Original Article

Preoperative diameters of aorta influence the remodeling after surgery for type A aortic dissection

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Background: Although current research revealed the preoperative diameter of the aorta is related to aortic remodeling, prognosis should consider the true lumen (TL) and false lumen (FL) respectively too.

Methods: The cohort of this retrospective analysis included 161 type A aortic dissection (TAAD) patients who underwent surgery at a single institution from September 1, 2017, to September 1, 2018. Computed tomography angiography (CTA) images were reviewed to assess changes of the diameters of the TL, FL and total aorta at the levels of the stented segment, distal end of the stent, celiac trunk, and below the renal artery.

Results: During the study period, positive remodeling was observed in 33 (20.5%) patients. The probability of negative remodeling far from the stent segment was greater than the aorta close to the stent. Only the TL diameter was associated with each levels' changes and underwent significant change (P<0.05). Multivariate analysis identified aortic regurgitation as a risk factor for remodeling in the distal end of the stent. The maximum diameter of the FL was the only risk factor related to the remodeling type (odds ratio =0.10; 95% confidence interval: 0.01–0.51), a maximum diameter of the FL of >1.28 cm was associated with a higher probability of negative remodeling after surgery (specificity =0.994; sensitivity =0.571; area under the receiver operating characteristic curve =0.76).

Conclusions: The TL and FL diameters on preoperative CTA images can be used to assess the risk of negative remodeling after surgery.

Keywords: Type A aortic dissection (TAAD); aortic remodeling; true lumen; false lumen

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Introduction

Aortic dissection is a devastating condition characterized by rapid onset that lets to a serious threat to humans' life (1). The Stanford classification of aortic dissections, first described in 1970, is based on the range of dissection and defines type A aortic dissection (TAAD) as dissection involving ascending aorta (2,3). At present, surgical intervention is the only viable treatment option for TAAD. However, dissection and a residual tear of the distal ascending aorta is often associated with adverse postoperative events, such as expansion of the distal false lumen (FL), compression of the true lumen (TL), critical limb ischemia, and even aortic rupture (4). Such adverse events are considered to be caused by negative remodeling, which lead to a poor prognosis and often require further treatment, such as open or interventional surgery (5,6). The preoperative diameter of the aorta is closely related to aortic remodeling; however prognosis should also consider the TL and FL respectively (7).

Accordingly, the aim of this study was to provide a theoretical basis for selecting a treatment strategy, including operative strategy and postoperative follow-up. Demographic features, computed tomography angiography (CTA) data, ultrasonography, and intraoperative data were used and the TL and FL diameters of the stented segment above the diaphragm level, at the celiac trunk level, and below the renal artery level were calculated to illustrated TAAD feature. We present this article in accordance with the STARD reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-266/rc).

Methods

Study approval and patient consent

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the institutional review board of Beijing Anzhen Hospital (No. 2023069X) and individual consent for this retrospective analysis was waived.

Patients

This was a retrospective study that consecutively collected CTA images of 204 patients with TAAD who received treatment at Beijing Anzhen Hospital from 2017 to 2018. The study cohort included 161 (78.9%) patients who met the following criteria: (I) age 18–80 years; (II) no history of malignancy, cerebral hemorrhage, cerebral infarction, blood disease, or other diseases with a predicted survival period of less than 1 year; (III) availability of complete preoperative CTA images of the whole aorta (from the aortic arch to the level of the bifurcation of the iliac artery) and aortic dissection below the renal artery; (IV) patients treated by aortic arch replacement and intraoperative stent placement; and (V) chronic patients. Of the 204 patients, 43 (21.1%) were excluded, which included 17 (8.3%) with less than one year of follow-up data, 14 (6.9%) with dissection that did not involve the target level (distal end of the stent, celiac trunk level, and below the renal artery level) or did not use intraoperative stents, 2 (1.0%) who were treated with drugs rather than surgical intervention, and 10 (4.9%) patients with chronic aortic dissection were excluded too. Echocardiographic and clinical data were collected from the electronic medical record system of Beijing Anzhen Hospital. Patients with diseases of the connective tissues (e.g., Marfan syndrome) or traumatic aortic injury were also excluded (Figure S1).

Surgical procedure

The subjects were divided into two groups: (I) ascending aorta replacement (replacing diseased blood vessels in ascending aorta by artificial graft) + aortic arch replacement + intraoperative stent placement and (II) Bentall procedure (replacing aortic valve, aortic sinus and ascending aorta) + aortic arch replacement + intraoperative stent placement. Thoracotomy was performed under general anesthesia and aortic valve replacement was performed during cardiopulmonary bypass for moderate to severe aortic insufficiency. At the same time, aortic arch replacement was performed with circulatory arrest of descending aorta and unilateral cerebral perfusion simultaneously, using the artificial vessel branch to rebuild three branches of the aortic arch. An intraoperative stent (CRONUS™ Stent Graft System; MicroPort Endovascular, Shanghai, China) was implanted and sutured to the distal end of four branched artificial graft. The stent length (80, 100, or 120 mm) and diameter (21–32 mm) were selected based on preoperative CTA. Patients who underwent simultaneous valve replacement were prescribed with anticoagulant drugs (warfarin: biological valve for 6 months or mechanical valve

Highlight box

Key findings

- The further away from the stent, the more prone to negative remodeling. The true lumen would influence the remodeling in each level. A maximum diameter of the false lumen of >1.28 cm was associated with a higher probability of negative remodeling after surgery.

What is known and what is new?

- The preoperative diameter of the total aorta is closely related to aortic remodeling.
- The positive remodeling of each level depends on the preoperative diameter of the true lumen, and the false lumen diameter is the only influencing factor of the negative remodeling of patients.

What is the implication, and what should change now?

- According to the preoperative aortic computed tomography angiography (CTA), the prognosis of patients after surgery can be predicted, which is convenient for screening high-risk patients, and provides proof for active treatment in the second stage.

for whole life).

Definitions

TAAD was classified based on chronicity and divided into four specific phases by symptom onset: hyperacute (within 24 h), acute (1–14 days), subacute (15–90 days), and chronic (>90 days) (5,8). Aortic remodeling was reflected by changes of the diameters of the TL and FL over the length of the dissection after treatment. In this study, aortic remodeling was classified as positive or negative, negative remodeling was defined as the diameter of the false lumen increases by more than 10% before surgery, while positive remodeling was defined as patients without negative remodeling. Pay attention to the overall aortic of the patient, 'the total aortic remodeling' situation was who showed positive remodeling at any levels (9,10).

Aortic morphology

All images ware measured by the first author, then they were submitted to clinician who had more than 10 years of clinical and imaging experience. Axial slices of CTA images of four segments of the aorta (stented segment, distal end of the stent, celiac trunk level, and below the renal artery) had comparison between preoperative and postoperative with RadiAnt software (https://www.radiantviewer.com/) (Figure S2). With the spine as an imaging landmark, changes to the aorta at the same levels (stented segment at T5 and 6, distal end of the stent at T9 and 10, not exceeding the diaphragm level, celiac trunk at T12 and L1, and below the renal artery at L3 and 4) before and after surgery were compared.

Standard measurements of the TL and FL diameters included the inner-edge to inner-edge (Figure S3) in a cross-section perpendicular to the aorta axis (Figure S4), which was the horizontal plane of the straightened aorta. The diameters of the TL and FL were measured perpendicular to the contour of the intimal flap on axial CT images (11). Measurements (cm) were acquired with RediAnt software.

Representative CTA images of positive remodeling were shown in Figure S5. At all four levels, the TL diameter was increased, while the FL diameter was decreased. Patients' information acquired after surgery showed no complications related to the aorta. Representative CTA images of negative remodeling all four levels after surgery were shown in Figure S6. Treatments of distal lesions in these patients were recommended.

Statistical analysis

Continuous variables were presented as the mean ± standard deviation and categorical variables as the frequency and percentage. Statistical analysis was performed using SPSS software, version 26.0 (IBM Corporation, Armonk, NY, USA) and R studio (https://posit.co/). The significance of differences between two groups was assessed with the *t*-test or a non-parametric test. A probability (P) value of <0.05 was considered statistically significant. All data were analyzed by single-factor analysis and multivariate analysis. To assess the performance of the threshold value of FL diameter in distinguishing negative remodeling from positive remodeling, we plotted the receiver-operating characteristic curves for the proportion of true positives against the proportion of false positives, depending on the prediction rule used to classify patients as having negative remodeling.

Results

Baseline characteristics

The demographic features, ultrasound indices, and surgical data of the patients are shown in *Table 1*. The average age of the patients was 44.8±10.3 years, 131 (81.4%) were male, 78 (48.4%) were smokers, and 37 (23.0%) had alcohol abuse. Most patients were in the hyperacute and acute phase [95 (59.0%) and 53 (32.9%), respectively]. The average heart rate and blood pressure measurements before surgery were within normal ranges.

Echocardiography was routinely performed before surgery to measure the ejection fraction and assess the condition of the aortic valve. The mean ejection fraction was 63.4%±6.2% (in the normal range) and 2 (0.01%) patients had heart failure. The number (percentage) of patients with normal, mild, moderate, and severe aortic regurgitation was 42 (26.1%), 36 (22.4%), 33 (20.5%), and 50 (31.1%), respectively. The Bentall procedure was considered for patients with moderate to severe aortic regurgitation.

All patients received replacement of aortic arch and the average surgical duration was 8.4±1.8 h. The Bentall procedure was performed in 77 (47.8%) patients and the others underwent ascending aorta replacement only. Most of the implanted stents (91.3%) were 100 mm in length.

Table 1 Demographic features, echocardiography indices and surgical data of patients with TAAD

Characteristics	Data
Demographic features	n=161
Age (years)	44.8±10.3
Male	131 (81.4%)
Smoke	78 (48.4%)
Drink	37 (23.0%)
Chronicity	
Hyperacute	95 (59.0%)
Acute	53 (32.9%)
Subacute	13 (8.0%)
Heart rate (bpm)	83.0±14.9
Systolic pressure (mmHg)	124.5±19.8
Diastolic pressure (mmHg)	66.0±14.9
Echocardiography indices	
Ejection fraction (%)	63.4±6.2
Aortic insufficiency	
Normal	42 (26.1%)
Mild	36 (22.4%)
Moderate	33 (20.5%)
Severe	50 (31.1%)
Surgical data	
Surgical duration (h)	8.4±1.8
Type of surgery	
Ascending aorta replacement	84 (52.2%)
Bentall	77 (47.8%)
Stent length (mm)	
80	4 (2.5%)
100	147 (91.3%)
120	10 (6.2%)
Cardiopulmonary bypass times (min)	200.8±42.0

Data are present as mean ± standard deviation for patient clinical information, which is continuous variable, and percentage for categorical variable. TAAD, type A aortic dissection.

Aorta morphology analysis

Changes to the diameters of the TL, FL, and total aorta over time were shown in Table S1.

At the stent level, the TL diameter had significantly increasing (0.31±0.33 cm, P<0.05), the FL diameter had significantly decreasing (−0.72±0.86 cm, P<0.05), and the aorta diameter had significantly decreasing (−0.41±0.73 cm, P<0.05). At the distal end of the stent, TL was still expanding (0.44±0.63 cm), the diameter of the FL decreased (−0.31±1.11), and relatively small changes in the diameter of the total lumen (0.13±0.77 cm, P<0.05). At the celiac trunk, the TL diameter was less than the FL diameter over time. The diameter of the TL increased (0.22±0.47 cm), while the FL diameter also increased (0.15±0.80 cm). Finally, the diameter of the TL increased below the renal artery, but not significantly (0.07±0.37 cm). The diameter of the FL obviously increased (0.28±0.60 cm) and the diameter of the total aorta tended to rise, while the slope had gradually decreased and the increase degree was the same at the celiac trunk level (0.37 *vs.* 0.35 cm, respectively).

Aortic remodeling at each level

Positive remodeling was more common at the aortic level near the stent (88.2%). The farther away from the stent, the extent of positive remodeling decreased gradually. At the distal end of the stent, the number of positive remodeling was double that of negative remodeling (103 *vs.* 58, number, respectively). At the celiac trunk level, the proportion of patients with positive remodeling was overtaken by negative remodeling. Below the renal artery, only 37.9% of patients had positive remodeling, while 62.1% had negative remodeling. Negative remodeling was much more common than positive remodeling in total aorta (79.5% *vs.* 20.5%, respectively, Table S2).

The preoperative true lumen diameter of positive remodeling was greater than that of negative remodeling, with significant differences at most levels, excepting the stented segment (P<0.05). On the contrary, the larger diameter of the FL tended more likely to undergo negative remodeling below the renal artery (P>0.05). There was no significant correlation between the preoperative diameter of the total aorta and remodeling (Table S3).

Table 2 Logistic regression of risk factors associated with positive remodeling

Characteristics	OR	95% CI	P
Stented segment (T5, T6)			
False lumen	0.57	0.32–0.97	0.042
Aortic insufficiency*	0.09	0.01–0.33	<0.01
Distal end of the stent (T9, T10)			
True lumen	1.81	1.01–3.37	0.052
Aortic insufficiency*	0.25	0.11–0.59	<0.01
Celiac artery (T12, L1)			
True lumen	2.36	1.13–5.13	0.025
Below the renal artery (L3, L4)			
True lumen	7.99	2.79–24.64	<0.01

*, aortic valve insufficiency was classified as normal, mild, moderate, or severe. OR, odd ratio; CI, confidence interval; T, thoracic vertebra; L, lumbar vertebra.

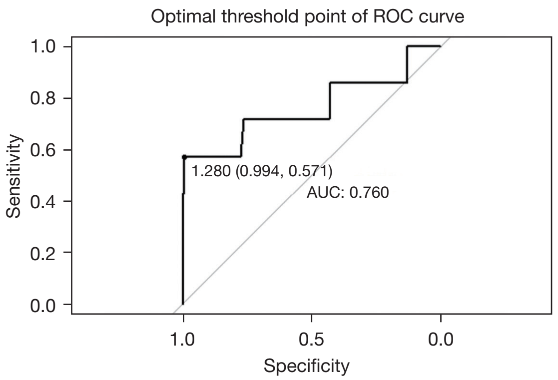

Figure 1 ROC curve showing the cutoff point of the relationship between the maximum diameter of the preoperative FL and type of remodeling. ROC, receiver operating characteristic curve; AUC, area under curve; FL, false lumen.

Factors related to aortic remodeling

The results of multivariate analysis of various factors associated with aortic remodeling at the stented segment, distal end of the stent, celiac trunk level, and below the renal artery level are presented in *Table 2*.

In the stented segment, the FL diameter and aortic regurgitation are important factors affecting aortic remodeling. The larger the preoperative FL diameter, the greater the probability of negative remodeling [odds ratio (OR) =0.57; 95% confidence interval (CI): 0.32–0.97]. Severe aortic insufficiency was more correlated with negative remodeling than a normal aortic valve (OR =0.09; 95% CI: 0.01–0.33). At the distal end of the stent, the TL diameter and severe aortic valve insufficiency were related to remodeling, as a larger TL diameter was more prone to positive remodeling (OR =1.81; 95% CI: 1.01–3.37). Similar to the stented segment, severe aortic insufficiency patients more easily developed to negative remodeling (OR =0.25; 95% CI: 0.11–0.59). At the celiac trunk level and below the renal artery, a larger TL diameter was associated with a greater probability of positive remodeling (OR =2.36 and 7.99; 95% CI: 1.13–5.13 and 2.79–24.64, respectively).

Multivariate analysis was used to assess the relationship between total aortic remodeling type and the aortic diameter, Demographic features, Echocardiography indices and Surgical data. The results showed that the maximum diameter of the FL was the only factor significantly correlated to total aortic remodeling (OR =0.10; 95% CI: 0.01–0.51). A maximum FL diameter greater than 1.28 cm was associated with a greater probability of negative remodeling (specificity =0.994; sensitivity =0.571; area under the receiver operating characteristic curve =0.76; *Figure 1*). The TL diameter at the celiac trunk level was also related to total aortic remodeling (OR =5.48; 95% CI: 1.16–26.10; P=0.028), while there was no correlation with the TL diameter and total diameter at other levels (*Table 3*).

Discussion

The results of this retrospective study showed the diameters of the TL, FL, and total aorta were different in each level. The farther away from the stented segment, changes to the TL diameter decreased, while the FL diameter and the total aortic diameter gradually increased. Positive remodeling was more common in the stented segment and the probability of negative remodeling increased when it came closer to the distal aorta. Analysis of the relationship between remodeling and diameter found that aortic remodeling was related to the TL diameter at the distal end of the stent, the celiac trunk, and below the renal artery. In the stented segment, the larger the FL diameter, FL would expand and there was more negative remodeling during the follow-up period. Insufficiency of the aortic valve was related to the type of remodeling at some levels during the follow-up period. Further analysis of factors influencing remodeling of the total aorta found that the preoperative FL diameter was the only factor significantly correlated to remodeling, negative remodeling tended to occur in population with larger FL

Table 3 Multivariate analysis of aortic diameter associated with total aortic remodeling

Level of aorta	OR	95% CI	P
True lumen			
Stented segment (T5, T6)	1.31	0.15–10.05	0.800
Distal end of the stent (T9, T10)	2.58	0.67–9.46	0.151
Celiac artery level (T12, L1)	5.48	1.16–26.10	0.028
Below the renal artery (L3, L4)	5.29	0.69–38.27	0.096
Maximum true lumen	1.44	0.18–10.18	0.720
False lumen			
Stented segment (T5, T6)	1.11	0.44–2.55	0.814
Distal end of the stent (T9, T10)	0.44	0.16–1.15	0.110
Celiac artery level (T12, L1)	0.22	0.06–0.69	<0.01
Below the renal artery (L3, L4)	0.65	0.19–2.09	0.480
Maximum false lumen	0.10	0.01–0.51	0.014
Transaortic lumen			
Stented segment (T5, T6)	1.21	0.42–3.07	0.696
Distal end of the stent (T9, T10)	0.57	0.13–1.80	0.408
Celiac artery level (T12, L1)	0.37	0.06–1.52	0.239
Below the renal artery (L3, L4)	1.18	0.24–3.93	0.808
Maximum total lumen	0.73	0.21–1.91	0.577

OR, odd ratio; CI, confidence interval; T, thoracic vertebra; L, lumbar vertebra.

diameter.

The aim of this study was to investigate the relationship between the preoperative diameters of TL and FL and postoperative remodeling at each level. Previous studies had reported a correlation between the overall diameter of the aorta and remodeling, when greater than 40 mm, the risks of complications would extremely increase (12,13). Aortic dissection consists TL and FL, an increase of the FL diameter and decrease of the TL diameter represent negative remodeling. Hence, simple analysis of the diameter of the total aorta is insufficient. In our research, an important finding was that the larger preoperative diameter of TL, the better prognosis at each level excepting the stented segment. The maximum FL diameter was negatively correlated to positive remodeling of the total aorta. Many previous studies often focused on the relationship between the aortic diameter and patient prognosis using thrombosis of the FL as the negative remodeling standard (13,14). The different method to using FL diameter assessing remodeling was easier, so it was a reasonable end point for related research.

Along with the farther away from the stent, the more negative remodeling was observed (15,16). In the stented segment, the TL expanded due to the radial force of the stent, which simultaneously caused the FL to contract or even disappeared by blocking aortic tears, slowing down blood flow into the FL, reducing the internal pressure and promoting thrombosis in the FL. The TL was replaced by a stent, the preoperative state of the TL had little influence on postoperative remodeling, while the preoperative diameter of the FL still influenced remodeling (OR =0.57; 95% CI: 0.32–0.97). In non-stented areas, the TL diameter increased at all levels, but the degree of expansion gradually decreased. Notably, below the renal artery, the TL diameter increased only 0.07±0.37 cm. In contrast, the FL diameter tended to increase (Table S1). These results demonstrate that when the observation of aorta went down, the effect of the stent gradually lessened and remodeling of the distal aortic became worse. Confirming the therapeutic efficacy of the stent gradually reduced when closing to the bifurcation of iliac artery. For these patients, the treatment of auxiliary technologies to increase the range of stents at appropriate positions was suggested to improve long-term prognosis (17,18). Since the TL was supported with the stent, the preoperative state of the TL had little impact on postoperative remodeling. In the aorta far away from the stent, the TL diameter was primarily correlated to positive remodeling of the aorta, however FL had no significant influence in each level's remodeling.

The status of the aortic valve influenced aortic remodeling too. Previous study shown that in patients with type B aortic dissection treated by thoracic endovascular aortic repair, anticoagulant and antiplatelet drugs had no adverse effect on aortic remodeling and survival (19). Likewise, the results of the present study found no interaction between aortic insufficiency and the type of surgery. Aortic valve insufficiency might only be a clue of the patient's characteristics, the main factor causing aortic valve insufficiency and negative remodeling needed to be further explored. The maximum FL diameter (threshold of 1.28 cm) was the only factor associated with the type of remodeling (OR =0.10; 95% CI: 0.01–0.51). Previous studies had also proposed that the patency of the FL was the only factor affecting total aortic remodeling after surgery (20,21). When the diameter of FL was greater than 1.28 cm before surgery, the probability of negative remodeling was significantly increased (specificity =0.994; sensitivity =0.571; area under the receiver operating characteristic curve =0.76). The TL and total aortic diameters are not significantly associated with overall remodeling. An increase in the FL diameter always was accompanied by destruction of the aortic wall, which rarely returned to original state. It was similar to an overstretched spring, due to the lack of self-healing ability, it would be a straight wire and lost its compliance. On the other hand, a larger diameter of the FL indicated more blood flow going through to the tear and greater pressure in the FL. However, it was difficult for the surgeon to fully resolved whole FL with one-stage surgery. Thus, negative remodeling still had problem, as the aorta would continue to expand or even rupture. We hoped patients who had been treated their TAAD could be classified to predict the prognosis by preoperative diameter of FL as the above discussion.

Study limitations

Multivariate analysis found that the diameter of the TL impacted remodeling of the total aorta at the celiac trunk level because the risk of residual tears of the celiac trunk was greater than that at other levels (22). In addition, the accuracy of measurements of the aortic diameter should be improved, it was best to use the artificial intelligence. Lastly, the rationale that aortic regurgitation affected remodeling in the stented segment needed further study, aortic regurgitation should not have remained postoperatively and the reason was not clear.

Conclusions

The effect of the aortic diameter on remodeling during the follow-up period can be used as a theoretical basis to formulate preoperative and postoperative treatment strategies to focus on patients more likely to have negative remodeling.

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Footnote

Reporting Checklist: The authors have completed the STARD reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-266/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-266/dss

Peer Review File: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-266/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-266/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the institutional review board of Beijing Anzhen Hospital (No. 2023069X) and individual consent for this retrospective analysis was waived.

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Supplementary

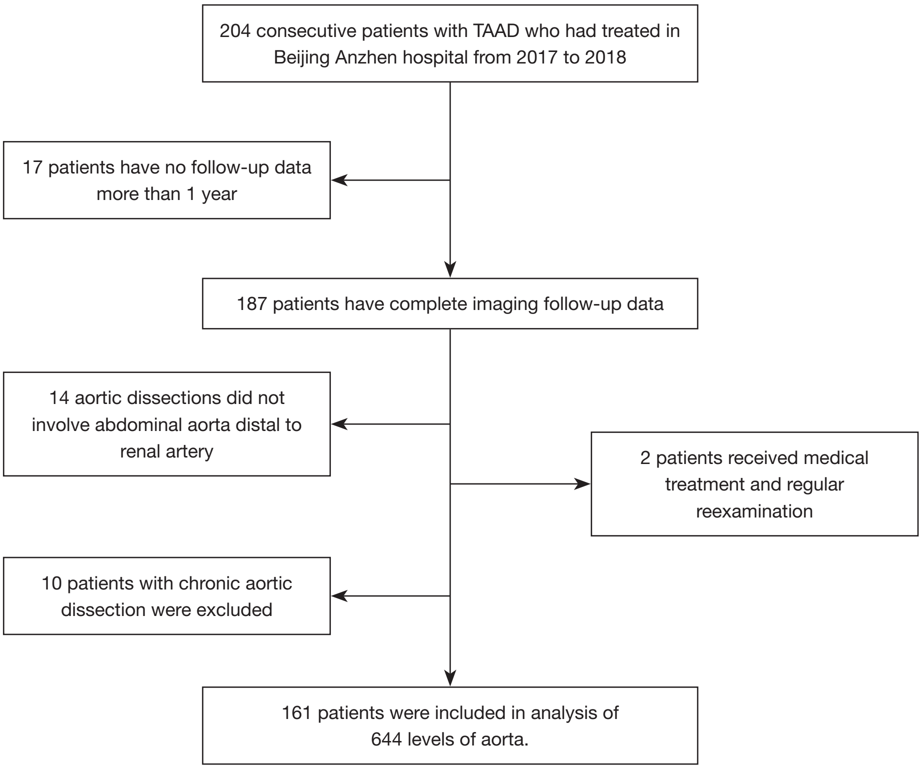

Figure S1 Flow chart of the patient selection process. TAAD, type A aortic dissection.

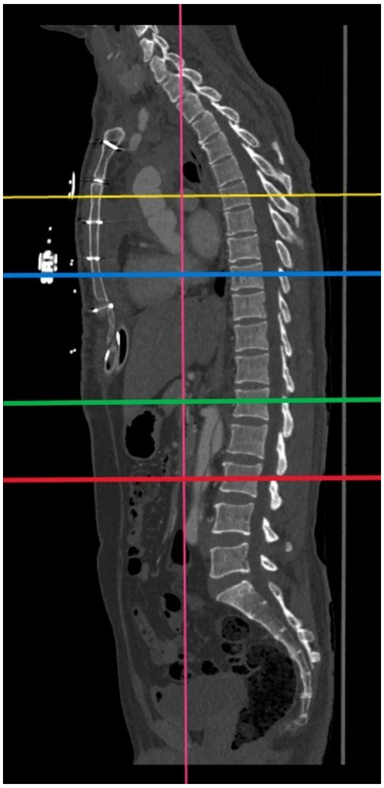

Figure S2 CTA of the four levels of the aortas. With the spine as the landmark, the stented segment is located at T5 and 6 (yellow horizontal line), the distal end of the stent at T9 and 10, not exceeding the diaphragm level (blue horizontal line), the celiac trunk at T12 and L1 (green horizontal line), and below the renal artery at L3 and 4 (red horizontal line). CTA, computed tomography angiography; T, thoracic vertebra; L, lumbar vertebra.

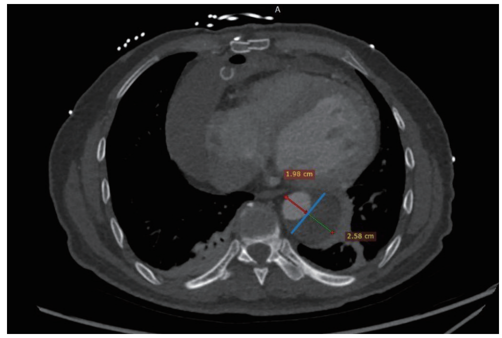

Figure S3 Measurements of the diameters of the TL, FL, and total aorta. The TL and FL diameters were measured from the inner-edge to inner-edge. The red line is the diameter of TL and the green line is the diameter of FL. The diameter of the TL and FL were measured perpendicular to the intimal flap on axial CT images (blue line). The total diameter is the sum of the red and green lines. TL, true lumen; FL, false lumen; CT, computed tomography.

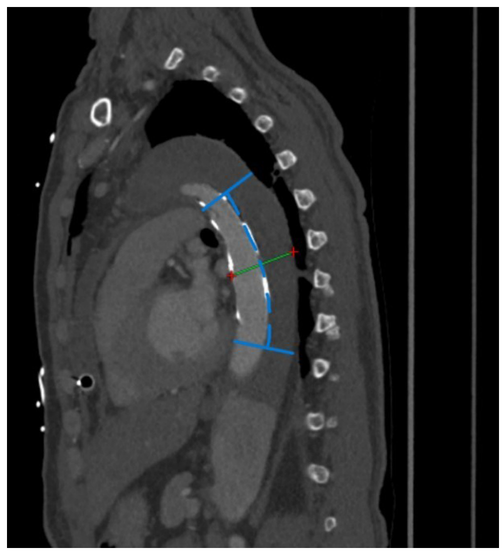

Figure S4 Measurement of the cross section. The angle of each horizontal line was adjusted and the cross section was set perpendicular to the centerline. The diameter of the TL, FL, and total aorta were measured based on the blue dotted line (center line of the aorta) and the green straight line (cross-section). TL, true lumen; FL, false lumen.

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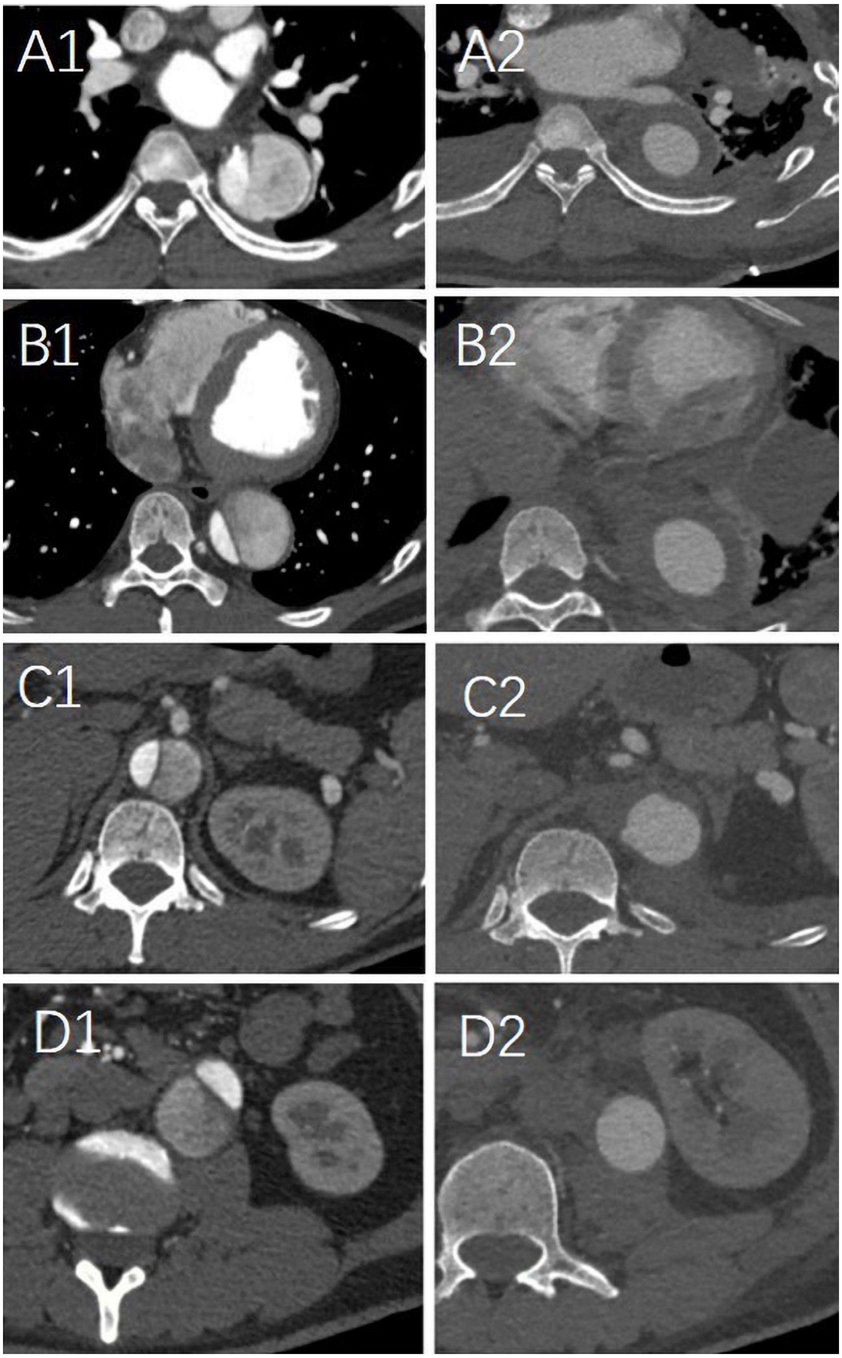

Figure S5 Representative CTA images of positive remodeling, where each level is perpendicular to the central axis of the aorta. The diameter of the FL was decreased at all four levels, while the diameter of the TL was increased. In the left four rows: A1: preoperative stent segment (T6); B1: preoperative distal end of the stent (T9); C1: preoperative celiac trunk (T12); D1: below the renal artery before surgery (L3). Similarly, in the right four rows: A2: preoperative stent segment (T6); B2: preoperative distal end of the stent (T9); C2: preoperative celiac trunk (T12); D2: below the renal artery before surgery (L3). CTA, computed tomography angiography; TL, true lumen; FL, false lumen; T, thoracic vertebra; L, lumbar vertebra.

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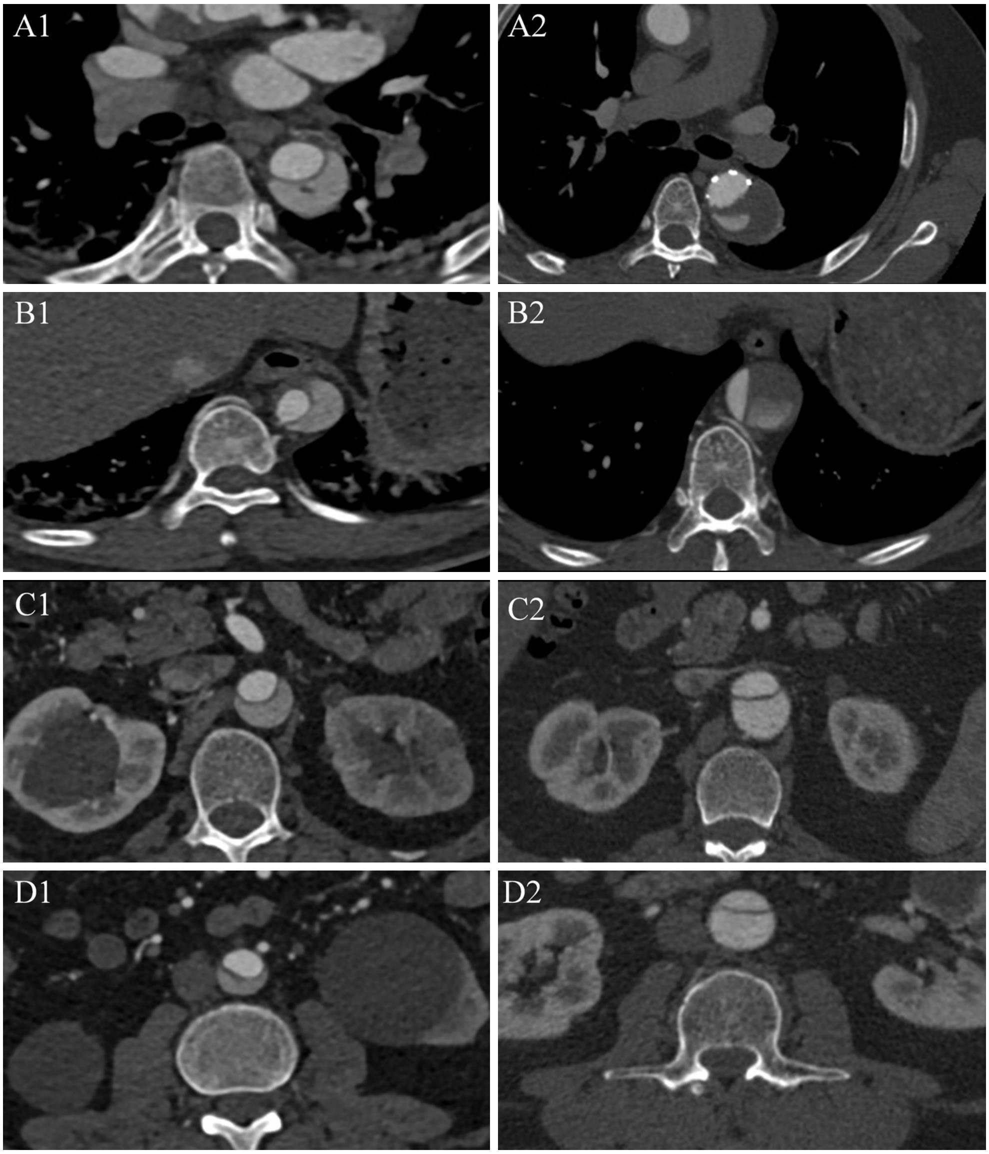

Figure S6 Representative CTA images of negative remodeling. At all four levels, the FL diameter had expanded, while the diameter of the TL had decreased. In the left four rows: A1: preoperative stent segment (T6); B1: preoperative distal end of the stent (T9); C1: preoperative celiac trunk (T12); D1: below the renal artery before surgery (L3). Similarly, in the right four rows: A2: preoperative stent segment (T6); B2: preoperative distal end of the stent (T9); C2: preoperative celiac trunk (T12); D2: below the renal artery before surgery (L3). CTA, computed tomography angiography; TL, true lumen; FL, false lumen; T, thoracic vertebra; L, lumbar vertebra.

Table S1 Changes to the diameters of the TL, FL, and total lumen (transaortic) over time at the stented thoracic aorta, distal end of the stent, celiac artery level, and below the renal artery

Variables	Preoperative	Follow-up	Change	P
Stented thoracic aorta (T5, T6)				
TL	2.38±0.36	2.69±0.33	0.31±0.33	<0.01
FL	1.30±0.85	0.59±0.95	–0.72±0.86	<0.01
Transaortic lumen	3.68±0.74	3.27±0.83	–0.41±0.73	<0.01
Distal end of the stent (T9, T10)				
TL	1.59±0.53	2.03±0.75	0.44±0.63	<0.01
FL	1.97±0.85	1.66±1.29	–0.31±1.11	<0.01
Transaortic lumen	3.57±0.70	3.69±0.90	0.13±0.77	0.035
Celiac artery branch level (T12, L1)				
TL	1.42±0.44	1.64±0.56	0.22±0.47	<0.01
FL	1.94±0.70	2.09±0.87	0.15±0.80	0.015
Transaortic lumen	3.36±0.66	3.73±0.60	0.37±0.62	<0.01
Below the renal artery (L3, L4)				
TL	1.18±0.34	1.25±0.41	0.07±0.37	0.017
FL	1.35±0.65	1.63±0.78	0.28±0.60	<0.01
Transaortic lumen	2.53±0.53	2.88±0.60	0.35±0.41	<0.01

Data are expressed as the mean ± standard deviation (cm). The maximum diameters were measured from the inner-edge to inner-edge. TL, true lumen; FL, false lumen; T, thoracic vertebra; L, lumbar vertebra.

Table S2 Changes to the aorta in the stented segment, distal end of the stent, celiac artery, and distal from the renal artery at about one year after surgery

Variable	Remodeling
Stented segment (T5, T6)	
Positive remodeling	142 (88.2%)
Negative remodeling	19 (11.8%)
Distal end of the stent (T9, T10)	
Positive remodeling	103 (64.0%)
Negative remodeling	58 (36.0%)
Celiac artery level (T12, L1)	
Positive remodeling	69 (42.9%)
Negative remodeling	92 (57.1%)
Below the renal artery (L3, L4)	
Positive remodeling	61 (37.9%)
Negative remodeling	100 (62.1%)
Total aorta	
Positive remodeling	33 (20.5%)
Negative remodeling	128 (79.5%)

All data are expressed as n (%). T: thoracic vertebra; L: lumbar vertebra.

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Table S3 Type of remodeling of the TL, FL, and transaortic lumen at the stented segment, distal end of the stent, celiac artery level, and below the renal artery

Aortic segment	Positive remodeling	Negative remodeling	P
Stented segment (T5, T6)			
Preoperative TL	23.9±3.6	23.3±3.9	0.446
Preoperative FL	12.4±8.3	15.9±9.4	0.073
Preoperative transaortic lumen	36.3±7.2	39.2±8.4	0.096
Distal end of the stent (T9, T10)			
Preoperative TL	16.6±5.6	15.0±4.8	0.045
Preoperative FL	19.7±9.0	19.8±7.8	0.970
Preoperative transaortic lumen	36.3±7.1	34.8±6.7	0.144
Celiac artery level (T12, L1)			
Preoperative TL	15.3±5.5	13.7±3.8	0.048
Preoperative FL	19.6±9.4	19.3±5.7	0.847
Preoperative transaortic lumen	34.9±9.0	33.0±5.1	0.148
Below the renal artery (L3, L4)			
Preoperative TL	13.7±4.8	11.2±2.7	<0.01
Preoperative FL	11.0±9.5	14.2±5.1	0.050
Preoperative transaortic lumen	24.7±6.7	25.4±4.8	0.543

All data are expressed as the mean ± SD (mm). TL: true lumen; FL: false lumen; T: thoracic vertebra; L: lumbar vertebra.

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