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Complete Endovascular Renal and Visceral Artery Revascularization and Exclusion of a Ruptured Type IV Thoracoabdominal Aortic Aneurysm

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Purpose: To present a technique for renal and visceral revascularization allowing complete endovascular treatment of a ruptured type IV thoracoabdominal aneurysm using devices already stocked in most centers performing endovascular aneurysm repair.

Technique: Open arterial access is obtained to both common femoral arteries and the left subclavian artery (LSA). Access to the visceral and renal arteries is obtained through separate 8-F sheaths for each visceral and renal branch. Both visceral arteries (celiac trunk and superior mesenteric artery) are accessed through 2 separate sheaths placed into the LSA, and both renal arteries are accessed through 2 separate sheaths placed into the left common femoral artery. Corresponding covered stents are introduced and positioned in the celiac trunk, superior mesenteric artery, and both renal arteries but not deployed. The aortic stent-graft is then introduced and deployed through the right common femoral artery. Once the aneurysm exclusion is completed, the stent-grafts to the branches are deployed so that they are positioned between the aortic wall and the aortic stent-graft. Finally, the branch stent-grafts as well as the aortic stent-graft are fully expanded with balloon catheters inflated simultaneously as in the kissing balloon technique.

Conclusion: To our knowledge, no one has reported using this technique to successfully treat a ruptured thoracoabdominal aneurysm and revascularize all 4 major renovisceral arteries. A main advantage of this technique over use of branched stent-grafts is that it can be performed even in the emergency setting with devices that are in stock in most institutions performing endovascular aneurysm exclusion.

Key words: ruptured aneurysm, thoracoabdominal aneurysm, stent-graft, endovascular aneurysm repair, endovascular branch revascularization, renal artery, visceral arteries
short or no proximal necks. However, to date there have been no reports, to our knowledge, using these techniques to treat thoracoabdominal aortic aneurysms (TAAA) involving all 4 major visceral and renal branches. In this article, we detail the successful use of standard off-the-shelf endografts placed parallel to and outside a standard thoracic endograft to treat a ruptured type IV TAAA and maintain blood flow to all the abdominal organs.

TECHNIQUE

The technique is illustrated in a 77-year-old man who while hospitalized for a spontaneous pneumothorax 5 years after a lobectomy for bronchial carcinoma developed sudden severe upper abdominal pain. Emergent computed tomographic angiography (CTA) revealed a ruptured Crawford type IV TAAA with a maximal diameter of 7.5 cm. The aneurysm extended from the distal thoracic aorta to an infrarenal bifurcated graft that had been surgically placed 17 years prior for abdominal aortic aneurysm (AAA). Blood extravasation outside the aneurysm extended from the visceral aorta upward along the esophagus into the mediastinum. In addition, a distal anastomotic aneurysm was detected in the left common iliac artery (Fig. 1). Because of the patient’s severely compromised lung function and the acute rupture, it was felt that the patient would not survive an open TAAA procedure, so we elected to perform a complete endovascular repair using the following technique.

With the patient under general anesthesia, open access was obtained to both common femoral arteries and the left subclavian artery (LSA) with the “Surgiclose” technique. Then, the celiac trunk and superior mesenteric artery were accessed through the LSA, each with an 8-F Arrow sheath (Arrow International Inc., Reading, PA, USA). In a similar way, 8-F Arrow sheaths were delivered to both renal arteries via the left common femoral artery. Branch cannulation was performed using a 5-F Chuang visceral reverse curve catheter (Cook, Inc., Bloomington, IN, USA). Over a Rosen wire (Cook, Inc.), a Viabahn stent-graft (W.L. Gore and Associates Inc., Flagstaff, AZ, USA) was inserted into the target artery. In this fashion, two 8-mm Viabahn stent-grafts (10 and 5 cm in length) were serially placed in the celiac artery; a single 8-mm×15-cm Viabahn device was placed in the superior mesenteric artery, and each renal artery received a 7-mm×10-cm Viabahn stent-graft. All these branch stent-grafts remained undeployed (Fig. 2A).

Next, a 28-mm×15-cm TAG (W. L. Gore and Associates Inc.) was delivered into the aorta to exclude the ruptured TAAA. Once the aneurysm exclusion was completed (Fig. 2B,C), the stent-grafts to the aortic branches were deployed so that they were positioned between the stent-graft and the aortic wall, running cranially or caudally beyond the ends.

Figure 1 - CT scans showing the ruptured aneurysm with extravascular blood (left, asterisks) and the distal anastomotic aneurysm of the left common iliac artery (left, arrow).
of the aortic stent-graft (Fig. 2D). Finally, the branch stent-grafts as well as the aortic stent-graft were fully expanded with balloon catheters inflated simultaneously as in the kissing balloon technique. An additional Wallstent (Boston Scientific, Natick, MA, USA) was deployed in the right renal Viabahn stent-graft to obtain full expansion. Finally, the left common iliac anastomotic aneurysm was excluded by placing a 24-mm Zenith stent-graft limb (Cook Inc.). There was a low-flow type Ib endoleak at the end of the intervention, which was treated conservatively based on our experience with these low-flow leaks after endovascular treatment of ruptured AAA cases. Postoperative ultrasound showed no

**Figure 2** ◆ Technique for endovascular branch revascularization and aneurysm exclusion. (A) The stent-grafts to the aortic branches are positioned. (B) The aortic endograft and the branch stent-grafts are positioned but still not deployed. (C) The aortic endograft is deployed first. (D) All stent-grafts are deployed and balloon dilated, allowing antegrade and retrograde flow to the visceral and renal arteries (arrows), respectively.

**Figure 3** ◆ (A) Pre-discharge CTA performed 2 weeks postoperatively showing complete sac thrombosis and patent stent-grafts to the branches. (B) 1–4: branch stent-grafts to the visceral and renal arteries, 5: aortic stent-graft, 6: separate Zenith 24-mm iliac extension to treat the left common iliac artery pseudoaneurysm.
increase in the hematoma, with regular perfusion of all visceral and renal arteries. The patient was clinically stable and recovered quickly, but pneumothorax treatment required 2 weeks before his air leak sealed. In the first postoperative CT on day 7, the very small (low-flow) endoleak Ib was still visible, but a repeat CT scan a week (Fig. 3) later documented that the endoleak had disappeared and the aneurysm was sealed. He was discharged 2 weeks after the endovascular procedure and remains well 6 months later; the 6-month CT scans show 30% shrinkage of the aneurysm sac (Fig. 4).

**DISCUSSION**

Chuter et al.\(^7\) reported in 2001 the successful use of a hastily constructed multi-branched stent-graft for the treatment of a contained rupture of a supraceliac ulcer and a large AAA ending proximally at the celiac artery. In 2006, Greenberg and colleagues\(^8\) published a series of 50 patients with TAAA successfully treated with branched endovascular grafts in the elective setting. Beyond that, several authors have described similar techniques to preserve aortic branch blood flow without the use of such branched stent-grafts. Greenberg et al.\(^9\) first reported a technique to extend the proximal landing zone across the renal arteries for preservation of renal blood flow. He created a longer neck by deploying a self-expanding stent into the renal artery with a segment of the stent “running parallel to the aortic wall” and the main stent-graft. Later, Larzon et al.\(^10\) described “the top fenestrating technique” in a series of 24 patients, wherein the covered renal arteries, left common carotid artery, or the LSA had flow maintained by deployment of preplaced stents, functionally working like a fenestration in an aortic stent-graft. Several authors have reported similar techniques of branch stenting (“snorkel” procedure) to preserve blood flow to the supra-aortic trunks when their origins were covered by the main aortic endograft.\(^1-3\) Finally, Ohrlander et al.\(^4\) proposed the term “chimney graft” when covered stent devices were employed in a similar fashion.

However, to our knowledge there is no report about these parallel stent-graft branch techniques being used to revascularize all 4 branches of a ruptured type IV TAAA. The technique described in our case allows such aneurysms to be treated in a totally endovascular fashion with devices that are routinely stocked in most endovascular facilities, making it a useful technique for urgent and emergent cases. It is particularly advantageous in high-risk patients who might not tolerate open repair, as was the case in this patient.

Branch stent-grafts extending through the proximal and distal landing zones might have a negative impact on sealing and durability. Therefore, we consider that the overlap of the parallel branch stent-grafts with the aortic stent-graft should be long (i.e., over 2–3 cm). Respecting this, our technique was successful in stopping blood leakage outside the aorta after deployment of the aortic stent-graft; it
also induced complete sac thrombosis within 14 days.

As regards the type Ib endoleak, our experience with low-flow endoleaks in ruptured AAA cases has shown us that they typically seal themselves within days.\textsuperscript{11} Indeed, this patient remained clinically stable and had no increase in the hematoma; the 14-day CT study documented disappearance of the endoleak and exclusion of the aneurysm.

An issue to consider with this technique is that the stent-grafts within the branches could compress the aortic stent-graft or vice versa, which could result in a blood flow reduction to the branches and/or the distal extremities. As we were aware of this problem, we performed selective pressure measurements in the distal aortic and branch lumens to exclude important flow restriction before removing the wires. This allowed us to perform additional stenting of the compressed right renal branch stent-graft, which successfully eliminated the pressure gradient.

Regarding feasibility, as the aortic landing zones have to be at least \( \sim 2 \) to 3 cm long, the technique precludes aneurysm extension into the arch and/or beyond the aortic bifurcation. Finally, reproducibility and durability of such a repair has to be proven by more experience and longer follow-up.

Conclusion

Complete endo-debranching of all 4 renal and visceral arteries with covered stents running parallel to and between the aortic stent-graft and the aortic wall in a patient with a ruptured type IV TAAA was successful and effective in maintaining blood flow to the aortic branches and completely sealing the aneurysm. This technique can be performed with devices in stock in most institutions doing endovascular aneurysm repairs and could be useful in the treatment of certain patients with TAAA rupture, particularly when open surgery is deemed to be of high risk. The subgroup of patients developing aneurysms extending to the renal and/or visceral arteries after infrarenal graft repair is not so rare, so we believe that the described technique could be a valuable bailout maneuver for the surgical community.

REFERENCES