Iatrogenic coarctation caused by branched thoracic endovascular aortic repair treated with Palmaz XL stent and triple kissing balloon technique

Wolf Eilenberg, MD, PhD,[a,b] Giuseppe Panuccio, MD, PhD,[a] Fiona Rohlffs, MD, PhD,[a] Ahmed S. Eleshra, MD, PhD,[a] Franziska Heidemann, MD,[a] *and* Tilo Kölbel, MD, PhD,[a] *Hamburg, Germany; and Vienna, Austria*

ABSTRACT

We have described a technique to treat iatrogenic coarctation caused by a branched thoracic endovascular aortic repair (TEVAR) procedure with a Palmaz XL stent (Palmaz Genesis; Cordis Corp, a Cardinal Health Company, Milpitas, Calif) and triple kissing balloons. A 42-year-old woman with Marfan syndrome had presented with aneurysmatic dilatation of the aortic arch 10 years after open aortic arch repair. After successful branched TEVAR, a significant coarctation just short of the left common carotid artery was noted with significant pressure gradient between the ascending and descending aorta. Branched TEVAR in previous open aortic arch replacement can result in iatrogenic coarctation that can be successfully treated using a Palmaz XL stent and triple kissing balloons. (J Vasc Surg Cases Innov Tech 2021;7:433-7.)

Keywords: Abdominal aortic aneurysm; Acute aortic syndrome; Aortic aneurysm; Aortic dissection; Endovascular therapy; Genetic aortic diseases

Patients with Marfan syndrome (MFS) frequently follow a pathway of repetitive aortic surgery due to the untreatable genetic tissue disorder, with aortic root aneurysm the most frequent cardiovascular manifestation with the need for surgical correction.[1] The reference standard for the treatment of aortic pathology in patients with genetic aortic syndromes (GASs) and aortic pathology has generally been considered open repair.[2] Patients with GASs frequently require staged open repair of multiple aortic segments, which can be associated with mortality ≤23%.[3] Landing a stent graft in the native aorta of a patient with GAS can lead to secondary complications such as dissection, ulcer, or rupture relating to the frailty of the vessel tissue.[3] The early results of thoracic endovascular aortic repair (TEVAR) to treat patients with GAS have been discouraging.[4] However, recent studies using endovascular aortic repair mainly as an adjunct when connecting graft-replaced aortic segments or as a temporary bridge have reported favorable results with low morbidity and mortality.[5-7]

The suitability of aortic arch pathology for branched TEVAR after previous open repair can be limited by kinks in the surgical graft, which can affect graft apposition and lead to a type Ia endoleak.[8] In the present technical note, we have described the case of a 42-year-old patient with MFS after open aortic arch repair and secondary aneurysmatic islet dilatation treated with a custom-made branched TEVAR graft. She had developed an intraoperative iatrogenic coarctation after stent-graft placement owing to a significant kink in the open surgical graft.

SURGICAL TECHNIQUE

A 42-year-old woman with MFS was referred from an outside tertiary center to our institution with a 5.5-cm aortic arch pseudoaneurysm originating from the anastomosis of an island patch of the supra-aortic arteries of an elephant trunk repair. The complex history of the patient included six major open surgical aortic procedures: (1) ascending repair of a peripartum acute type A aortic dissection, (2) a mechanical Bentall procedure, (3) an elephant trunk repair, (4) reoperation for chylothorax, (5) tubular descending thoracic aortic repair, and (6) open thoracoabdominal bi-iliac repair, resulting in complete aortic replacement despite the island patch in the aortic arch. An interdisciplinary aortic board, consisting of cardiac surgeons, cardiologists with a focus on GASs, and vascular surgeons, deemed the patient at high risk of open repair owing to the multiple previous open operations. With the patient also refusing open surgery, we offered an endovascular treatment option using

From the German Aortic Center, Department of Vascular Medicine, University Heart and Vascular Center, University Hospital Hamburg-Eppendorf, Hamburg[a]; and the Division of Vascular Surgery, Department of General Surgery, Medical University of Vienna, Vienna.[b]

Author conflict of interest: T.K. receives royalties, speaking fees, and research, travel, and educational grants from Cook Medical and is a consultant to and proctor for and has intellectual property with Cook Medical. W.E., G.P., F.R., and A.S.E. have no conflicts of interest.

Correspondence: Wolf Eilenberg, MD, PhD, Division of Vascular Surgery, Department of General Surgery, Medical University of Vienna, Währinger Gürtel 18-20, Vienna A-1090, Austria (e-mail: wolf.eilenberg@meduniwien.ac.at).

The editors and reviewers of this article have no relevant financial relationships to disclose per the Journal policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

2468-4287

https://doi.org/10.1016/j.jvscit.2021.05.012

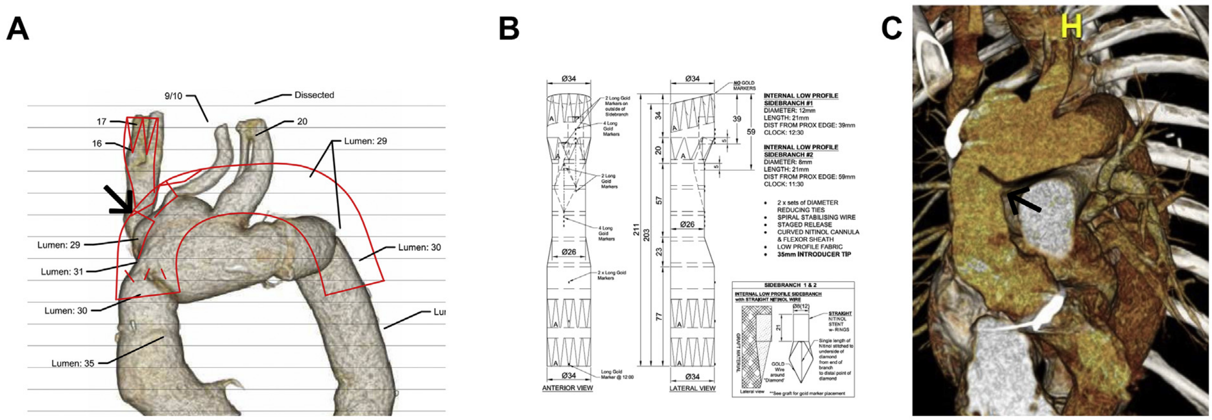

Fig 1. Planning of a custom-made two-branched arch endograft. **A,** Anatomy sketch of the aortic aneurysm and endografts. **B,** Graft plan. Reprinted with permission from Elsevier. **C,** Three-dimensional computed tomography scan of the aortic arch. The *arrow* indicates the coarctation.

an inner branched arch endograft landing in replaced aortic segments.

The patient was treated in three steps: (1) left common carotid artery (LCCA) interposition graft and left carotid-subclavian bypass; (2) embolization of the left subclavian artery using Amplatzer vascular plugs (St Jude Medical, Inc, St Paul, Minn); and (3) branched TEVAR landing in the replaced aortic segments, the native innominate artery (IA), and the graft-replaced LCCA.

The planned arch endograft with two inner branches for the IA and LCCA requires cervical debranching to the left subclavian artery. Because this step required dissection of the LCCA, we decided to replace a segment with a 6-mm Dacron interposition graft, including the proximal anastomosis of the carotid–subclavian bypass. This decision was made to avoid landing the bridging covered stent in the native LCCA owing to the patient's vulnerable arterial wall and because the LCCA had required exposure and later correction would have been difficult.

The endovascular procedure of step 3 (Fig 1) was conducted with the patient under general anesthesia and full heparinization, with an activated clotting time goal of 250 to 350 seconds, in a hybrid operating room with a fixed imaging system (Allura Clarity; Philips Healthcare, Amsterdam, The Netherlands) and computed tomography fusion (Vesselnavigator; Philips Healthcare). Over a super-stiff wire (Lunderquist; Cook Medical, Bloomington, Ind) in the ascending aorta to the mechanical aortic valve, the branched main graft (Cook Medical) was deployed (Fig 2). An extra short 3.5-cm tip was used to deploy the graft proximally in the ascending aorta without crossing the mechanical aortic valve (Fig 3, *A*). Two extensions were introduced through a right common carotid artery cutdown used for the innominate artery (20 mm/73 mm and 20 mm/90 mm) and relined with a balloon expandable 10 × 59-mm Genesis stent (Cordis Corp, a Cardinal Health Company, Milpitas, Calif). A Fluency 9-mm/80-mm self-expanding bridging covered stent (BD/Bard Peripheral Vascular, Tempe, Ariz) and an Advanta balloon-expandable 10-mm/59-mm bridging covered stent (Getinge, Merrimack, NH) relined with a Genesis 9-mm/59-mm stent (Cordis Corp) were used to connect the LCCA interposition graft to the second branch.

After placement of the bridging components, a significant systolic blood pressure difference of 90 mm Hg was noted between the IA and descending thoracic aorta (Fig 3, *B*). Fluoroscopy showed an obstruction caused by the two inner branches at the previous kink in the aortic arch (Fig 3) that could not be passed easily with a catheter. To treat this iatrogenic coarctation, a 4-cm Palmaz XL stent (Palmaz Genesis; Cordis Corp) was mounted on a 14-mm, 4-cm high-pressure balloon (Atlas Gold; BD/Bard Peripheral Vascular) and deployed using the Sternbergh technique[9] through a 12F, 80-cm Flexor sheath (Cook Medical; Fig 4, *A*). During postdilatation with an 18-mm high-pressure balloon (Atlas Gold Bard; BD/Bard Peripheral Vascular), protective balloons in both inner branches were inflated using a triple kissing technique to prevent compression of these vital arch branches (Fig 4, *B*). The final angiogram showed unimpeded flow into both branches and the descending thoracic aorta without remaining stenosis (Fig 4, *C*). No blood pressure gradient between the ascending and descending aorta was detectable. The procedure time was 224 minutes. The fluoroscopy time was 78 minutes. A total of 110 mL of contrast agent was used. The postoperative computed tomography angiogram demonstrated patency of all target vessels and exclusion of the aortic arch aneurysm without an endoleak or stenosis, with excellent computed tomography angiography findings at 6 months of follow-up (Fig 5) without any signs of coarctation. The patient provided written informed consent for the report of their case details and images.

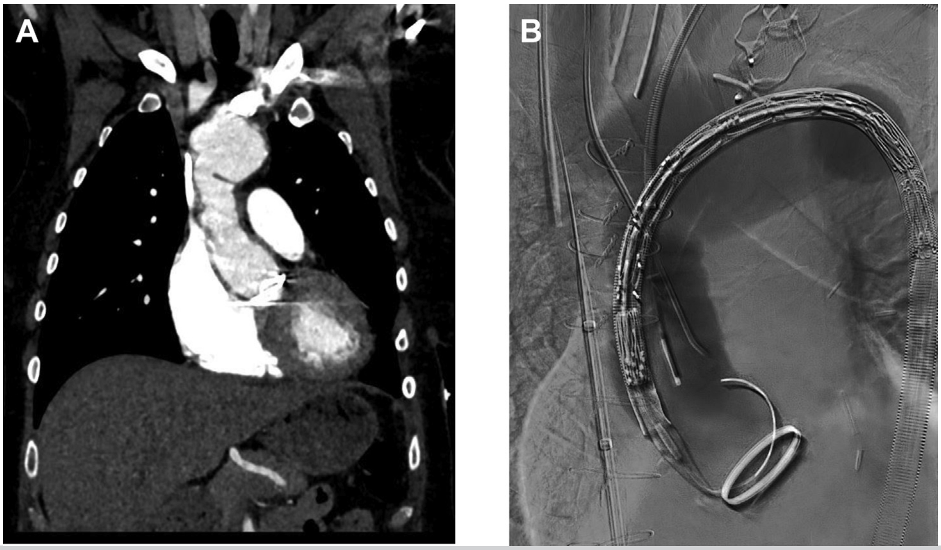

Fig 2. A, Two-dimensional reconstruction of the aortic arch showing ventral view with 90° curve at the aortic ascending artery. The *arrow* indicates the tissue flap in the corner of the aortic arch. **B,** Intraoperative angiogram before main stent-graft placement. Right and left carotid artery (LCCA) both inserted with a guidewire and super stiff Lunderquist wire (Cook Medical) just in front of the mechanical aortic valve.

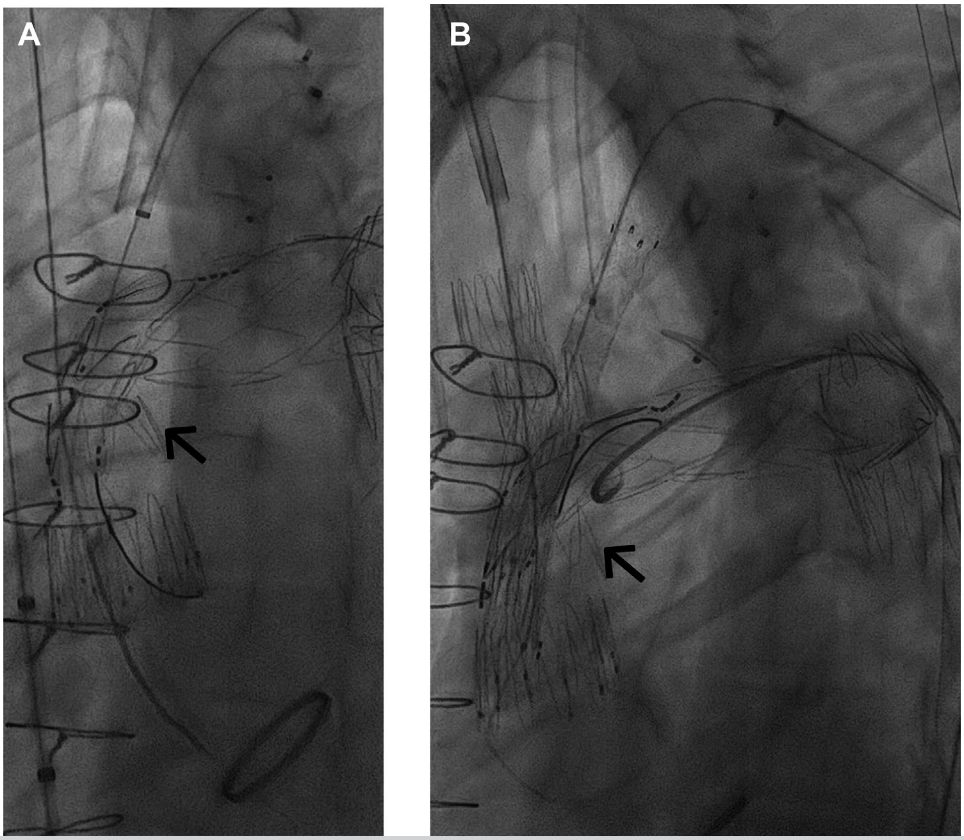

Fig 3. A, Intraoperative fluoroscopy after main stent-graft placement. Super stiff Lunderquist wire (Cook Medical) inserted just in front of the mechanical aortic valve. The main branched stent-graft showed some signs of insufficient deployment with a 90° curve (*arrow*). **B,** Intraoperative fluoroscopy after main stent-graft and branch deployment. High-grade stenosis caused intraoperative mean gradient arterial pressure differences of >20 mm Hg (*arrow*), with recanalization succeeding after several attempts.

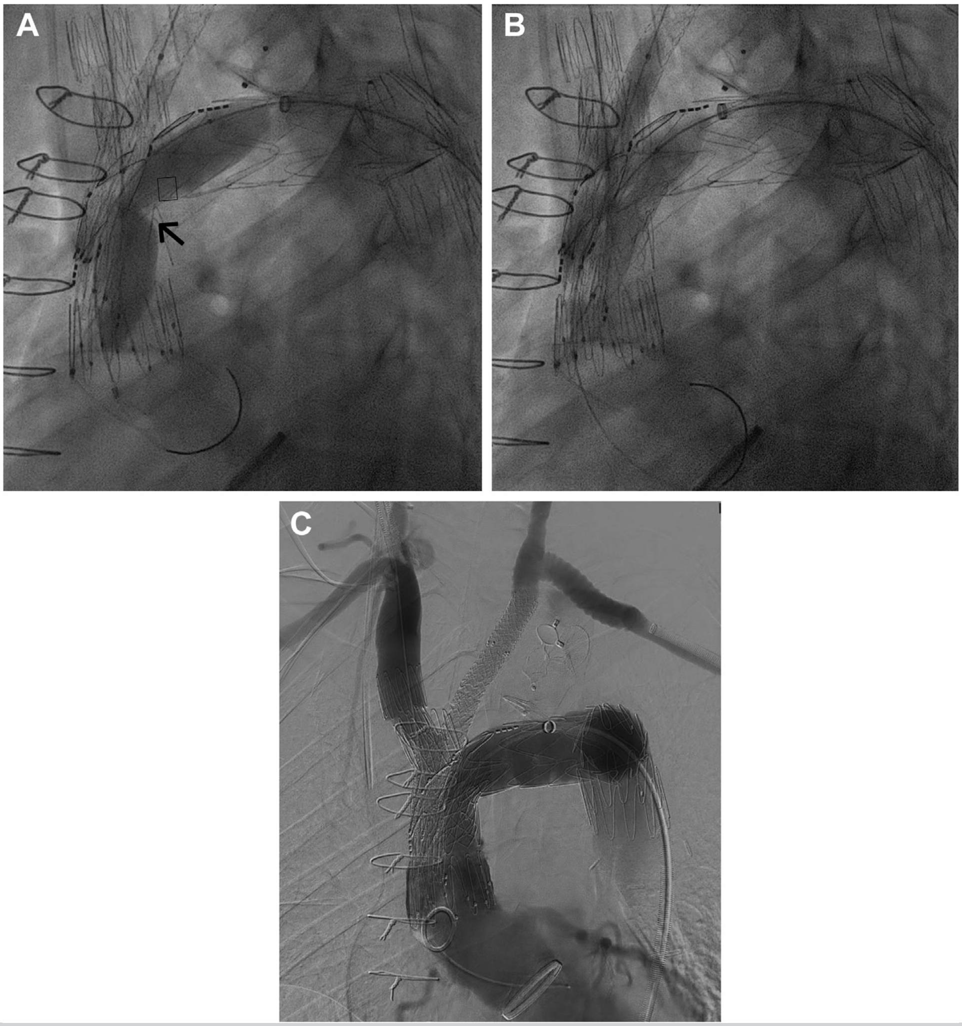

Fig 4. A, Intraoperative dilatation with Coda balloon (Cook Medical) and 4-cm Palmaz XL stent (Palmaz Genesis; Cordis Corp) deployment after successful positioning of super stiff Lunderquist (Cook Medical) inserted just in front of the mechanical aortic valve. *Arrow* indicates stenosis. **B,** Triple-balloon kissing technique dilatation of the ascending aorta, innominate artery (IA), and left common carotid artery (LCCA). **C,** Final digital subtraction angiogram showing unimpeded flow to all supra-aortic arteries and the descending thoracic aorta. The Palmaz XL stent is widely open.

DISCUSSION

Our 42-year-old patient with MFS was judged to be at high risk of open surgical repair owing to multiple previous surgical repairs. Therefore, she underwent an endovascular procedure. Bridging the graft-replaced aortic segments using TEVAR was reported to have favorable results with low morbidity and mortality even in patients with GASs.[5-7] The key suitability criterion for stent-graft procedures in the aortic arch is an appropriate proximal landing zone, which a graft-replaced ascending aorta frequently can provide.[10] The suitability of the proximal landing zone can be limited by kinks in the surgical graft, which can affect graft apposition and lead to type Ia endoleakage.[8] In the reported case, the proximal landing zone was excellent despite the presence of a mechanical valve, which was mitigated by the use of an extra-short nosecone. However, the stent-graft caused an iatrogenic coarctation owing to the inner branches at the level of the kink. In the present technical note, we have illustrated the versatility of a Palmaz XL stent as a bail-out, when high radial forces are needed to overcome recoil and stenosis of endografts in previous open or endovascular grafts. The protective use of triple kissing balloons helped to successfully treat this complication in a sensitive aortic segment without jeopardizing the flow to vital aortic branches.

CONCLUSIONS

Palmaz XL stent placement in the aortic arch and triple balloon kissing technique successfully treated an iatrogenic-induced aortic coarctation in a patient with MFS during branched TEVAR.

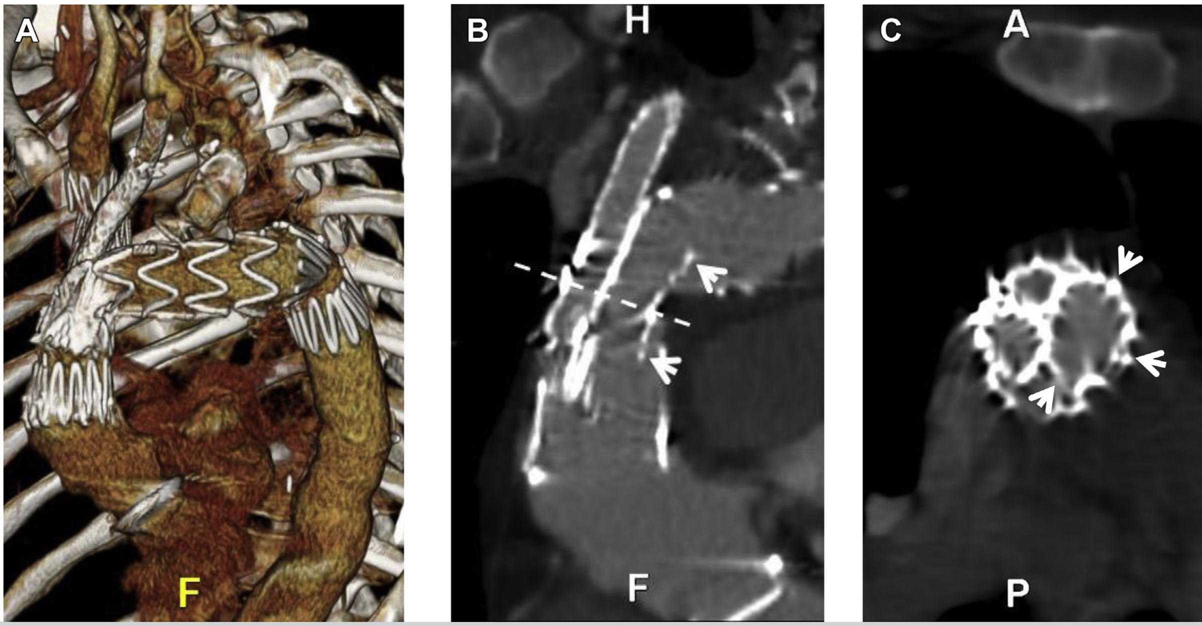

Fig 5. Computed tomography angiogram at 6 months of follow-up. **A,** Volume rendering demonstrating unchanged position of the endografts. **B,** Multiplanar reconstruction of the aortic arch. *Arrows* indicate the Palmaz XL stent (Palmaz Genesis; Cordis Corp) in unchanged expansion. **C,** Multiplanar perpendicular reconstruction at the level of the previous graft infolding (*dotted line*) showing well-expanded bridging covered stents to the innominate artery, left common carotid artery (LCCA), and well-expanded Palmaz XL stent (*arrows*).

REFERENCES

1. Orozco-Sevilla V, Whitlock R, Preventza O, de la Cruz KI, Coselli JS. Redo aortic root operations in patients with Marfan syndrome. Int J Angiol 2018;27:92-7.
2. Riambau V, Bockler D, Brunkwall J, Cao P, Chiesa R, Coppi G, et al. Editor's choice – management of descending thoracic aorta diseases: clinical practice guidelines of the European Society for Vascular Surgery (ESVS). Eur J Vasc Endovasc Surg 2017;53:4-52.
3. Erbel R, Aboyans V, Boileau C, Bossone E, Bartolomeo RD, Eggerecht H, et al. 2014 ESC guidelines on the diagnosis and treatment of aortic diseases: document covering acute and chronic aortic diseases of the thoracic and abdominal aorta of the adult. The task force for the diagnosis and treatment of aortic diseases of the European Society of Cardiology (ESC). Eur Heart J 2014;35:2873-926.
4. Kouchoukos NT, Kulik A, Castner C. Branch graft patency after open repair of thoracoabdominal aortic aneurysms. J Thorac Cardiovasc Surg 2017;2:S14-9.
5. Eleshra AS, Panuccio G, Rohlffs F, Scheerbaum M, Tsilimparis N, Kolbel T. Complex endovascular aortic repair with a branched endograft to revascularize 5 renovisceral vessels and an intercostal artery in a Marfan patient. J Endovasc Ther 2019;26:736-41.
6. Roselli EE, Idrees JJ, Lowry AM, Masabni K, Soltesz EG, Johnston DR, et al. Beyond the aortic root: staged open and endovascular repair of arch and descending aorta in patients with connective tissue disorders. Ann Thorac Surg 2016;101:906-12.
7. Shalhub S, Eagle KA, Asch FM, LeMaire SA, Milewicz DM. Endovascular thoracic aortic repair in confirmed or suspected genetically triggered thoracic aortic dissection. J Vasc Surg 2018;68:364-71.
8. Tsilimparis N, Drewitz S, Detter C, Spanos K, Kodolitsch Y, Rohlffs F, et al. Endovascular repair of ascending aortic pathologies with tubular endografts: a single-center experience. J Endovasc Ther 2019;26:439-45.
9. Kim JK, Noll RE Jr, Tonnessen BH, Sternbergh WC III. A technique for increased accuracy in the placement of the "giant" Palmaz stent for treatment of type Ia endoleak after endovascular abdominal aneurysm repair. J Vasc Surg 2008;3:755-7.
10. Milne CP, Amako M, Spear R, Clough RE, Hertault A, Sobocinski J, et al. Inner-branched endografts for the treatment of aortic arch aneurysms after open ascending aortic replacement for type A dissection. Ann Thorac Surg 2016;6:2028-35.

Submitted Mar 8, 2021; accepted May 19, 2021.