บทความวิชาการ

Update in Thoracic Endovascular Aortic Repair

Thiti Chanmayka
Department of Surgery, Faculty of Medicine, Khon Kaen University.

As the general population ages, physicians will continue to encounter more advanced and complex aortic disease and severe comorbidities. In many cases, these comorbidities prohibit open surgical repair of thoracic aortic disease, whereas complex aortic anatomy is prohibitive against standard endovascular repair of both aneurysms and dissection of the thoracic aorta.

Thoracic endovascular aortic repair is a treatment option for aortic diseases and becomes the preferred option for most thoracic aortic disease patients. TEVAR proved itself to this day dued to the need for each innovative step forward to stand on its own merits and increasing accumulation of long-term data. Building on the platform of Thoracic endovascular aortic repair (TEVAR) and the complexities of aortic dieases, procedures have been improved to treat more extensive thoracic aortic diseases with branched stent graft , fenestrated stent graft and custom-made stent graft. These procedures have also been used in thoraco-abdominal aortic aneurysm (TAAA), repairing paravisceral aorta, ascending aorta and aortic arch.

Endovascular Repair of Thoraco-Abdominal Aortic Aneurysm (TAAA)

Multiple clinical series and systematic reviews have shown high success rates and lower morbidity and mortality rates with using fenestrations and directional branches compared to conventional open surgical repairs. Anatomical feasibility of the t-Branch stent graft has been assessed by Sweet et al[1]. Surprisingly 88% of patients met all of the anatomical criteria proposed in Figure 1. It is estimated that more than half of the TAAA patients are suitable for the device in a single procedure, with even greater suitability with staged procedures[2]. Experts agree that directional branches are ideal for down-going vessels that originate from large aortic lumens without a high degree of precision, which is needed for fenestrated stent grafts. Some disadvantages occurred, including higher rates of type III endoleaks, branch disconnection, and not ideal in patients with symptomatic and ruptured aneurysms.

Endovascular Aortic Arch Repair

The unique anatomic characteristics and hemodynamic of aortic arch make procedure in this region challenging. The future of fenestrated and branched TEVAR in the aortic arch evolved and experience grows, more patients will be candidate for this technique. Inaccuracy of stent graft placement can have fatal consequences for the patient and also increase the risk of endoleaks and stroke.

- Hybrid Arch Repair : Consisting with aortic arch branch bypass with TEVAR. This technique has shown good results over the last 10 years[3]. Underwent aortic arch debranching and proximal sealing in Ishimaru zones 0 and 1 had higher morbidity rates compared to those with more distally located landing zones.

- Chimney techniques : Using parallel or chimney stent grafts has increasingly, but recent meta-analysis presented incidence rates of type Ia and II endoleaks were 11% and 8%, respectively[4], this could be major drawback of this technique.
- Custom-made fenestrated and branched stent graft : Fenestrated endografts can be manufactured with a fenestration for the LCCA and a large scallop for the innominate artery in Figure 2.

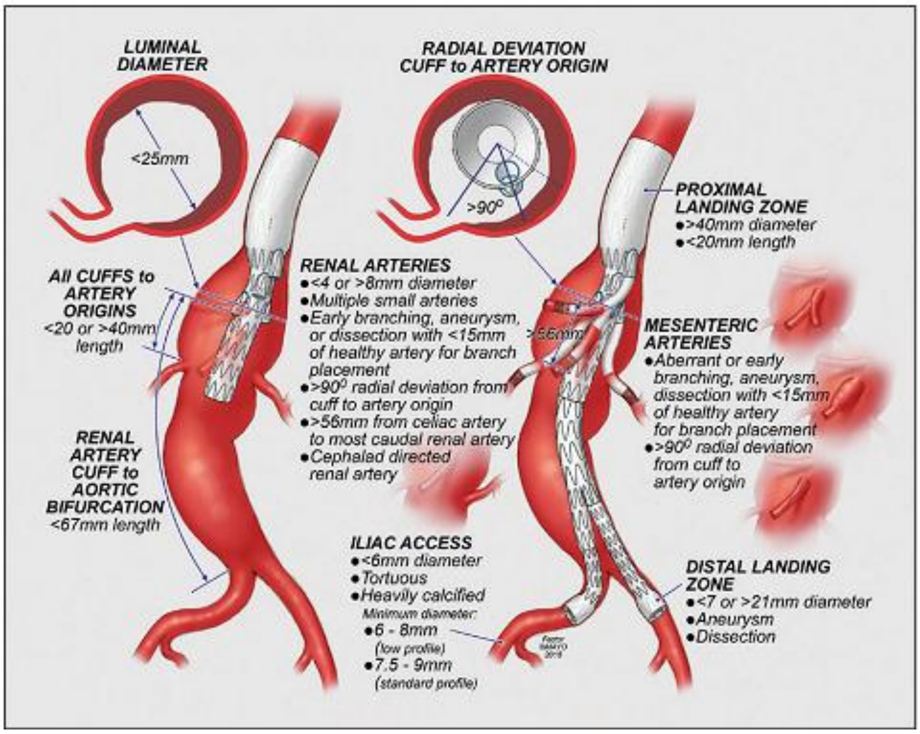

Figure 1. Anatomical criteria for the t-Branch stent graft. Important considerations are the minimal luminal diameter of 25 mm, ability to incorporate all vessels within a 90° angle to each cuff, and the target vessel diameter of 4 to 8 mm for the renal arteries

(Sweet MP, Hiramoto JS, Park KH, et al. A standardized multibranched thoracoabdominal stent graft for endovascular aneurysm repair. J Endovasc Ther. 2009;16:359-364.).

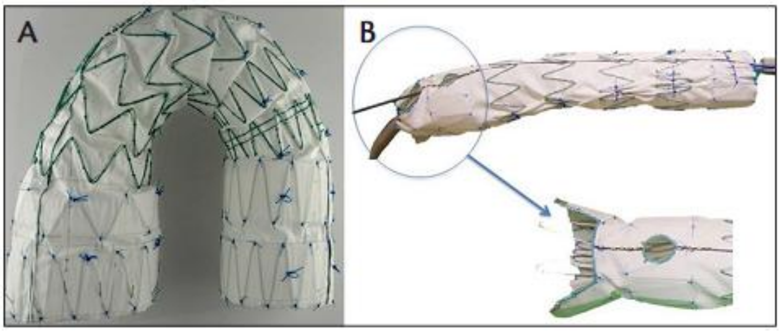

Figure 2. The Zenith arch branched endograft* (A) and the Zenith arch fenestrated endograft (B), both by Cook Medical.

Endovascular Repair for Ascending Aortic pathology

Ascending aortic pathology epresent extremely challenging cases with high associated mortality and morbidity. Type A aortic dissection alone had 30% mortality rate. And 30% of these patients were unfitted for open surgical repair[5]. Anatomic and hemodynamic limitations are difficult to treat with endovascular technique. Improving in endograft technology have lead to shorter and larger-diameter endografts with shorter tips and more flexible delivery systems.

Suitable anatomy for endovascular repair consists of[6,7]

- Entry tear present in the ascending aorta
- ≥ 2 cm distance between the sinotubular junction and the entry tear
- ≥ 0.5 cm distance between entry tear and brachiocephalic trunk (≥ 2 cm for some groups)
- No signs of cardiac tamponade, severe aortic regurgitation, or ischemia of the aortic branches
- No previous cardiac revascularization originating from the ascending aorta

Initial success rate of approximately 96% and a relatively low intraoperative and 30-day mortality rate of 8%. Stroke may be resulting from embolization and iatrogenically induced progression of a dissection into the supra-aortic vessels. Ventricular trauma from guide wire or device misplacement may also occur.

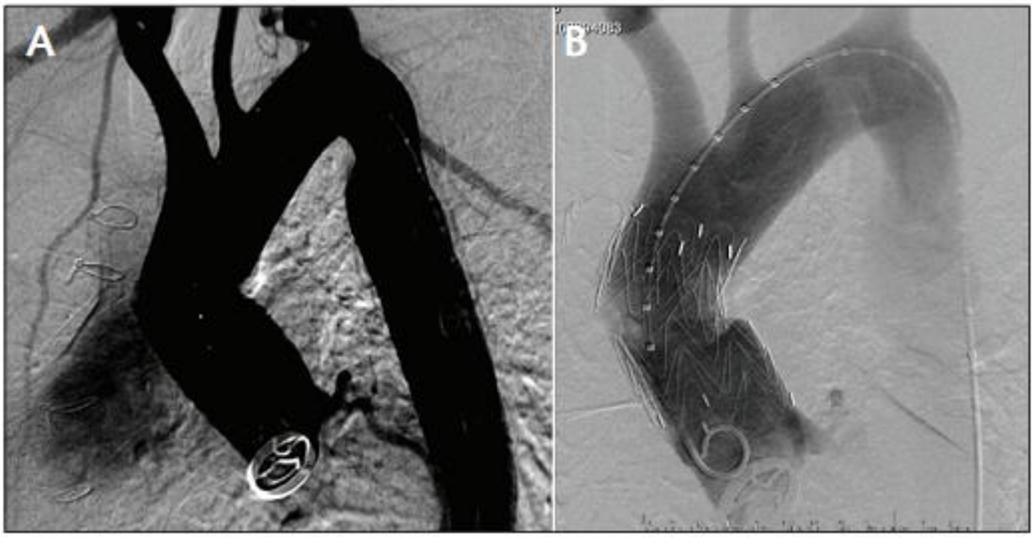

Figure 3. Intraoperative angiogram before (A) and after (B) placement of the ascending endograft to treat a pseudo-aneurysm. No endoleaks or other complications were detected.
(GASPAR MESTRES, et al., Endovascular Techniques for Treating Ascending Aortic Pathology , ENDOVASCULAR TODAY NOVEMBER 2014).

Management of Type B Aortic Dissection

Type B aortic dissection (TBAD) is a complex clinical condition requiring rigorous understanding of the pathology and the patient's individual characteristics. Anatomically, dissections can be classified as proximal, with involvement of the ascending aorta or the aortic arch (Stanford type A, DeBakey types I and II), or as a distal dissection without involvement of the ascending aorta (Stanford type B, DeBakey type III) (Figure 4).

In the INSTEAD-XL study, TEVAR presented a reduction of all-cause mortality (11% vs 19%; p< .05), aortic-related mortality (7% vs 19%; p < .05), and total diameter change (27% vs 46%; p< .05) at 5-year followup compared to optimal medical treatment alone[8].

Dake et al assessed six factors that influenced the decision making for invasive treatment of TBAD when considering thoracic endovascular aortic repair (TEVAR)[9]:

(1) duration from the onset of symptoms
(2) location of the primary entry tear
(3) size of the aorta
(4) segmental extent of aortic involvement
(5) complications of the dissection
(6) false lumen (FL) status

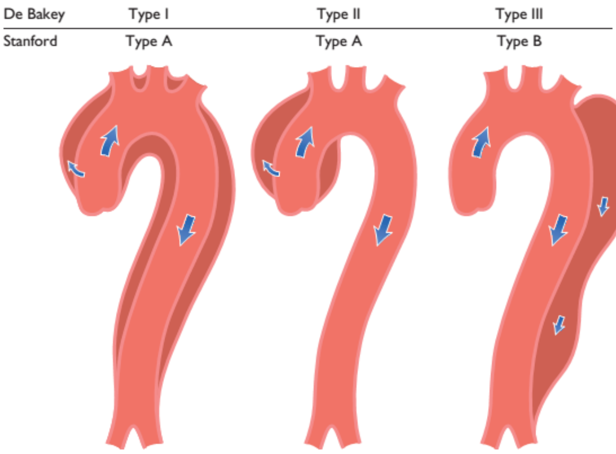

Figure 4. Classification of aortic dissection localization. Schematic drawing of aortic dissection class 1, subdivided into DeBakey Types I, II, and III. Also depicted are Stanford classes A and B. Type III is differentiated in subtypes III A to III C.

(2014 ESC Guidelines on the diagnosis and treatment of aortic diseases, European Heart Journal (2014)35, 2873–2926).

The combination of a proximal stent graft for coverage of the entry tear with an uncovered stent or PETTICOAT technique(Provisional ExTension To Induce COmplete ATtachment = PETTICOAT), remains a treatment option in patients with persistent malperfusion or true lumen collapse[10]. The concept of implanting a large self-expandable bare stent distal to the covered stent graft over the visceral segment to reduce malperfusion has been postulated (Figure 4,5). Conversely some reports presented PETTICOAT technique promotes faster expansion of the true lumen without significantly decreasing the volume of the FL in the thoracic and abdominal aorta , which was the indication for re-intervention[11].

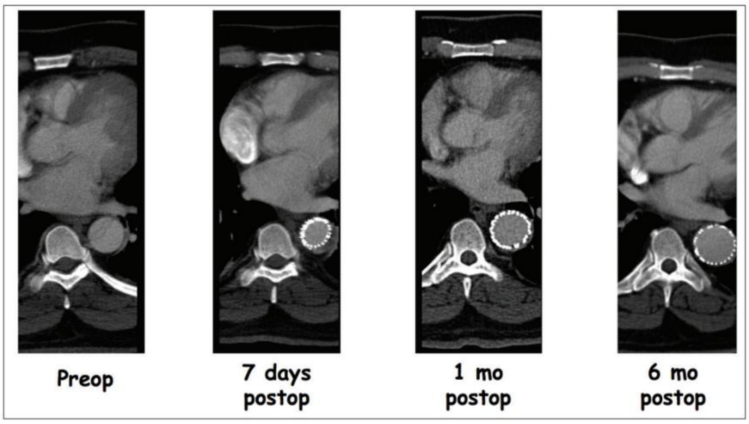

Figure 4. A patient with acute complicated type B aortic dissection was treated with a composite device design. CTAs showing remodeling of the thoracic aorta, including expansion of the true lumen and thrombosis of the false lumen.

(JONATHAN SOBOCINSKI, et al , Exploring the Use of Bare Stents in the Treatment of Type B Dissection, SUPPLEMENT TO ENDOVASCULAR TODAY EUROPE VOLUME 4, NO. 1).

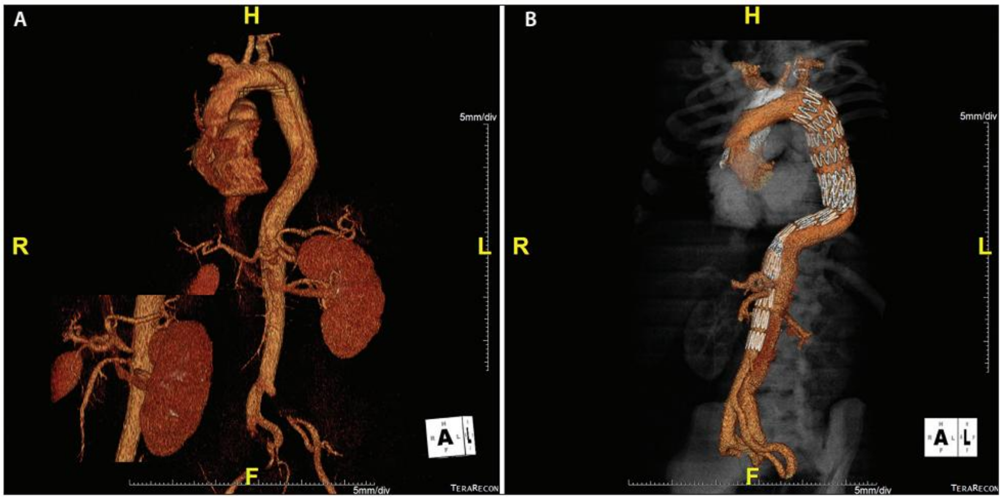

Figure 5. A patient presented with acute type B aortic dissection complicated with visceral and lower limb malperfusion (preoperative CTA) (A). The postoperative CTA showed that the use of a composite device design promoted sufficient true lumen expansion to correct the malperfusion syndrome without additional selective stenting or fenestration (B). At this early stage, the distal false lumen was still patent.

(JONATHAN SOBOCINSKI, et al , Exploring the Use of Bare Stents in the Treatment of Type B Dissection, SUPPLEMENT TO ENDOVASCULAR TODAY EUROPE VOLUME 4, NO. 1).

Landing Zone Expanding for TEVAR

The application of traditional TEVAR with aortic stent graft requires a proximal and distal landing zone of at least 2 cm. Aortic pathology can present with a disease that extends into the aortic arch, this was unsuitable proximal landing zone distal to the left subclavian artery. To ensure proper landing zone and minimize complications when the stent graft is placed in zones 0, 1, or 2 of the arch (Figure 6), a careful evaluation and plan for revascularization of the arch vessels is very essential.

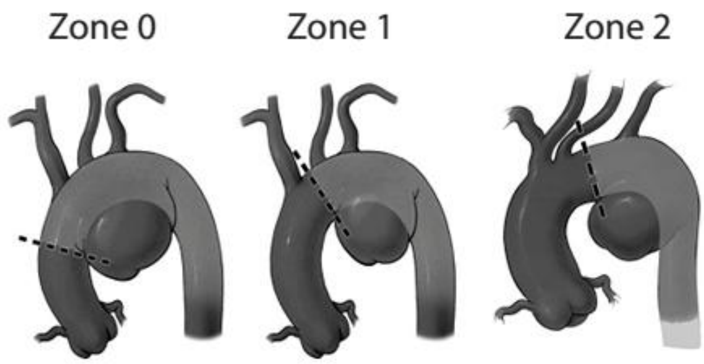

Figure 6. Ishimaru classification of proximal landing zones.

(Roberto Chiesa, et al, Endovascular treatment of aortic arch aneurysms, J Vasc Bras 2008, Vol. 7, N° 2).

Management for expansion for TEVAR consists of:

TEVAR LANDING IN ZONE 2

- Left Carotid-Subclavian Artery Bypass (Figure 7A.)
- Left Carotid-Subclavian Artery Transposition (Figure 7B.)

TEVAR LANDING IN ZONE 1

- Carotid-Carotid Crossover Bypass (Figure 7C.)
- Subclavian-Subclavian and Axilloaxillary Artery Bypass (Figure 8.)

TEVAR LANDING IN ZONE 0

- Aorta bypass to right common carotid artery (RCCA)-LCCA-LSA bypass (Figure 9.)

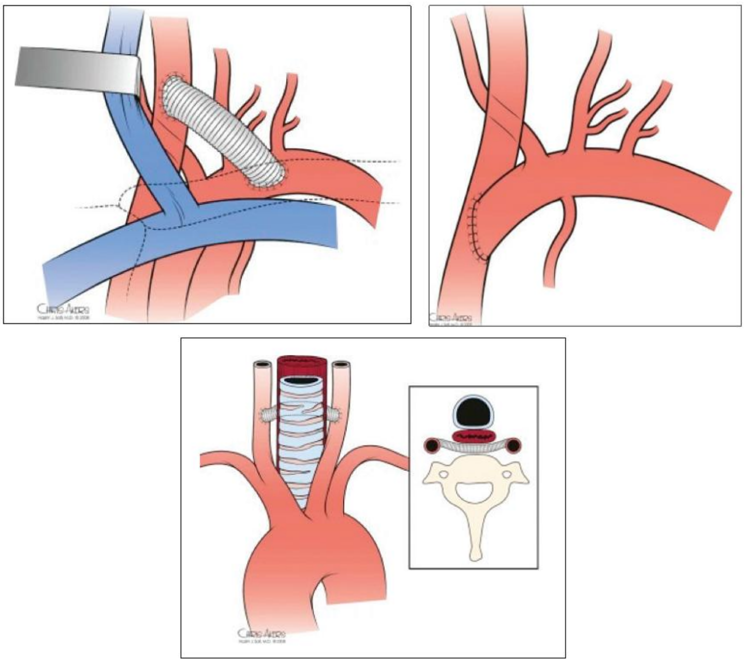

Figure 7. Carotid-subclavian bypass (A), Carotid-subclavian transposition (B), Carotid-carotid crossover bypass (C), (Desai S, Safi HJ. Brachiocephalic artery: surgical treatment. In: Cronenwett JL Johnston KW, eds. Rutherford's Vascular Surgery. 8th ed. Philadelphia: Elsevier Saunders; 2014:1615-1626.)

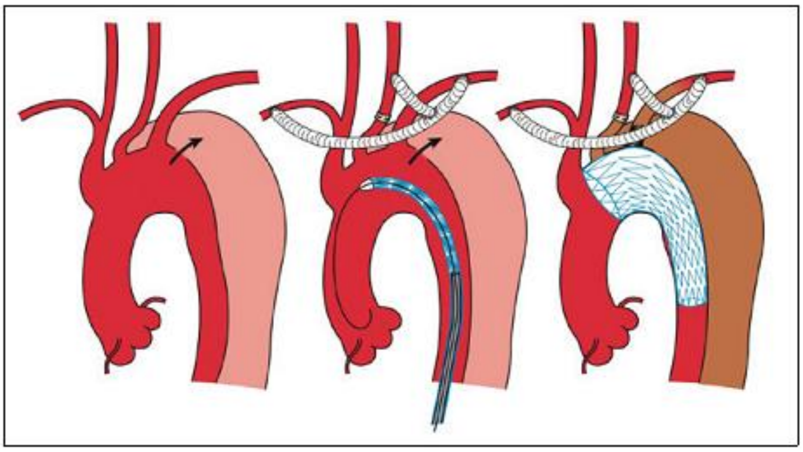

Figure 8. An axilloaxillary artery bypass,

(Kuratani T. Best surgical option for arch extension of type B dissection: the endovascular approach. Ann Cardiothorac Surg. 2014;3:292–299.)

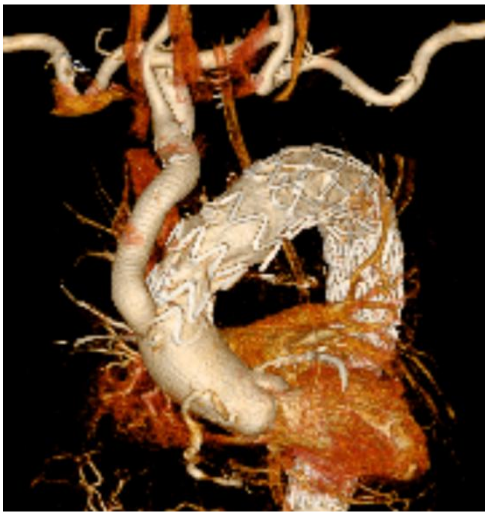

Figure 9. Aorta bypass to right common carotid artery (RCCA)-LCCA-LSA bypass.

In a meta-analysis of hybrid procedures, Moulakakis et al reviewed 26 studies including 820 patients who underwent aortic arch debranching[4]. Endoleaks were observed in 16.6% and retrograde type A dissection was found 4.5% of patients , 11.9% perioperative mortality, a 7.6% stroke rate, and a 3.6% spinal cord injury rate. Aortic debranching allowed for high technical success with a relatively low mortality risk for patients considered unfit for traditional open surgery.

Conclusions

TEVAR has come of age. It has clearly become the standard of care for thoracic aortic disease patients, yet its future is undefined. The importance of meticulous planning and the aid of intraoperative imaging cannot be underestimated in these complex procedures. Although studies are ongoing, early data show reasonable complication rates, given the alternative of standard open surgical repair.

Reference

1. Sweet MP, Hiramoto JS, Park KH, et al. A standardized multibranched thoracoabdominal stent graft for endovascular aneurysm repair. J Endovasc Ther. 2009;16:359-364.
2. Gasper WJ, Reilly LM, Rapp JH, et al. Assessing the anatomic applicability of the multibranched endovascular repair of thoracoabdominal aortic aneurysm technique. J Vasc Surg. 2013;57:1553-1558.
3. Antoniou GA, Mireskandari M, Bicknell CD, et al. Hybrid repair of the aortic arch in patients with extensive aortic disease. Eur J Vasc Endovasc Surg. 2010;40:715-721.
4. Moulakakis KG, Mylonas SN, Markatis F, et al. A systematic review and meta-analysis of hybrid aortic arch replacement. Ann Cardiothorac Surg. 2013;2:247-260.
5. Hagan PG, Nienaber CA, Isselbacher EM, et al. The International Registry of Acute Aortic Dissection (IRAD): new insights into an old disease. JAMA. 2000;283:897-903.

6. Lu Q, Feng J, Zhou J, et al. Endovascular repair of ascending aortic dissection: a novel treatment option for patients judged unfit for direct surgical repair. J Am Coll Cardiol. 2013;61:1917-1924.
7. Ronchey S, Serrao E, Alberti V, et al. Endovascular stenting of the ascending aorta for type A aortic dissections in patients at high risk for open surgery. Eur J Vasc Endovasc Surg. 2013;45:475-480.
8. Nienaber CA, Kische S, Rousseau H, et al. Endovascular repair of type B aortic dissection: long-term results of the randomized investigation of stent grafts in aortic dissection trial. Circulation Cardiovascular interventions. 2013;6:407-416.
9. Dake MD, Thompson M, van Sambeek M, et al. DISSECT: a new mnemonic-based approach to the categorization of aortic dissection. Eur J Vasc Endovasc Surg. 2013;46:175-190.
10. Nienaber CA, Kische S, Zeller T, et al. Provisional extension to induce complete attachment after stent-graft placement in type B aortic dissection: the PETTICOAT concept. J Endovasc Ther. 2006;13:738-746.
11. Sobocinski J, Lombardi JV, Dias NV, et al. Volume analysis of true and false lumens in acute complicated type B aortic dissections after thoracic endovascular aortic repair with stent grafts alone or with a composite device design. J Vasc Surg. 2016;63:1216-1224.