Height alone, rather than body surface area, suffices for risk estimation in ascending aortic aneurysm

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ABSTRACT

Background: In international guidelines, risk estimation for thoracic ascending aortic aneurysm (TAAA) is based on aortic diameter. We previously introduced the aortic size index (ASI), defined as aortic size/body surface area (BSA), as a predictor of aortic dissection, rupture, and death. However, weight might not contribute substantially to aortic size and growth. We seek to evaluate the height-based aortic height index (AHI) versus ASI for risk estimation and revisit our natural history calculations.

Methods: Aortic diameters and long-term complications of 780 patients with TAAA were analyzed. Growth rate estimates, yearly complication rates, and survival were assessed. Risk stratification was performed using regression models. The predictive value of AHI and ASI was compared.

Results: Patients were stratified into 4 categories of yearly risk of complications based on their ASI and AHI. ASIs (cm/m^2) of ≤2.05, 2.08 to 2.95, 3.00 to 3.95 and ≥4, and AHIs (cm/m) of ≤2.43, 2.44 to 3.17, 3.21 to 4.06, and ≥4.1 were associated with a 4%, 7%, 12%, and 18% average yearly risk of complications, respectively. Five-year complication-free survival was progressively worse with increasing ASI and AHI. Both ASI and AHI were shown to be significant predictors of complications ($P < .05$). AHI categories 3.05 to 3.69, 3.70 to 4.34, and ≥4.35 cm/m were associated with a significantly increased risk of complications ($P < .05$). The overall fit of the model using AHI was modestly superior according to the concordance statistic.

Conclusions: Compared with indices including weight, the simpler height-based ratio (excluding weight and BSA calculations) yields satisfactory results for evaluating the risk of natural complications in patients with TAAA. (J Thorac Cardiovasc Surg 2018;155:1938-50)

Height (inches)	Height (m)	Aortic Size (cm) 3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0
55	*1.40*	2.50	2.86	3.21	3.57	3.93	4.29	4.64	5.00	5.36	5.71
57	*1.45*	2.41	2.76	3.10	3.45	3.79	4.14	4.48	4.83	5.17	5.52
59	*1.50*	2.33	2.67	3.00	3.33	3.67	4.00	4.33	4.67	5.00	5.33
61	*1.55*	2.26	2.58	2.90	3.23	3.55	3.87	4.19	4.52	4.84	5.16
63	*1.60*	2.19	2.50	2.81	3.13	3.44	3.75	4.06	4.38	4.69	5.00
65	*1.65*	2.12	2.42	2.73	3.03	3.33	3.64	3.94	4.24	4.55	4.85
67	*1.70*	2.06	2.35	2.65	2.94	3.24	3.53	3.82	4.12	4.41	4.71
69	*1.75*	2.00	2.29	2.57	2.86	3.14	3.43	3.71	4.00	4.29	4.57
71	*1.80*	1.94	2.22	2.50	2.78	3.06	3.33	3.61	3.89	4.17	4.44
73	*1.85*	1.89	2.16	2.43	2.70	2.97	3.24	3.51	3.78	4.05	4.32
75	*1.90*	1.84	2.11	2.37	2.63	2.89	3.16	3.42	3.68	3.95	4.21
77	*1.95*	1.79	2.05	2.31	2.56	2.82	3.08	3.33	3.59	3.85	4.10
79	*2.00*	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
81	*2.05*	1.71	1.95	2.20	2.44	2.68	2.93	3.17	3.41	3.66	3.90

= low risk (~ 4% per year) = moderate risk (~ 7% per year) = High risk (~ 12% per year) = severe risk (~ 18% per year)

Light green area indicates low risk, yellow area indicates moderate risk, orange area indicates high risk, and red area indicates severe risk.

Risk of complications in ascending aortic aneurysm as a function of aortic diameter and height.

Central Message

In patients with ascending aortic aneurysm, a simple aortic diameter/height ratio showed very similar performance as diameter/BSA ratio in accurately predicting the risks of dissection, rupture, and death.

Perspective

Indexing absolute aortic diameter to anthropometric measurements provides individualized risk classification in patients with thoracic aortic aneurysm. Unlike weight, height does not change during adult life, and the AHI (aortic size/height) is as good as the ASI (aortic size/BSA) for risk stratification. Therefore, height-based relative aortic measures may be a more reliable long-term predictor of risk.

See Editorial Commentary page 1951.

See Editorial page 1925.

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Abbreviations and Acronyms

AHI	= aortic height index
ASI	= aortic size index
BSA	= body surface area
CT	= computed tomography
MRI	= magnetic resonance imaging
TAA	= thoracic aortic aneurysm
TAAA	= thoracic ascending aortic aneurysm
TEE	= transesophageal echocardiography
TTE	= transthoracic echocardiography

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In international guidelines, preemptive surgical intervention criteria for thoracic ascending aortic aneurysm (TAAA) are based on absolute raw aortic diameter: ≥5.5 cm for asymptomatic TAAA and between 4.0 and 5.0 cm for various genetically effectuated aortopathies.[1,2] These size cutoffs in turn are based on the established, escalating yearly and cumulative natural risk of devastating complications—aortic rupture, dissection and/or death—with increasing degrees of aneurysmal aortic enlargement.[1,3-5]

A drawback of using aortic diameter in this regard for risk estimation is the inability to factor in a significant determinant of aortic dimensions: the patient's body size.[6] To this end, in previous work, our group introduced and validated a relative aortic measure, the aortic size index (ASI), defined as aortic diameter divided by body surface area (BSA), as a more patient-specific predictor of dissection, rupture, and death than absolute aortic diameter.[7]

However, we came to suspect that a patient's weight might not contribute substantially to aortic size and growth. Moreover, weight fluctuates throughout the lifespan and can be deliberately influenced. Furthermore, indexing patient height to aortic dimensions has recently been shown to enhance mortality prognostication in patients with TAAA.[8] Therefore, in the present study we compared the predictive value of a simple height-based relative aortic size measure, the aortic height index (AHI), defined as aortic size divided by patient height, with that of the BSA-corrected ASI for risk estimation of TAAA complications. We also revisit our previous calculations regarding the natural history of TAAA, using a significantly larger cohort of patients with ascending aortic aneurysm.

METHODS

This investigation was approved by the Human Investigation Committee of the Yale University School of Medicine.

Patients

As part of our ongoing investigations into the natural history of thoracic aortic aneurysm (TAA), our database at the Aortic Institute at Yale–New Haven Hospital currently includes a total of 3349 patients with TAA. Among these, 780 patients with a TAAA, with a total of 1272 ascending aortic size measurements and a mean radiologic follow-up of 47.7 months (range, 5 days to 256.7 months), compose a subset in which all radiologic studies were reread and reanalyzed in a standardized manner[9] for the purpose of this study. Anthropometric, radiologic, and clinical data were manually accrued retrospectively from individual electronic medical records and hospital charts. All 780 patients had height and weight data available, a maximal ascending aortic size ≥3.5 cm, and at least one verified aortic size measurement. Long-term survival follow-up was performed according to the Yale Aortic Institute method as described previously.[10] Exclusion criteria included chronic Stanford type A and type B dissection

TABLE 1. Patient characteristics

Variable	Value
Total number of patients	780
Males, n (%)	530 (67.9)
Females, n (%)	250 (32.1)
Age, y, mean ± SD (range)	61.9 ± 15.0 (14-94)
Height, cm, mean ± SD (range)	173.8 ± 11.4 (127-206)
Weight, kg, mean ± SD (range)	87.5 ± 17.7 (41-267)
Body surface area, m^2, mean ± SD (range)	1.99 ± 0.27 (1.273-3.399)
Aortic size index, cm/m^2, mean ± SD (range)	2.507 ± 0.578 (1.354-6.624)
Aortic height index, cm/m, mean ± SD (range)	2.831 ± 0.535 (1.862-6.774)
Bicuspid aortic valve, n (%)	197 (25.2)
Bovine aortic arch, n (%)	115 (14.7)
Marfan syndrome, n (%)	31 (4.0)
Family history, n (%)	
Proven	174 (22.3)
Likely	55 (7.1)
Possible	41 (5.3)
Unknown	106 (13.6)
None	404 (51.8)
Previous cardiac surgeries, n (%)	
AVR	44 (5.6)
CABG	23 (2.9)
MVR	4 (0.5)
AVR + CABG	6 (0.8)
AVR + MVR	2 (0.3)

SD, Standard deviation; *AVR*, aortic valve replacement; *CABG*, coronary artery bypass grafting; *MVR*, mitral valve replacement.