Descending aortic diameter of 5.5 cm or greater is not an accurate predictor of acute type B aortic dissection

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Objective: The risk of acute type B aortic dissection is thought to increase with descending thoracic aortic diameter. Currently, elective repair of the descending thoracic aorta is indicated for an aortic diameter of 5.5 cm or greater. We sought to investigate the relationship between aortic diameter and acute type B aortic dissection, and the utility of aortic diameter as a predictor of acute type B aortic dissection.

Methods: We examined the descending aortic diameter at presentation of 613 patients with acute type B aortic dissection who were enrolled in the International Registry of Acute Aortic Dissection between 1996 and 2009, and analyzed the subset of patients with acute type B aortic dissection with an aortic diameter less than 5.5 cm.

Results: The median aortic diameter at the level of acute type B aortic dissection was 4.1 cm (range 2.1–13.0 cm). Only 18.4% of patients with acute type B aortic dissection in the International Registry of Acute Aortic Dissection had an aortic diameter of 5.5 cm or greater. Patients with Marfan syndrome represented 4.3% and had a slightly larger aortic diameter than patients without Marfan syndrome (4.68 vs 4.32 cm, $P = .121$). Complicated acute type B aortic dissection was more common among patients with an aortic diameter of 5.5 cm or greater (52.2% vs 35.6%, $P < .001$), and the in-hospital mortality for patients with an aortic diameter less than 5.5 cm and 5.5 cm or greater was 6.6% and 23.0% ($P < .001$), respectively.

Conclusions: The majority of patients with acute type B aortic dissection present with a descending aortic diameter less than 5.5 cm before dissection and are not within the guidelines for elective descending thoracic aortic repair. Aortic diameter measurements do not seem to be a useful parameter to prevent aortic dissection, and other methods are needed to identify patients at risk for acute type B aortic dissection. (J Thorac Cardiovasc Surg 2011;142:e101-7)

Acute type B aortic dissection (ABAD) is a serious cardiovascular condition that is associated with high mortality and morbidity rates, and its incidence has increased over the last decades.¹⁻⁴ The risks of ABAD and aortic rupture are

thought to increase with increasing descending thoracic aortic diameter.⁵⁻⁷ For thoracic aortic aneurysms with a diameter larger than 6 cm, dissection occurs in approximately 3.7% per year, and dissection, rupture, or death occurs in approximately 15% per year.⁵⁻⁷ The risks of elective thoracic aortic repair for preventing acute dissection or rupture also are considerable, and the risks of elective surgery have to be balanced against the risks of the natural course of descending thoracic aortic aneurysms. Establishing a diameter threshold value that discriminates low from high risk of acute dissection is therefore crucial. Although the optimal diameter threshold is still under debate, current indications are to treat when the descending thoracic aortic diameter is greater than 5.5 or 6.0 cm.⁵⁻⁹

However, on investigation of the descending thoracic aortic diameter among patients with ABAD who were enrolled in the International Registry of Acute Aortic Dissection (IRAD), we observed that a substantial number of these patients do not seem to have markedly dilated aortic diameters. We sought to assess the utility of aortic diameter as a predictor of ABAD by investigating the subset of patients with ABAD and an aortic diameter less than 5.5 cm who

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Abbreviations and Acronyms

ABAD	= acute type B aortic dissection
IRAD	= International Registry of Acute Aortic Dissection
OR	= odds ratio

were enrolled in the IRAD, for whom elective descending thoracic aortic repair would not be recommended.

MATERIALS AND METHODS**Patient Selection**

The inception and structure of the IRAD have been described (Appendix 1).¹⁰ All patients presenting with ABAD who were enrolled in the IRAD between 1996 and September 2009 were selected for analysis. In total, we identified 613 patients with ABAD for whom data regarding the aortic diameter were available. ABAD was defined as any dissection that originated at the descending thoracic aorta in a patient who presented within 14 days after onset of symptoms. Only patients in whom the descending aortic diameter at presentation was available were included for this evaluation; traumatic aortic dissections were excluded. Patients were categorized according to aortic diameter less than 5.5 cm and 5.5 cm or greater, and demographics, clinical presentation, management, and outcomes of the 2 groups were compared.

Data Collection

Data were collected using standardized forms with more than 290 clinical variables, including demographics, medical history, clinical presentation, clinical findings, imaging studies, medical and surgical management, and in-hospital outcomes. The maximum descending aortic diameters were measured by computed tomography angiography, transesophageal echocardiography, magnetic resonance imaging, or angiography at the time of presentation with ABAD. If patients underwent multiple imaging studies, diameters from the study that identified the largest aortic diameter were selected for analysis. The maximum aortic diameter was measured at cross-sectional images perpendicular to the long axis of the descending aorta. In the IRAD, all aortic diameter measurements were obtained after aortic dissection had occurred. Data were collected at presentation or by retrospective review and were submitted to the IRAD coordinating center at the University of Michigan. Submitted forms are checked for face validity and analytic internal validity.

Data Analysis

Data analysis was performed with the Statistical Package for the Social Sciences (SPSS Inc, Chicago, Ill). The chi-square test was used for comparing categorical variables between patients with an aortic diameter less than 5.5 cm and 5.5 cm or greater; the Student *t* test was used for comparing continuous variables between both groups. Summary statistics are presented as frequencies and percentages for categorical variables and mean $\pm$ standard deviation for continuous variables. In all cases, missing data were not defaulted to negative, and denominators reflect only cases reported. Forward stepwise logistic regression analysis was performed with variables that reached *P* less than .20 on univariate analysis to investigate independent predictors of in-hospital mortality at aortic diameter less than 5.5 cm.

RESULTS**Aortic Diameters**

The mean maximum diameter at the level of ABAD was 4.40 ± 1.35 cm (range, 2.1–13.0 cm), and the median de-

scending thoracic aortic diameter was 4.1 cm (Figure 1). Among all 613 patients with ABAD, 81.6% had an aortic diameter less than 5.5 cm, which is the current threshold for elective descending thoracic aortic repair (Figure 1), and 40.3% had an aortic diameter less than 4.0 cm. Only 18.4% of patients with ABAD in the IRAD had an aortic diameter of 5.5 cm or greater.

Demographics and Clinical History

Patients with an aortic diameter of 5.5 cm or greater were more likely to have experienced a prior aortic dissection (19.1% vs 7.7%, *P* < .001) or a known aortic aneurysm (39.6% vs 16.8%, *P* < .001). Marfan syndrome was present in 6.4% of patients with an aortic diameter 5.5 cm or greater compared with 3.8% in patients with an aortic diameter less than 5.5 cm (*P* = .227) (Table 1). The mean aortic diameter in patients with Marfan syndrome was 4.68 cm versus 4.32 cm in patients without Marfan syndrome (*P* = .121).

Presentation and Imaging Results

Patients with an aortic diameter less than 5.5 cm presented more frequently with hypertension (70.1% vs 47.3%, *P* < .001) and less frequently with normotension (26.1% vs 45.5%, *P* < .001) or in hypovolemic shock (0.6% vs 3.6%, *P* = .008). Complicated ABAD, defined as patients presenting with preoperative mesenteric ischemia/infarction or acute renal failure, limb ischemia, spinal cord ischemia, shock, recurrent pain, refractory pain, or refractory hypertension, were more common among patients with an aortic diameter 5.5 cm or greater (52.2% vs 35.6%, *P* < .001, Table 2). Periaortic hematoma was more frequently diagnosed in this group (28.0% vs 13.7%, *P* < .001).

As expected, patients with an aortic diameter less than 5.5 cm were more likely to have a normal chest x-ray (29.1% vs 10.6%, *P* < .001), whereas a widened mediastinum, an abnormal aortic contour, displacement of the aorta, and pleural effusion were more frequent on chest x-rays of patients with an aortic diameter 5.5 cm or greater (Table 2). Partial false lumen thrombosis was more common in patients with enlarged aortas (53.0% vs 33.0%, *P* < .001).

Mean aortic arch diameter was 3.61 cm (± 1.24) and significantly larger in patients with an aortic diameter 5.5 cm or greater (3.49 vs 4.16, *P* < .001). The site of origin of the ABAD was more commonly at the level of the left subclavian artery for those patients with an aortic diameter less than 5.5 cm (58.7% vs 44.0%, *P* = .005), whereas for those with an aortic diameter 5.5 cm or greater, the ABAD was more likely to be in the descending aorta (20.9% vs 33.9%, *P* = .002) (Table 2).

Management and Outcomes

Medical management was offered to 72.0% of patients with an aortic diameter less than 5.5 cm compared with

FIGURE 1. Descending aortic diameter in patients with ABAD in the IRAD. Among all 613 patients with ABAD, 81.6% had an aortic diameter less than 5.5 cm, which is the current threshold for elective descending thoracic aortic repair.

59.5% of patients with an aortic diameter 5.5 cm or greater ($P = .009$). Surgical management was used more frequently in patients with an aortic diameter 5.5 cm or greater (39.6% vs 20.6%, $P < .001$), whereas patients with an aortic diameter less than 5.5 cm were more likely to undergo endovascular management (7.4% vs 0.9%, $P = .008$).

Increasing diameter was associated with increasing risk of in-hospital mortality (Figure 2). Overall, the in-hospital mortality was 6.6% for patients with an aortic diameter less than 5.5 cm and 23.0% for patients with an aortic diameter 5.5 cm or greater ($P < .001$). The mean aortic diameter

of nonsurvivors was 5.22 cm, compared with 4.32 cm for survivors ($P < .001$). Among patients managed medically, the in-hospital mortality was 4.4% versus 25.4% for patients with an aortic diameter less than 5.5 cm and 5.5 cm or greater, respectively ($P < .001$). The mortality did not differ significantly between groups after surgical or endovascular management (Table 3).

Independent predictors for mortality among patients with an aortic diameter less than 5.5 cm were hypotension or shock (odds ratio [OR], 8.6; $P = .001$), acute renal failure (OR, 3.6; $P = .014$), mesenteric ischemia/infarction (OR,

TABLE 1. Demographics and clinical history

	Overall	Descending aortic diameter < 5.5 cm	Descending aortic diameter ≥ 5.5 cm	P value
N (%)	613 (100)	500 (81.6)	113 (18.4)	
Demographics				
Age (SD)	63.9 (±14.0)	62.9 (±13.5)	65.2 (±14.1)	.111
Age ≥ 70 y	219 (36.6)	168 (34.3)	51 (47.2)	.012
Male	409 (66.7)	335 (67.0)	74 (65.5)	.758
History				
Marfan syndrome	26 (4.3)	19 (3.8)	7 (6.4)	.227
Bicuspid aortic valve	9 (1.9)	8 (2.0)	1 (1.3)	.997
IMH	116 (19.1)	97 (19.5)	19 (17.1)	.561
Hypertension	486 (79.8)	392 (78.7)	94 (84.7)	.157
Atherosclerosis	207 (34.3)	166 (33.5)	41 (38.0)	.380
Diabetes	42 (7.0)	31 (6.3)	11 (10.2)	.154
Known aortic aneurysm	127 (21.0)	83 (16.8)	44 (39.6)	<.001
Prior aortic dissection	59 (9.8)	38 (7.7)	21 (19.1)	<.001
Prior aortic repair	84 (14.1)	63 (13.0)	21 (19.3)	.089
Prior CABG	28 (4.8)	23 (4.8)	5 (4.6)	.943
Prior catheterization/angiography	42 (9.1)	37 (9.6)	5 (6.5)	.392
Iatrogenic dissection	12 (2.1)	12 (2.5)	0 (0)	.136

SD, Standard deviation; IMH, intramural hematoma; CABG, coronary artery bypass grafting.

TABLE 2. Presenting symptoms and imaging findings

N (%)	Overall	Descending aortic diameter < 5.5 cm	Descending aortic diameter ≥ 5.5 cm	P value
Presenting hemodynamics				
Hypertensive	396 (65.9)	344 (70.1)	52 (47.3)	<.001
Normotensive	178 (29.6)	128 (26.1)	50 (45.5)	<.001
Hypotensive	20 (3.3)	16 (3.3)	4 (3.6)	.842
Shock	7 (1.2)	3 (0.6)	4 (3.6)	.008
Complicated	237 (38.7)	178 (35.6)	59 (52.2)	.001
Chest x-ray findings				
Normal	140 (25.5)	129 (29.1)	11 (10.6)	<.001
Widened mediastinum	249 (46.2)	190 (43.5)	59 (57.8)	.009
Abnormal aortic contour	244 (46.2)	187 (43.8)	57 (56.4)	.022
Displacement/calcification of aorta	47 (9.1)	30 (7.2)	17 (17.2)	.002
Pleural effusion	84 (16.1)	61 (14.5)	23 (23.0)	.037
Additional imaging findings				
Periaortic hematoma	90 (16.3)	62 (13.7)	28 (28.0)	<.001
Patent false lumen	230 (47.9)	199 (50.1)	31 (37.3)	.034
Partial false lumen thrombosis	175 (36.5)	131 (33.0)	44 (53.0)	.001
Complete thrombosis	75 (15.6)	67 (16.9)	8 (9.6)	.099
Mean descending aorta diameter	4.40 (±1.35)	3.90 (±0.74)	6.62 (±1.22)	<.001
Site origin LSA	335 (56.0)	287 (58.7)	48 (44.0)	.005
Site origin descending aorta	135 (22.6)	98 (20.0)	37 (33.9)	.002
Site origin abdominal	21 (3.5)	18 (3.7)	3 (2.8)	.634

"Complicated" includes those with mesenteric ischemia, acute renal failure, limb ischemia, spinal cord ischemia, shock, periaortic hematoma, recurrent pain, refractory pain, or refractory hypertension. LSA, Left subclavian artery.

5.4; $P = .012$), and periaortic hematoma (OR, 3.4; $P = .019$) (Table 4).

DISCUSSION

The risks of aortic dissection or rupture are thought to increase with increasing aortic diameter, and for thoracic aortic aneurysms larger than 6 cm, the annual risk of aortic dissection, rupture, or death is approximately 15%.⁵⁻⁷ The natural history analysis by Elefteriades⁵ revealed a sharp hinge point of risk for descending thoracic aortas 7 cm or greater, where aortic dissection or rupture becomes more likely. Current guidelines therefore recommend elective descending thoracic aortic intervention in cases of an aortic

diameter larger than 5.5 or 6.0 cm in an effort to prevent life-threatening complications.⁵⁻⁹

Our IRAD data show that more than 80% of patients with ABAD in the IRAD had an aortic diameter less than 5.5 cm at presentation. On this basis, elective surgery would not have been indicated to prevent aortic B dissection according to current guidelines. Elefteriades⁵ showed that the annual incidence of thoracic aortic rupture gradually increased from 0% to 3.6% in patients with aortic diameters of 3.5 cm and 6.0 cm, respectively, whereas the incidence of aortic dissection only increased from 2.2% to 3.7% for patients with similar aortic measurements. Therefore, the relationship between increasing aortic diameter and risk of aortic

TABLE 3. In-hospital management and outcomes

N (%)	Overall	Descending aortic diameter < 5.5 cm	Descending aortic diameter ≥ 5.5 cm	P value
Definitive management				
Medical	426 (69.7)	360 (72.0)	66 (59.5)	.009
Surgery	147 (24.1)	103 (20.6)	44 (39.6)	<.001
Endovascular	38 (6.2)	37 (7.4)	1 (0.9)	.008
In-hospital mortality	53 (9.6)	30 (6.6)	23 (23.0)	<.001
Medical	29 (7.7)	14 (4.4)	15 (25.4)	<.001
Surgery	20 (14.5)	12 (12.2)	8 (20.0)	.240
Endovascular	4 (11.1)	4 (11.4)	0 (0)	.732

FIGURE 2. In-hospital mortality related to the descending aortic diameter. The in-hospital mortality was 6.6% for patients with an aortic diameter less than 5.5 cm and 23.0% for patients with an aortic diameter 5.5 cm or greater ($P < .001$).

rupture is far more linear than that for aortic dissection. This calls to mind the notion that fundamentally, rupture and dissection presumably have different triggers, and current science is inadequate for risk assessment and prevention. The median diameter of ABAD in the IRAD cohort was 4.1 cm, and it was surely even smaller when the acute event occurred, because the aortic measurements reported in the registry were obtained after acute dissection. These aortic diameters are also considerably smaller than those reported for ruptured descending thoracic aortas, which usually range from 6 to 8 cm.^{5-8,11-13}

Although ABAD seems to occur at a considerably smaller size than the current threshold for elective descending thoracic aortic repair, lowering the cutoff for aortic intervention is certainly not the solution for this problem. It is likely that many affected individuals in the world have a descending aorta larger than 4 cm in diameter. Yet, we believe that only a small fraction will ultimately dissect. The medical, emotional, and financial risk of intervening on this population would be substantial and unpredictable. Before eventually genetic, proteomic, or imaging profiles help to identify patients at high risk, a conservative approach is justified.

TABLE 4. Independent predictors of death in patients with aortic diameter less than 5.5 cm

Variable	Odds ratio	95% CI	P value
Hypotension/shock	8.60	2.30–32.04	.001
Acute renal failure	3.56	1.28–9.87	.014
Mesenteric ischemia	5.42	1.45–20.28	.012
Peri-aortic hematoma	3.40	1.22–9.49	.019

CI, Confidence interval.

Predicting ABAD seems to be more difficult than predicting descending thoracic aortic rupture, and other risk factors than increasing aortic diameter may play an important role in the development of ABAD. Identification of patients with aortic diameters less than 5.5 cm who are at risk for developing acute aortic events remains essential. Patients with ABAD with an aortic diameter less than 5.5 cm presented more frequently with hypertension, whereas the overall prevalence of preexisting hypertension before dissection was similar in both groups (<5.5 cm and ≥5.5 cm). In this context, poor blood pressure control may play a role in the cause of ABAD in patients with an aortic diameter less than 5.5 cm.

In patients with Marfan syndrome, the risk of aortic dissection and rupture, particularly of the aortic root, is increased,^{5,6,14} and the thresholds for prophylactic aortic replacement are typically lower for this specific patient group.^{5,6,14-17} In the IRAD ABAD cohort, the incidence of Marfan syndrome was not increased among patients with an aortic diameter less than 5.5 cm, but the mean aortic diameter tended to be even slightly larger in patients with Marfan syndrome than in others (4.68 vs 4.32 cm). Although type B aortic dissection did not develop in patients with Marfan syndrome and smaller aortic diameters than patients without Marfan syndrome in the IRAD, conclusions are difficult to draw with a limited sample size.

It remains unclear whether the patients in whom type B aortic dissections develop in aortas less than 5.5 cm are different from others. The IRAD cannot be used to investigate which patients are at risk of developing ABAD because of the observational nature of this registry and the absence

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of a disease-free control group. Several inherited connective tissue disorders are known to affect the integrity of the arterial wall, resulting in increased risks of aortic dissection, aneurysm formation, and rupture, such as Marfan syndrome, Ehlers–Danlos syndrome type IV, Turner’s syndrome, and other less well-known connective tissue disorders that have been associated with aortic dissection.^{18–21} Recent research has focused on the genetic and proteomic background of thoracic aortic disease, and it seems that up to 20% of patients with thoracic aortic aneurysms or dissections have a family history of thoracic aortic disease without being affected by any syndrome.^{5,22,23} Research projects on aortic diseases, such as the National Registry of Genetically Triggered Thoracic Aortic Aneurysms and Cardiovascular Conditions, have been established to further investigate genetically triggered thoracic aortic disease and the optimal clinical management of these patients.²⁴ Such initiatives may improve the current knowledge on individualized treatment of the descending thoracic aorta with a diameter less than 5.5 cm, who are at high risk for ABAD and require prophylactic thoracic aortic medical treatment or intervention to prevent its development.

Although ABADs developed in aortas less than 5.5 cm in the majority of patients in the IRAD, complicated ABAD was more common among patients with an aortic diameter 5.5 cm or greater. In particular, periaortic hematoma, suggesting “contained” aortic rupture, was more common among these patients, who subsequently underwent surgery. The increased incidence of complicated ABAD among patients with an aortic diameter greater than 5.5 cm paralleled with increased mortality in this group.

The present study has several strengths and limitations. The IRAD database contains the largest series of patients with ABAD to date, which provided a unique opportunity to investigate the relationship between aortic diameter and ABAD. Aortic size measurements were obtained after acute dissection and thus would tend to overestimate size, which further supports the inaccuracy of aortic diameter as a predictor of ABAD. Unfortunately, the IRAD does not have a disease-free control group, and therefore the data cannot be used to investigate which patients are at risk of developing ABAD. Furthermore, data regarding blood pressure control before the event, which may play an important role in the cause of dissection, were unavailable in IRAD.

CONCLUSIONS

The majority of patients with ABAD present with a descending aortic diameter less than 5.5 cm and miss the threshold for elective descending thoracic aortic repair. The findings of the present study suggest that descending aortic diameter is not a useful parameter to predict acute type B dissection. To prevent ABAD, further natural history studies are needed, as well as research on genetic predispo-

sition for thoracic aortic disease. These may reveal other risk factors for aortic dissection in addition to increasing aortic diameter, resulting in better medical and interventional criteria for prophylactic thoracic aortic repair.

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APPENDIX 1

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