



Midterm outcomes of thoracic endovascular repair for uncomplicated type B aortic dissection with double-barrel type

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Abstract

Objective The midterm outcomes and aortic remodeling after thoracic endovascular aortic repair (TEVAR) for uncomplicated type B aortic dissection (TBAD) were evaluated.

Methods Forty-seven patients (mean age 66 ± 12 years) who underwent TEVAR for uncomplicated TBAD with double-barrel type from January 2012 to December 2017 were retrospectively analyzed. The indication for TEVAR for entry closure was a maximum aortic diameter > 40 mm with a patent false lumen. Twenty-six patients (55.3%) had TEVAR in chronic phase, over 6 months after the onset of aortic dissection.

Results There was no hospital death or serious complication. During follow-up (mean 35 ± 16 months), overall 3-year survival was $95.6 \pm 3.1\%$. A significant trend was observed with a higher rate of shrinkage of overall aortic diameter, expansion of the true lumen, and shrinkage of the false lumen more proximally from the stent graft-covered site. Rate of aortic shrinkage in chronic with aortic diameter more than 50 mm was lower compared with the other (proximal: 33.3% vs. 80–100%, distal 0–16.7% vs. 50–52.9%). Rate of aortic dilation distally to the stent graft-covered site was 28% in chronic compared with 5% in non-chronic. Adverse events were mainly due to distal aortic dilation, and 3-year freedom from all adverse events was $79.8 \pm 6.5\%$.

Conclusions Favorable aortic remodeling of the proximal stent graft-covered site could be expected even in the chronic phase if preoperative aortic dilation over 50 mm is unaccompanied. Careful follow-up focusing on dilation of the distal aortic segment is mandatory especially in patients who underwent TEVAR in chronic phase.

Keywords Type B aortic dissection · Uncomplicated · Thoracic endovascular repair

Introduction

The term “uncomplicated type B aortic dissection” (TBAD) commonly refers to Stanford type B aortic dissection without hemodynamic instability or organ malperfusion [1]. This aortic pathology has traditionally been treated with optimal medical management including anti-hypertensive medical treatment, with early mortality of approximately 10% [2,

3]. However, despite the initial success of optimal medical management, patients with uncomplicated TBAD have a lifelong risk of aneurysm formation of the dissected aorta. Many studies have reported that medical treatment failed to prevent late aortic events [4–8].

Although the investigation of stent grafts in aortic dissection (INSTEAD) trial failed to find short-term benefits of thoracic endovascular aortic repair (TEVAR), the long-term survival and remodeling outcomes did favor endovascular management compared with the best medical treatment alone [9, 10]. In addition, the acute dissection stent grafting or best medical treatment (ADSORB) trial showed the benefits of TEVAR in aortic remodeling at 1-year follow-up [11]. Following these prospective studies reporting potential benefits of TEVAR for uncomplicated TBAD, a preemptive endovascular approach has been increasingly used to prevent aneurysmal degeneration. However, the long-term

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results remain to be investigated. The aim of this study was to evaluate the midterm outcomes and aortic remodeling after TEVAR for uncomplicated TBAD.

Methods

Patients

The present study protocol was reviewed and approved by each institutional database and office record committee, and the study complied with the requirements of the Declaration of Helsinki (2013 version). Individual consent was waived.

A retrospective review of our database identified 47 patients [mean 66 ± 12 (41–89) years old, 36 males] who underwent TEVAR for uncomplicated TBAD to prevent further aortic dilation in three facilities, the National Cerebral and Cardiovascular Center, Hyogo Brain and Heart Center, and Kitaharima Medical Center, from January 2012 to December 2017.

Uncomplicated TBAD is defined as a condition without rupture, malperfusion syndrome, or refractory pain. This study included residual aortic dissection after aortic repair, such as hemi-arch or total arch repair, for acute type A aortic dissection ($n = 11$). All patients had dissection of the double-barrel type and not from new formation of an ulcer-like projection (ULP), which was described in previous reports [12, 13] as limited patency of the false lumen near the entry. The aortic diameter of over 60 mm and patients with connective tissue disorders were also excluded.

In the surveillance for patients with uncomplicated TBAD and residual dissection after proximal aortic repair for acute type A aortic dissection, entry closure using TEVAR was indicated for uncomplicated TBAD if the maximum aortic diameter with the patent false lumen exceeded 40 mm. In patients whose all intercostal arteries in descending thoracic aorta or visceral branches originated from false lumen, the TEVAR was basically not indicated because of possibility of spinal cord ischemic injury or serious complication due to occlusion of visceral arteries.

The patients' medical records were retrospectively reviewed to collect their characteristics, clinical outcomes, and follow-up data. The size change and the rate of false lumen thrombosis at each segment of the aorta between the preoperative and the latest follow-up images were also examined to assess aortic remodeling.

In this study, the timing of TEVAR was classified into three periods from the onset of initial aortic dissection: within 14 days (acute); 15 days to 6 months (subacute); and after 6 months (chronic). TEVAR was performed in 3 patients in the acute phase, 18 patients in the subacute phase, and 26 patients in the chronic phase.

Preoperative imaging assessment and operative technique

Preoperative computed tomography (CT) data were assessed using a three-dimensional workstation (Ziostation2, Ziosoft, Tokyo, Japan) (Fig. 1). The location and size of initial entry and the extent of aortic dissection were examined. The multiplanar reconstruction view created the planes perpendicular to the center line of the aorta, which were the candidates for the proximal (Fig. 1b) and distal landing zones (Fig. 1c). The diameter of the whole aorta and the preoperative oval or crescent-shaped true lumen was calculated by its internal circumference divided by π . A non-dissected "healthy" section of the aorta was selected as the proximal landing zone. In four patients after hemi-arch replacement for type A aortic dissection, a dissected aortic portion was selected for the proximal landing zone, and in seven patients after total arch replacement, an artificial graft for elephant trunk was used. In these seven patients, the elephant trunk was utilized for the proximal landing zone for TEVAR. The distal landing zone was set at the straight portion of the middle descending aorta, usually 15 cm distal from the proximal landing zone. As the second priority for the distal landing zone, the distal end of the endograft was planned to be placed above the seventh thoracic vertebra to avoid closing the possible segmental artery from which the artery of Adamkiewicz branched.

Endograft size was selected with 5–10% oversize of the calculated diameter of the aorta in the proximal landing zone and the true lumen in the distal landing zone. In the case of a difference in diameter of greater than 4 mm between the proximal and distal landing zones, a tapered shape endograft or a small size aortic cuff was used.

All TEVAR procedures were performed in a hybrid operation theater under general anesthesia with exposure of the femoral or iliac artery. If the risk of spinal cord ischemic injury was considered high, such as coverage of a critical segmental artery, preoperative cerebrospinal fluid drainage was indicated. After placement of the endograft, balloon touch-up was in principle not performed to avoid aortic injury. After TEVAR, patients were carefully monitored in intensive care units for at least 12 h. Excessive high or low blood pressure was avoided to prevent retrograde aortic dissection or spinal cord ischemic injury. The mean blood pressure was strictly kept around 70 mmHg in the intensive care units.

Follow-up and imaging analysis

Postoperative and all follow-up CT scans were reviewed in all patients. The standard scan regimen after TEVAR was 1 week, 3 months, 6 months, 12 months, and yearly

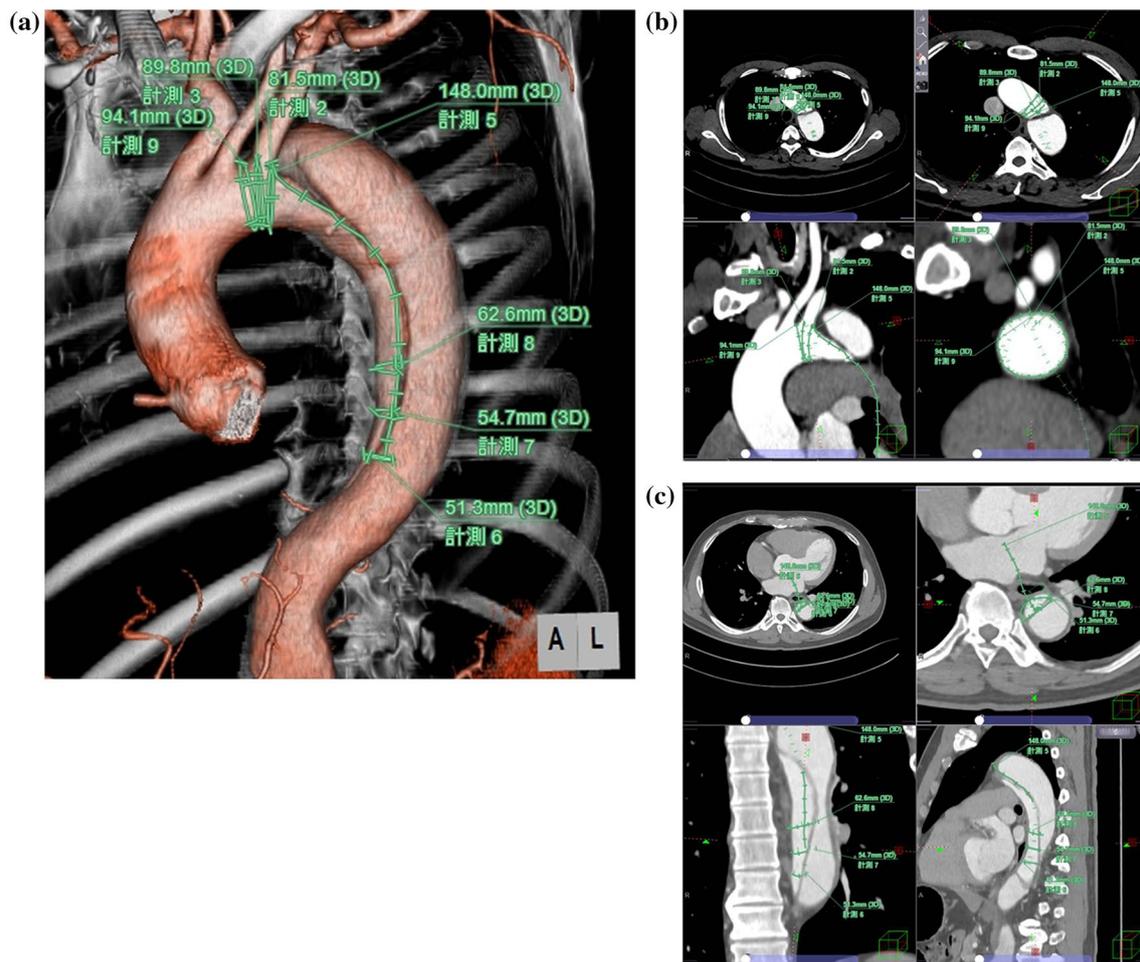


Fig. 1 A typical preoperative imaging assessment. 3D imaging view of the aorta (a). The multiplanar reconstruction view of the proximal (b) and distal (c) landing zones. In this case, zone 2 landing TEVAR was planned. A non-dissected “healthy” section of the aorta was

selected as the proximal landing zone. The distal landing zone was set at the straight portion of the middle descending aorta, usually 15 cm distal from the proximal landing zone

thereafter, though it could differ for individual patients, depending on the findings. Follow-up CT scans were reviewed by two cardiovascular radiologists and analyzed on three-dimensional workstations to measure the size and confirm the status of the true and false lumens in detail.

The diameter of the aorta orthogonal to the centerline and the intimal flap was measured in the following locations: (1) the proximal portion of the endograft (proximal landing zone), (2) the distal portion of the endograft (distal landing zone), (3) abdominal aorta at the level of the celiac artery (CA level), and (4) the abdominal aorta below the renal arteries (infra-renal). At each location, the diameters of the true and false lumens were also measured in the inner contour of the affected aorta. In patients with the elephant trunk used as the landing zone, the diameter at the descending aorta just distal to the elephant trunk was measured as the “proximal landing zone”.

The state of the false lumen was classified using three categories: (1) evidence of contrast without evidence of thrombus (patent), (2) evidence of both contrast and thrombus (partially thrombosed), and (3) evidence of thrombus without evidence of contrast (completely thrombosed).

Statistical analysis

Data were statistically analyzed using SPSS version 11.0 (SPSS, Chicago, IL, USA). Continuous variables are reported as means and standard deviation, and categorical variables are reported as counts with percentages. Comparisons of the aortic diameter at each segment were performed using Student’s *t* test. The Cochran–Armitage test for linear trend was used to examine the size change among the four levels of CT measurement. Patient survival

and freedom from adverse events rates were estimated using the Kaplan–Meier method.

Table 1 Preoperative patients’ characteristics and operative outcomes

	<i>N</i> =47 (%)
Preoperative patients’ characteristics	
Mean age	66 ± 12
Male	36 (76.6)
BSA (m ²)	1.74 ± 0.26
Serum creatine (mg/dl)	0.99 ± 0.29
Residual dissection after repair of acute type A aortic dissection	11 (23.4)
Mean maximum aortic diameter (mm)	47 ± 5
Maximum aortic diameter	
40 mm ≤ 50 mm	30 (63.8)
50 mm ≤ 55 mm	11 (23.4)
55 mm ≤ 60 mm	6 (12.8)
DeBakey IIIa	4 (8.5)
DeBakey IIIb	43 (91.5)
Time from onset to TEVAR	
Acute	3 (6.4)
Subacute	18 (38.3)
Chronic	26 (55.3)
Operative outcomes	
Proximal landing zone 1/2/3/4	4/22/11/10
Operation time (min)	187 ± 84
Supra-aortic arch bypass	26 (55.3)
Hospital death	0
Type 1 A endoleak detected 1 week after the operation	2 (4.3)
Postoperative stroke	0
Spinal cord ischemic injury	0

BSA body surface area

Results

Early outcomes

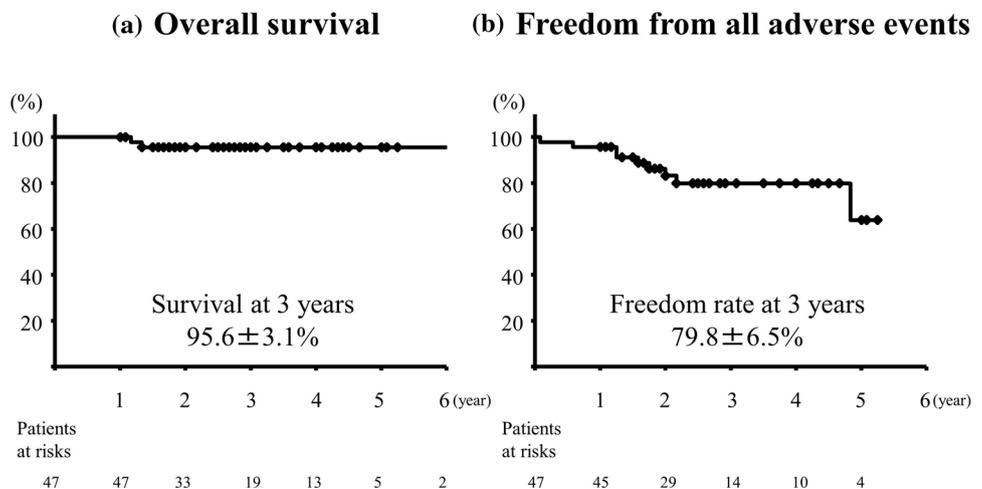
Table 1 shows the preoperative patients’ characteristics and operative outcomes. The median time from onset to TEVAR was 9 days in acute (range 7–12 days), 69 days in subacute (18–149 days), and 539 days in chronic (180–4310 days) cases.

In all patients treated with landing zone 1 or zone 2 TEVAR, supra-aortic arch bypass was carried out simultaneously. The endoprosthesis used was Gore TAG or cTAG (W.L. Gore & Associates, Flagstaff, AZ, USA) in 22 patients, Zenith TX2 (Cook Medical Inc., Bloomington, IN, USA) in 21, and Medtronic Valiant Captivia (Medtronic, Minneapolis, MN, USA) in 4. There was no type Ia endoleak at the completion angiography during TEVAR. However, type Ia endoleak was detected in two patients at the post-operative CT 1 week later, and they resolved spontaneously within 3 months after TEVAR. There were no hospital deaths or serious postoperative complications, including stroke and spinal cord ischemia.

Late outcomes

During the follow-up period (35 ± 16 months, range 12–81 months), overall survival at 3 years was 95.6% ± 3.1% (Fig. 2a). Two late deaths occurred due to brain tumor (14 months) and aortic-related cause (16 months). This aortic-related death was due to multiple organ failure 30 days after the emergency surgery of total arch replacement and the Bentall operation for acute type A aortic dissection. In this patient, who developed de novo type A aortic dissection 16 months after zone 2 landing TEVAR using Gore TAG endoprosthesis, the entry was located around the level

Fig. 2 Overall survival (a) and freedom from all adverse events after TEVAR for uncomplicated type B aortic dissection (b)



of the sino-tubular junction, and no evidence suggesting a stent graft-induced new entry was confirmed.

Nine adverse events occurred, including stent graft infection ($n = 1$, 1 month), intervention for aortic dilation distal to the TEVAR site ($n = 2$, 7 months, 26 months), stent graft-induced new entry (SINE) around the distal stented site ($n = 3$, 15 months, 19 months, 24 months), de novo type A aortic dissection ($n = 1$, 15 months), open surgery for aortic dilation distal to the TEVAR site ($n = 1$, 21 months), and a type Ia endoleak ($n = 1$, 58 months). Freedom from all adverse events was $79.8\% \pm 6.5\%$ at 3 years (Fig. 2b).

In detail, six of nine adverse events were related to aortic dilation distal to the TEVAR site. The TEVARs for these patients were all in the chronic phase (307, 315, 618, 1263, 3107, and 3722 days). The patient with graft infection was a drug-abuser who required emergent surgery to remove the infected stent graft and perform graft replacement. In three patients, distal SINE without any symptom was detected by routine follow-up CT 15, 19, and 24 months after TEVAR and treated by secondary TEVAR for subsequent aortic dilation 26, 1, and 2 months, respectively, after the detection of distal SINE. The used stent graft in first TEVAR was Gore cTAG in one, Zenith TX2 in one, and Medtronic Valiant in one. Two patients with false lumen dilation had re-entry closure using endovascular technique. The re-entry in these patients, located around the orifice of the celiac artery, was sealed by an aortic cuff endoprosthesis after coil embolization of the false lumen. The type Ia endoleak, which was detected 58 months after zone 2 TEVAR, was treated by additional TEVAR, and no evidence of dilation of the aorta was observed.

In all patients who required secondary interventions, their postoperative courses and follow-up were uneventful, except for the patient with de novo type A aortic dissection.

Aortic remodeling

To investigate the efficacy of TEVAR for aortic remodeling, follow-up CT scans of 45 patients (95.7%) who had completed more than 1 year CT imaging follow-up were analyzed. The mean period from TEVAR to the latest follow-up CT was 30 ± 17 months (median 24 months, range 12–79 months). Twenty-two patients (51.2%) had been followed up for more than 2 years.

Figure 3 shows the chronological diameter changes of the whole aorta, true lumen, and false lumen at each location of the aorta (Fig. 3). Comparing each diameter and state of the false lumen between preoperative and 1 year postoperatively, at the proximal landing zone, complete thrombosis of false lumen was achieved in all patients with a significant decrease of whole aortic diameter from 44.8 ± 7.1 mm to 39.3 ± 9.4 mm ($p = 0.0000$). This was accompanied by significant expansion of the true lumen and shrinkage of the

false lumen. At the distal landing zone, complete thrombosis of the false lumen was observed in 82.3% (37/45), with significant expansion of the true lumen and shrinkage of the false lumen, but no significant change in whole aortic diameter ($p = 0.3740$). Among patients in whom aortic dissection extended beyond the infra-renal aorta, complete thrombosis of the false lumen at the level of the celiac artery and below the renal artery was observed in 17.1% (6/35) and 9.7% (3/31) of cases, respectively.

To combine the quantitative and qualitative evaluations, the Cochran–Armitage test was used to examine the linear trend of the size change. Table 2 shows the number of patients who showed dilation of the diameter ≥ 5 mm, no change (change within ± 5 mm), or shrinkage with reduction of the diameter ≥ 5 mm of the whole aorta, true lumen, and false lumen at each location. A linear trend was observed, with a higher rate of shrinkage of the overall aortic diameter, dilation of the true lumen, and shrinkage of the false lumen from the proximal landing zone to the distal site of the whole aorta.

Table 3 shows the distribution of the size change regarding the timing of TEVAR and preoperative aortic diameters. There was no patient who had aortic dilation in the stent graft-covered site. Aortic dilation of the aorta distal to the stent graft-covered site was noted in seven patients (28%, 7/25) who had TEVAR in the chronic phase. Six of these patients had secondary intervention for distal aortic dilation.

In all six patients who underwent secondary interventions for distal aortic dilation, dilation of the false lumen was observed within 2 years after TEVAR. In patients whose CT showed no dilation until 2 years after TEVAR, the aortic diameter of the distal site remained stable during further follow-up.

Discussion

In this study, the midterm outcomes of TEVAR for uncomplicated TBAD and aortic remodeling on CT surveillance were reported. In the management of uncomplicated TBAD, there is still concern that some patients eventually have complex aortic aneurysmal degeneration despite optimal medical management. Recently, several studies reported the value of TEVAR for uncomplicated TBAD to prevent aneurysm formation [6, 10, 11]. The INSTEAD trial with extended follow-up (INSTEAD–XL) showed that TEVAR for uncomplicated TBAD at an early stage was beneficial in terms of freedom from aortic adverse events [10].

TEVAR for uncomplicated TBAD is pre-emptive and not indicated for the prevention of an impending fatal complication. The safety of pre-emptive TEVAR is more critical, and its use is ideally limited to patients whose disease is expected to be complicated by aneurysmal dilation [14].

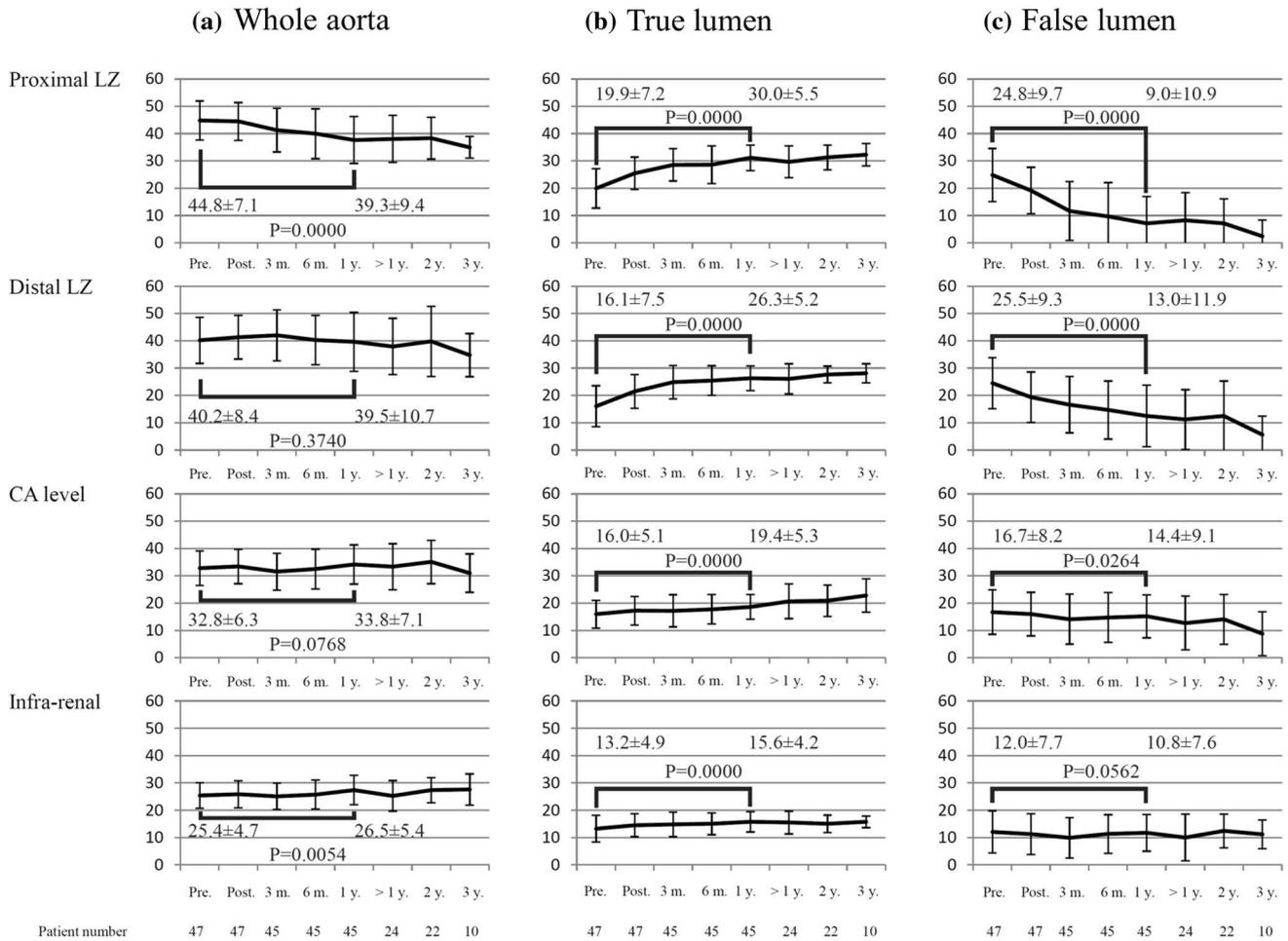


Fig. 3 The chronological diameter change of the whole aorta (a), true lumen (b), and false lumen (c) at each location of the aorta. LZ landing zone, CA celiac artery

Table 2 Number of patients who showed dilation, no change, and shrinkage at each aortic location

	Proximal landing zone	Distal landing zone	Level of celiac artery	Level of infra-renal aorta	p value
Aortic diameter					
Overall					
Dilation	0	8 (17.8)	3 (6.7)	1 (2.2)	0.7893
No change	12 (26.7)	21 (46.7)	39 (86.6)	43 (95.6)	0.0000
Shrinkage	33 (73.3)	16 (35.6)	3 (6.7)	1 (2.2)	0.0000
True lumen					
Dilation	39 (86.7)	38 (84.4)	10 (22.2)	4 (8.9)	0.0000
No change	6 (13.3)	7 (15.6)	35 (77.8)	41 (91.1)	0.0000
Shrinkage	0	0	0	0	N/A
False lumen					
Dilation	0	0	3 (6.7)	0	0.4075
No change	2 (4.4)	10 (22.2)	33 (73.3)	41 (91.1)	0.0000
Shrinkage	43 (95.6)	35 (77.8)	9 (20.0)	4 (8.9)	0.0000

N/A not available

Table 3 Number of patients who showed dilation, no change, and shrinkage at each aortic location classified with the timing of TEVAR and aortic diameter

Phase	Aortic diameter	Patient number	Proximal			Distal		
			Stent graft-covered site			From distal of the stent graft to infra-renal aorta		
			Shrinkage	No change	Dilation	Shrinkage	No change	Dilation
Acute	40 ≤ 50 mm	2	100% (2/2)	0	0	50% (1/2)	50% (1/2)	0
	50 ≤ 55 mm	1	100% (1/1)	0	0	0	100% (1/1)	0
	55 ≤ 60 mm	0						
Subacute	40 ≤ 50 mm	17	100% (17/17)	0	0	52.9% (9/17)	41.2% (7/17)	5.9% (1/17)
	50 ≤ 55 mm	0						
	55 ≤ 60 mm	0						
Chronic	40 ≤ 50 mm	10	80% (8/10)	20% (2/10)	0	50% (5/10)	10% (1/10)	40% (4/10)
	50 ≤ 55 mm	9	33.3% (3/9)	66.7% (6/9)	0	0%	100% (9/9)	0%
	55 ≤ 60 mm	6	33.3% (2/6)	66.7% (4/6)	0	16.7% (1/6)	33.3% (2/6)	50% (3/6)

Aortic diameter greater than 40 mm is reportedly a simple and useful predictor for late aortic expansion from several previous studies [7, 15, 16]. In the present study, pre-emptive TEVAR was basically indicated if the aortic diameter exceeded 40 mm and the false lumen was patent.

The safety of pre-emptive TEVAR was confirmed because neither hospital death nor serious complication including stroke and spinal cord ischemic injury occurred. In coverage of the left subclavian artery by a stent graft, left subclavian artery bypass was reportedly useful for the prevention of cerebral infarction and spinal cord ischemia [17–19]. Thus, in this situation, bypass to the left subclavian artery was simultaneously performed in the present study. In addition to operative procedures, careful postoperative management including optimal maintenance of mean blood pressure seemed to be important to prevent retrograde aortic dissection or spinal cord ischemic injury [20].

During the follow-up period, emergency open aortic surgeries were indicated in two patients: one with graft infection and the other with de novo type A aortic dissection. The cause of graft infection was thought to be illegal drug abuse and does not affect the discussion of pre-emptive TEVAR.

In the patient who developed de novo type A aortic dissection, no relationship with TEVAR was diagnosed because the location of the entry site, the aortic root, was far from the proximal edge of the stent graft. Type A aortic dissection is a serious complication after TEVAR; a recent meta-analysis reported an incidence of 2.5% and a mortality rate of 37.1% [21]. This fatal complication was significantly more frequent in patients treated for dissection than in those treated for an aneurysm. In addition, the incidence became higher with proximal landing zones 0 and 1 [21]. The cause of type A aortic dissection after TEVAR has been mainly discussed in terms of the mechanical formation of a tear near the proximal edge of the stent graft resulting in retrograde dissection. However, other causes, such as the nature of the aortic wall

in the patient with aortic dissection and the change in aortic compliance after TEVAR, should be comprehensively considered.

Distal SINE was observed in three asymptomatic patients detected by the routine surveillance CT. Oversizing was reported as a risk factor for distal SINE [22, 23], but it was not evident in these cases. To avoid excessive oversizing, a small aortic cuff device was deployed at the distal landing zone prior to the deployment of the main stent graft or the tapered stent graft was used. Other mechanisms, such as the timing of TEVAR or the morphology of the distal landing zone, were not specific. Interestingly, in these patients, the false lumens had been completely thrombosed and had shrunk along the stent grafts, but they were partially thrombosed below the stent grafts before SINE formation. The change in morphology of the distal landing zone could be related to this, but further study is necessary to determine the cause of distal SINE.

The appropriate timing of TEVAR for uncomplicated TBAD should be decided based on its efficacy and safety. Several studies reported the timing threshold to ensure the efficacy of TEVAR. The VIRTUE Registry showed that aortic plasticity in TEVAR for uncomplicated TBAD was significantly lower 3 months after onset than within 3 months [24]. Kinoshita et al. reported that aortic remodeling was better in patients with TEVAR within 7 months after the index dissection than in those over 7 months [25].

In the present study, the range of the timing of TEVAR was wide since over half of the patients underwent TEVAR in the chronic phase. The timing of TEVAR in six patients requiring secondary intervention due to distal aortic dilation was all chronic phase. TEVAR for uncomplicated TBAD in the chronic phase might be less effective for aortic remodeling [25, 26].

The rate of the shrinkage at the proximal stent graft-covered site in the chronic phase with aortic diameter more than

50 mm is lower compared with the other (Table 3, proximal: 33.3% vs. 80–100%, distal 0–16.7% vs. 50–52.9%). Certainly, this outcome is suboptimal in the point of better aortic remodeling; however, no dilation in proximal stent graft-covered site was encountered regardless of the treatment timing or preoperative aortic diameter. Aortic dissection continues to have a substantial risk of aneurysmal dilation over time. Stabilization of the aortic diameter at the proximal component of the dissected aorta might be effective for the prevention of complex aneurysmal change. Although the limitation of TEVAR seems to exist in these groups, TEVAR might have an advantage, altering the severity of aneurysm degeneration. If operative risk is acceptable, staged hybrid operation utilizing the previous stent graft as the proximal anastomosis might be an effective option and avoid complex aortic surgery [27, 28]. Further follow-up and accumulation of data are necessary regarding the efficacy of TEVAR for these subjects in the chronic phase with aortic dilation more than 50 mm.

The present midterm outcome with 3-year freedom from all adverse events of nearly 80% seemed compatible with previous studies reporting favorable results of TEVAR for uncomplicated TBAD [6, 10]. The present data might reflect real-world practice for uncomplicated TBAD, including a wide range of TBAD. It was noteworthy that majority of patients showed size reduction and no patient had aortic dilation at the proximal descending aorta covered by a stent graft, but some patients would have also had distal aortic dilation with a decreased rate of aortic remodeling according to the distance from the stent graft. This led us to speculate that persistent flow from re-entry is the key issue since a sub-analysis of the ADSORB trial showed that the number of visceral vessels originating from the false lumen was an independent predictor of false lumen growth [29].

The other side of aortic remodeling is that, when early expansion of aortic diameter was not observed until 2 years after TEVAR, aortic diameter of the distal site remained stable during further follow-up. Intervention to cover the re-entry in the early phase might be an important option to achieve aortic remodeling.

Limitations

This study has several limitations, including its retrospective design and non-comparative study in the small patient number. In addition, this study included the residual aortic dissection after repair for acute type A aortic dissection. The nature of this aortic pathology may be quite different from classical type B aortic dissection. This point may affect the outcome. Since downstream aortic enlargement after the repaired type A aortic dissection is one of the major concerns in clinical studies, we included this aortic pathology

for analysis. There are also limitations to using strict diameter measurements of the true and false lumens to characterize aortic remodeling and predict aortic enlargement. Volumetric analysis might be more ideal to assess aortic remodeling.

Conclusions

TEVAR for uncomplicated TBAD was performed safely. Favorable aortic remodeling of the proximal stent graft-covered site could be expected even in the chronic phase if preoperative aortic dilation over 50 mm is unaccompanied. Careful follow-up focusing on dilation of the distal aortic segment is mandatory especially in patients who underwent TEVAR in chronic phase.

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Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

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