

➤ **Original Article** ◀

Early and Mid-Term Outcomes Following TEVAR for Chronic Type B Aortic Dissection

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We examined the outcomes of aortic remodeling for chronic type B aortic dissection (cTBD) after thoracic endovascular aneurysm repair (TEVAR).

Objective & Methods: Thirty-eight patients underwent TEVAR for cTBD at our institution. We classified cTBD patients into the early cTBD group (16 cases, 2 weeks–4 months from onset) and late cTBD group (22 cases, >4 months from onset).

Results: There were no cases of paraplegia, stroke, and hospital death in both groups. There was no worsening of complicated cases. We achieved false lumen thrombosis in cases with a double-barreled thoracic aorta. The early cTBD group had more complete shrinkage cases (60%) than the late cTBD group (11%).

Conclusion: We obtained favorable mid-term outcomes after TEVAR for cTBD patients. Early cTBD patients obtained good aortic remodeling with TEVAR. (This is a translation of *Jpn J Vasc Surg* 2016; 25: 233–239.)

Keywords: type B aortic dissection, TEVAR, aortic remodeling

Introduction

In recent years, as represented by the INSTEAD-XL trial, performing thoracic endovascular aortic repair (TEVAR) during the early chronic phase of Stanford type B aortic dissection (TBD) has been reported to lead to a good long-term prognosis. At our department, we actively performed TEVAR in the early chronic phase of TBD. We examined treatment results, including aortic remodeling, compared with the results of TEVAR performed in the late chronic phase.

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Subjects and Methods

We examined 38 patients in whom TEVAR was performed using a commercially available device between December 2007 and December 2015. Patients were divided into two groups based on the chronic phase: 16 in the early chronic phase group (2 weeks to 4 months since the onset) and 22 in the late chronic phase group (>4 months since the onset; **Table 1**).

In the early chronic phase group, seven patients had complications due to dissection (five with malperfusion/ischemia and two with rapid enlargement of a false lumen) and eight had no complication [one with a true + false lumen of ≥ 55 -mm diameter, three with narrowing of the true lumen, and four with an ulcer-like projection (ULP)]. In the late chronic phase group, three patients had complications (two with malperfusion/ischemia and one with difficulty swallowing) and 19 had no complication (14 with a true + false lumen of ≥ 55 -mm diameter, three with narrowing of the true lumen, and two with ULP; **Table 2**).

We performed TEVAR in patients with ULP as well as in those with a false lumen obstruction in which the entry position could be estimated to a certain degree and surgery was considered necessary. Of these patients, two were in the early chronic phase group (one with rapid enlargement of a false lumen and one with a true + false lumen of ≥ 55 -mm diameter) and two were in the late chronic phase group (one with a true + false lumen of ≥ 55 -mm diameter and one with narrowing of the true lumen). The categorization of patients with malperfusion/ischemia is shown in **Table 2**. The aortic diameters (sum of the diameters of the preoperative true and false lumens) were 42 ± 6.4 mm in the early chronic phase and 55 ± 13 mm in the late chronic phase groups.

For the proximal landing zone, we left the tip of the stent graft in the undissected aorta on principle. We sized the stent grafts as follows. For the proximal side, we used a graft with a diameter of 108%–115% of the aortic diameter. For the distal side, we used the true lumen as a reference when the graft landed in a double lumen structure and the aortic diameter as a reference when the graft landed in areas without a false lumen. We used grafts with a diameter of 100%–110% and 90%–100% of that of



Table 1 Characteristics

	Early chronic (n=16)	Late chronic (n=22)	
Age	65±12 (40–85)	65±9 (49–78)	
Male:Female	14:2	16:6	
Co-morbidities (%)			
Stroke	19	14	
IHD	13	18	
Hypertension	100	100	
Dyslipidemia	69	36	
CKD	19	23	
COPD	13	23	
Smoking	100	59	p<0.05

IHD: ischemic heart disease; CKD: chronic kidney disease; COPD: chronic obstructive pulmonary disease

Table 2 TEVAR indication for early and late type B dissection

	Early chronic (n=16)		Late chronic (n=22)	
	Complicated (n=7)	Uncomplicated (n=9)	Complicated (n=3)	Uncomplicated (n=19)
Malperfusion/ischemia				
—SMA stenosis	1		1	
—limb ischemia	2		1	
—renal artery stenosis	2			
Dysphagia			1	
FL rapid expansion (>5mm/1 month)	2			
True+false lumen>55mm		1		14
ULP		4		2
Narrow true lumen		4		3

SMA: superior mesenteric artery; ULP: ulcer like projection; FL: false lumen

FL thrombosed type: 1 FL rapid expansion case and 1 True+false lumen >55 mm case in early chronic TBD

1 True+false lumen >55 mm case and 1 Narrow true lumen case in late chronic TBD

the reference for the early and late chronic phase groups, respectively.

To prevent paraplegia, we maintained the mean blood pressure at ≥ 80 mmHg from the time of installing the stent graft to the day after the operation. On principle, we performed contrast computerized tomography (CT) 4 days postoperatively and evaluated endoleak, blood vessel diameter, etc. Subsequently, contrast CT was performed 3 and 6 months and 1 year postoperatively and was repeated every year as long as there was no complication.

For statistical analysis to compare two groups, we used the t-test, χ^2 test, and Fisher's exact test. The Kaplan–Meier method was used to obtain the survival curve. Numerical values were presented as mean \pm standard deviation, and $P < 0.05$ was considered significantly different.

Results

In the early and late chronic phase groups, the duration from onset of the dissection to TEVAR was 2.3 ± 0.9

and 71 ± 71 months, respectively; the duration of operation was 119 ± 50 and 116 ± 52 min, respectively; and the mean observation period was 38 ± 26 and 41 ± 21 months, respectively.

TAG (seven patients), Zenith TX2 (six patients), Zenith TXD (two patients), and CTAG (one patient) grafts were used in the early chronic phase group, whereas TAG (nine patients), Zenith TX2 (10 patients), Najuta (one patient), RELAY Plus (one patient), and Zenith TXD (one patient) grafts were used in the late chronic phase group.

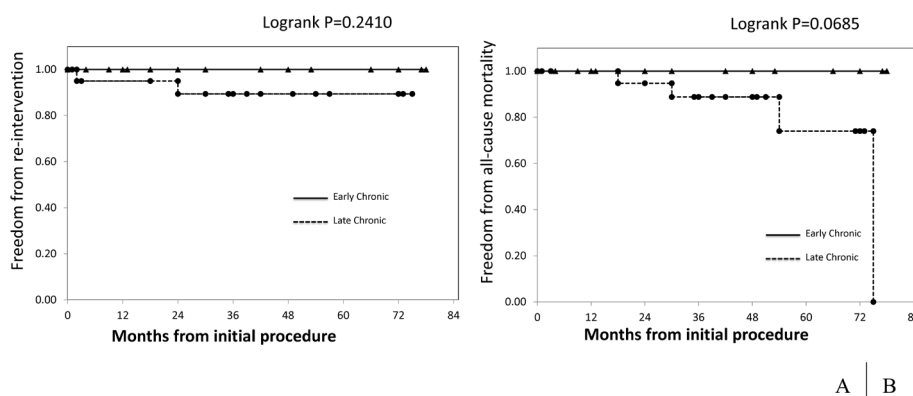
Proximal landing sites were zones 2, 3, and 4 in four, six, and six patients, respectively, in the early chronic phase group and 0, 2, 3, and 4 in one, eight, 12, and one patient, respectively, in the late chronic phase group (Table 3).

No perioperative death or major complication, such as paraplegia and cerebral infarction, occurred in either group (Table 3). Long-term follow-up demonstrated that reintervention was not required in any patient in the early chronic phase group, and no long-term death occurred

Table 3 Early and mid-term outcomes

	Early chronic (n=16)	Late chronic (n=22)	
TEVAR from onset (month)	2.3±0.9 (0.6–3.7)	71±71 (6–300)	p<0.01
Stent-graft			
Najuta	0	1	
TAG (CTAG)	8 (1)	9 (0)	
TX2 (TXD)	8 (2)	11 (1)	
RELAY Plus	0	1	
Proximal landing zone			
0	0	1	
2	4	8	
3	6	12	
4	6	1	
Concomitant EVAR	3	1	
LSCA chimney	0	1	
Op duration (minute)	119±50 (58–214)	116±52 (55–293)	
ICU stay (day)	1.0±0 (1.0–1.0)	1.0±0 (1.0–1.0)	
Hospital stay (day)	12±10 (7–45)	8.5±4.2 (4–18)	
F/U period (month)	38±26 (4–78)	41±21 (1–75)	
Type I endoleak	3	2	
Type II endoleak	0	1	
Stroke	0	0	
Spinal cord ischemia	0	0	
Early death	0	0	

LSCA: left subclavian artery

**Fig. 1** Freedom from reintervention and survival following TEVAR for early and late chronic type B aortic dissection. There is no significant difference between the early and late cases.

(Fig. 1). On the other hand, two patients with a type Ia endoleak in the late chronic phase group required repeat TEVAR (Fig. 1A) and further interventions (one aortic arch replacement and one endovascular aneurysm repair). In addition, four patients in the late chronic phase group died due to other illnesses in the long term (one due to ureteral cancer, one due to pneumonia, one due to colon cancer, and one due to an unknown cause; Fig. 1B).

Next, we examined aortic remodeling in 28 patients with communicating aortic dissections (Table 4). Ten patients were in the early chronic phase group and 18 in

the late chronic phase groups. Thrombosis was achieved in the thoracic descending aorta in all patients in both groups. Complete disappearance of the false lumen (complete shrinkage) was significantly more common in the early chronic phase group than in the late chronic phase group (60% and 11%, respectively). In the late chronic phase group, the false lumen increased in two patients, whereas it shrunk by ≥ 5 mm in many. Regarding abdominal false lumens, the thrombus occlusion rate was low in both groups with no significant difference. One patient with a patent abdominal false lumen after TEVAR in the

Table 4 Fate of false lumen at the final follow-up MD-CT

	Complete shrinkage	Shrinking	Thrombosis		Double-barreled	
			No change	Enlargement		
Thoracic						Complete shrinkage
Early chronic (n=10)	6 (60%)	3 (30%)	1 (10%)			p<0.05
Late chronic (n=18)	2 (11%)	10 (56%)	4 (22%)	2 (11%)		
Abdominal						Thrombosis
Early chronic (n=10)	2 (20%)		1 (10%)		7 (70%)	n.s.
Late chronic (n=18)			2 (11%)		16*(89%)	

Complete shrinkage: false lumen disappearance; Shrinking: false lumen diameter \geq 5 mm shrinkage

*: 1 case needed reentry closure with EVAR for false lumen expansion 3 years after first procedure

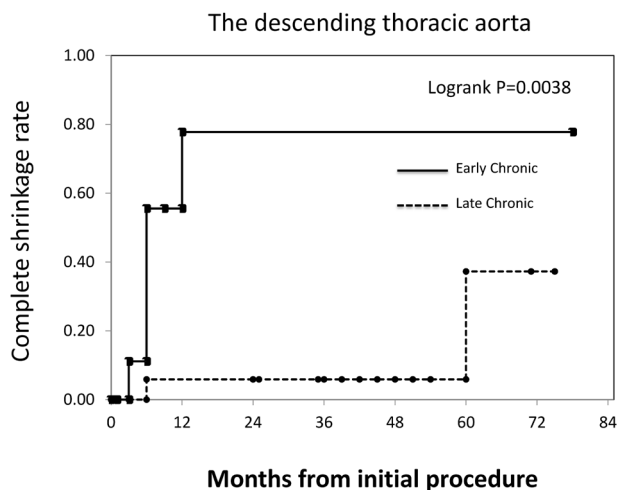


Fig. 2 Aortic remodeling of false lumen at the descending thoracic aorta. All early chronic type B aortic dissection cases got shrunk within 1 year.

late chronic phase group had an enlarged false lumen due to blood flow from reentry in the renal artery–lower abdominal aorta. Thus, closure of the reentry via EVAR was required 3 years after TEVAR. Changes in the aortic remodeling are shown in the graph in Fig. 2. The vertical axis indicates the complete shrinkage rate of the thoracic descending aorta, and changes in the false lumen are shown over time. As shown in the graph, compared with the late chronic phase group, complete shrinkage of the false lumen was achieved significantly earlier following TEVAR in the early chronic phase group. Changes were noted within 1 year in patients with complete shrinkage in the early chronic phase group.

In addition, mean blood vessel diameter up to 1 year after TEVAR at the level of the maximum diameter of the thoracic aorta, at the level of 10cm distal from the left subclavian artery, and at the celiac axis are shown in Fig. 3. At the level of the thoracic aorta, enlargement of the true lumen and shrinkage of the false lumen were noted in both groups, but at this level 1 year later in the early chronic phase group, the mean diameter of the false lumen

was almost zero. On the other hand, the change was less at the level of the celiac axis than at the level of the thoracic aorta.

Discussion

According to the Guidelines for Diagnosis and Treatment of Aortic Aneurysm and Aortic Dissection (2011 revised edition), in the treatment of chronic-phase Stanford TBD, surgery is recommended for dissecting an enlarged aorta with \geq 60-mm diameter, whereas nonsurgical treatment is recommended for dissecting an aorta of <50-mm diameter without complications or rapid enlargement (class I).¹⁾ Surgical treatment also is recommended for dissecting an aorta of 55–60-mm diameter (class IIa).¹⁾ At our department, TEVAR is performed for such cases if anatomical conditions are suitable. The effectiveness of TEVAR for complicated cases of acute-phase TBD that present with rupture, organ ischemia, and rapid enlargement of the aortic diameter has been established, and TEVAR is actively being performed in such cases.¹⁾ However, the intimal flap is fragile in the acute phase, and the risk of retrograde type A aortic dissection increases. Therefore, at our department, unless the case was fatal, we performed TEVAR after 14 days from the onset to avoid the acute phase.²⁾ We could stop the progress of symptoms in a complicated case in the early chronic phase even after 14 days from the onset by performing TEVAR. During our study interval (approximately 8 years), we performed TEVAR during the acute phase in only two patients, including one with rupture.

The acute-phase prognosis in patients with acute TBD without complication was good, and conservative treatment has been recommended.¹⁾ However, when conservative treatment was performed on patients without complications, within 5 years, 40% suffered enlargement of the aneurysm to \geq 60 mm or rupture and required surgery.³⁾ Nienaber et al.⁴⁾ reported on the INSTEAD trial-XL and showed that TEVAR during the early postoperative stage in patients without complications does not improve the survival rate in that stag and more frequently requires

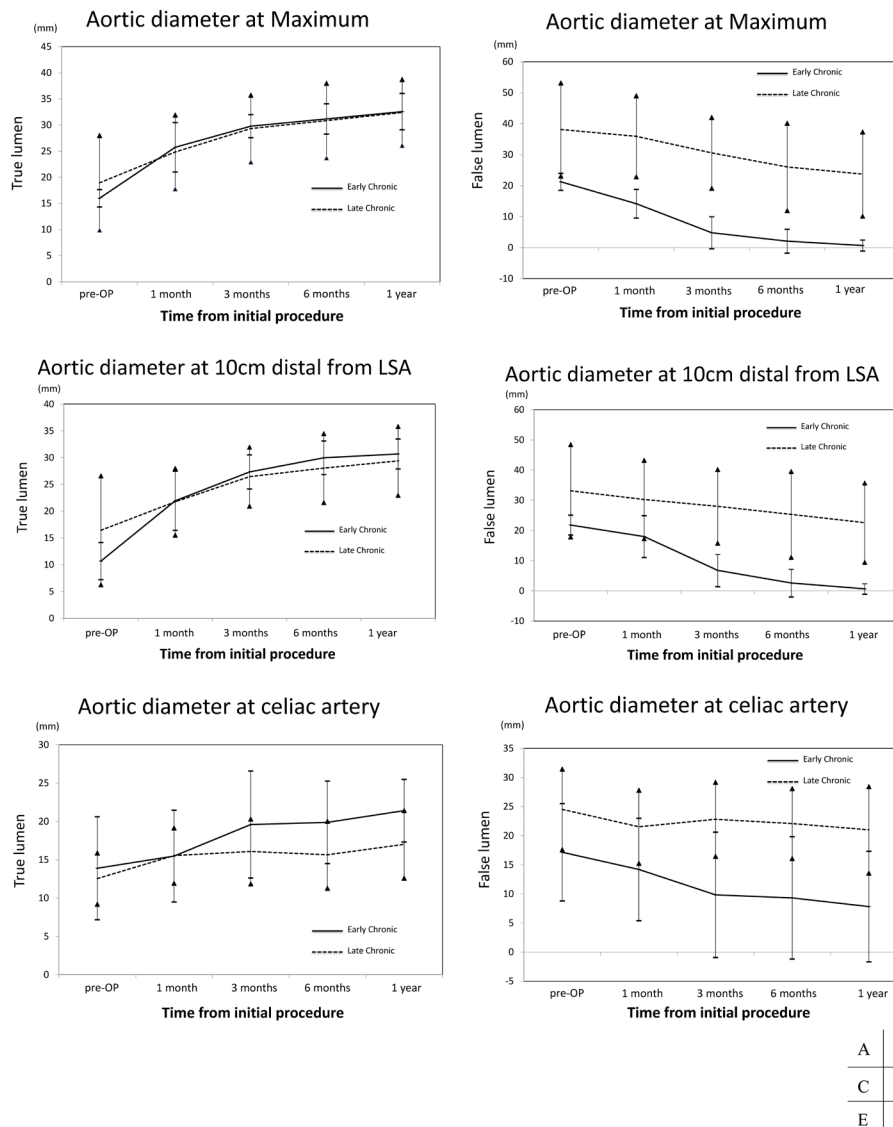


Fig. 3 Morphological change of true (TL) and false lumen (FL) after TEVAR. TL and FL diameters at maximum, at 10cm distal to LSCA, and at celiac artery orifice.

reintervention; however, in the long term, adverse events related to the aorta and enlargement of the aneurysm are reduced, along with deaths related to the aorta.⁴⁾ Aortic remodeling was consistently better in the TEVAR group.⁴⁾

Thompson et al.⁵⁾ defined 2 weeks to 3 months after onset as the subacute phase in the VIRTUE registry and showed that when TEVAR is performed during the subacute phase, the 3-year survival rate is lower in the subacute phase group than in the other two groups and that aortic remodeling (shrinkage of the false lumen and enlargement of the true lumen) is similar to that when TEVAR is performed during the acute phase.⁵⁾ On the other hand, shrinkage of the false lumen and the rate of thrombosis have been reported to be significantly poorer in the chronic phase group (3 months after onset) than in the acute and subacute phase groups.⁵⁾ In our department,

most patients treated with TEVAR in the early chronic phase (subacute phase) group achieved complete shrinkage of the false lumen within 1 year at the level of the thoracic aorta. Most patients treated with TEVAR after the late chronic phase had a decreasing false lumen but two had enlargement of the false lumen. On the other hand, 51 patients in the chronic phase group have been reported to show significant remodeling by undergoing TEVAR at a mean of 46.2 months after onset.⁶⁾ We also performed TEVAR in a patient 10 years after onset and obtained complete shrinkage of the false lumen. Further examination of the timing of TEVAR and shrinkage of the false lumen is necessary.

Regarding aortic remodeling, Watanabe et al.⁸⁾ examined the aortic event avoidance rate in patients in whom aortic remodeling was and was not confirmed. The long-

term follow-up results over 10 years were high in the group with significant aortic remodeling. In other words, aortic remodeling is directly linked to long-term follow-up results and is an extremely important prognostic factor.⁸⁾

Regarding the relationship between the range of dissection area and aortic remodeling, Eriksson et al.⁹⁾ reported that although aortic remodeling is good for DeBakey IIIa cases, aortic remodeling is significantly poor in DeBakey IIIb cases. This is assumed to be due to the remaining reentry blood flow from subabdominal peripheral vessels. At our department, all patients without shrinkage of the thoracic aorta false lumen of ≥ 5 -mm diameter had dissection reaching the abdomen. Zenith TXD, a device exclusive for aortic dissection, was developed to overcome these issues and became available in Japan in 2015 upon approval of the insurance coverage. This device closes the entry site with a stent graft and leaves a large bare stent in the peripheral vessels. In the STABLE trial in which Zenith TXD was used for cases of complicated acute TBD, not only remodeling of the thoracic aorta but also possibilities for an enlarged true lumen and decreased false lumen in the abdominal aorta were indicated.¹⁰⁾ In our study, this graft was used in three patients, but no difference was observed with the use of other devices at this point, and accumulation of future cases is necessary.

Finally, we demonstrated application of TEVAR for uncomplicated aortic dissections. Dake⁷⁾ summarized future aneurysm factors from previous studies. For cases in which MD-CT (multidetector-row computed tomography) at onset showed primary entry tear location (concave), partial false lumen thrombosis, total aortic diameter ≥ 4 cm, false lumen diameter ≥ 22 mm, and primary entry tear diameter ≥ 10 mm, as well as for uncomplicated cases, there was a high risk of future enlargement of the false lumen, and medical intervention was desired. In our study, for seven patients in whom narrowing of the true lumen was used as the surgical indication, we judged the suitability of comprehensively including indicators and anatomical conditions. Complete shrinkage of the thoracic false lumen was observed in four of four and one of three patients who underwent TEVAR during the early and late chronic phases, respectively. Shrinkage of the false lumen was not observed in two of three patients who underwent TEVAR during the late chronic phase, but a false lumen thrombosis occurred, and the false lumen diameter did not increase. TEVAR was effective for aortic remodeling in the early chronic phase. By performing TEVAR, even in uncomplicated cases in the late chronic phase, enlargement of the false lumen could be suppressed. We plan to continue our study and further examine the cases.

Conclusion

We performed TEVAR in cases of complicated TBD and achieved a good prognosis in intermediate results. Good aortic remodeling occurred in patients in whom TEVAR was performed during the early chronic phase up to 4 months after onset. Even in uncomplicated cases, performing TEVAR in the early chronic phase is likely to achieve complete shrinkage of the false lumen. On the other hand, even if complete shrinkage of the false lumen could not be achieved, our study suggested that performing TEVAR in the late chronic phase in uncomplicated cases is effective to suppress enlargement of the false lumen.

Disclosure Statement

The author and coauthors have no conflict of interest to declare.

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