Endovascular repair of a proximal aortic arch aneurysm: A novel approach of supra-aortic debranching with antegrade endograft deployment via an anterior thoracotomy approach

Wei Zhou, MD,* Michael E. Reardon, MD,† Eric K. Peden, MD,* Peter H. Lin, MD,* Ruth L. Bush, MD,* and Alan B. Lumsden, MD,* Houston, Texas

Although open surgical repair continues to be the standard therapy for thoracic aortic aneurysms, endovascular intervention has evolved into an acceptable strategy for patients who have prohibitive risks for conventional surgical treatments. Aortic arch aneurysm, in particular, is associated with substantial surgery-related morbidity, yet is typically not suitable for endovascular intervention. We describe a combined technique of supra-aortic trunk debranching through an anterior thoracotomy followed by endovascular repair of a large proximal arch aneurysm in an 82 year-old man 8 years after an ascending aortic aneurysm repair. (J Vasc Surg 2006;43:1045-8.)

If left untreated, a thoracic aortic aneurysm (TAA) with a diameter of more than twice the proximal uninvolved aorta is associated with a 2-year patient survival rate of <30%.1 Conversely, elective operative therapy has reported mortality rate of 3% to 20%.2,3 The rapid evolution of catheter-based technology has laid the foundation for the treatment of TAA.4-6 Recent Food and Drug Administration approval of the TAG thoracic endoprosthesis (W. L. Gore and Associates, Flagstaff, Ariz) further provides opportunities for patients not enrolled in clinical trials who are unfit for open surgical repair. Aortic arch aneurysms, however, are often deemed unsuitable for endovascular repair because of the close proximity of the supra-aortic trunks. A combined endovascular and open approach has therefore recently been adopted as a valuable alternative.

Several reported cases describe open surgical debranching of the supra-aortic trunk via sternotomy followed by stent-graft deployment in patients whose aneurysms involved the innominate arteries.6-9 However, repeat sternotomies for patients with prior surgeries are technically challenging, particularly in the presence of large aneurysms next to the sternums.

We report a unique combined approach of open surgical debranching of supra-aortic trunks via an anterior thoracotomy followed by an antegrade stent-grafting to treat a large proximal aortic aneurysm in a patient with prohibitive comorbidities for open repair who had a prior sternotomy for an ascending aortic aneurysm repair.

CASE REPORT

An 82-year-old man with a medical history of an ascending aortic aneurysm repair 8 years earlier developed a 6.3-cm aortic arch aneurysm distal to the previous repair. Open surgery was withheld owing to his severe chronic obstructive pulmonary disease that required home oxygen therapy. Endovascular intervention alone would also be challenging because of the involvement of the supra-aortic vessels and a stenotic lesion at the site of the distal anastomosis of the previously placed ascending aortic graft (Fig 1). An adjunctive procedure of debranching supra-aortic trunks, on the other hand, would make endovascular repair feasible. We therefore decided on a combined endovascular and open approach with an antegrade placement of the most proximal piece of stent-graft through the ascending graft.

A cerebrospinal fluid drainage system was instituted preoperatively, and a double lumen endotracheal tube was inserted. A pigtail marker catheter was used to measure an 8-cm segment of ascending aortic graft above the coronary arteries. This necessitated a very proximally located anastomosis to allow an adequate proximal landing of the stent-graft without covering the anastomosis. A small anterior right thoracotomy was made through the fourth intercostal space, which provided the optimal exposure of the most proximal portion of the ascending graft.

Meanwhile, a 10-mm-wide Dacron graft was sutured to a 14-mm-wide Dacron trunk in an end-to-side fashion. The 10-mm
limb was used for supra-aortic vessel inflow, and the 14-mm-wide trunk was anastomosed to the ascending graft and used as a conduit for stent-graft insertion (Fig 2, A). The 14-mm limb was selected so that the introducer sheath would be nonocclusive and thus permit continuous perfusion of the supra-aortic trunks during endograft deployment.

Once the ascending aortic graft was exposed, a partially occlusive aortic clamp was placed, and the branched graft was sutured to the proximal ascending graft. The 10-mm limb was next tunneled to the neck and anastomosed to the right common carotid artery (CCA). Afterward, the 7-mm Dacron grafts were used to perform a right-to-left CCA bypass and a bypass from the CCA to the left subclavian artery. The innominate artery and the proximal right CCA were then suture ligated. The left subclavian artery was coiled later because of poor visualization of the origin of the left vertebral artery through our surgical exposure. Subsequently, the 14-mm limb was tunneled through the sixth intercostal space to optimize the angle for stent-graft insertion.

A guidewire was then advanced to the ascending aorta through the 14-mm limb, and a stiff Meier wire (Boston Scientific, Oakland, NJ) was exchanged. A 24F guiding sheath was subsequently inserted over the Meier wire, along which a 5F short guiding sheath was inserted for contrast administration.

After an angiographic confirmation, a 34-mm × 20-cm stent-graft was deployed via the 14-mm limb, followed by a 37-mm × 20-cm stent-graft deployment via the right common femoral artery. A 5-cm overlap was ensured (Fig 2, B). As demonstrated by Fig 2 (B), a Kelly clamp was placed at the anastomotic site between the 14-mm conduit and ascending graft to mark the origin of the conduit and to ensure that the proximal end of the stent-graft was deployed beyond the origin of the conduit.

Two pieces of stent-graft were used to extend the grafting area to the normal appearing descending aorta. Next, the origin of left subclavian artery was coiled to prevent a potential type II endoleak. Completion angiography confirmed total aneurysm exclusion, with a brisk antegrade flow to the cervical arteries and patent vertebral arteries (Fig 3). Finally, the stump of the 14-mm limb was oversewn, and the thoracotomy was closed in the standard fashion.

The patient had an uneventful recovery and was discharged 5 days later. A 1-month follow-up computed tomography scan showed markedly a decreased aneurysmal size.

DISCUSSION

Endovascular stent-grafting for TAA has become increasingly popular since its efficacy was demonstrated in several recent clinical investigations. However, high-risk patients with large aortic arch aneurysms were often excluded from endovascular modalities because of anatomicies associated with arch aneurysms. By using a combined endovascular and open surgical method, these patients may be successfully treated. Our case highlights the feasibility and efficacy of treating proximal arch aneurysms in patients with prior sternotomies by using combined techniques of surgically debranching supra-aortic trunks via an anterior thoracotomy followed by endovascular stent-grafting.

Compared with the substantial morbidity and mortality rates associated with open surgical repair of TAA, endovascular intervention has fewer procedure-related complications, a shorter convalescence, and minimal neurologic deficits. Despite promising results from endovascular repair of TAA, anatomic unsuitability, particularly inadequate landing zones, often exclude patients from endovascular interventions.

The general anatomic inclusion criteria used in various clinical trials are fusiform TAA of 5 cm in maximal diameter or saccular aneurysm at least 20 mm distal to the origin of the left CCA and 20 mm proximal to the origin of the celiac artery, and proximal and distal neck diameters ≥18 mm and ≥42 mm. These anatomic inclusion criteria are deemed important to ensure a successful stent-graft treatment and proper circumferential seals. Therefore, aortic arch aneurysms are generally excluded from endovascular interventions owing to inadequate landing zones and risks of flow obstruction to the supra-aortic trunks.

By utilizing a combined surgical and endovascular approach, however, an adequate landing zone may be created, and high-risk patients who would otherwise be unsuitable for endovascular repair may thus be potentially...
qualified for endovascular intervention. This is a particularly valuable strategy for patients with arch aneurysms.

Reconstructions of common carotid and subclavian arteries to provide adequate proximal landing zones for endograft repair have been well-described in the literature, but the reconstruction of innominate arteries is rarely performed. Moriyama et al. successfully treated three patients with distal arch aneurysms by using stent-grafts combined with bypass from the ascending aorta to the left auxiliary artery under hypothermic circulatory arrest. Mangino et al. without using hypothermic circulatory arrest, successfully treated one patient with arch

Fig 2. A, Schematic drawing shows a 10-mm limb being sutured to a 14-mm trunk. The 10-mm limb is tunneled superiorly to revascularize supra-aortic trunks, and the 14-mm trunk is used as the conduit for stent-graft placement. A 24F guide sheath is being inserted into the 14-mm trunk over a wire along with a 5F short guide sheath for contrast administration. B, Intraoperative angiography shows the proximal piece of stent-graft being advanced to the ascending aorta via the 14-mm limb approach and a second Meier wire being advanced to the descending aorta through groin approach. The 10-mm limb is temporarily clamped, and a Kelly clamp marks the anastomosis between the 14-mm limb and the ascending graft to ensure the stent-graft is deployed beyond the limb origin.

Fig 3. Completion angiography shows total aneurysmal exclusion and brisk antegrade flow to the cervical vessels.
aneurysm by using a combined open and endovascular technique. However, they used a median sternotomy approach to access the ascending aorta.\(^{16}\)

As for our patient, a prior ascending aneurysm repair and the close proximity of the large aneurysm to the sternum would have made a repeat median sternotomy extremely dangerous. Anterior thoracotomy, on the other hand, avoided the area previously operated on and provided a direct approach to the ascending graft without requiring hypothermic circulatory arrest.

In addition, the proximal location of the aneurysm necessitated deploying the stent-graft in a very proximal location and placing the stiff portion of the guidewire near aortic valves and, potentially, the right atrium if the femoral approach was used for deployment. Placing the most proximal piece of the stent-graft through an antegrade approach, on the other hand, provided maximum precision with minimal cardiac irritation. Furthermore, anastomotic stricture proximal to the aneurysm requires increased guidewire manipulation and potentially makes delivering the stent-graft via a femoral approach more difficult.

**CONCLUSION**

Supra-aortic trunk debranching in combination of endovascular stent-grafting provides a unique opportunity for patients with aortic arch aneurysms who are unfit for conventional open repair. Furthermore, anterior thoracotomy under radiographic guidance is an effective alternative to median sternotomy, particularly for patients who have had a prior operation. This technique further expands the aortic territory that can be grafted. Although some of these adjunctive procedures remain major operations, they avoid the requirement of aortic cross-clamping and the need for hypothermic circulatory arrest. Until branched aortic endografts become available, debranching techniques combined with aortic stent-grafting provide the optimal approach for the management of complex thoracic aneurysms.

**REFERENCES**