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Original Article / Özgün Makale

Does endovascular repair affect aortic remodeling in acute complicated type B aortic dissection?

Akut komplike tip B aort diseksiyonunun endovasküler tamiri aortun yeniden biçimlenmesini etkiler mi?

Serkan Ertugay,[1] Halil Bozkaya,[2] Celal Çınar,[2] Mustafa Parıldar,[2] Hakan Posacıoğlu[1]

Departments of [1]Cardiovascular Surgery, [2]Radiology, Medical Faculty of Ege University, İzmir, Turkey

ABSTRACT

Background: This study aims to analyze the volume changes of true and false lumens at a late stage in patients undergoing thoracic endovascular aortic repair (TEVAR) due to acute complicated type B aortic dissection.

Methods: Between March 2006 and November 2012, 18 consecutive patients (14 males, 4 females; mean age was 61.9±11 years; range 39 to 77 years) who underwent TEVAR for acute complicated type B aortic dissection in our clinic were included in this study. Computed tomography scans obtained at the final visit were used for the volume analysis of true and false lumens. The median follow-up was 35.3 (range, 12 to 84) months. Indications for intervention were rupture or malperfusion in 17 patients (both in some patients) and persistent chest pain in one patient. The stent-graft part of the descending thoracic aorta (DTA) was defined as Segment 1, DTA without stent-graft (supraceliac) as Segment 2, and the abdominal aorta as Segment 3.

Results: In segment 1, the mean volume of true lumen increased from 74.4±49 mL to 110±50 mL (p=0.0145), while the mean volume of false lumen decreased from 124.2±81 mL to 59.5±59 mL (p<0.00001). In segment 2, the mean volume of true lumen increased from 23.1±28 mL to 40.5±33 mL (p=0.0015), while the mean volume of false lumen decreased from 32.8±29 mL to 29±1 mL (p=0.624). In segment 3, the mean volume of true lumen increased from 46.5±63 mL to 57.3±74 mL (p=0.0388), the mean volume of false lumen decreased from 41.8±30 mL to 37.6±32 mL (p=0.5195). True and false lumens volume changes were statistically significant except volume decrease in segment 3.

Conclusion: Endovascular repair of type B aortic dissection may positively affect aortic remodeling in chronic settings and may prevent possible aorta-related complications during long-term follow-up.

Keywords: Aortic remodeling; complicated type B aortic dissection; thoracic endovascular aortic repair.

ÖZ

Amaç: Bu çalışmada, akut komplike tip B aort diseksiyonu nedeniyle torasik endovasküler aort tamiri (TEVAR) uygulanan hastalarda, uzun dönemdeki gerçek ve yalancı lümenlerin hacim değişiklikleri araştırıldı.

Çalışma planı: Mart 2003 - Kasım 2012 tarihleri arasında kliniğimizde akut komplike tip B aort diseksiyonu nedeniyle TEVAR uygulanan 18 ardışık hasta (14 erkek, 4 kadın; ort. yaş 61.9±11 yıl; dağılım 39-77 yıl) çalışmaya dahil edildi. Son vizitte elde edilen bilgisayarlı tomografi taramaları, gerçek ve yalancı lümen hacimlerini ölçmek için kullanıldı. Ortanca takip süresi 35.3 (dağılım 12-84) ay idi. Girişim endikasyonu 17 hastada rüptür veya malperfüzyon (bazı hastalarda her ikisi birlikte), bir hastada ise inatçı göğüs ağrısı idi. İnen torasik aortun (DTA) stentli kısmı Segment 1, DTA'nın stentsiz olan kısmı (supraçölyak) Segment 2 ve abdominal aort Segment 3 olarak tanımlandı.

Bulgular: Segment 1'de ortalama gerçek lümen hacmi 74.4±49 mL'den 110±50 mL'ye yükselirken (p=0.0145), ortalama yalancı lümen hacmi 124.2±81 mL'den 59.5±59 mL'ye düştü (p<0.00001). Segment 2'de, ortalama gerçek lümen hacmi 23.1±28 mL'den 40.5±33 mL'ye yükselirken (p=0.0015), ortalama yalancı lümen hacminin 32.8±29 mL'den 29±1 mL'ye düştü (p=0.624). Segment 3'te ise ortalama gerçek lümen hacmi 46.5±63 mL'den 57.3±74 mL'ye yükselirken (p=0.0388), ortalama yalancı lümen hacminin 41.8±30 mL'den 37.6±32 mL'ye düştü (p=0.5195). Gerçek ve yalancı lümendeki volüm değişiklikleri, segment 3'deki volüm azalması dışında istatistiksel olarak anlamlı bulunmuştur.

Sonuç: Tip B aort diseksiyonunun endovasküler tamiri kronik hastalıklarda aortun yeniden biçimlenmesini olumlu etkileyebilir ve uzun dönem takipte muhtemel aort komplikasyonlarını önleyebilir.

Anahtar sözcükler: Aortun yeniden biçimlenmesi; komplike tip B aort diseksiyonu; torasik endovasküler aort tamiri.

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Correspondence: Serkan Ertugay, M.D. Ege Üniversitesi Tıp Fakültesi Kalp ve Damar Cerrahisi Anabilim Dalı, 35100 Bornova, İzmir, Turkey.
Tel: +90 533 - 526 29 50 e-mail: serkanertugay80@gmail.com

Although acute (≤2 weeks) non-complicated type B aortic dissection can be successfully managed with medical treatment, its in-hospital mortality is still as high as ~10%.[1] In case of complications, however, the emergent repair of aorta either open or endovascular is needed. The main goal of both therapies is to exclude the main entry of tear to provide re-expansion of true lumen (TL) and the thrombosis of false lumen (FL), which is called as 'aortic remodeling'. Open repair of type B aortic dissection has a higher mortality and morbidity than endovascular treatment in acute settings.[2,3]

In the long-term period, the main causes of hospital admissions for this patient population include FL aneurysms and ruptures. In non-complicated group, which can be managed medically, FL aneurysms requiring intervention range between 20 and 50% over five years.[3-5] In complicated group, on the other hand, which has been already treated with endovascular or open techniques, the risk of an aneurysm formation outside of the treated segment is lower than the non-complicated group.[6] The diameter or lumen volume has been assessed to analyze the aortic remodeling by several authors to predict the complication risk due to FL aneurysms.[4,7-10]

In this study, we aimed to analyze the volume changes of TL and FL at a late stage in patients who underwent thoracic endovascular aortic repair (TEVAR) due to acute complicated type B aortic dissection.

PATIENTS AND METHODS

A total of 19 consecutive patients were treated for acute complicated type B aortic dissection between March 2006 and November 2012. However, one patient was excluded due to short-term follow-up and remaining 18 patients (14 males, 4 females; mean age was 61.9±11 years; range 39 to 77 years) were included. Computed tomography (CT) angiography of the entire aorta was performed on all patients at baseline, one, and six months, and annually, thereafter. The CT scans obtained at the last visit were used for volume analysis of TL and FL. The median follow-up was 35.3 (range, 12 to 84) months after TEVAR procedure. Indications for treatment were ruptures or malperfusion in 17 patients (both in some patients) and persistent chest pain in one patient (Table 1). The dissection extended into the iliac arteries in 15 patients, into the abdominal aorta in two patients, whereas it was limited to the thoracic aorta in one patient. A complete written informed consent was obtained from each patient or her/his relatives.

Thoracic endovascular aortic repair procedure was performed under general anesthesia in a hybrid operating room. Single femoral artery exploration was done in 16 patients and iliac artery in two patients due to the small size of the femoral artery. For pigtail catheter angiography, the ascending aorta was catheterized by axillary or brachial artery site. The mean diameter of stent-grafts (W.L.Gore & Associates, Inc. Flagstaff, AZ, and USA) was 33 mm (range, 26 to 40 mm). The decision of graft diameter was made according to the expected landing zone diameter. Oversizing strategy for the graft selection was not used. If zone 2 was a landing zone, rapid ventricular pacing was used to prevent graft migration due to the blood pressure effect. In other zones, graft implantation was done under controlled low blood pressure with medical therapy.

Computed tomography angiography continuous scans showing the entire aorta, including the proximal supra-aortic vessels to the femoral artery bifurcation, were obtained using a dual source 64-section multidetector CT scanner (Somatom Definition AS, Siemens Healthcare, Erlangen, Germany) with the following scanning parameters: 250 mAs, 120 kV, pitch 1, 1 mm reconstruction interval, and 1 mm reconstruction section thickness. An iodinated contrast agent (120 to 140 mL) was continuously injected using an automatic injector (Missouri, Ulrich Medizintechnik, Ulm, Germany) through the catheter in the antecubital vein at a rate of 4 mL/s. To ensure the maximum aortic contrast concentration, a circular region of interest was placed in the ascending aorta (threshold value: 120 HU). The raw data were transferred to an independent workstation to calculate volumes (Syngo version V35, Siemens Healthcare, Erlangen, Germany).

Preoperative examination was done on the same day or a day before the procedure. Postoperative examinations were carried out in accordance with the follow-up scheme of TEVAR procedure.

All CT scans were analyzed by a single radiologist. Descending thoracic aorta (DTA) starting from the origin of left subclavian artery to the iliac bifurcation was divided into three segments. The stent-graft placed part of DTA was defined as Segment 1, DTA without stent-graft (supraceliac) as Segment 2, and the abdominal part of the aorta as Segment 3.

The presence of thrombosis in each segment, whether partial or complete, was recorded. From the corrected axial plan image using the multi-planar reconstruction (MPR) technique, the areas of TL and FLs in each centimeter of aorta were measured.

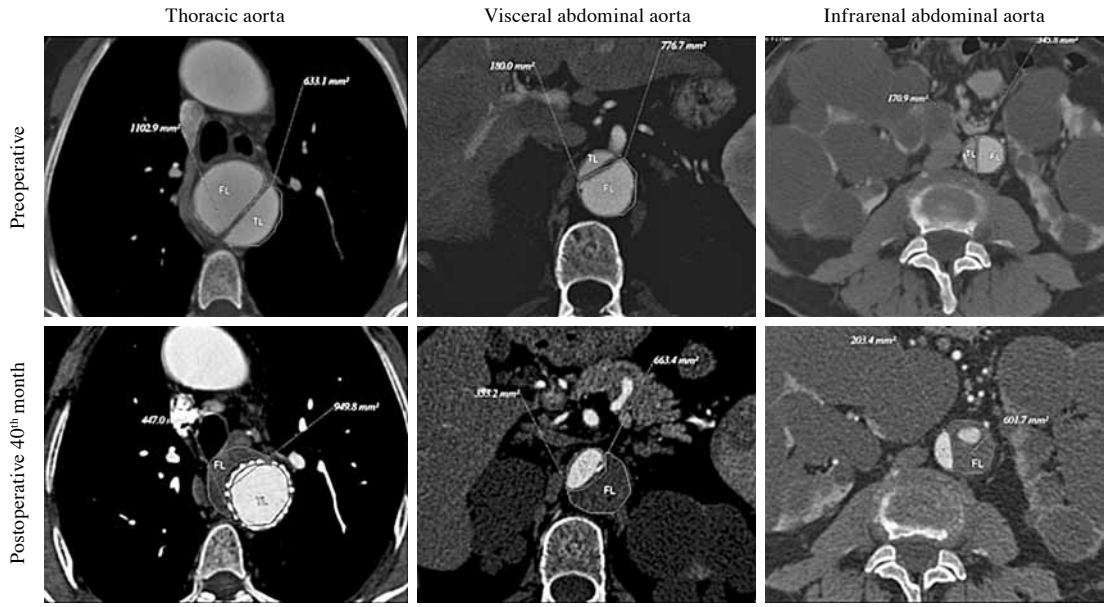

Figure 1. Computed tomography scans showing preoperative and postoperative volumes of true and false lumens.

The volume calculation was made by addition of areas (sum of areas technique) measured in each 1 cm segment. The TL and FL volumes of each segment were calculated separately (Figure 1). Total FL volume was calculated as the volume of the perfused FL plus the volume of the thrombosed FL. In addition to the mean volume changes, we also documented the number of patients with increased or decreased volumes or volume stagnation of the TL and FL.

Statistical analysis

Statistical analysis was performed using the SPSS version 16.0 software package (SPSS Inc., Chicago, IL, USA). Continuous variables are presented in median ± standard deviation, while categorical variables are given as expressed in number and percentage. Continuous variables were analyzed using a paired t test. A p value of <0.05 was considered statistically significant.

RESULTS

Back pain was the most common symptom leading to hospital admission in 14 patients. The median time from the symptom onset to the intervention was 3.5 days. Preoperative characteristics are shown in Table 1. The operative success defined as no switch to open repair was 100%. In a patient, a peripheral bare stent was placed into the superior mesenteric artery, celiac artery, hepatic artery, and left renal artery which showed dynamic obstruction by the intimal flap after the implantation of thoracic stent-graft. Another patient with limb ischemia was treated with axillofemoral graft bypass until the stent-graft was provided. Additional endovascular repair (EVAR) was performed in a patient with previous degenerative aneurysm of the abdominal aorta. The mean length of aortic coverage was 17.5 cm (range, 15 to 20 cm).

In segment 1, the mean volume of TL increased from 74.4±49 mL to 110±50 mL (p=0.0145), while the mean volume of FL decreased from 124.2±81 mL to 59.5±59 mL (p<0.00001). The FL was completely thrombosed and volume of FL decreased in all patients (Figure 2). On the other hand, TL volume increased in 13 patients (72.2%), while three patients with a previous history of TL aneurysm had decreased volumes.

In segment 2 (supraceliac segment of DTA, without stent-graft), the mean volume of TL increased from

Table 1. Preoperative characteristics of patients

Characteristics	n	%	Mean±SD	p
Age (years)			61.9±11	NA
Sex (male)	14	77.7		
Hypertension	16	88.8		
Active tobacco user	8	44.4		
Preoperative hemodialysis	3	16.6		
Complication				
Rupture	5	27.7		
Malperfusion	15	83.3		
Refractory pain	1	5.5		

SD: Standard deviation; NA: Not available.

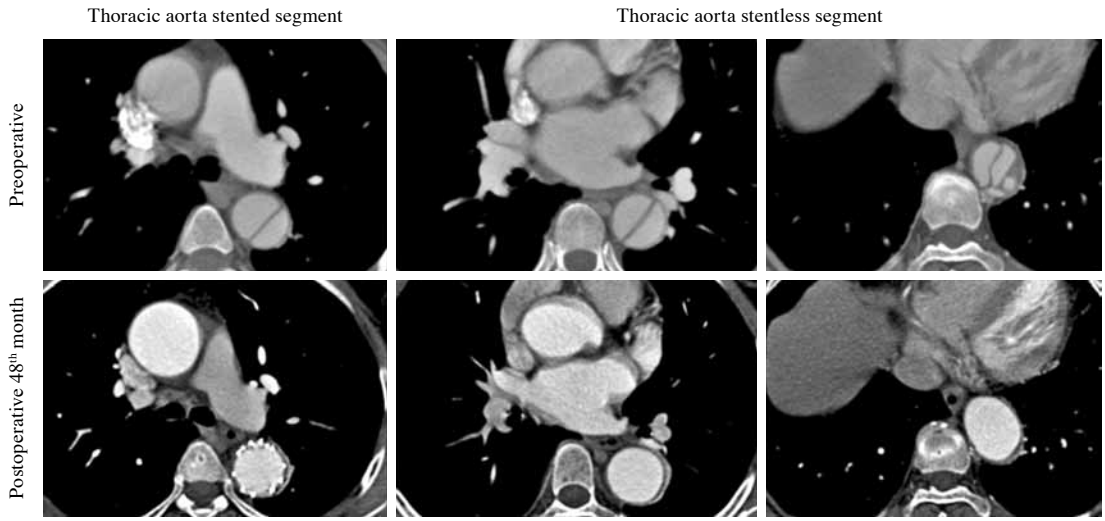

Figure 2. Compute tomography scans showing complete recovery of true lumens 48 months after stent-graft implantation.

23.1±28 mL to 40.5±33 ml (p=0.0015), while the mean volume of FL decreased from 32.8±29 mL to 29±1 mL (p=0.624). Total thrombosis and partial thrombosis were achieved in seven and five patients, respectively. The TL volume increased in 14 patients (77.7%), whereas two of remaining showed a slight decrease of TL volume. The FL volume decreased in five patients (27.7%), while the volume increased in five patients (27.7%) (Figure 3).

In segment 3 (infraceliac part of abdominal aorta without stent-graft), the mean volume of TL increased from 46.5±63 mL to 57.3±74 mL (p=0.0388), while the mean volume of FL decreased from 41.8±30 mL to 37.6±32 mL (p=0.5195). The FL was thrombosed completely in only two patients and partially in four patients. The TL volume increased in nine patients (50%), whereas it decreased in one patient, and remained unchanged in eight patients (44.4%). The FL volume decreased in eight patients (44.4 %), while it increased in four patients (22.3%) (Table 2).

When Segment 2 was evaluated in conjunction with Segment 3, the mean volume of TL increased from 69.6±28 mL to 97.8±33 mL (p=0.0009). The mean volume of FL decreased from 74.5±30 mL to 66.1±28 mL (p=0.377). The mean volume of TL increased in 13 patients (72.2%), decreased in one patient (5.6%), remained unchanged in four patients (22.2%). The FL volume decreased in seven patients (38.8%), increased in four patients (%22.4), and remained unchanged in seven patients (38.8%) (Table 2).

In the stented aortic segment, the decrease in FL volume and the increase in TL volume were statistically significant. In the segment distal to the stent-graft

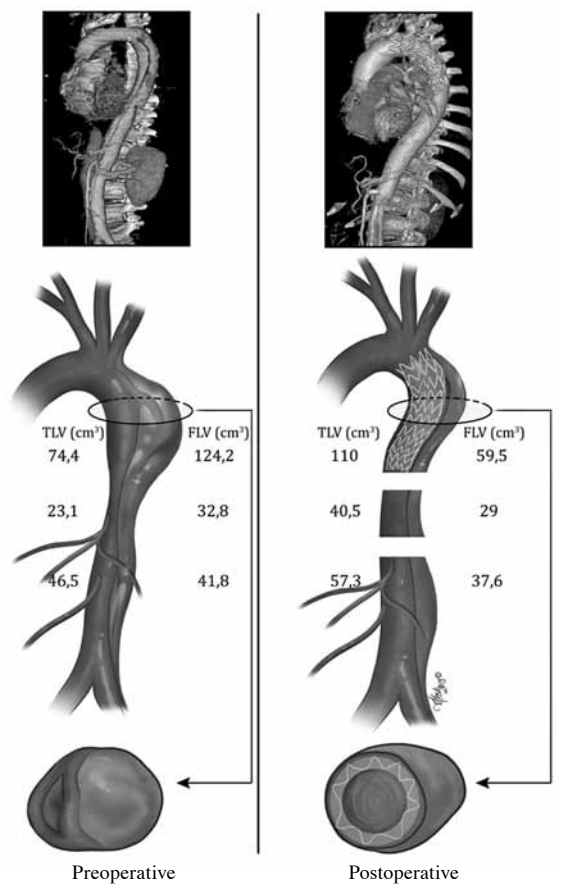

Figure 3. Illustration showing volume changes in each segment of dissected thoracic and abdominal aorta.

Table 2. True and false lumen volume changes of the three segments of the aorta after thoracic endovascular aortic repair

	Stented segment				Supraceliac segment				Infraceliac segment			
	Preoperative		Postoperative		Preoperative		Postoperative		Preoperative		Postoperative	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
True lumen (mL)	74.4	12.1-207.6	110	61.8-254.4	23.1	0-45.2	40.5	0-107.6	46.5	0-225.1	57.3	9.8-304.3
False lumen (mL)	124.2	44.1-370.5	59.5	0-213.1	32.8	0-80.8	29.1	0-89.8	41.8	0-133.9	37.6	0-114.1

(segments 2+3), the increase in TL was statistically significant; however, the decrease in FL volume reached no statistical significance (Figures 4, 5).

From the perspective of visceral complications, a patient presented with liver abscess before TEVAR due to hepatic ischemia and was drained by catheterization and treated with antibiotherapy. The patient who was dialysis-dependent before TEVAR experienced a significant improvement of the renal function after the procedure, which led to dialysis discontinuation. Acute pancreatitis was detected postoperatively in another patient with visceral malperfusion and resolved with medical therapy. None of the patients underwent ischemic causes-related bowel resection. A patient with history of mesenteric ischemia due to dissection presented with brid ileus and underwent laparotomy two months after TEVAR.

The median stay in the intensive care unit was 36 hours. Three patients who had hemodialysis preoperatively had recovery of renal function. Four patients had gastrointestinal complications which did not require bowel resection. Operative mortality was seen in none of the patients. There was no late rupture in thoracic aorta. Rupture of infra-renal segment of the abdominal aorta was seen only in a patient at 22 months after TEVAR and treated with endovascular technique. Neurological complications such as paraplegia or stroke were not observed. All patients survived and no procedure-related event requiring an intervention occurred, until the date of study design.

DISCUSSION

Since the first endovascular stent-graft replacement for type B aortic dissection by Dake in 1999, the number of TEVAR for thoracic aortic diseases

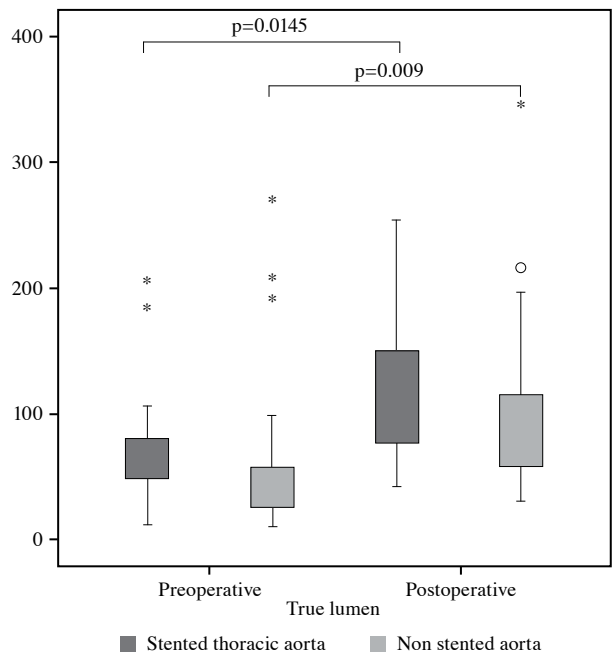

Figure 4. Volumetric changes of the true lumen during follow-up in the stented and non-stented segments of the aorta after TEVAR (The mean follow-up: 35.3 months).

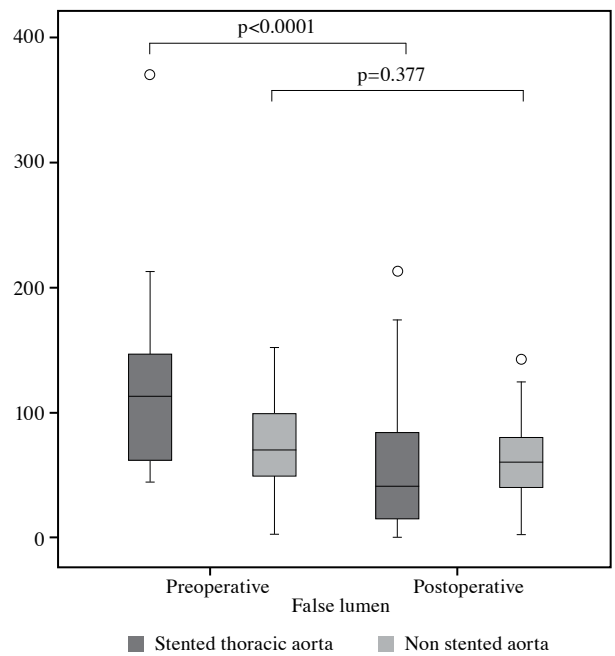

Figure 5. Volumetric changes of the false lumen during follow-up in the stented and non-stented segments of the aorta after TEVAR (The mean follow-up: 35.3 months).

has increased rapidly.[11] However, the effect of the endovascular treatment of acute non-complicated type B aortic dissection is still unclear. Up-to-date, the INvestigation of STEnt Grafts in Aortic Dissection (INSTEAD) trial showed no significant difference in the survival rates between patients undergoing medical treatment and TEVAR. However, in term of aortic remodeling which means TL expansion and FL thrombosis, TEVAR appeared to have a positive impact.[12] Another trial, namely Acute Uncomplicated Aortic Dissection Type B: evaluating stent-graft placement or best medical treatment alone (ADSORB), which is still ongoing, is a prospective randomized study investigating the efficacy of TEVAR in non-complicated patient population.[13]

One of the causes of mortality for chronic type B aortic dissection in the long-term is the formation of an aneurysm in FL and related ruptures. The incidence of this fatal complication is about 20-50% and requires intervention.[3] Previous studies showed that complete FL thrombosis was a predictor of reduced aortic enlargement and dissection-related mortality.[14] In such cases, TEVAR is an option; however, membrane dissection becomes less elastic which cannot be compressed by the expansion of the stent-graft in chronic settings. Kim et al.[9] evaluated the volume changes in patients with acute complicated type B aortic dissection who were treated with endovascular stent-graft and they found a progressively increased TL volume and decreased FL volume in the absence of an endoleak. Similarly, in a comparative study, Huptas et al.,[15] demonstrated that aortic remodeling was stronger with TEVAR than medical therapy in non-complicated group, even. In our study, we found a significant increase of TL volume in all three segments of the aortic dissection. However, the decrease of FL volume in the abdominal segment of aorta was not found to be significant. In the INSTEAD trial analyzing the impact of TEVAR in acute type B aortic dissection, the authors showed a significant progression of TL and regression of FL, despite no benefit on survival at two years.[12] In our study, the aortic volume changes did not affect survival.

Another criterion for aortic remodeling is FL patency. In patients with chronic type B aortic dissection who are followed with medical treatment, spontaneous thrombosis in FL is extremely rare. In almost 80% of these patients, there was an increased FL volume. Tsai et al.[16] reviewed the International Registry of Acute Aortic Dissection (IRAD) to assess the possible relationship between FL patency and mortality in acute type B aortic dissection. The authors found that partial thrombosis of FL had a higher mortality rate than complete patency. Therefore, aortic remodeling which targets the complete thrombosis of FL, resulting in TL expansion should be achieved. After TEVAR, FL thrombosis is only limited with the stented thoracic aorta segment. However, spontaneous thrombosis of FL is extremely rare and total aortic volume usually increases with a high-risk of rupture in patients with chronic type B aortic dissection on medical treatment.[15] As a result, closure of the proximal intimal tear by aortic stent-grafting and ensuring the thrombosis of FL in the stented segment may return the flow to its previous stance and cause aortic remodeling by ameliorating the flow in visceral arteries. Also, this process is not limited to the early stage after TEVAR and continues in the late stage, as well. In addition, self-expandable stent-grafts have a positive impact on the expansion of TL and compression of FL. From this point of view, we achieved total thrombosis of FL at the stented segment in all patients immediately after TEVAR procedure. Complete thrombosis of FL in Segment 2 and 3 was also achieved in seven and two patients, respectively. However, thrombosis was not seen in six patients for Segment 2 and in nine patients for Segment 3. In one patient, FL aneurysm and rupture due to resistant flow in the abdominal segment was observed and these were treated with endovascular method. The rates of FL thrombosis distal to the stent graft were particularly poor, indicating that a long length of aortic coverage is required to gain better FL thrombosis and aortic remodeling.

Furthermore, there is currently no consensus on the optimal pathway to measure or report aortic changes after TEVAR. Volumetric measurement of the aorta due to the altered shape of TL and FLs seems to be more appropriate to assess the aortic remodeling.[4] In this study, volumetric measurement of the dissected segment of the aorta through highly sensitive CT scan was used to evaluate the aortic remodeling due to the altered shape of the lumen structure. Although the diameter analysis has been done in recent studies,[4,7] some authors claimed that uni-dimensional diameter analysis of the dissected aorta provides inaccurate data to predict the risk of rupture.[5,15] Another twilight zone for TEVAR is the length of aortic coverage with the stent-graft. Extensive implantation of an endograft for FL thrombosis may increase the risk for spinal injury after TEVAR. In a review, Nienaber and Eagle[17] emphasized that the graft implantation which did not exceed 18 cm had a low risk for paraplegia. In this cohort, the mean length of aortic coverage was found to be 17.5 cm. Therefore, we believe that

postoperative neurological events were not seen in any patient, despite cerebrospinal fluid drainage was not used.

On the other hand, this study has some limitations. Firstly, we had a small sample size. Secondly, the retrospective design of the study precluded a thorough investigation. Thirdly, we did not have a comparison group to make a comprehensive comparison of two techniques.

In conclusion, endovascular repair of type B aortic dissection may cause an expected aortic reverse remodeling which prevents aorta-related complications in the long-term.

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Declaration of conflicting interests

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