Surgical Indication for Chronic Aortic Dissection in Descending Thoracic and Thoracoabdominal Aorta

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***Background*—**To address the lack of information about the size of ruptures associated with chronic dissection in the descending and thoracoabdominal aorta, we evaluated the natural history of this pathology.

***Methods and Results*—**We analyzed data from 571 patients (mean age, 69.4±11.6 years) with unrepaired chronic aortic dissection in the descending or thoracoabdominal aorta with a maximal aortic diameter of ≥3.5 cm from 2007 to 2014. This was a cross-sectional study. Data on the timing of computed tomographic scan were as follows: for ruptured cases: at the time of rupture; for nonruptured cases: the initial aortic diameter. Patients with connective tissue disorders were excluded. The primary end point was evidence of aortic rupture on computed tomographic images. The median maximal diameter was 4.3 cm (limits, 3.5–9.0 cm) for all aortas and 5.6 cm (n=31; limits, 3.6–8.0 cm) for ruptured aortas. For aortic diameters of 4.0 to 4.4, 4.5 to 4.9, 5.0 to 5.4, 5.5 to 5.9, and 6.0 to 6.4 cm, the incidence of rupture was 0%, 3.3%, 15.3%, 18.8%, and 28.6%, respectively. The risk factors for rupture were absence of hypertension, chronic heart failure, chronic-phase dissection, and Yale index.

***Conclusions*—**The risk of aortic rupture increased with an aortic diameter of ≥5.0 cm in patients with chronic aortic dissection in the descending or thoracoabdominal aorta. We would recommend 5.0 cm as an acceptable size for elective resection of subacute or chronic aortic dissection in the descending or thoracoabdominal aorta. **(*Circ Cardiovasc Interv*. 2017;10:e004292. DOI: 10.1161/CIRCINTERVENTIONS.116.004292.)**

Key Words: aortic rupture ■ dissection ■ natural history ■ thoracic aortic aneurysm ■ thoracoabdominal aortic aneurysm

Chronic aortic dissection of the descending thoracic or thoracoabdominal aorta is a life-threatening condition because of the associated risk of rupture. In addition, this condition is associated with high mortality and morbidity if complications occur. To determine the appropriate criteria for surgical intervention and type of surgical therapy, it is important to evaluate the diameter of unrepaired chronic aortic dissections in order to determine the risk of rupture. However, there are limited natural history data to support clinical criteria for timely intervention. This analysis aimed to define scientific criteria for surgical intervention based on the natural history data obtained from this group of patients.

Methods

This was a cross-sectional study. A computerized search was performed to identify all patients who underwent computed tomographic (CT) scanning and were diagnosed with chronic aortic dissection at the National Cerebral and Cardiovascular Center at Osaka, Japan, between January 2007 and December 2014. Of 828 patients with chronic aortic dissection in the descending thoracic or thoracoabdominal aorta, the database included 571 CT scans performed on 571 patients with unrepaired chronic aortic dissection in the descending thoracic or thoracoabdominal aorta with a maximal aortic diameter of ≥3.5 cm. We reviewed the charts of these 571 patients (mean age, 69.4±11.6 years; 364 males). Patients were excluded if they had connective tissue disorders, such as Marfan syndrome, Ehlers–Danlos syndrome, Loeys–Dietz syndrome, or mutation in smooth muscle α-actin (ACTA2); were <40 years of age; had an aortic arch diameter of ≥3.5 cm, symptomatic aneurysm, or mycotic aneurysm; or had undergone any surgical intervention for the descending thoracic or thoracoabdominal aorta.

Imaging Variables

Radiologists at our center performed all measurements of aortic diameter. The following imaging variables were prespecified and carefully assessed at each examination: (1) Data on the timing of CT scan were as follows: for ruptured cases: at the time of rupture; for nonruptured cases: the initial aortic diameter on CT scan at our center. (2) The largest short-axial diameter perpendicular to the outer contour of the aorta was measured.[1] We measured the dissected aorta including both true and false lumen. Maximal aortic diameter in the descending and thoracoabdominal dissected aorta were determined by CT scan. In cases in which the cross-sectional slice of the aorta had an elliptical shape, the smaller of the 2 diameters was recorded.[2] (3) The status of the false lumen on CT imaging was classified as patent if flow was present in the absence of thrombus, as partially thrombosed if both flow and thrombus were present, and as completely thrombosed if no flow was present.[3]

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WHAT IS KNOWN

- There are limited natural history data to support clinical criteria for timely intervention in patients with unrepaired chronic aortic dissection in the descending or thoracoabdominal aorta.
- The current guidelines of American College of Cardiology/American Heart Association recommend surgical intervention for descending thoracic aortic diameter exceeding 5.5 cm or demonstrating rapid expansion (>5 mm/y).

WHAT THE STUDY ADDS

- The incidence of rupture increases with larger aortic size. At 4.0 to 4.4, 4.5 to 4.9, 5.0 to 5.4, 5.5 to 5.9, and 6.0 to 6.4 cm, the incidence of rupture was 0%, 3.3%, 15.3%, 18.8%, and 28.6%, respectively.
- The risk of rupture drastically increased at an aneurysmal diameter of 5.0 cm with a gradual increase in risk of rupture with increasing maximal aortic diameter.

Subgroup Analysis

We compared the risks of rupture between patients with aortic dissection extending to the descending thoracic aorta (n=132) and those with aortic dissection extending to the thoracoabdominal aorta (n=439) and between those with type A aortic dissection (n=242) and those with type B aortic dissection (n=329). Among patients with type A aortic dissection, 91.7% (222/242) underwent proximal aortic arch repair at initial dissection, and 8.3% (20/242) received medical treatment at initial type A dissection.

Follow-Up Data in Patients With Unruptured Aorta

The mean follow-up time was 3.8±5.5 years from the date of the initial CT scan. Ninety-three percent of patients were followed up at our center, and 7.0% were followed up by a practicing physician. A follow-up CT scan was performed every 6 months or 1 year in all patients. All patients with hypertension were adequately followed up by a physician, given the history of acute aortic dissection.

Definitions

The primary end point was aortic rupture shown on CT scan. All cases of rupture were diagnosed by CT scan by a radiologist at our center. Open rupture was defined as active bleeding from the perforation site in the aorta. Contained rupture was defined as the presence of a periaortic hematoma on CT scan. Symptomatic aneurysm was defined as an aneurysm in a patient presenting with pain probably related to the aneurysm, which was found unruptured on CT scan. Subacute aortic dissection was defined as aortic dissection diagnosed between 15 and 90 days after onset. Chronic aortic dissection was defined as aortic dissection diagnosed >91 days after onset. Chronic heart failure was defined as a left ventricular ejection fraction of <40% on echocardiogram. Patients were considered not to have hypertension if they had systolic blood pressure of <135 mm Hg without receiving treatment.

Statistical Analysis

To evaluate the indexed aortic diameters relative to body size, body surface area (BSA) was calculated based on the DuBois formula (body surface area=0.007148×weight 0.425×height 0.725),[4] and Yale index (maximal aortic diameter [cm]/body surface area [m^2]) was calculated.[5]

All continuous variables are presented as means±SD. Noncontinuous and categorical variables are presented as frequencies or percentages and were compared using the Mann–Whitney *U* test. Univariate logistic regression analysis was performed using covariates that significantly predicted rupture of chronic dissections. Stepwise selection with a *P* value of 0.05 for backward elimination was used for multivariable logistic regression with the use of covariates with statistical significance in univariate analyses.

Considering that the association between the diameter of the aneurysm and the incidence of rupture was not linear, we used a systematic search for the best-fitting fractional polynomial function for aneurysmal diameter and other covariates using the MVRS command of Stata by Royston and Sauerberi.[6,7] This expectation–maximization method–based algorithm searched whether any specific thresholds existed for covariates changing at the specific value and select based model using linear, quadric, or cubic spline terms. For example, linear splines allow estimation of the relationship between y and x as a piecewise linear function, which is a function composed of straight lines. One linear segment represents the function for values of x below $x0$, another linear segment handles values between $x0$ and $x1$, and so on. These cutoff points are called the knots. After selection of a best-fitted spline variable for logistic regression coefficients, the position of the knot, which corresponds to the threshold aneurysmal diameter for the risk of rupture, was determined. The predicted odds ratio (OR) for rupture at each aneurysmal diameter was plotted. All statistical tests were 2-sided, and *P* values of <0.05 were regarded as indicating statistical significance. The Bonferroni method was used to adjust the *P* values in multiple testing for univariate analyses. Statistical analysis was performed with PASW Statistics 20 software (SPSS, Chicago, IL) and STATA version 12 (StataCorp LP, College Station, TX). The study was approved by an institutional review committee, and the subjects gave informed consent.

Results

Table 1 summarizes the profiles of patients at the time of measurement of aortic diameter. Regarding the false lumen status, 26.4% had a patent false lumen, 40.3% had partial thrombosis, and 33.3% had complete thrombosis. The location of the maximal aortic diameter was the descending aorta in 534 patients (93.5%) and the thoracoabdominal aorta in 37 patients (6.5%).

There were 250 patients in the subacute dissection phase (15–90 days) and 321 patients in the chronic dissection phase (>90 days). At the time of measurement of aortic diameter, a β-adrenergic blocking agent was administered in 71.0% of patients, calcium blocker in 72.8%, angiotensin receptor blocker in 49.2%, angiotensin-converting enzyme inhibitor in 12.8%, and α-adrenergic blocking agent in 13.9%.

Baseline Aortic Diameter

There were 187 patients with maximal aortic diameter 3.5 to 3.9 cm, 149 patients with 4.0 to 4.4 cm, 90 patients with 4.5 to 4.9 cm, 59 patients with 5.0 to 5.4 cm, 32 patients with 5.5 to 5.9 cm, 34 patients with 6.0 to 6.4 cm, and 20 patients with ≥6.5 cm. The mean and median maximal aorta diameters were 4.5±0.9 and 4.3 cm (limits, 3.5–9.5 cm).

Details of Cases of Aortic Rupture

Thirty-one patients presented with aortic rupture. The mean and median diameters of the aortic rupture were 5.6±0.8 and 5.6 cm (limits, 3.6–8.0 cm), with mean and median Yale index values of 3.6±0.7 and 3.5 (limits, 2.3–5.0). Open rupture occurred in 16 patients and contained rupture in 15 patients. The patient's status at the time of rupture was as follows: loss of consciousness (n=16, 51.6%), shock vital (n=14, 45.2%),

Table 1. Patients' Characteristics at the Measurement

Age at measurement, y	69.4±11.6
Age at initial acute dissection, y	65.8±12.8
Male sex, n (%)	364 (63.7)
Mean BSA, m²	1.64±0.20
Previous aortic surgery, n/total n (%)	335 (58.7)
The status of the aortic dissection	
Stanford classification	
Type A aortic dissection, n/total n (%)	242 (42.4)
Previous proximal aortic arch repair at initial type A dissection, n/total n (%)	222 (38.9)
Type B aortic dissection, n/total n (%)	329 (57.6)
Extending to descending aorta	132 (23.1)
Extending to thoracoabdominal aorta	439 (76.9)
The status of the false lumen	
Patent, n/total n (%)	142 (26.4)
Partial thrombosis, n/total n (%)	217 (40.3)
Complete thrombosis, n/total n (%)	179 (33.3)
Location of maximum aorta	
Descending aorta, n/total n (%)	534 (93.5)
Abdominal aorta, n/total n (%)	37 (6.5)
Median time from initial aortic dissection, d (limits)	229 (14 d to 25 y)
The size of aortic diameter	
Mean maximal aortic size, cm	4.5±0.9
Maximal aorta ≥5.0 cm, n/total n (%)	145 (25.4)
Yale index*	2.8±0.7
Coexisting diseases	
Hypertension, n/total n (%)	533 (95.5)
Coronary artery disease, n/total n (%)	73 (12.8)
Chronic heart failure, n/total n (%)	26 (4.6)
Previous cerebral vascular accident, n/total n (%)	64 (11.2)
COPD, n/total n (%)	38 (6.7)
Asthma, n/total n (%)	14 (2.5)
Peripheral vascular disease, n/total n (%)	9 (1.6)
Chronic kidney disease, n/total n (%)	39 (6.8)
Hemodialysis, n/total n (%)	17 (3.0)
Bicuspid aortic valve, n/total n (%)	4 (0.7)

Chronic kidney disease was defined as serum creatinine level ≥2.0 mg/dL. BSA indicates body surface area; and COPD, chronic obstructive pulmonary disease.

*Yale index=maximal aortic diameter (cm)/BSA (m²).

and cardiopulmonary arrest (n=11, 35.5%). Twenty patients underwent emergency operation. Fifteen patients (48.4%) died from aortic rupture.

Relationship Between Aortic Diameter and Rupture

Figure 1A shows the cumulative incidence of rupture as a function of maximal aortic diameter. The incidence of rupture increases with larger aortic diameter. For aortic diameters of 3.5 to 3.9, 4.0 to 4.4, 4.5 to 4.9, 5.0 to 5.4, 5.5 to 5.9, and 6.0 to 6.4 cm, the incidence of rupture was 0.5%, 0%, 3.3%, 15.3%, 18.8%, and 28.6%, respectively. Figure 1B shows the relationship between aortic diameter and the OR for risk of rupture. After selection of the best-fitted spline function, the linear spline function of 2 degrees of freedom with the knot at an aneurysmal diameter of 5.0 cm was selected (P<0.0001). We plotted the OR for rupture at an aneurysmal diameter of 4.5 cm as the reference value using the linear spline function (Figure 1C). This analysis revealed that the risk of rupture increased drastically at an aneurysmal diameter of 5.0 cm (OR, 7.4; 95% confidence interval, 2.8–19.8), with a gradual increase in the risk of rupture with increasing aneurysmal diameter (Table 2).

Risk Factor Analysis of Aortic Rupture

Tables 3 shows the risk factor analysis for all ruptures and for ruptures <5.5 cm according to patient characteristics and the phase of aortic dissection on CT imaging. No oral medications were found to be significant predictors of aortic rupture. Table 4 shows the multivariate analysis of the risk factors for all ruptures and for ruptures of <5.5 cm. The risk factors for all ruptures were absence of hypertension (OR, 4.5), chronic heart failure (OR, 15.4), chronic dissection phase (OR, 7.9), and Yale index (OR, 4.4). The risk factors for ruptures of <5.5 cm were chronic dissection phase (OR, 8.4) and Yale index (OR, 10.9).

Relationship Between Rupture and Time From Initial Aortic Dissection

Figure 2 shows the incidence of rupture according to the time from initial aortic dissection.

During the subacute dissection phase (15–90 days), the incidence of rupture was 0.8%. During the chronic dissection phase (91 days to 6 months), the incidence of rupture increased to 17.2%. After 6 months, the incidence of rupture tended to increase with increase in the time from initial dissection.

Subgroup Analysis

Comparison Between the Group With Aortic Dissection Extending to the Descending Thoracic Aorta and the Group With Aortic Dissection Extending to the Thoracoabdominal Aorta

Patients with aortic dissection extending to the descending aorta were significantly more likely to present with ruptures of small diameter (<5.5 cm) than were patients with aortic dissection extending to the thoracoabdominal aorta (Table 5). In patients with partial thrombosis of the false lumen, aortas with dissection extending to the descending aorta were more likely to rupture than aortas with dissection extending to the thoracoabdominal aorta.

Comparison Between Type A and Type B Aortic Dissection

There were no significant differences between the 2 groups in the number with rupture of <5.5 cm, status of false lumen, extension of aortic dissection, or comorbidities (Table 6).

Discussion

To determine the appropriate criteria for surgical intervention and type of surgical therapy, it is important to understand the

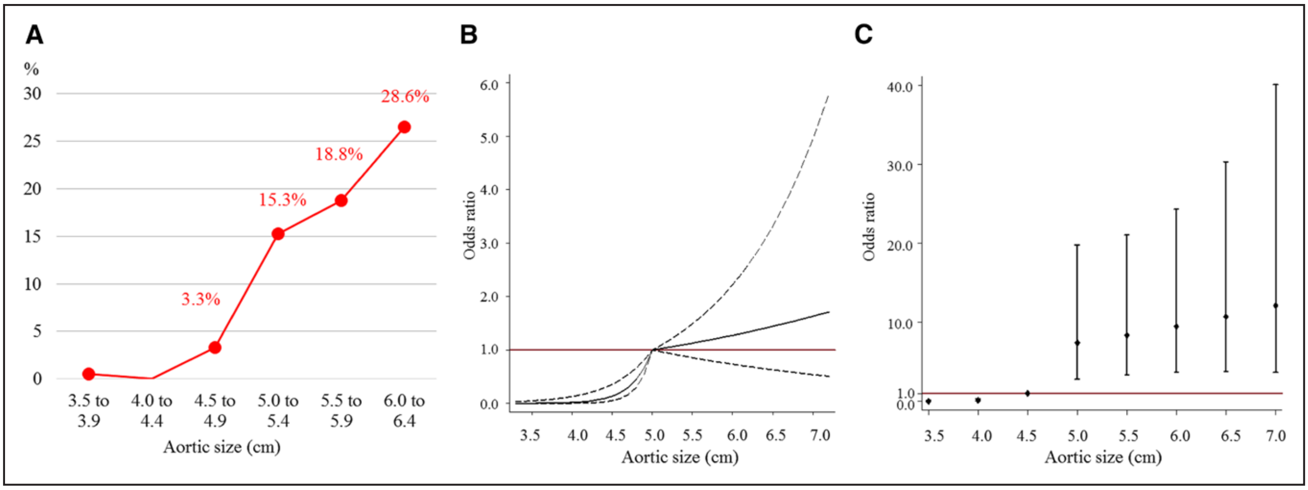

Figure 1. A, Cumulative incidence of rupture as a function of maximal aortic diameter. **B**, After the selection of best-fitted spline function, the linear spline function of 2 degrees of freedom with the knot at an aneurysmal diameter of 5.0 cm was selected (*P*<0.0001). **C**, Plotting the odds ratio for rupture at an aneurysmal diameter of 4.5 cm as the reference value using the linear spline function revealed that the risk of rupture drastically increased at an aneurysmal diameter of 5.0 cm (odds ratio, 7.4; 95% confidence interval, 2.8–19.8; Table 2).

natural history of untreated chronic aortic dissection. According to Laplace's law, it is widely considered that aortic wall stress is greatly dependent on the diameter of the aorta. The current guidelines of the American College of Cardiology/American Heart Association recommend surgical or interventional aortic repair for patients with chronic dissection, particularly if it is associated with a connective tissue disorder without significant comorbid disease and a descending thoracic aortic diameter exceeding 5.5 cm or demonstrating rapid expansion (>5 mm/y).[1,5,8–10]

There are some studies of the natural history and surgical indications of arteriosclerotic asymptomatic aneurysms of the descending aorta and thoracoabdominal aorta. Coady et al[9] reported that surgical intervention in patients with an ascending aorta of ≥5.5 cm in diameter and a descending aorta of ≥6.5 cm will prevent most ruptures and dissections. A recent case series reported that even among patients with aortic diameters of 5.0 cm, 5.5% had definite and 8.0% had possible aortic events within 1 year. Consideration should, therefore, be given to lowering the threshold for intervention, particularly if less invasive endovascular approaches are feasible.[11]

However, there are limited natural history data on chronic dissection of the descending aorta and the thoracoabdominal

Table 2. Odds Ratio of Rupture According to Aortic Size

Size, cm	No. of Rupture Patients/ No. of Patients	Odds Ratio	95% CI
3.5–3.9	1/187	0.02	0.00–0.13
4.0–4.4	0/149	0.13	0.05–0.36
4.5–4.9	3/90	1.00	1.00–1.00
5.0–5.4	10/59	7.43	2.79–19.80
5.5–5.9	5/32	8.40	3.35–21.07
6.0–6.4	9/34	9.49	3.70–24.3
6.5–6.9	2/8	10.73	3.79–30.34
≥7.0	1/12	12.12	3.67–40.07

CI indicates confidence interval.

aorta to support clinical criteria for timely intervention. Elefteriades et al[12] suggested that patients with chronic aortic dissection should be treated when the aorta reaches 6 cm in diameter, similar to the value for which treatment is recommended in patients with arteriosclerotic descending thoracic aortic aneurysms. However, Crawford[13] found that in 23% of patients presenting with rupture of a chronically dissected descending aorta, the aorta was 5.0 to 6.0 cm in diameter. Similarly, the Mount Sinai group found that the last median diameter before rupture was 5.4 cm (limits, 3.2–6.7 cm).[14] In our study, the mean and median diameters of ruptured aortas were 5.6±0.8 cm and 5.6 cm (n=31; limits, 3.6–8.0 cm). Twenty-nine percent of patients presenting with rupture had diameters in the range of 5.0 to 5.5 cm. Moreover, plotting the OR for rupture at an aneurysmal diameter of 4.5 cm as the reference value by using a linear spline function (Figure 1B and 1C) revealed that the risk of rupture drastically increased at an aneurysmal diameter of 5.0 cm (OR, 7.4; Table 2), with a gradual increase in risk of rupture with increasing maximal aortic diameter.

A recent publication reported mortality rates of 4.7%–5.0% for elective open repair of the descending aorta and thoracoabdominal aorta.[15,16] A previous meta-analysis of the operative risks of conventional open thoracoabdominal aortic repairs in the current era involving 27 studies and 7833 surgical patients undergoing open thoracoabdominal aortic repair found a median early mortality rate of 5.1% (range, 1.3%–10.3%) and rates of permanent neurological damage of <5% under elective circumstances.[17] After comparing these surgical risks with our results for aortic rupture, we propose that patients with chronic dissection in the descending thoracic aorta or thoracoabdominal aorta with a maximal aortic diameter of ≥5.0 cm should receive preemptive surgical therapy.

Juvonen et al[18] reported that age, symptoms, chronic obstructive pulmonary disease, and the diameters of the descending aorta and thoracoabdominal aorta emerged as independent risk factors for rupture of aneurysms of the descending or thoracoabdominal aorta. In our study, multivariate analysis showed that the risk factors for all ruptures

Table 3. Risk Factor for All Ruptures and Rupture of <5.5 cm at Univariate Analysis According to the Characteristics of Patients

	All Patients (N=571) Rupture (n=31)			The Aorta Size of <5.5 cm (N=492) Rupture of <5.5 cm (n=15)		
	No. of Rupture/ No. of Patients, %	Odds Ratio (95% CI)	*P* Value	No. of Rupture/ No. of Patients, %	Odds Ratio (95% CI)	*P* Value
Age at measurement, y		1.02 (0.99–1.06)	0.153		1.05 (0.99–1.10)	0.063
Male sex	20/364 (5.5)	1.04 (0.49–2.21)	0.927	10/310 (3.2)	1.18 (0.40–3.51)	0.77
Previous proximal repair for type A aortic dissection	10/222 (4.5)	0.84 (0.40–1.80)	0.66	5/199 (2.5)	0.73 (0.25–2.17)	0.57
Nonhypertension	5/25 (20.0)	5.08 (1.76–14.65)	0.003*	4/22 (18.2)	9.11 (2.64–31.41)	<0.001*
Chronic kidney disease	4/39 (10.2)	2.01 (0.67–6.06)	0.22	4/29 (13.8)	6.17 (1.83–20.75)	0.003*
Chronic heart failure	4/26 (15.4)	3.48 (1.12–10.82)	0.031*	2/21 (9.5)	3.92 (0.82–18.66)	0.087
COPD	5/38 (13.2)	2.95 (1.06–8.18)	0.038	3/34 (8.8)	3.59 (0.96–13.39)	0.057
Initial aortic dissection <50 y of age	8/90 (8.9)	2.31 (0.99–5.37)	0.052	3/73 (4.1)	0.08 (0.48–6.40)	0.40
Chronic-phase dissection >90 d	29/321 (9.0)	11.06 (2.61–46.85)	0.001*	14/265 (5.3)	12.97 (1.69–99.41)	0.014*
Yale index†		4.83 (2.89–8.09)	<0.001*		14.08 (4.70–42.19)	<0.001*
The status of false lumen						
Patent	3/142 (2.1)	0.31 (0.09–1.03)	0.056	1/130 (0.8)	0.19 (0.03–1.48)	0.11
Partial thrombosis	17/217 (7.8)	2.06 (1.00–4.28)	0.051	8/177 (4.5)	2.23 (0.76–6.52)	0.15
Complete thrombosis	7/179 (6.1)	0.62 (0.26–1.48)	0.28	5/158 (3.2)	1.08 (0.36–3.29)	0.89
Aortic dissection extending to descending aorta	10/132 (7.6)	1.63 (0.75–3.56)	0.22	7/119 (5.9)	2.852 (1.01–8.04)	0.047
Type B aortic dissection	20/329 (6.1)	1.36 (0.64–2.89)	0.43	10/274 (3.6)	1.61 (0.54–4.79)	0.39
Location of the maximum aorta						
Descending aorta	18/402 (4.5)	0.63 (0.18–2.17)	0.46	14/466 (3.0)	0.77 (0.09–6.13)	0.81

Chronic kidney disease was defined as serum creatinine level ≥2.0 mg/dL. Bonferroni corrected *P* value threshold is 0.0031250.05/16 tests. BSA indicates body surface area; CI, confidence interval; and COPD, chronic obstructive pulmonary disease.

*Significant difference after Bonferroni correction.

†Yale index=maximal aortic diameter (cm)/BSA (m^2).

were absence of hypertension, chronic heart failure, chronic dissection phase, and Yale index. The risk factors for rupture of aneurysms of <5.5 cm were chronic dissection phase and Yale index. Interestingly, patients who did not have a history of hypertension were at high risk for aneurysm rupture in our study, although it is known that hypertension is one of the risk factor for aortic rupture. It is possible that the aortic wall of patients who develop aortic dissection despite not having hypertension may be weaker than the aortic wall of patients with hypertension. Ziganshin et al[19] reported that they initiated a clinical program for routine genetic testing of individuals for thoracic aortic aneurysm and dissection by whole-exome sequencing (n=102, mean age 56.8 years; range: 13–83; 70 men). They found that rare variants in genes currently known to cause thoracic aortic aneurysm and aortic dissection were present in 22.5% of patients. Thus, we consider that the patients who develop aortic dissection despite not having hypertension might have some sort of gene mutations and need a genetic testing even in elderly patients.

Davies et al[5] reported that the aortic size index (Yale index), which takes into account both aortic diameter and body surface area, has been found to be a better predictor of adverse events than the maximal aortic diameter. We also found on multivariate analysis that the Yale index was a good predictor of aortic rupture.

Table 4. Risk Factor Analysis for All Ruptures and Rupture <5.5 cm After Stepwise Selection

	All Ruptures			Rupture of <5.5 cm		
Variable	No of Rupture/ No. of Patients, %	Odds ratio (95% CI)	*P* Value	No. of Rupture/ No. of Patients, %	Odds Ratio (95% CI)	*P* Value
Nonhypertension	5/25 (20.0)	4.48 (1.04–14.30)	0.044		Not selected	
Chronic heart failure	4/26 (15.4)	5.07 (1.34–19.09)	0.016		Not selected	
Chronic-phase dissection >90 d	29/321 (9.0)	7.85 (1.78–34.44)	0.006	14/265 (5.3)	8.35 (1.04–66.92)	0.046
Yale index*		4.42 (2.49–7.83)	<0.001	25/159 (15.7)	10.93 (3.52–33.97)	<0.001

BSA indicates body surface area; and CI, confidence interval.

*Yale index=maximal aortic diameter (cm)/BSA (m^2).

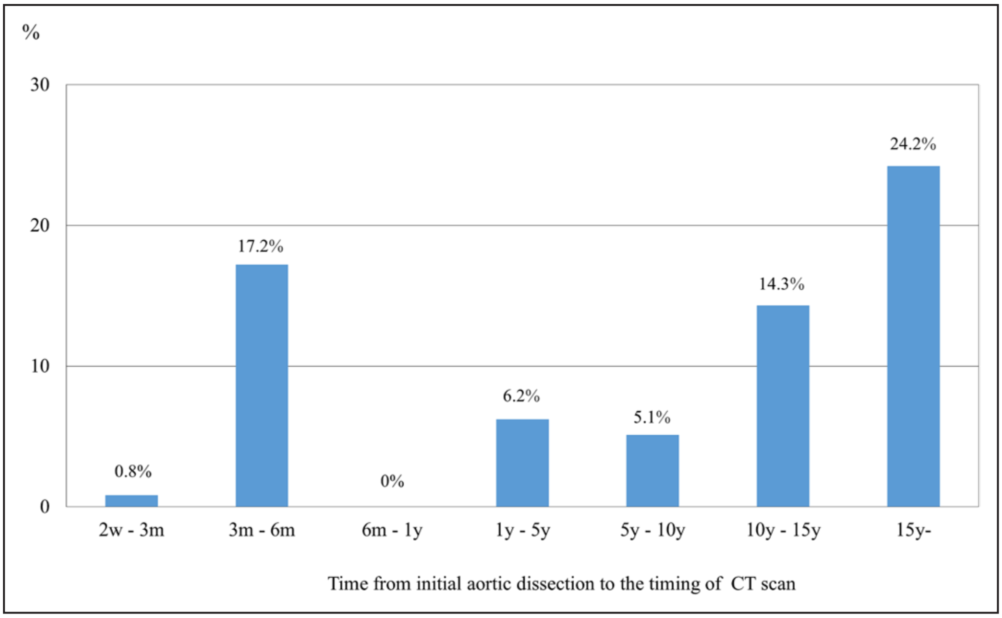

Figure 2. Incidence of aortic rupture according to the time from initial aortic dissection to the timing of computed tomographic (CT) scan (for ruptured cases: at the time of rupture; for non-ruptured cases: the initial aortic diameter).

The incidence of rupture of aneurysms with chronic dissection at 91 days to 6 months from initial dissection was high compared with the incidence of rupture of aneurysms with subacute dissection (15–90 days; Figure 2). These results suggest that this period (91 days to 6 months from initial dissection) may be consistent with the period in which patient activity level becomes relatively high, such as during work. We think that patients with aortic dissection should be followed up more strictly for 6 months from the onset of dissection and that the definition of subacute dissection should be extended from 15 days to 6 months.

The subgroup analysis of the comparison between the group with aortic dissection extending to the descending aorta and with aortic dissection extending to the thoracoabdominal aorta showed that patients in the first group were more likely to present with ruptures of a smaller diameter than were patients in the second group. We assume that short-range aortic dissections may tend to rupture because there is no capacity to contain aortic pressure. Therefore, we recommend that surgical intervention should be performed earlier in patients with chronic dissection extending to the descending aorta than in patients with chronic dissection extending to the thoracoabdominal aorta. Tsai et al[3] reported that in the observations of the International Registry of Acute Aortic Dissection, partial thrombosis of the false lumen, compared with complete patency, is a significant independent predictor of postdischarge mortality in these patients. Concordantly, we found that in patients with partial thrombosis of the false lumen, aortic dissections extending to the descending aorta were more likely to rupture than were aortic dissections extending to the thoracoabdominal aorta. In contrast, the subgroup analysis of the comparison between patients with type A and type B aortic dissections did not reveal any significant differences between the 2 groups.

Table 5. Comparison of the Incidence of Rupture Between Extending to Descending Aortic Dissection and Extending to Thoracoabdominal Aorta

	Extending to Descending Aorta (N=132) No. of Rupture/ No. of Patients, %	Extending to Thoracoabdominal Aorta (N=439) No. of Rupture/ No. of Patients, %	*P* Value
Rupture	10/132 (7.6)	21/439 (4.8)	0.27
Rupture of <5.5 cm	7/119 (5.9)	8/373 (2.1)	0.039
Mean ruptured aortic size, cm	5.3±0.8	5.8±0.8	0.23
Median ruptured aortic size, cm (limits)	5.4 (3.6–6.5)	5.7 (4.6–8.0)	
The status of false lumen			
Patent	0/10	3/132 (2.3)	0.63
Partial thrombosis	6/34 (17.6)	11/183 (6.0)	0.021
Complete thrombosis	2/80 (2.5)	5/99 (5.1)	0.38

Mann–Whitney *U* test was used.

Table 6. Comparison of the Incidence of Rupture Between Type A and Type B Aortic Dissection

	Type A Dissection (N=242) No. of Rupture/ No. of Patients, %	Type B Dissection (N=329) No. of Rupture/ No. of Patients, %	*P* Value
Rupture	11/242 (4.5)	20/329 (6.1)	0.43
Rupture of <5.5 cm	5/218 (2.3)	10/274 (3.6)	0.39
Mean ruptured aortic size, cm	5.3±0.8	5.8±0.8	0.15
Median ruptured aortic size, cm (limits)	5.6 (3.6–6.3)	5.8 (4.6–8.0)	
The status of false lumen			
Patent	1/71 (1.4)	2/71 (2.8)	0.56
Partial thrombosis	7/110 (6.4)	10/107 (9.3)	0.42
Complete thrombosis	3/44 (6.8)	5/135 (3.7)	0.80

Mann–Whitney *U* test was used.

Limitations

There were some limitations to this study. The logistic regression analyses were limited by the small number of events. Our analyses had low power to detect moderate risk factor effects and therefore likely generated high false-negative rate. This limited sample size also did not allowed us to stratified multivariable analyses for detailed subgroups, such as chronic type A and type B dissections, and subacute and chronic dissections. This might be some source of bias for clinical heterogeneity in this study. This was a cross-sectional study, and the data set represented the experience of a single tertiary center. Thus, the data were subject to referral (entry) bias from the community. This is the cross-sectional study that focused on the size of aneurysm between ruptured case with no previous information before coming to the hospital and nonruptured cases that were incidentally identified. From the cross-sectional nature of the study, prevalence–incidence bias may exist, and we cannot make the definite causal inferences between size and aneurysmal size. To predict the risk of rupture, the ideal study design is prospective cohort study with CT scanning for all cohort members. However, the aortic aneurysm is relatively rare for doing population-based study. In addition, already certified indication of size >5.5 cm did not allow us to observe natural history of patients with size >5.5 cm. Under these circumstances, we selected cross-sectional study as second best choice for risk analyses. Future prospective study for patients under 5 cm, which are currently no definite indication for surgery is needed. We established the diagnosis of Marfan syndrome based on the revised Ghent criteria.[20] Moreover, patients who were suspected of having a connective tissue disorder, such as those who presented with aortic dissection at ≤50 years of age or who had a family history of aortic dissection, underwent genetic testing. However, there was still a potential inclusion of patients with connective tissue disorders.

Conclusions

Aortic diameter was the principal factor related to aortic rupture in unrepaired subacute or chronic aortic dissection of the descending thoracic or thoracoabdominal aorta. The risk of aortic rupture started to increase with an aortic diameter of ≥5.0 cm. We would recommend 5.0 cm as an acceptable size for elective resection of subacute or chronic aortic dissection of the descending thoracic or thoracoabdominal aorta.

Disclosures

None.

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