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ORIGINAL RESEARCH

Ascending Aortic Length and Its Association With Type A Aortic Dissection

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BACKGROUND: The aim of this study was to determine the role of ascending aortic length and diameter in type A aortic dissection.

METHODS AND RESULTS: Computed tomography scans from patients with acute type A dissections (n=51), patients with proximal thoracic aortic aneurysms (n=121), and controls with normal aortas (n=200) were analyzed from aortic annulus to the innominate artery using multiplanar reconstruction. In the control group, ascending aortic length correlated with diameter (r^2=0.35, P<0.001), age (r^2=0.17, P<0.001), and sex (P<0.001). As a result of immediate changes in aortic morphology at the time of acute dissection, predissection lengths and diameters were estimated based on models from published literature. Ascending aortic length was longer in patients immediately following acute dissection (median, 109.7 mm; interquartile range [IQR], 101.0–115.1 mm), patients in the estimated predissection group (median, 104.2 mm; IQR, 96.0–109.3 mm), and patients in the aneurysm group (median, 107.0 mm; IQR, 99.6–118.7 mm) in comparison to controls (median, 83.2 mm; IQR, 74.5–90.7 mm) (P<0.001 all comparisons). The diameter of the ascending aorta was largest in the aneurysm group (median, 52.0 mm; IQR, 45.9–58.0 mm), followed by the dissection group (median, 50.3 mm; IQR, 46.6–57.5 mm), and not significantly different between controls and the estimated predissection group (median, 33.4 mm [IQR, 30.7–36.7 mm] versus 35.2 mm [IQR, 32.6–40.3 mm], P=0.09). After adjustment for diameter, age, and sex, the estimated predissection aortic lengths were 16 mm longer than those in the controls and 12 mm longer than in patients with nondissected thoracic aneurysms.

CONCLUSIONS: The length of the ascending aorta, after adjustment for age, sex, and aortic diameter, may be useful in discriminating patients with type A dissection from normal controls and patients with nondissected thoracic aneurysms.

Key Words: aortic dissection ■ cardiovascular surgery ■ computed tomography ■ epidemiology ■ imaging

Patients with ascending thoracic aortic aneurysms (TAAs) are at elevated risk for aortic dissection or rupture. Current clinical guidelines suggest elective repair of most ascending TAAs at diameters ≥55 mm to prevent these complications.[1–4] However, data from IRAD (International Registry of Acute Aortic Dissection) demonstrated that using a diameter cutoff of ≥55 mm fails to identify nearly 60% of patients treated for acute type A aortic dissection (ATAD).[5,6] Furthermore, as acute expansion of the aorta as a consequence of type A dissection is well described, aortic sizes before dissection are smaller than immediately postdissection[7]; therefore, the proportion of patients at risk for ATAD missed by current guideline threshold diameters is underestimated[8]. Rylski et al[6] adjusted the aortic diameters in patients presenting with ATAD to their predissection sizes and found that >90% of patients with ATAD would not meet diameter thresholds for elective repair of their TAA before dissection. Better clarity surrounding the role of TAA dimensions and risk of dissection is urgently needed.

Previously, with limitations in computed tomography (CT) imaging analysis, aortic diameter as measured in the axial plane was the only readily available dimension

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CLINICAL PERSPECTIVE

What Is New?

- After adjusting for age, sex, and aortic diameter, patients with type A aortic dissection presented with ascending aortas that were 16 mm longer than in normal controls and 12 mm longer than in patients with nondissected aneurysms.
- Alternatively, patients with type A aortic dissection presented with ascending aortas that were 16% to 19% longer than expected given age, sex, and aortic diameter.

What Are the Clinical Implications?

- Absolute aortic diameter or length cutoffs have significant limitations in distinguishing patients at risk for aortic dissection.
- Comparing ascending aortic length with expected length using a multivariable model is a promising approach to detect patients before dissection.

Nonstandard Abbreviations and Acronyms

ATAD	acute type A dissection
IRAD	International Registry of Acute Aortic Dissection
TAA	thoracic aortic aneurysm
TAIPAN	Tübingen Aortic Pathoanatomy
UHN	University Health Network

accessible to clinicians. However, with the advent of multiplanar reconstruction and centerline analysis, more refined assessments of geometric changes associated with aortic aneurysms are possible. The use of aortic length to identify patients at risk for ATAD was introduced as part of the TAIPAN (Tübingen Aortic Pathoanatomy) project, in which the lengths of the ascending aorta in 150 patients who had aortic dissection were observed to be significantly longer than control patients.[9] More recently, the Yale group proposed that an ascending aortic length of 11 cm had a stronger association than diameter with long-term aortic adverse events.[10] However, neither study accounted for the geometric changes associated with the dissection event.[6,8]

Our study examines aortic dimensions, ie, diameter and length, in patients who have had ATAD and compares aortic geometry with normal aortic controls and patients with nondissected ascending TAAs. Dissection patients are also modeled to their pre-ATAD aortic geometry based on previously reported models[6,8,10] for additional analysis. We hypothesize that increased aortic length may be a distinguishing feature of patients who have had an ATAD.

METHODS

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Study Population

This study was approved by the research ethics board of the University Health Network (UHN), Toronto, Canada. Informed consent was waived for this study.

The Division of Cardiovascular Surgery Database at UHN was reviewed for surgical cases between January 2016 to December 2018. In this period, a total of 65 patients underwent surgery for ATAD. Of these patients, 57 had CT scans available for review. After excluding patients with connective tissue disease (n=6), 51 patients formed our postdissection cohort. All scans were performed within 24 hours of symptom onset and before surgical treatment at UHN.

Our aneurysm cohort (n=121) consisted of patients who had undergone surgery for ascending TAAs and those with small aneurysms under surveillance between January 2016 to December 2018. Patients with previous dissections and known connective tissue diseases were excluded.

Our control cohort (n=200) was formed through review of chest and abdominal CT scans with contrast performed at UHN in January 2016. Scans performed for aortic related indications such as those for ruling out aortic dissection and/or rupture and those for following known aneurysms, or postaortic repair, were excluded. Scans that incidentally diagnosed the presence of aortic disease, as determined by review of the radiologists' reports, were also excluded.

All patient records were reviewed, and relevant clinical data were collected. Height was available for all patients in the aneurysm and postdissection cohorts; however, for a majority of the control patients (n=113 [73%]), height data were unavailable for review. In the control patients for whom height was available, we observed a strong correlation between T1-L5 measurement and patient height (r^2=0.61, P<0.001) (Figure S1). Therefore, for the control cohort, T1-L5 measurements were used as a surrogate for patient height.

Aortic Dimension Measurements

All image analysis for this study was performed using Aquarius iNtuition (TeraRecon, Inc.). In the coronal view, digital markers were placed from the annulus to the most distal end of the visible aorta, ensuring accurate coverage up to the aortic arch (Figure 1A). A semiautomatic centerline was generated through the entire length of the aorta, with manual inspection for appropriate symmetry around the centerline. For aortic length measurements, manually placed markers at the annulus and proximal limit of the origin of the innominate artery were used to define the ascending aorta (Figure 1B) (Video S1). The maximal diameter measurements for this segment were then generated from built-in volume analysis tools, with manual inspections and adjustments made as needed.

Predissection Estimates

Recent literature comparing patients with available predissection and postdissection imaging studies report an immediate and significant increase in aortic dimensions as a direct result of aortic dissection.[6,8,10] Two groups have reported increases in both aortic diameter and length of the ascending aorta as measured exclusively with CT and multiplanar reconstruction, pre-ATAD and immediately following ATAD: Rylski et al[8] (n=63) and Wu et al (n=10).[10] These patients had ATADs and CT scans from before the dissection that were available for review and reanalysis. Rylski et al found a median increase of 12.8 mm (+32%) in diameter and 5.4 mm (+5.4%) in length and Wu et al found a mean increase of 8 mm (+18%) in diameter and 3 mm (+2.7%) in length of the ascending aorta following dissection. A weighted average based on these models was calculated, resulting in an estimated 30% increase in diameter and 5% increase in length of the ascending aorta as a result of acute aortic dissection. Analysis was repeated using the Rylski et al and Wu et al models separately and similar results were achieved, suggesting robustness of our findings (Figure S2). We applied these factors to the CT measurements recorded from the postdissection cohort, and the resulting adjusted measurements comprised the dimensions of our estimated predissection cohort.

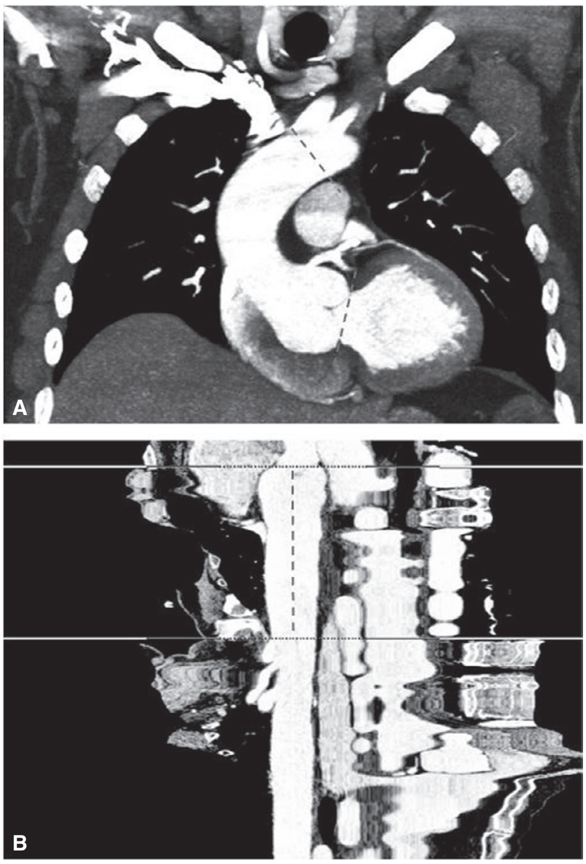

Figure 1. Measuring ascending aortic length by computed tomography.
(**A**) Markers placed at the annulus and proximal innominate artery define the proximal and distal boundaries of the ascending aorta. (**B**) Ascending aortic length is measured on the centerline analysis as shown.

Statistical Analysis

All continuous data are presented as median and interquartile range [quartile 1–quartile 3]. All categorical data are presented as an absolute number with accompanying percentage. To assess between-group differences in continuous variables, we considered Mann-Whitney tests for 2-group comparisons and Kruskal-Wallis tests for 3-group comparisons. If the overall between-group difference was statistically significant, multiple comparison using Dunnett tests was performed to determine the pairs of groups with significant differences.

Linear regression models were used to quantify the associations of independent variables with aortic length and diameter. Factors associated with aortic length in univariate analysis were then used in a multivariable linear regression model for aortic length.

All analyses assumed a significance level of 5% and were implemented using Prism 5 (GraphPad) and R version 3.6.2 (RStudio).

RESULTS

Demographic data for the control, aneurysm, and dissection groups are found in the Table. The dissection group was the youngest (median age, 60 years; interquartile range [IQR], 51–74 years), with mostly men (67 %) and a high rate of hypertension (73%). There was only 1 patient in the dissection cohort with a bicuspid aortic valve.

Normal Ascending Aortic Dimensions

Aortic morphology of the control group was evaluated to establish normal diameter (median, 33.4 mm; IQR,

Table. Patient Demographics and Clinical Variables

	Control Patients (n=200)	Patients With Aneurysm (n=121)	Patients With Dissection (n=51)
Age, y	62 (51–72)	65 (55–71)	60 (51–74)
Women, %	54	37	33
Weight, kg	…	77 (67–85)	79 (69–92)
Height, kg	…	170 (161–177)	170 (160–177)
T1-L5, mm*	431 (408–452)	…	…
Hypertension, %	…	54	73
Dyslipidemia, %	…	26	26
BAV, %	…	34	2.0

Continuous variables are displayed as median (interquartile range) and categorical variables are displayed as percentage.
BAV indicates bicuspid aortic valve.
*T1-L5 as measured from top of T1 to bottom of L5 in the sagittal plane.

30.7–36.7 mm) and length (median, 83.2 mm; IQR, 74.5–90.7 mm) measurements of the ascending aorta. Increased age was associated with wider and longer aortas in both women (diameter: r^2=0.26 [P<0.001]; length: r^2=0.14 [P<0.001]) and men (diameter: r^2=0.24 [P<0.001]; length: r^2=0.16 [P<0.001]) (Figure 2A and 2B). Women had smaller aortas than men, in diameter (31.7 mm versus 36.1 mm, respectively; P<0.001) and length (79.6 mm versus 88.0 mm, respectively; P<0.001) (Figure 2C and 2D). The surrogate height, defined by linear measurement from the top of T1 to the bottom of L5 in the sagittal plane, of men (median, 450.0 mm; IQR, 432.7–466.6 mm) was taller than women (median, 412.8 mm; IQR, 397.2–431.1 mm) (P<0.001).

Surrogate height had no correlation with aortic diameter in men or women (Figure 2E). Increasing surrogate height had minimal and likely no correlation with ascending aortic length of men only (r^2=0.04, P=0.05) (Figure 2F). A significant positive association between aortic length and diameter was observed in women (r^2=0.23, P<0.001) and men (r^2=0.24, P<0.001) (Figure 2G).

Ascending Aortic Diameter in Patients With Aneurysms and Dissections

Diameters of the ascending aorta in the postdissection group were similar to those in the aneurysm group (median, 50.3 mm [IQR, 46.6–57.5 mm] versus 52.0 mm [IQR, 45.9–58.0 mm], P>0.90), and were both larger than the aortic diameter of the control group (median, 33.4 mm; IQR, 30.7–36.7 mm [P<0.001]) (Figure 3A).

Unlike the control group, there was no significant difference between ascending aortic diameters of women and men in the postdissection cohort (median, 53.4 mm [IQR, 44.9–58.6 mm] versus 50.3 mm [IQR, 47.0–55.7 mm], P=0.99) or aneurysm cohort (median, 50.1 mm [IQR, 44.9–57.8 mm] versus 53.2 mm [IQR, 47.9–58.6 mm], P=0.12). There was no correlation between age or height and aortic diameter in the aneurysm or postdissection cohorts (Table S1).

In the postdissection group, 36 of 51 (70.6%) patients presented with ascending aortic diameters ≤55 mm, below the diameter threshold for elective surgical repair. In the aneurysm group, 45 of 121 (37.2%) patients had TAAs ≥55 mm with no evidence of dissection.

Ascending Aortic Length in Aneurysms and Dissections

The length of the ascending aorta in the aneurysm group (median, 107.0 mm; IQR, 99.6–118.7 mm) was not statistically different than the length of the aorta in the postdissection group (median, 109.7 mm; IQR, 101.0–115.1 mm) (P>0.90). Both the lengths in the aneurysm and postdissection groups were significantly longer than the control group (median, 83.2 mm; IQR, 74.5–90.7 mm) (all P<0.001) (Figure 3B).

Ascending aortic length of the postdissection group showed no significant difference between women and men (median, 109.4 mm [IQR, 93.3–113.8 mm] versus 110.8 mm [IQR, 104.6–117.1 mm], P=0.10); however, the length of the ascending aorta in women was shorter than that in men in the aneurysm group (median, 99.9 mm [IQR, 90.6–107.2 mm] versus 113.3 mm [IQR, 102.5–122.1 mm], P<0.001). The length of the ascending aorta in the postdissection and aneurysm groups was not correlated with age. The height of patients in these groups had no association with the length of the ascending aorta in men. The height of women correlated modestly with the length of the ascending aorta in only the aneurysm group (Table S1).

An 11-cm aortic length cutoff, proposed by Wu et al, was suggested after identifying 2 aortic length hinge points with sharp increases in yearly occurrence of adverse aortic events: 11.5 cm to 12.0 cm and 12.5 cm to 13.0 cm.[10] An 11-cm length cutoff would capture 23

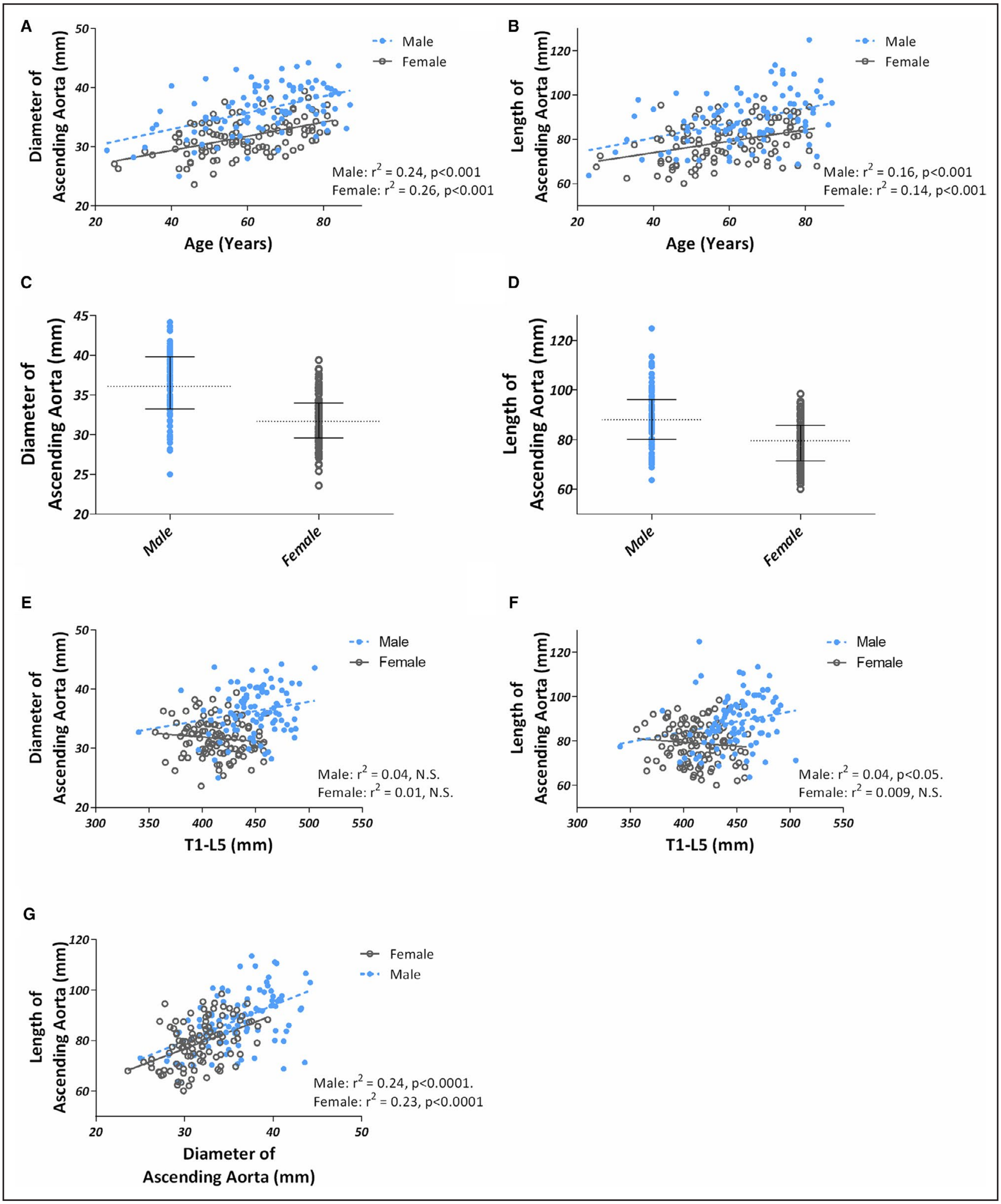

Figure 2. Diameter and length of normal ascending aortas and their relationship with clinical variables.
(**A**) The diameter of the ascending aorta positively correlates with increasing age in men and women. (**B**) The length of the ascending aorta also positively correlates with increasing age in men and women. (**C**) The diameter of the ascending aorta was significantly larger in men than in women. (**D**) The length of the ascending aorta was significantly longer in men than in women. (**E**) The diameter of the ascending aorta does not correlate with surrogate height, as measured from T1-L5 vertebrae. (**F**) There is minimal and likely no correlation between the length of the ascending aorta. (**G**) The length of the ascending aorta has a strong, positive association with the diameter of the ascending aorta in men and women. Blue circles: men, open grey circles: women. Linear regression are represented by r^2 and *P* values.

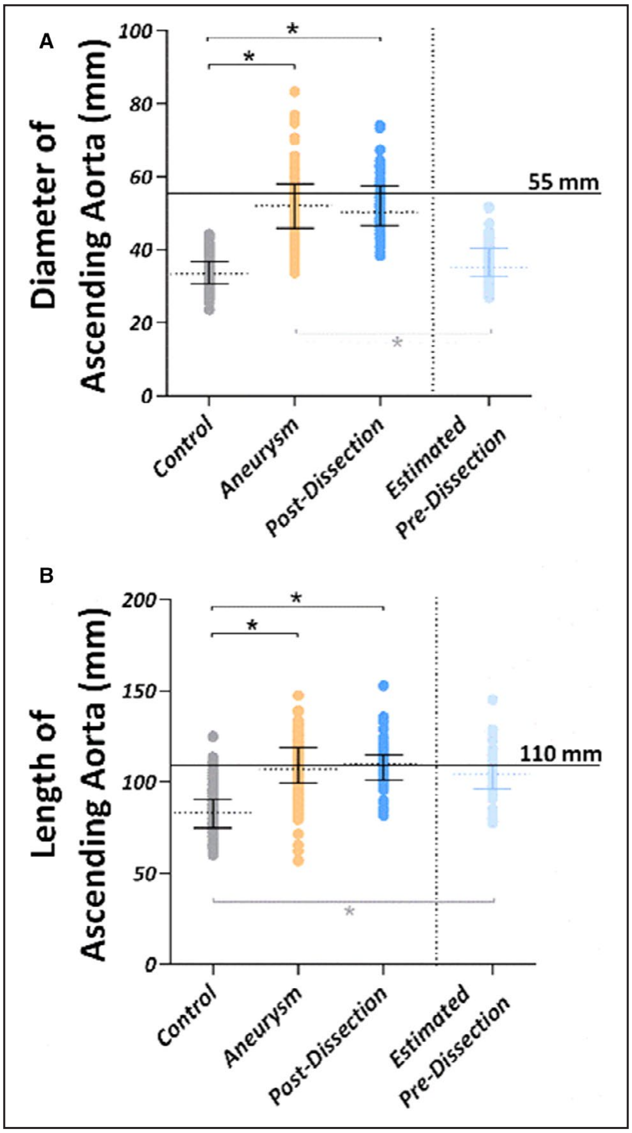

Figure 3. Comparison of ascending aortic diameter and length as measured by computed tomography between patient groups: control patients with normal aortas (grey), patients with ascending aortic aneurysms (orange), patients who had acute aortic dissection (dark blue), and patients who had acute aortic dissection whose aortas were modeled to their estimated predissection sizes (light blue).

(**A**) Diameter of the ascending aorta in the aneurysm group was largest, followed by diameter of the postdissection group. Both diameter in the aneurysm group and dissection group were significantly larger than in the control group. Diameter in the control group and predissection group were not significantly different. (**B**) Length of the ascending aorta in the aneurysm, postdissection, and estimated predissection groups were significantly longer than in the control group. Kruskal-Wallis test was performed for 3-group comparison (control vs aneurysm vs dissection group); Dunnett's test was performed to determine pairs with significant difference. **P*<0.001 after Dunnett test. Dotted horizontal line: median. Error bars: interquartile range.

of 51 (45%) patients in the postdissection cohort. In the aneurysm group, 52 of 121 (43%) of patients had aortic lengths ≥11 cm.

Ascending Aortic Size With Predissection Modeling

After modeling the ascending aorta to estimated predissection size, the diameter in the estimated predissection group (median, 35.2 mm; IQR, 32.6–40.3 mm) was significantly smaller than in the aneurysm group (*P*<0.001) and similar to the diameter in the control group (*P*=0.09) (Figure 3A). After modeling, the length in the estimated predissection group (median, 104.2 mm; IQR, 96.0–109.3 mm) and in the aneurysm group were not significantly different (*P*>0.90). The length in the estimated predissection group, however, was significantly longer than the length in the control group (*P*<0.0001) (Figure 3B).

After predissection modeling, we found that 51 of 51 (100%) patients underwent dissection at aortic diameters below the threshold for interventional elective surgery (<55 mm) and 49 of 51 (96%) patients underwent dissection at aortic diameters <50 mm. Using the 11-cm aortic length cutoff, only 11 of 51 (22%) patients in the predissection group would be captured before dissection onset.

Multivariable Analysis

We examined the aortic length between patient groups with adjustment for covariates with significant associations with length: age, sex, and aortic diameter. After these adjustments, the aortic length in the postdissection group was 8 mm longer than in the control group and 2 mm longer than in the aneurysm group (*P*<0.001) (Table S2).

Multivariable analysis was then repeated using estimated predissection dimensions, which corrects for the immediate changes in aortic geometry following aortic dissection. After adjustments, the estimated aortic length in the predissection group was 16 mm longer than in the control group and 12 mm longer than in the aneurysm group (*P*<0.001) (Figure 4) (Table S3). In other words, patients with ascending aortas 19% to 19% longer than expected, depending on age, sex, and aortic diameter, would be at higher risk for aortic dissection according to our model.

DISCUSSION

In this study of systematic measurement of ascending aortic diameters and lengths in patients with acute aortic dissections and TAAs, we found that length may be a distinguishing marker for acute dissection. After adjusting for covariates associated with aortic length (ie, age, sex, and aortic diameter), we found that the ascending aorta in patients who have had aortic dissection was disproportionately longer than in patients without aortic disease by 8 mm and similar to patients with aortic aneurysms (by 2 mm). If we account for the

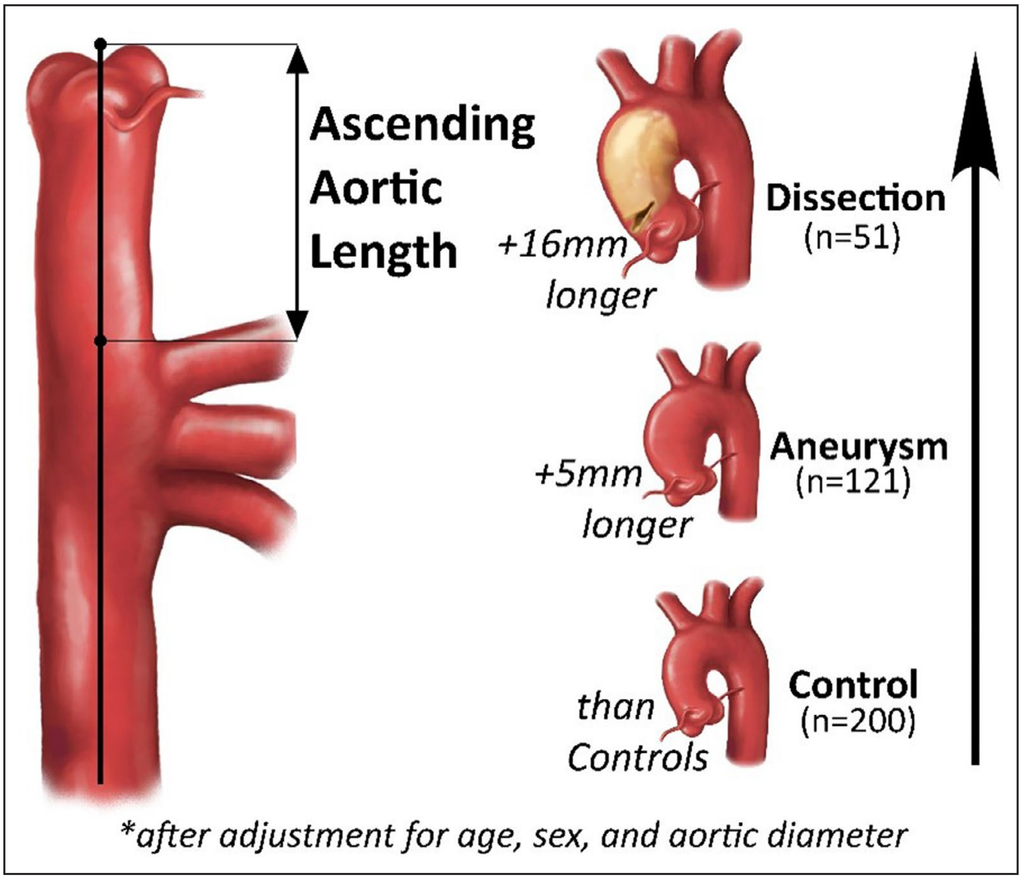

Figure 4. After adjustment for age, sex, and aortic diameter, the length of the ascending aorta for patients before type A dissection (predissection) is 16 mm longer than in patients with normal aortas.

The length of the ascending aorta in patients with nondissected aneurysms is 5 mm longer than in patients with normal aortas.

immediate geometric changes that occur with aortic dissection, we found that the ascending aorta in patients who have had aortic dissection had aortas that were 16 mm longer than patients without aortic disease, and 12 mm longer than patients with aortic aneurysms. We would therefore be concerned about the risk of dissection in patients with 16% to 19% longer aortas than expected given age, sex, and aortic diameter. On the other hand, the estimated predissection ascending aortic diameters in these same patients was not significantly different from patients without aortic disease and was significantly smaller than in patients with aortic aneurysms. Therefore, our study is in line with several previous studies that also cast doubt on the utility of diameter alone in distinguishing patients at risk for dissection[5,6,9,10] and supports the continued investigation of aortic length as a biomarker for aortic dissection.

One possible explanation for the increased aortic length phenomenon relates to a premature aging process seen in patients with vulnerable aortas. Unfolding of the ascending aorta is a well-described consequence of the aging process attributed to the modification in aortic wall microstructure.[9–14] Similar microstructural changes have been reported in younger patients who have had aortic dissection.[12,14] These changes include a decrease in elastin concentration, previously shown to impact the aorta's biomechanical function and, in turn, its geometric structure.[10,11,13,15] However, further analyses into the composition of the aortic tissue of each patient group and the pathophysiology driving the compositional changes are required.

Krüger et al[9] and the TAIPAN group were the first to examine aortic length in patients with ATAD. We corroborated their findings that increased aortic length was observed in the dissection group in comparison to patients with normal aortas. To refine this observation, we adjusted aortic length with respect to available clinical variables and found improved significance from unadjusted models. Our group also systematically used a predissection model to estimate predissection size. Through these additional analyses, we found that patients who had type A aortic dissection before their dissection had estimated aortic lengths 16 mm longer than would be expected.

Wu et al evaluated the yearly occurrence of adverse aortic events at varying aortic lengths and diameters, and their findings also support aortic elongation as an important finding in patients at risk for aortic dissection. They further identified hinge points in predicted aortic risk models and suggested that an aortic length cutoff of 11 cm may be used for risk evaluation of patients with TAAs.[10] However, more than half of the patients included in our study would have failed to be identified before presentation with aortic dissection. Our approach, rather than using an absolute cutoff value for length, incorporates easily accessible variables to provide a more nuanced and individualized approach to answer the question of "how long is too long?" The increases in ascending aortic length seen in the predissection group are relative to what would be expected for an individual given a specific age and sex. Larger population studies are required before recommending any relative increases in length as signaling a clinically important increase that would prompt elective surgery.

Study Limitations

The most important limitation of this study is the use of a predissection model to estimate aortic dimensions before ATAD onset. Given the spontaneous nature of aortic dissection, adequate predissection imaging studies are typically unavailable. However, not adjusting for the geometric changes resulting from the dissection would misrepresent the patient population at risk, as reported in previous predissection and postdissection imaging studies.[5,6] While this predissection modeling would not be accurate on an individual patient level, when applied to a larger cohort for examination of global trends, issues with individual variability are mitigated.[6] Although our study is limited in this manner, we believe the novel and intriguing findings are a worthy contribution to this emerging literature.

Our cross-sectional population analysis demonstrated a positive association between age and length of the ascending aorta, suggesting aortic elongation with increasing age. However, an individual's growth curve is unique. Whether the patients who had aortic dissection arrived at longer aortic lengths than would be expected for their age and sex quickly over a short period, or gradually over a longer period, is not captured using our methodology.

We acknowledge that our multivariable model of aortic length was not an exhaustive model of all potential factors that may influence aortic length. For example, while the literature on aortic length in general is sparse, previous studies have reported notable relationships between hypertension, atherosclerosis, and aortic elongation.[10,16,17] We were limited by the retrospective nature of our study, which made acquisition of clinical variables, particularly in the control cohort, difficult. However, the simplicity of our model also increases its clinical utility.

In this study, adjusted aortic length was able to better classify patients presenting with aortic dissection from patients with nondissected aneurysm over diameter alone. However, dissection or rupture of wider aortic sizes does occur, and therefore aneurysms >55 mm should still be considered at risk until better biomarkers are validated.

CONCLUSIONS

The length of the ascending aorta, in conjunction with patient demographics and diameter of the ascending aorta, discriminated patients with type A aortic dissection from patients without aortic disease and nondissected TAAs better than aortic diameter alone. As more groups develop interest in aortic length, compilation and sharing of data would lead to more robust modeling of geometric parameters and their association with aortic dissection.

ARTICLE INFORMATION

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Disclosures

None.

Supplementary Material

Video S1
Tables S1–S3
Figures S1–S2

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SUPPLEMENTAL MATERIAL

Table S1. Relationships between dimensions of the ascending aorta and the age and height of the patient, across groups of patients with normal aortas (Control), ascending aortic aneurysms and aortic dissection.

	Control				**Aneurysm**				**Dissection**			
Diameter	**Male**		**Female**		**Male**		**Female**		**Male**		**Female**	
	r^2	**p value**	**r^2**	**p value**	**r^2**	**p value**	**r^2**	**p value**	**r^2**	**p value**	**r^2**	**p value**
Age	***0.24***	***<0.001***	***0.26***	***<0.001***	0.01	0.45	0.00	0.92	0.02	0.38	0.06	0.36
Height*	0.04	0.051	0.01	0.27	0.00	0.83	0.05	0.15	0.09	0.08	0.07	0.32
Length	**Male**		**Female**		**Male**		**Female**		**Male**		**Female**	
	r^2	**p value**	**r^2**	**p value**	**r^2**	**p value**	**r^2**	**p value**	**r^2**	**p value**	**r^2**	**p value**
Age	***0.16***	***<0.001***	***0.14***	***<0.001***	0.03	0.16	0.02	0.38	0.05	0.22	0.04	0.43
Height*	***0.04***	***0.05***	0.01	0.34	0.01	0.48	***0.15***	***0.01***	0.01	0.62	0.00	0.79

Linear regression was used to analyze these relationships. *Height of Control patients were unavailable for review. For the Control cohort, T1-L5 measurements were used as surrogate height.

Table S2. **Coefficient summary of multivariable linear regression analysis with post-dissection measurement (Dissection).**

	Coefficients	Standard Error	t-value	p-value
Age by decade (year)	0.08	0.04	2.04	0.04
Sex (male)	7.50	1.15	6.51	<0.001
Diameter (mm)	0.90	0.08	10.74	<0.001
Patient Group:				
Aneurysm	5.28	1.97	2.68	0.01
Dissection	7.68	2.22	3.46	<0.001

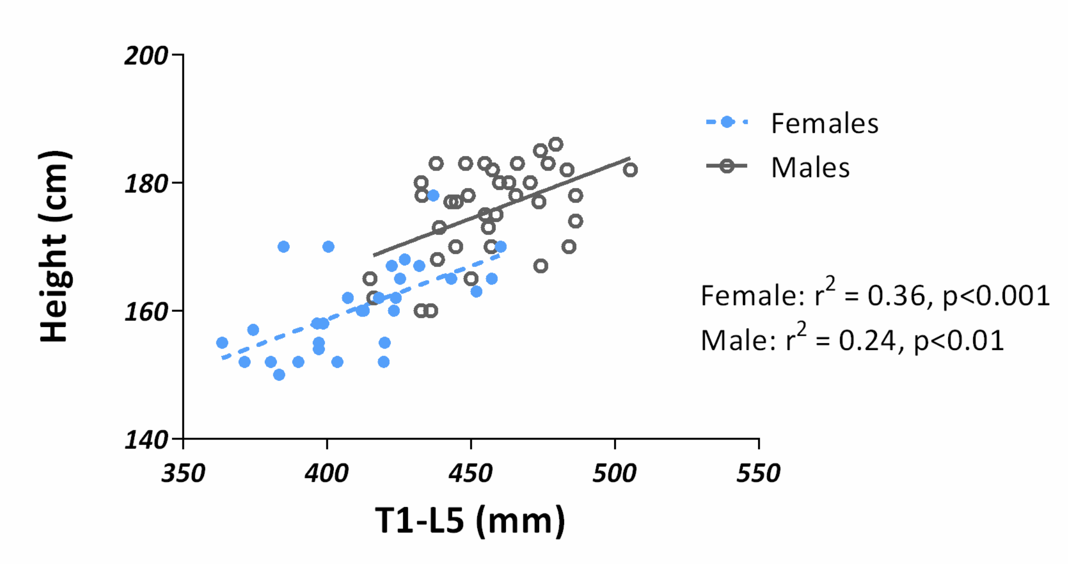
Each co-variant adds significant value to the model. R^2=0.66, p<0.001.

Table S3. Coefficient summary of multivariable linear regression analysis with estimated pre-dissection measurement (Pre-Dissection).

	Coefficients	Standard Error	t-value	p-value
Age by decade (year)	0.08	0.04	1.94	0.05
Sex (male)	7.31	1.15	6.38	<0.001
Diameter (mm)	0.95	0.09	10.73	<0.001
Patient Group:				
Aneurysm	4.46	2.03	2.20	0.01
Pre-dissection	16.21	1.67	9.73	<0.001

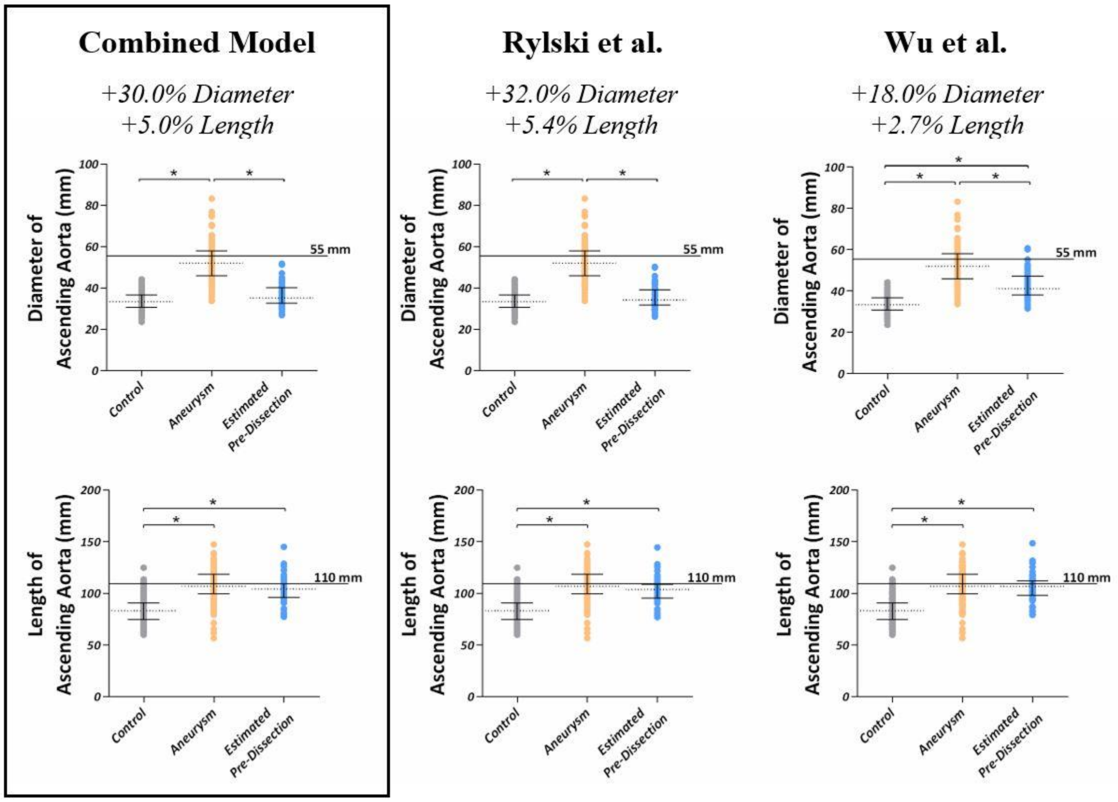
Each co-variant adds significant value to the model. R^2=0.64, p<0.001.

Figure S1. **Relationship between patient height and T1-L5 length measurement.**



There is strong, positive association between height and T1-L5 measurements in both males and females. T1-L5 is taken as surrogate height, given their significant association in males and females.

Figure S2. Comparison of weighted average pre-dissection estimate model with individual averaged models.



Comparable results were observed across all models.

Supplemental Video Legend:

Video S1. The video shows how to measure ascending aortic length using computed tomography and centerline methodology. Best viewed with Windows Media Player.