Endovascular Treatment of Arch and Descending Aortic Pathologies

Addressing the challenging anatomies of the arch and descending aorta with custom-made options from the Relay® platform.

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The widespread acceptance of thoracic endovascular aortic repair (TEVAR) for descending aortic pathologies has led to its application in off-label situations. The recent shift in thinking around the treatment of Stanford type B aortic dissections—from predominantly conservative to invasive strategies anticipating long-term remodeling and better outcomes—contributed to an expanding indication spectrum.[1,2] Now, very ill patients with disease of the descending thoracic or thoracoabdominal aorta with a landing zone in the aortic arch who are not candidates for open surgery may be treated by wholly endovascular or hybrid repair.[3] This expanded use of TEVAR means stenting the arch with or without open great vessel debranching.

Hybrid aortic arch reconstructions require surgical revascularization of at least one supra-aortic trunk (SAT) vessel to extend the proximal landing zone of the stent graft into the arch. Although open surgical repair remains the gold standard of care for complete aortic arch replacement, it is associated with the use of complex circulatory management and adjunct cerebral protection strategies and may be associated with significant morbidity and mortality from both neurologic and cardiovascular complications. Less invasive endovascular procedures with or without SAT debranching show promising results in the aortic arch in terms of decreased surgical morbidity and mortality. Advantages include that no sternotomy (or mini-sternotomy) is needed and the procedure is performed under general anesthesia without hypothermic circulatory arrest or cardiopulmonary bypass.

Patients with chronic aortic dissection can benefit from the hybrid approach as they often require repeat interventions to occlude entry tears due to enlargement of the pressurized false lumen or disseminated intravascular coagulation. Residual false lumen perfusion can persist even after performing the candy plug technique or branched stent graft repair in some cases.

We have performed more than 1,200 endovascular procedures in our center for different pathologies of abdominal, thoracic, thoracoabdominal aorta, and the arch. In addition to the different types of commercially available endovascular grafts, we have experience with the use of fenestrated, branched, custom-made, and physician-modified grafts and more complex procedures with parallel grafts and hybrid procedures. Before we started endovascular repair of the arch, we performed many implantations of Terumo Aortic stent grafts in thoracic and abdominal aorta with very good results. This article describes the features of the Relay stent graft (Terumo Aortic) platform and presents four examples, using custom-made RelayPlus devices in challenging anatomies of the arch and descending aorta.

THE RELAY PLATFORM FEATURES

The RelayPlus stent graft is indicated for the treatment of thoracic aortic pathologies including aneurysms, pseudoaneurysms, dissections, penetrating aortic ulcers, and intramural hematomas. The device consists of polyester vascular graft fabric sutured to a self-expanding scaffold created by nitinol stents. Each zone of the graft is designed to optimize conformability and seal with optimal radial load distribution. Two proximal seal stents overlap, providing multiple fixation points and equal distribution of seal radial load. Variable bare stent lengths and a proximal clasp allow for accurate alignment and controlled deployment. A flexible zone to the next stent allows for independent operation of the primary seal and fixation from the rest of the graft. A curved nitinol S-bar provides column strength and longitudinal support for the endograft and enhances "pushability" as well as conformability, even in small arch diameters. The delivery system consists of a precurved nitinol inner catheter and dual (inner and outer) sheaths. The flexible inner sheath allows for atraumatic advancement and staged graft expansion for better control, while the outer sheath

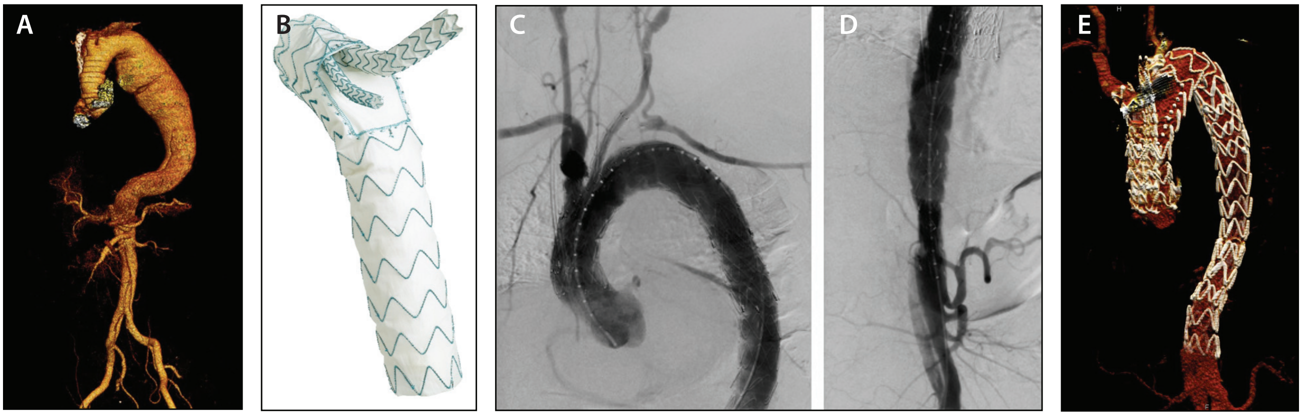

Figure 1. Preoperative CTA (A). The RelayBranch device (B). Intraoperative control angiograms (C, D). CT images 6 months postimplantation (E).

provides support during delivery and protects access vessels by acting as a conduit for the inner sheath.

The RelayNBS Plus (non-bare stent) is the covered proximal end configuration of Terumo Aortic's thoracic technology and was designed to avoid the gap and prevent retroflex deployment. Two asymmetrical clasping points located on the outer curve allow repositioning of the device and minimize any bird beak effect.

The Relay platform has a broad range of standard sizes and tapers and is complemented by the ability to customize to the precise needs of each individual patient. Standard diameters are from 22 and 46 mm and lengths from 100 to 250 mm. Tapering is possible on 150-, 200-, and 250-mm lengths with proximal diameters ranging from 28 to 46 mm, decreasing incrementally by 4 mm over the length of the stent graft.

Both RelayPlus and RelayNBS Plus are offered in custom-made configurations: individualized designs include fenestration and/or scallop, a bare distal stent, tapering (including reverse), and varying lengths. The latest configurations include arch branch designs (mostly single and double but some triple have been presented) based on RelayNBS and intended for zone 0 deployment. They have internal tunnels located in a window deployed under the ostia of target vessels (usually the brachiocephalic trunk [BCT] and left common carotid artery [LCCA]), which are connected to the main stent graft with covered, self-expandable bridging stents. Both configurations require creation of extra-anatomic bypass or transposition of the left subclavian artery (LSA). Custom manufacturing and delivery take 3 weeks.

CASE 1

A 61-year-old man with hypertension, coronary artery disease, and chronic renal insufficiency on dialysis was diagnosed with thoracic aortic aneurysm with dissection (originating at the level of the LSA) and a maximum diameter of 83 mm. A type III arch and BCT and LCCA tortuosity presented additional challenges (Figure 1A). We elected to use a Relay double-branch device (Figure 1B) measuring 36/26 X 270 mm with

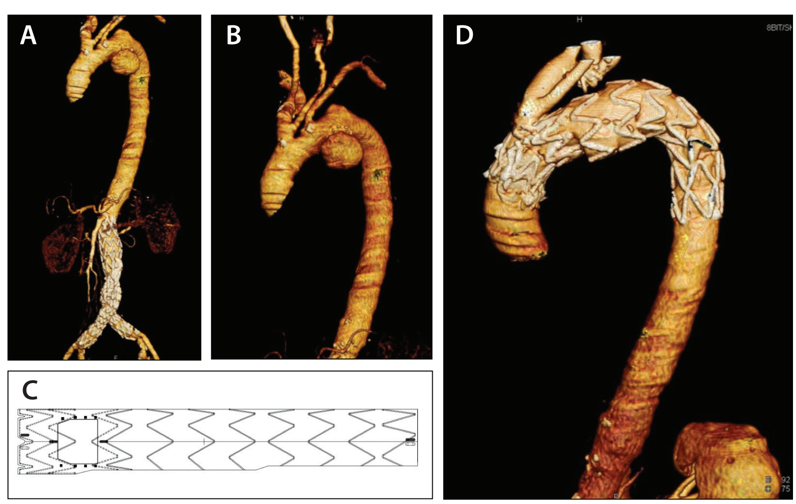

Figure 2. Preoperative CT showing pseudoaneurysm dilatation of the arch with coexisting dilatation (A, B). Case planning with specifications of the custom-made fenestrated RelayNBS Plus device (C). One-year follow-up CT showing complete seal, patent branches, and no endoleaks (D).

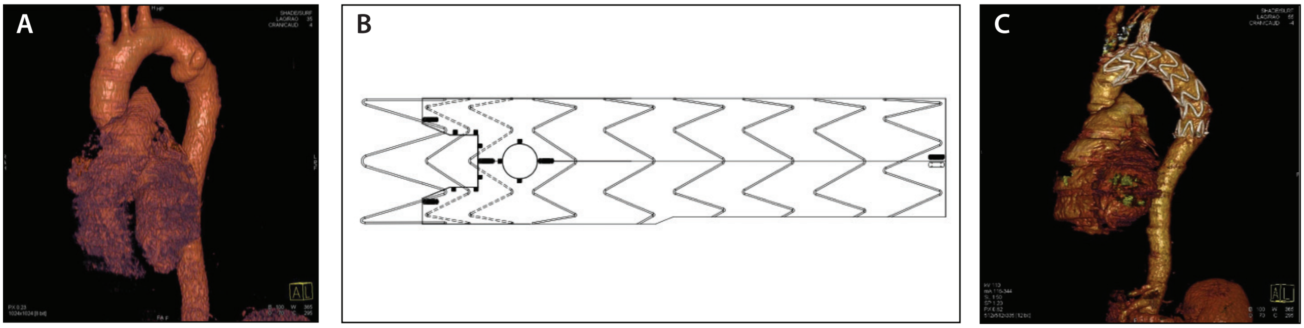

Figure 3. Preoperative CTA (A). Stent graft design with a scallop for the LCCA and fenestration for the LSA (B). CT at 1-month follow-up showing good seal and branch patency (C).

a window with two internal tunnels located 60 mm from the proximal end of the graft with two internal tunnels of 12-mm diameter each, extended distally with standard Relay stent grafts—a 28/24- X 200-mm RelayNBS Plus and a 26/26- X 100-mm RelayNBS Plus in the descending aorta. This configuration enabled tapering of the diameters from 36 to 26 mm. The LSA was occluded with an Amplatzer vascular plug (Abbott) to prevent endoleak. Intraoperative control angiograms showed successful implantations of all stent grafts with no endoleak (Figures 1C and 1D). Follow-up at 6 months showed patent vessels and no endoleak (Figure 1E).

CASE 2

An 80-year-old woman with prior endovascular repair of an abdominal aortic aneurysm (an Incraft device [Cordis, a Cardinal Health company] with "double ballerina" configuration of the legs caused by improper implantation of the stent graft) was diagnosed with a large pseudoaneurysm of the aortic arch with maximum diameter of 73 mm on the inner curvature and aneurysmatic dilatation on the opposite wall (Figures 2A and 2B). Her case was further complicated by a type III bovine arch. A tapered 34- X 30- X 200-mm fenestrated RelayNBS Plus device was implanted to zone 0 of the arch (Figure 2C). The flexibility of the Relay delivery system meant that there were no difficulties passing the primary sheath of the delivery system through the tortuous legs of the abdominal endograft nor crossing the arch with the flexible inner sheath. The LSA was occluded with an Amplatzer vascular plug to prevent endoleak. The postoperative course was uneventful with no complications. Follow-up at 1 year showed complete aneurysm seal, patent branches, and no endoleaks or migration (Figure 2D).

CASE 3

A 45-year-old man with no significant comorbidities but a history of work-related chronic bronchitis was diagnosed with two pseudoaneurysms of the descending aorta located close to the LSA (Figure 3A). Open surgical repair was our first option, but the patient refused thoracotomy. We therefore turned to endovascular options and designed a custom-made, tapered 30/28- X 150-mm RelayPlus device with a scallop for the LCCA and fenestration for the LSA

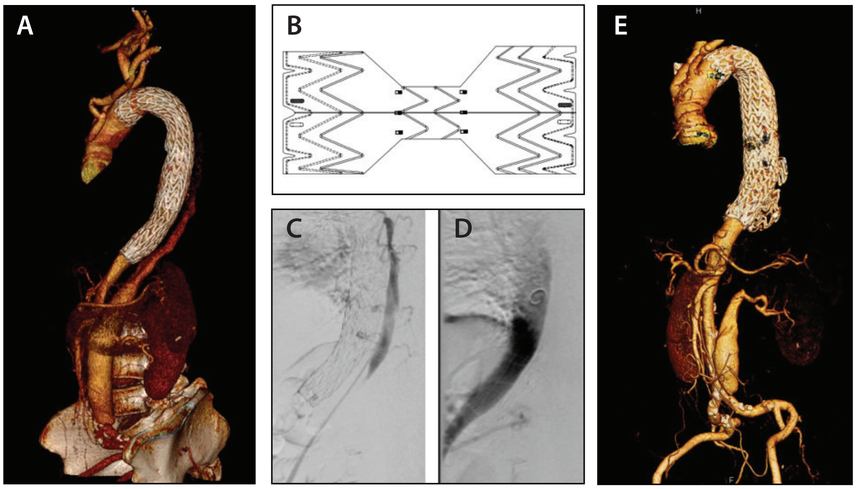

Figure 4. Preoperative CTA (A). Design of the custom-made candy plug Relay device (B). Intraoperative image showing type Ib endoleak to the false lumen (C). Intraoperative image showing complete exclusion after implant of the candy plug Relay device (D). CT at 1 year showed no false lumen perfusion (E).

(Figure 3B). The postoperative course was uneventful with no complications. Imaging at 30 days showed a patent LCCA and LSA and no endoleak (Figure 3C).

CASE 4

A 49-year-old woman presented after a Bentall procedure with hypertension and New York Heart Association class II heart failure. She had a history of endovascular repair for dissection of the descending aorta and persistent type Ib endoleak leading to enlargement of the false lumen originating at the level of the celiac trunk and superior mesenteric artery (Figure 4A). We planned a custom-made 30- X 16- X 32-mm candy plug Relay device (Figure 4B). The false lumen was closed successfully with the candy plug Relay device and an Amplatzer vascular occluder placed in the middle (Figures 4C and 4D). The postoperative course was uneventful with no complications. Imaging at 1 year showed no false lumen perfusion (Figure 4E).

CONCLUSION

Treatment of aortic arch pathologies continues to be a challenge and involves a creative combination of open and endovascular procedures requiring a multidisciplinary team evaluating risk and benefit case by case. The range of different configurations offered by Terumo Aortic's custom-made stent grafts based on the Relay platform offers the possibility to choose the most individualized product for each complex anatomy. The main potential benefit is extension of the proximal sealing zone in the inner curvature of the arch while preserving SAT flow. The recent CE Mark of a low-profile version of the standard device (RelayPro) with a 3- to 4-F profile reduction to treat patients with smaller anatomies[4] is another important step in establishing Relay as the thoracic endograft of choice. Experience with standard devices from Terumo Aortic is important to take full advantage of the platform's features as is familiarity with different endovascular techniques, including scallops, fenestrations, CHIMPS (chimney, periscope, or sandwich), and open surgical SAT reconstructions. ■

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