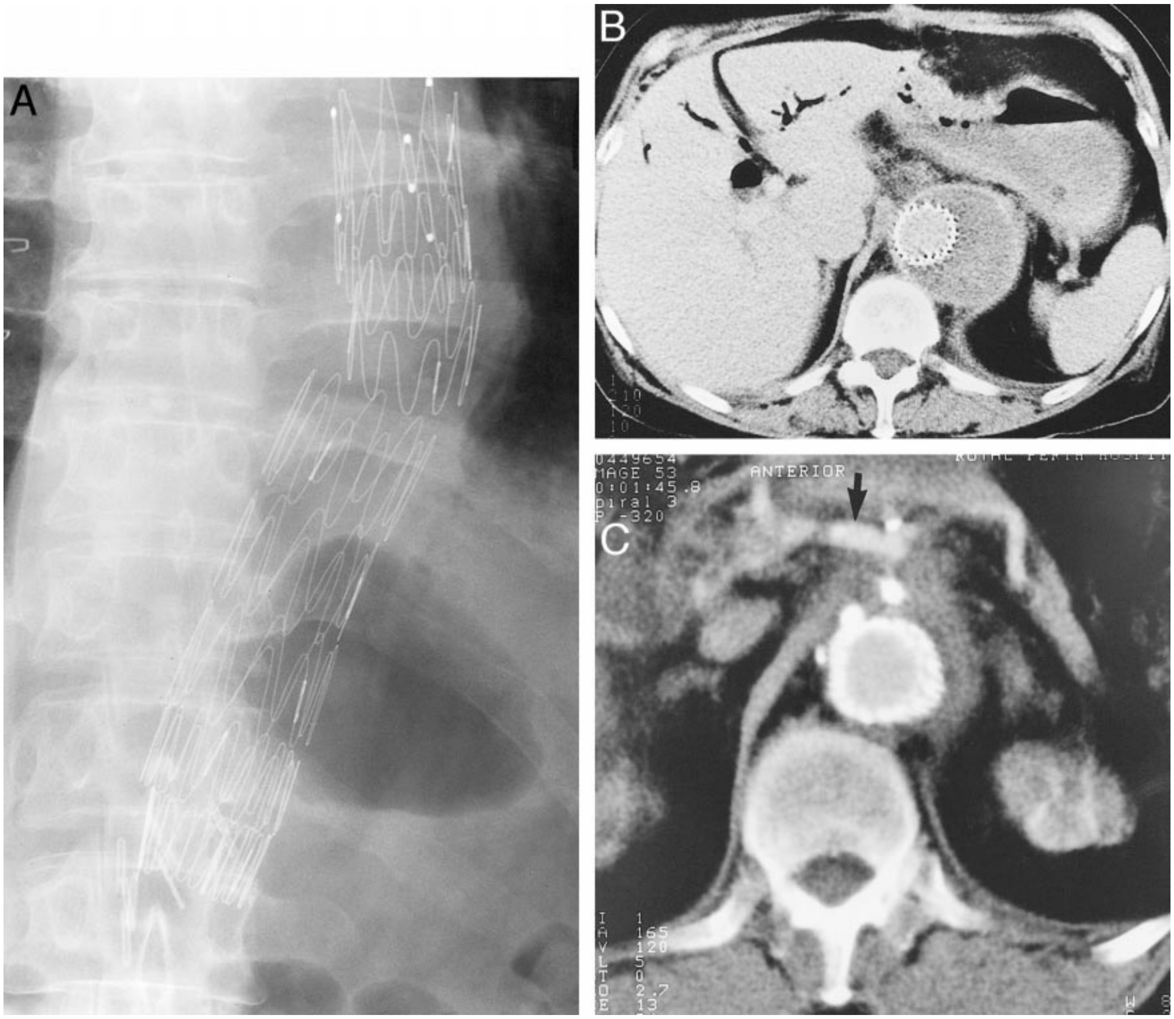

Figure 6 ◆ **(A)** The stent-graft is easily visualized on noncontrast radiography in the female patient before discharge. The Ligaclips seen at the lower end of the stent mark the site of the Dacron ring sutured circumferentially to the aorta and stent-graft. The computed tomography scans show adequate exclusion of the aneurysm in the female patient **(B)** before discharge and in the male patient at 1 month **(C)**. In the latter scan, note the satisfactory flow through the hepatic artery (arrow).

scanning was performed as an outpatient procedure at 1 month and showed no endoleak from the graft (Fig. 6C). Until his death from cardiac disease 3 years after endografting, this patient's thoracic aneurysm remained excluded and without evidence of endoleak.

DISCUSSION

Aneurysms of the thoracic aorta can be effectively treated by endovascular stent-grafting,[7–10] but this approach requires suitable lengths of normal aorta proximal and distal to the defect for device fixation. Moreover, if a major arterial branch lies within the aneurysm, the repair is more complex and may involve concomitant surgical or endoluminal procedures to reroute blood flow to vital organs or prevent continued perfusion of the aneurysm sac.

Because thoracic aneurysms often involve the abdominal aorta to some extent, the applicability and complexity of endograft repair depends on the number of critical vessels arising from or immediately adjacent to the aneurysm. In type I thoracoabdominal aneurysms, the celiac artery may be the only vessel involved. Nevertheless, the distance between the celiac and SMA origins is only about 1 cm, which is not sufficient to provide a secure fixation site. Moreover, the celiac artery is often patent, which will result in backfilling of the aneurysm sac, with the continued risk of rupture.

In constructing a treatment plan for these patients, we selectively catheterized the SMA to mark the level of distal deployment for the endograft. To insure against distal migration, the deployed endograft was anchored in 2 phases, first to the aorta with interrupted nonabsorbable sutures and then to a Dacron band wrapped and sutured around the aorta. The banding and suturing also apposed the endograft to the aortic wall and eliminated the possibility of an endoleak. Dividing the celiac artery was necessary to prevent retrograde perfusion (type II endoleak) of the aneurysm sac; it also provided a good working distance above the SMA. If there had been limited flow to the hepatic and splenic arteries, then a short bypass graft to the disconnected celiac artery would have been easily possible.

In the more than 3 years since we treated these patients, hybrid techniques have been used simultaneously to repair thoracic aneurysms involving the arch and descending aorta[12] and even an unusual type IV thoracoabdominal aneurysm,[13] but Hollier,[14] in his 1998 commentary on combining endovascular and surgical techniques for thoracic aortic aneurysms, predicted the potential utility of this approach for type I thoracoabdominal aneurysm involving one or more visceral vessels.

Our experience with these 2 cases attests to the potential of thoracoabdominal aneurysm repair by using a hybrid technique that is less stressful than the conventional open procedure. Moreover, the ≥3-year follow-up in these patients gives some indication of the durability that may be anticipated with these devices. As endograft technology advances and branched or fenestrated devices become available,[15] such minimally invasive techniques may be applied to more extensive thoracoabdominal aneurysms via side branch cannulation and branch graft deployment.

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