Ratio of the false lumen to the true lumen is associated with long-term prognosis after surgical repair of acute type A aortic dissection

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ABSTRACT

Objectives: The aim of this study was to assess potential predictors of aortic events after an emergency surgery for acute type A aortic dissection, especially paying attention to the findings of computed tomography (CT) performed immediately after the surgery.

Methods: Between January 2001 and December 2015, 72 patients, who were diagnosed as having Stanford type A acute aortic dissection with a patent false lumen in the descending thoracic aorta, survived the emergency operation, and had postoperative CT scan data, were included in this study (mean follow-up, 8.2 ± 3.8 years; range 0.8-17.4 years). From the CT scan data, the diameter of the false lumen (FL-D) and true lumen (TL-D) were measured, and the FL-D:TL-D ratio was calculated. Long-term outcomes of the FL-D > TL-D group (n = 30) and the FL-D < TL-D group (n = 42) were compared.

Results: In the late follow-up, 17 aortic events in the downstream aorta were observed. The FL-D:TL-D ratio (P = .01) was an adjusted risk of aortic events in multivariable analysis. The rates of freedom from aortic events at 5 and 9 years were superior in the FL-D > TL-D group than in the FL-D < TL-D group (92.0% and 88.6% vs 81% and 60.7%; log rank P < .05).

Conclusions: Our results suggest that the false lumen:true lumen ratio predicts long-term prognosis after surgical repair of acute type A aortic dissection. (JTCVS Open 2022;10:75-84)

CENTRAL MESSAGE
False lumen:true lumen ratio in postoperative computed tomography images predicts the long-term prognosis after surgical repair of acute type A aortic dissection.

PERSPECTIVE
The presence of a morphological parameter reflecting the internal pressure within the dissected aorta would help us to determine the most appropriate therapy strategy to effectively reduce internal pressure of the false lumen to improve the long-term outcomes. In postoperative follow-up, preemptive endovascular interventions such as vascular plug, stent graft, coils, and glues might be a choice.

See Commentary on page 85.
Although previous studies have reported some predictive factors of postoperative aortic events and dilatation of the descending aorta in late follow-up, it remains unclear an effective predictor that reflects the internal pressure within the dissected aorta. It is difficult to measure the internal pressure of the false lumen directly; therefore, a noninvasive method is required to assess the pressure from the postoperative computed tomography (CT) data. The aim of the present study was to assess the potential predictive factor of aortic events after initial emergency surgery for ATAAD from our long-term results, with special attention to the morphology of the dissected descending aorta and the findings of CT performed immediately after the surgery.

METHODS

This study was a retrospective single-center study, and informed consent for the publication of this study was obtained from all patients at admission. The institutional review board of Fukushima Medical University approved this study (approval number: 2019-272; approval date February 25, 2020). Video 1 summarizes the study protocol and the key results of this study.

Patient Inclusion Criteria

One hundred sixty-three ATAAD patients underwent emergency surgical aortic repair in our hospital between January 2001 and December 2015. In the preoperative CT images, 109 patients were diagnosed as Stanford type A acute aortic dissection with a patent false lumen in the descending thoracic aorta. After the emergency operation, 90 patients survived, 74 of whom underwent a postoperative CT scan within 14 days after the operation. Two patients with Marfan syndrome were excluded. Finally, 72 patients were enrolled in this study. The patient inclusion criteria are shown in Figure 1.

Surgical Procedures

Using general anesthesia and mechanical ventilation, the patient’s chest was opened via full median sternotomy. An extracorporeal circulation was established with perfusion from the subclavian artery and femoral artery, and drainage from the superior and inferior vena cava. After insertion of a left ventricular vent from the right superior pulmonary vein, systemic cooling was started and continued until the patient’s bladder temperature reached 26°C. If the false lumen was patent in the ascending aorta, we crossclamped the aorta. If the false lumen was thrombosed, we did not. In all cases, we performed distal anastomosis in an open fashion with circulatory arrest and moderate hypothermia and resected the clamped part of the aorta. During crossclamping of the ascending aorta, retrograde cardiopulmonary blood was infused to achieve cardiac arrest. Historically, for patients in early years, gelatin-resorcinol-formaldehyde glue was used for readhesion of the intima and adventitia, followed by BioGlue R (CryoLife, Inc). When the temperature reached 26°C, circulatory arrest was achieved, and selective cerebral perfusion was established. If the primary entry was in the ascending aorta, only the ascending aorta was replaced. If the primary entry was located in the aortic arch, partial or total arch replacement was selected.

Data Acquisition and Follow-up

We reviewed the medical records of the 72 patients and obtained their preoperative characteristics, operative data, postoperative early results, and postoperative information at follow-up visits. We were able to follow-up on all 72 patients. After discharge, they underwent medical follow-ups in our hospital or outpatient clinic regularly and underwent annual CT scans. When the diameter of the dissected descending aorta reached over 55 mm in CT scan, secondary intervention was considered. The patients’ conditions were assessed via medical records, direct telephone interviews, and questionnaires. The mean follow-up period was 8.2 ± 3.8 years (range, 0.8-17.4 years).

Morphological Analysis With CT

After surgery, postoperative enhanced CT was performed on all 72 patients. We used helical CT (Aquilion ONE; Canon Medical Systems) with 320 detectors that produce 0.5-mm slice axial images from the top of the aortic arch to the abdominal aorta. A thrombosed false lumen was defined when the false lumen was thrombosed throughout the thoracic descending aorta. A partially thrombosed false lumen was defined when the false lumen was thrombosed between the distal anastomosis of the graft and the proximal descending aorta at the level of the carina only. The morphology of the dissected proximal descending aorta was measured at the level of the carina in the axial view. The diameters of the proximal descending aorta (DA-D, mm), false lumen (FL-D, mm), and true lumen (TL-D, mm) were measured. DA-D was measured as a distance between an outer point and contralateral outer point of aortic wall. FL-D and TL-D were measured as a distance between an inner point and contralateral inner point of the lumen in a center line perpendicular to the intimal flap (Figure 2). The FL-D/TL-D ratio and the FL-D/DA-D ratio were calculated as percentage. In addition, considering measurement error, DA-D category...
RESULTS

Patient Characteristics

The preoperative patient characteristics are summarized in Table 1. The median age was 64 (IQR, 75-75) years. Thirty-five patients were female (49%), and the primary entry was located in the ascending aorta in 48 patients (67%). Preoperative shock state in 5 patients (7%), cardiac tamponade in 9 (13%), rupture in 2 (3%), and organ malperfusion in 20 (28%) were observed. Postoperative aortic events were also observed in 17 patients in the late follow-up.

Operative Data and Early Results

The perioperative data and early results are summarized in Table 2. Ascending aorta replacement was performed in 44 cases (61%), partial arch replacement in 11 cases (15%), and total arch replacement in 17 cases (24%). Resection of primary tear was achieved in 64 cases (89%). As a concomitant procedure, coronary artery bypass grafting was performed in 4 cases (6%). The median operation time, extracorporeal circulation time, aortic cross-clamping time, and circulatory arrest time were 443 (IQR, 393-553), 216 (IQR, 191-249), 137 (IQR, 118-151), and 55 (IQR, 49-62) minutes, respectively. The median period of stay in the intensive care unit and the hospital stay were 4 (IQR, 2-5) and 26 (IQR, 19-34) days, respectively.

| Total 163 patients underwent surgical repair for acute type A aortic dissection during January 2001 to December 2015 |
| 136 patients who had dissected descending aorta |
| 109 patients with the patent false lumen on the preoperative CT scan |
| 90 patients survived the emergency surgery |
| In 74 patients The postoperative CT scan before within 14 days after the operation was available to this analysis. |
| Finally, 72 patients were included in this study. |
| 27 patients who had no dissected descending aorta were excluded |
| 27 patients with the thrombosed false lumen were excluded |
| 19 patients of in-hospital death were excluded |
| 16 patients who have no well-visualized postoperative CT scan were excluded |
| 2 patients of Marfan syndrome were excluded |

FIGURE 1. Selection process and number of patients. Between January 2001 and December 2015, 163 patients underwent emergency surgery for acute type A aortic dissection in our institute. Seventy-two patients, who were diagnosed as having Stanford type A acute aortic dissection with a patent false lumen in the descending thoracic aorta survived the emergency operation, and had postoperative computed tomography (CT) scan data, were included in this study. Two Marfan patients were excluded.

(category 1 = 25-29 mm, category 2 = 30-34 mm, category 3 = 35-39 mm, category 4 = 40-44 mm, category 5 = 45-49 mm), FL-D category (category 1 = 0-4 mm, category 2 = 5-9 mm, category 3 = 10-14 mm, category 4 = 15-19 mm, category 5 = 20-24 mm, category 6 = 25-29 mm, category 7 = 30-34 mm), and TL-D category (category 1 = 5-9 mm, category 2 = 10-14 mm, category 3 = 15-19 mm, category 4 = 20-24 mm, category 5 = 25-29 mm, category 6 = 30-34 mm, category 7 = 35-39 mm) were defined as another scale. From the same CT scan data, the number of visceral arteries originating from the false lumen, conditions of dissected supra-arch vessels, and the presence of intimal tear in the thoracic descending and abdominal aorta were evaluated (Figure 2).

Statistical Analysis

Statistical analysis was performed using Statistical Package for Social Sciences, version 25 (SPSS Inc) and R version 4.1.0 (The R Foundation for Statistical Computing). Preoperative characteristics, operative data, and postoperative early results were analyzed. Data are expressed as median with interquartile range (IQR; 25th-75th percentile) for continuous variables. Categorical variables are expressed as numbers and percentages. In univariable analyses, continuous and categorical variables were compared using the Student t test, \( \chi^2 \), or Fisher exact test as appropriate (Fisher exact test was used only when 1 of the 4 cells of a 2 × 2 table had <5 observations.). In multivariable analyses, Cox proportional hazard regression analysis was used to identify risk factors for postoperative aortic events in the downstream aorta in the late follow-up, and variables with \( P \) values < .05 in the univariable analyses were included. As the result, DA-D and FL-D:TL-D ratio were included in the final Cox model without other categorical variables. Survival curves were estimated using the Kaplan–Meier method, and comparisons between 2 groups was performed using the log rank method. All tests were 2-sided.
The morphology of dissected proximal descending aorta was measured at the level of carina.

**FIGURE 2.** Definitions of morphological parameters of the dissected descending aorta. In the axial view, the diameters of the proximal descending aorta (DA-D, black arrow), false lumen (FL-D, blue arrow) and true lumen (TL-D, red arrow) were measured. The FL-D:TL-D ratio and the FL-D:DA-D ratio were calculated (A, case 1 and 2). Thrombosed false lumen was defined when the false lumen was thrombosed throughout the thoracic descending aorta (B). Partial thrombosis was defined when the false lumen was thrombosed between the distal anastomosis of the graft and the proximal descending aorta only (C).
Findings of Postoperative CT Imaging
The findings of postoperative CT scan are summarized in Table 3. The patent false lumen of the descending aorta was observed in 54 cases (75%). Partially thrombosed false lumen in the proximal descending aorta was observed in 35 cases (49%). The number of visceral arteries originating from the false lumen was 1 (IQR, 0-2). The presence of intimal tear in the descending aorta and abdominal aorta

TABLE 1. Preoperative patient characteristics

| Variable                          | Total (n = 72) | Aortic event group (n = 17) | Control group (n = 55) | P value |
|-----------------------------------|---------------|-----------------------------|------------------------|--------|
| Age, y                            | 64 (57-75)    | 75 (67-82)                  | 68 (58-75)             | .963   |
| Octogenarian                      | 5 (7)         | 1 (6)                       | 4 (7)                  | .663   |
| Female sex                        | 35 (49)       | 8 (47)                      | 27 (49)                | .884   |
| Height, cm                        | 159 (150-166) | 160 (150-170)               | 162 (154-166)          | .608   |
| Weight, kg                        | 57 (47-72)    | 64 (58-69)                  | 61 (53-77)             | .608   |
| Body mass index                   | 23.5 (20.6-25.8) | 24.8 (23.9-25.8)           | 24.1 (22.0-27.5)       | .573   |
| Hypertension                      | 48 (67)       | 14 (82)                     | 34 (62)                | .116   |
| Dyslipidemia                      | 8 (11)        | 1 (6)                       | 7 (13)                 | .390   |
| Diabetes mellitus                 | 5 (7)         | 1 (6)                       | 4 (7)                  | .663   |
| Smoking                           | 13 (18)       | 4 (24)                      | 9 (16)                 | .364   |
| COPD                              | 2 (3)         | 1 (6)                       | 1 (2)                  | .419   |
| CVA                               | 4 (6)         | 1 (6)                       | 3 (6)                  | .668   |
| CAD                               | 5 (7)         | 1 (6)                       | 4 (7)                  | .663   |
| Creatinine, mg/dL                 | 0.84 (0.65-1.09) | 0.91 (0.84-0.98)            | 0.97 (0.75-1.22)       | .874   |
| eGFR                              | 56 (48-76)    | 54 (49-59)                  | 55 (39-76)             | .925   |
| Pre-cardiac surgery               | 1 (1)         | 0                           | 1 (2)                  | .764   |
| Pre-AAA surgery                   | 3 (4)         | 1 (6)                       | 2 (4)                  | .560   |
| Primary tear in ascending aorta   | 48 (67)       | 11 (65)                     | 37 (67)                | .844   |
| Preoperative shock state          | 5 (7)         | 2 (12)                      | 3 (6)                  | .337   |
| Cardiac tamponade                 | 9 (13)        | 2 (12)                      | 7 (13)                 | .642   |
| Rupture                           | 2 (3)         | 0                           | 2 (4)                  | .581   |
| Malperfusion                      | 20 (28)       | 4 (24)                      | 16 (29)                | .455   |

Data are presented as median (interquartile range) or n (%) except where otherwise noted. COPD, Chronic obstructive pulmonary disease; CVA, cerebrovascular accident; CAD, coronary artery disease; eGFR, estimated glomerular filtration rate; AAA, abdominal aortic aneurysm.

TABLE 2. Perioperative data and early results

| Variable                          | Total (n = 72) | Aortic event group (n = 17) | Control group (n = 55) | P value |
|-----------------------------------|---------------|-----------------------------|------------------------|--------|
| Procedure                         |               |                            |                        |        |
| Ascending aorta replacement       | 44 (61)       | 9 (53)                      | 35 (64)                | .429   |
| Partial arch replacement          | 11 (15)       | 2 (12)                      | 9 (16)                 | .490   |
| Total arch replacement            | 17 (24)       | 6 (35)                      | 11 (20)                | .165   |
| Resection of primary tear         | 64 (89)       | 15 (88)                     | 49 (89)                | .610   |
| Concomitant procedure             |               |                            |                        |        |
| CABG                              | 4 (6)         | 1 (6)                       | 3 (6)                  | .668   |
| Operation time, min               | 443 (393-553) | 376 (344-407)               | 407 (391-469)          | .235   |
| ECC time, minutes                 | 216 (191-249) | 195 (193-197)               | 194 (175-215)          | .320   |
| ECC time > 4 h                    | 22 (31)       | 7 (41)                      | 15 (27)                | .277   |
| AoX time, minutes                 | 137 (118-151) | 110 (103-117)               | 123 (111-136)          | .251   |
| Circulatory arrest time, min      | 55 (49-62)    | 48 (43-52)                  | 54 (48-60)             | .240   |
| Early results                     |               |                            |                        |        |
| ICU stay, d                       | 4 (2-5)       | 4 (3-4)                     | 3 (2-5)                | .692   |
| Hospital stay, d                  | 26 (19-34)    | 21 (18-24)                  | 26 (16-37)             | .879   |

Data are presented as median (interquartile range) or n (%) except where otherwise noted. CABG, Coronary artery bypass grafting; ECC, extracorporeal circulation; AoX, aorta cross-clamping; ICU, intensive care unit.

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was observed in 22 (31%) and 18 cases (25%), respectively. The DA-D was 35.3 (IQR, 33-37.8) mm, the FL-D was 17.2 (IQR, 12.8-19.4) mm, and the TL-D was 18.6 (IQR, 15.5-22.7) mm. The DA-D category, the FL-D category and the TL-D category were 3 (IQR, 2-3), 4 (IQR, 3-4), and 3 (IQR, 2-3), respectively. The FL-D:TL-D ratio was 95 (IQR, 58-124) and the FL-D/DA-D ratio was 49 (IQR, 22-76). In 30 cases (42%), the FL-D was greater than the TL-D. Reentry in the brachiocephalic artery, the left common carotid artery, and the left subclavian artery were observed in 12 cases (17%), 4 cases (6%), and 8 cases (11%), respectively. Between the aortic event group and the control group, there were differences in the DA-D (36.6 [IQR, 33.3-39.8] mm vs 35.5 [IQR, 32.2-39.5] mm; P < .05), the FL-D:TL-D ratio (176 [IQR, 86-136] vs 49 [IQR, 46-58]; P < .05), and FL-D > TL-D (12 cases [71%] vs 18 cases [33%]; P < .05).

### The Predictive Factor of Aortic Events in the Downstream Aorta in Late Follow-up

In the late follow-up, we detected 17 aortic events in the downstream aorta (5 cases of ruptured thoracic aneurysm, 4 cases of redo aortic arch repair, 4 cases of thoracic endovascular aortic repair, 1 case of replacement of the thoracoabdominal aorta, 1 case of descending aorta replacement, 1 case of new acute type B aortic dissection, and 1 case of sudden death). In the multivariable analysis, the FL-D:TL-D ratio (P < .05; hazard ratio. 1.009; 95% confidence interval, 1.002-1.016) was an adjusted risk of aortic events in the downstream aorta in late follow-up (Table 4).

### Long-Term Outcomes

The overall survival rates at 5 and 10 years were 88% and 67.5%, respectively. The rates of freedom from aortic death at 5 and 10 years were 98.3% and 88.9%, respectively. The rates of freedom from aortic events in the downstream aorta at 5 and 10 years were 87.7% and 71.3%, respectively (Figure 3).

### Subgroup Analysis of the Relation Between the False Lumen Patency and Long-Term Outcome

We compared 2 groups with patent false lumen (n = 54) and thrombosed false lumen (n = 18) (Figure 4). The rates of freedom from aortic events in the downstream aorta at 5 and 7 years were 87.7% and 77.1% in the group with patent false lumen diameter of the proximal descending aorta; FL-D, false lumen diameter; TL-D, true lumen diameter; BCA, brachiocephalic artery; LCCA, left common carotid artery; LSCA, left subclavian artery.

### Table 3. Postoperative computed tomography findings

| Variable                                      | Total (n = 72) | Aortic event group (n = 17) | Control group (n = 55) | P value |
|------------------------------------------------|---------------|----------------------------|------------------------|---------|
| Patent false lumen of the descending aorta     | 54 (75)       | 13 (77)                    | 41 (75)                | .575    |
| Partially thrombosed false lumen in the proximal descending aorta | 35 (49)       | 8 (47)                     | 27 (49)                | .884    |
| Number of visceral arteries originating from false lumen | 1 (0-2)       | 1 (0-1)                    | 1 (0-3)                | .576    |
| DA-D, mm                                       | 35.3 (33-37.8)| 36.6 (33.3-39.8)           | 35.5 (32.2-39.5)       | .039    |
| DA-D category                                  | 3 (2-3)       | 3 (2-3)                    | 3 (2-3)                | .079    |
| FL-D, mm                                       | 17.2 (12.8-19.4)| 18.9 (7-30.4)            | 17.5 (15.3-19)         | .009    |
| FL-D category                                  | 4 (3-4)       | 5 (2-7)                    | 4 (4-4)                | .014    |
| TL-D, mm                                       | 18.6 (15.5-22.7)| 17.7 (9.4-26)            | 17 (14-22)             | .260    |
| TL-D category                                  | 3 (3-4)       | 3 (1-5)                    | 3 (2-4)                | .384    |
| FL-D:TL-D ratio                                | 95 (58-124)   | 176 (28-323)               | 97 (86-136)            | .028    |
| FL-D/DA-D ratio                                | 49 (37-55)    | 49 (22-76)                 | 49 (46-58)             | .028    |
| FL-D > TL-D                                    | 30 (42)       | 12 (71)                    | 18 (33)                | .006    |
| Reentry in the BCA                             | 12 (17)       | 1 (6)                      | 11 (20)                | .161    |
| Reentry in the LCCA                            | 4 (6)         | 0                          | 4 (7)                  | .332    |
| Reentry in the LSCA                            | 8 (11)        | 4 (24)                     | 4 (7)                  | .083    |
| Presence of intimal tear in the descending aorta | 22 (31)       | 7 (41)                     | 15 (27)                | .277    |
| Presence of intimal tear in the abdominal aorta | 18 (25)       | 5 (29)                     | 13 (24)                | .425    |

Data are presented as median (interquartile range) or n (%) except where otherwise noted. DA-D, Diameter of the proximal descending aorta; FL-D, false lumen diameter; TL-D, true lumen diameter; BCA, brachiocephalic artery; LCCA, left common carotid artery; LSCA, left subclavian artery.

### Table 4. Predictive factors of aortic events in the downstream aorta in late follow-up

| Variable                                      | Multivariable analysis |
|------------------------------------------------|------------------------|
| Diameter of the proximal descending aorta     | .053                   |
| False lumen diameter: true lumen diameter ratio | .01                  |

CI, Confidence interval.
false lumen, respectively, and 87.7% in the group with thrombosed false lumen, respectively.

**Subgroup Analysis of the Relation Between the Morphology of False Lumen and Long-Term Outcome**

We compared 2 groups, with (n = 30) and without (n = 42) FL-D > TL-D (Figure 4). The rates of freedom from aortic events in the downstream aorta at 5 and 9 years were 81% and 60.7% in the FL-D > TL-D group, respectively, and 92% and 88.6% in the FL-D < TL-D group, respectively. The rates of freedom from aortic death at 5 and 9 years were 96% and 86.1% in the FL-D > TL-D group, respectively, and 100% and 96.6% in the FL-D < TL-D group, respectively. Figure 5 shows the measurement of morphologic parameters of dissected aorta and the main results of the current study.

**DISCUSSION**

In this study, we found that the FL-D:TL-D ratio was an adjusted risk of postoperative aortic events in the downstream aorta. Previous studies have reported predictive factors of postoperative aortic events and dilatation of the descending aorta in late follow-up. The most basic predictive factor was the presence of a patent false lumen. In addition, the presence of a large intimal tear in the proximal descending aorta, location of the intimal tear, maximum diameter of the thoracic

**FIGURE 3.** Kaplan–Meier curves of actuarial survival (upper), freedom from aortic death (middle), and aortic events in the downstream aorta (lower) with number of patients at risk and 95% confidence intervals.
descending aorta on the postoperative CT scan, presence of a patent false lumen of dissected supra-arch vessels, presence of visceral arteries or intercostal arteries originating from the false lumen, and Marfan syndrome were also reported as predictive factors. Most of these previous studies suggest that the presence of the channel of blood supply causes the patent false lumen, which then results in the dilatation of the false lumen and descending aorta. If higher internal pressure of the false lumen is maintained, the dilatation of the descending aorta will occur with high probability. However, because hemodynamics into the false lumen are diverse depending on the number, location, and size of the channels of blood supply, it is difficult to assess internal pressure conditions of the

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**FIGURE 4.** Subgroup analysis in long-term outcome. A, Kaplan–Meier curves of freedom from aortic events between the groups with patent false lumen and thrombosed false lumen with number of patients at risk and 95% confidence intervals. B, Kaplan–Meier curves of freedom from aortic events between the FL-D > TL-D group and FL-D < TL-D group with number of patients at risk and 95% confidence intervals. C, Kaplan–Meier curves of freedom from aortic death between the FL-D > TL-D group and FL-D < TL-D group with number of patients at risk and 95% confidence intervals. FL-D, False lumen diameter; TL-D, true lumen diameter.
false lumen according to any of the anatomical conditions. When the internal pressure of the false lumen becomes higher, the false lumen will dilate naturally. We therefore hypothesized that the diameters of the true and false lumen reflect changes in the internal pressure of the dissected descending aorta just after the initial operation because the dissected intimal flap is soft and flexible.

Immer and colleagues\textsuperscript{16} reported that a large false lumen with an area of the true lumen < 30\% 6 months after surgery is the strongest predictor for secondary dilatation of the diseased downstream aorta. This finding is consistent with the results of the current study. Matsushita and colleagues\textsuperscript{17} also reported an initial aortic diameter of >40 mm and FL-D > TL-D were predictors of major adverse events after uncomplicated acute type B aortic dissection. Song and colleagues\textsuperscript{18} reported that a >22 mm false lumen diameter of the upper descending thoracic aorta on initial CT images predicted a late aneurysm with a sensitivity of 100\% and a specificity of 76\% in the patients with acute aortic dissection, and patients with initial upper descending thoracic aorta false lumen diameter >22 mm showed higher event rates (aneurysm or death) than others.

In the present study, we measured the FL-D and the TL-D and calculated an FL-D:TL-D ratio from the CT data performed immediately after surgery. As a result, the FL-D:TL-D ratio was an adjusted risk of aortic events in the late follow-up. We believe that the measurement of these parameters is a very simple and effective method to predict aortic events.

Although the progress of endovascular aortic repair has brought about the reduction of invasiveness in secondary surgery and improved the outcomes, it remains unclear regarding an appropriate indication, timing, and combination of therapy techniques after the initial surgery for ATAAD. To improve the long-term outcomes, a strategy to effectively reduce internal pressure of the false lumen is required. In postoperative follow-up, preemptive endovascular interventions such as vascular plug, stent graft, coils, and glue might be a choice if the blood flow from the intimal tear to the false lumen is severe.\textsuperscript{19-21} From this standpoint, the presence of a morphological parameter reflecting the internal pressure would help us to determine the most appropriate therapy strategy.

This study has some limitations. First, it is a retrospective single-center study. There are some statistical limitations because of the very small sample size. We observed only 17 cases of aortic events in late follow-up. The data in the Kaplan–Meier methods were unadjusted. Our multivariable stepwise regression model limits interpretability of this study. Not only residual confounding, but measurement

| Variables | P value | Hazard ratio | 95\% CI |
|-----------|---------|--------------|--------|
| FL-D:TL-D ratio | .01 | 1.009 | 1.002–1.016 |

FIGURE 5. Data of 72 patients, who were diagnosed as having Stanford type A acute aortic dissection with a patent false lumen in the descending thoracic aorta, survived the emergency operation, and had postoperative CT scan data, were analyzed. The diameters of the false lumen (FL-D) and true lumen (TL-D) were measured, and the FL-D:TL-D ratio was calculated. Long-term outcomes for the FL-D > TL-D group (n = 30) and the FL-D < TL-D group (n = 42) were compared. In the late follow-up, 17 aortic events in the downstream aorta were observed. The FL-D:TL-D ratio was an independent predictor of aortic events in multivariable analysis. The rates of freedom from aortic events at 5 and 9 years were superior in the FL-D < TL-D group than in the FL-D > TL-D group. Our results suggest that the false lumen:true lumen ratio predicts long-term prognosis after surgical repair of acute type A aortic dissection. DA-D, Diameter of the proximal descending aorta; CI, confidence interval.
error and sampling error could greatly influence results in a small population. Second, we could not remove the confounding of heterogeneity of cases and procedures. Third, we did not assess the influence of the flexibility and pliability of the intimal flap or aortic wall on the measured morphological parameters. Fourth, the relationship between the tortuosity of the aorta and the dilatation of the false lumen was not examined. Fifth, some debate exists about use of a center line measurement to determine the true transverse diameter as well as either double oblique versus orthogonal measurements. These approaches might adjust for any overestimation in measurement. Finally, we selected clinical outcomes such as survival and aortic events as the end points in this study. Therefore, the actual degree of aortic dilatation was not examined.

CONCLUSIONS
We found that the FL-D/TL-D ratio and FL-D > TL-D were adjusted risks of aortic events in the downstream aorta. In long-term outcome, the rate of freedom from aortic events in the downstream aorta was inferior in the FL-D > TL-D group compared with the FL-D < TL-D group. These results suggest that the morphology of the false lumen predicts the long-term prognosis after surgical repair of ATAAD.

Conflict of Interest Statement The authors reported no conflicts of interest.

The Journal policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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