

Differences in Echocardiographic Measures of Aortic Dimensions by Race



Troy M. LaBounty, MD^{a,*}, Theodore J. Koliass, MD^a, Eduardo Bossone, MD^{a,b}, and David S. Bach, MD^a

It is not clear whether there are differences in aortic dimensions by race. Our hypothesis was that race-specific differences in aortic size exist. We compared the relation between race and aortic dimensions among 15,295 adults without known risk factors for cardiovascular disease or aortic dilatation, who underwent clinically indicated transthoracic echocardiography. We compared inner edge-to-inner edge measurements between whites (n = 12,932), blacks (n = 958), Asians (n = 827), Hispanics (n = 366), Native Americans (n = 38), and others (n = 174). Multivariate analysis compared measurements indexed with body surface area (BSA) between races and adjusted for variables including age, gender, and mean blood pressure. Mean age was 49.9 ± 17.6 years, and 58.7% were female. On gender-specific comparisons, there were significant differences in aortic size between races ($p < 0.001$ for each). Using whites as a baseline, multivariable analysis demonstrated that blacks had smaller BSA-indexed aortic sinus (-0.34 mm/m^2 , $p < 0.001$) and ascending aorta (-0.43 mm/m^2 , $p < 0.001$) dimensions; Asians had larger BSA-indexed aortic sinus (0.36 mm/m^2 , $p < 0.001$), ascending aorta (0.41 mm/m^2 , $p < 0.001$), and aortic arch (0.20 mm/m^2 , $p = 0.002$) dimensions; Hispanics had larger BSA-indexed aortic arch dimensions (0.15 mm/m^2 , $p = 0.01$); Native Americans had increased BSA-indexed aortic arch dimensions (0.32 mm/m^2 , $p = 0.01$); and other races had increased BSA-indexed aortic arch dimensions (0.11 mm/m^2 , $p = 0.03$). In a cohort without known risk factors for aortic dilatation, race is associated with significant differences in aortic dimensions. In conclusion, these findings suggest that reference ranges for aortic size should be established using racially diverse cohorts to prevent misdiagnosis of aortic dilatation based on race. © 2019 Elsevier Inc. All rights reserved. (Am J Cardiol 2019;123:2015–2021)

Defining aortic dilatation remains challenging given various measurement techniques and available imaging modalities, and differences in aortic size related to gender, age, and body surface area (BSA).¹ Recent guidelines¹ endorse reference ranges based on small studies performed in the United States or Europe and do not define the racial makeup of their cohorts.^{2–5} There are limited data comparing aortic size by race/ethnicity.⁶ Given the potential for differences in aortic size by race/ethnicity, existing reference ranges derived from studies without defined racial/ethnic diversity may result in incorrect classification of aortic size in some individuals. Our hypothesis was that race/ethnic-specific differences in aortic size exist. We examined a cohort of individuals without known risk factors for cardiovascular disease or aortic dilatation and compared aortic diameters between individuals stratified as white (non-Hispanic), black, Asian, Hispanic, Native American, and multiracial/other categories.

Methods

We examined aortic diameters in adult patients with known race referred for a clinically indicated transthoracic

echocardiogram and with at least one outpatient or inpatient visit. As recommended by guidelines,¹ we examined adults without known cardiovascular disease or risk factors for aortic dilatation by excluding individuals with a systolic blood pressure $>140 \text{ mm Hg}$ or diastolic blood pressure $>90 \text{ mm Hg}$ (mean of 3 values); obesity; or history of hypertension, tobacco smoking, diabetes, chronic renal disease, coronary artery disease, valve replacement, bicuspid aortic valve, the Marfan syndrome, the Ehlers-Danlos syndrome, the Loeys-Dietz syndrome, aortic coarctation, aortic dissection, or aortic aneurysm. We also excluded subjects with $>$ mild aortic regurgitation, aortic valve peak gradient $\geq 16 \text{ mm Hg}$, or inadequate aorta images.

From a total population of 86,378 adults with an echocardiogram, adequate images, and known race, 16,810 individuals remained after applying clinical exclusion criteria. An additional 1,515 subjects were excluded after applying echocardiographic exclusion criteria. This resulted in a final cohort of 15,295 individuals. For patients with multiple studies, we used the first study. Aortic sinus, ascending aorta, and aortic arch diameters were available in 15,158, 10,873, and 4,735 patients, respectively. The most common echocardiography indications were dyspnea, fatigue, chest pain, syncope, presyncope, palpitations, murmur, cancer, abnormal ECG, and preoperative testing.

Race/ethnicity is simplified as “race,” and white refers to non-Hispanics for brevity. The study was approved by the institutional review board with a waiver of informed consent. The study is consistent with the Declaration of Helsinki.

^aDepartment of Medicine, University of Michigan, Ann Arbor, Michigan; and ^bHeart Department, University Hospital, Salerno, Italy. Manuscript received January 8, 2019; revised manuscript received and accepted March 5, 2019.

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*Corresponding author: Tel: 734-764-7440; fax: 734-232-4132.

E-mail address: labt@med.umich.edu (T.M. LaBounty).

Echocardiograms were performed at a tertiary care academic medical center, 6 affiliated satellite clinics located in 5 cities, and an affiliated hospital in a fifth city. All studies were performed by experienced sonographers and interpreted by a core group of nonblinded cardiologists with Level III training in echocardiography. Echocardiography performance was comprehensive and followed recommended standardized guidelines.⁷ Aortic dimensions were measured using inner edge-to-inner edge diameters during diastole as endorsed by some guidelines⁸; this approach is more reproducible and matches computed tomography and magnetic resonance angiography, but results in smaller measurements than the leading edge-to-leading edge approach endorsed by other guidelines.^{1,9,10}

Echocardiograms were performed using Philips EPIQ 7 and iE33 systems (Philips Healthcare, Andover, MA); Acuson Sequoia 512 systems (Siemens, Malvern, PA); or GE Vivid 7, Vivid 9, or Vivid E9 systems (GE Healthcare, Wauwatosa, WI). Images reviewed using contemporary versions of Synapse Cardiovascular Client (Fujifilm Medical Systems, Valhalla, NY). Clinical data were extracted from the electronic medical record. Medical history was extracted from diagnosis codes and problem lists from clinical encounters. Race was self-reported.

Comparisons of continuous variables without normal distribution were made using the Kruskal-Wallis test. Comparisons of continuous variables with a normal distribution used ANOVA. Categorical variables were compared by the chi-square test.

Multivariable analyses were performed using stepwise linear regression with comparisons between races using whites as a baseline, and were adjusted for age, gender (except for gender-specific analyses), and mean arterial blood pressure. *p* Values <0.05 were considered significant. Statistical analyses were performed using IBM SPSS version 25 for Mac (IBM Corporation; Armonk, NY).

Results

The mean age was 49.9 ± 17.6 years, and 58.7% were female. Among individuals stratified by whites (*n* = 12,932), blacks (*n* = 958), Asian (*n* = 827), Hispanic (*n* = 366), Native American (*n* = 38), and multiracial/other (*n* = 174) cohorts, there were significant differences between groups in age, body size, and blood pressure (Table 1).

Table 1
Differences in patient characteristics by race

Variable	White (<i>n</i> = 12,932)	Black (<i>n</i> = 958)	Asian (<i>n</i> = 827)	Hispanic (<i>n</i> = 366)	Native American (<i>n</i> = 38)	Multiracial/ other (<i>n</i> = 174)	<i>p</i>
Age (years)	52 (37-64)	44 (29-57)	45 (36-56)	41 (29-55)	47 (39-63)	41 (29-56)	<0.001
Female	58.4%	61.6%	60.0%	63.1%	60.5%	52.9%	0.08
Body mass index (kg/m ²)	24.6 (22.2-27.0)	25.1 (22.3-27.6)	23.2 (21.3-25.7)	25.1 (22.4-27.2)	25.0 (22.0-27.9)	24.9 (21.9-27.1)	<0.001
Body surface area (m ²)	1.80 (1.66-1.97)	1.80 (1.68-1.95)	1.67 (1.55-1.82)	1.74 (1.61-1.89)	1.73 (1.63-1.97)	1.76 (1.61-1.92)	<0.001
Systolic blood pressure (mm Hg)	117 (109-126)	117 (108-126)	113 (105-121)	115 (107-123)	123 (110-128)	114 (107-124)	<0.001
Diastolic blood pressure (mm Hg)	67 (62-73)	68 (63-74)	67 (62-72)	67 (61-71)	68 (62-74)	67 (62-72)	0.003

Percentage or median values (interquartile range) provided.

There were significant differences in gender-specific comparisons of aortic size by race for the aortic sinus, aortic sinus indexed to BSA, ascending aorta, ascending aorta indexed to BSA, and aortic arch. There was a significant difference between races in the aortic arch diameter indexed to BSA for women but not for men (Figure 1).

In comparison to whites, blacks had smaller nonindexed and BSA-indexed aortic sinus and ascending aorta diameters, which largely persisted in gender-specific subgroups (Table 2). Asians, in comparison to whites, had smaller nonindexed values for all 3 aortic diameters but larger BSA-indexed dimensions for each, with a similar pattern in gender subgroups (Table 3). Hispanics had smaller nonindexed aortic sinus and ascending aorta diameters compared with whites; after indexing to BSA, the only difference was a larger aortic arch diameter observed in the overall cohort and in the male subgroup (Table 4). Native Americans had larger nonindexed and BSA-indexed aortic arch diameters, which was only seen in the overall cohort and in the female subgroup (Table 5). In the multiracial/other cohort, the aortic arch indexed to BSA was larger than whites, but this was not observed either gender subgroup (Table 6).

Discussion

We observed significant differences in echocardiographic measures of aortic diameters by race in our cohort without known risk factors for cardiovascular disease or aortic dilatation. Differences in aortic dimensions remained after indexing to BSA, adjusting for other variables, and evaluating in gender-specific subgroups. Although these differences are relatively small, they could result in underdiagnosis or overdiagnosis of aortic dilatation in some individuals when using reference ranges derived from studies with unknown racial diversity.

One study examined the ascending aorta on magnetic resonance angiography and reported larger sizes in Chinese American subjects and smaller sizes in blacks after adjusting for variables including body size, with no difference in Hispanic Americans; dimensions of the aortic sinus and aortic arch were not evaluated.⁶ Similarly, we observed BSA-indexed ascending aorta diameters that were smaller in blacks, larger in Asian Americans, and not different in Hispanic Americans. Our study further observed race-specific differences in the aortic sinus and aortic arch, including smaller BSA-indexed aortic sinus diameters in blacks,

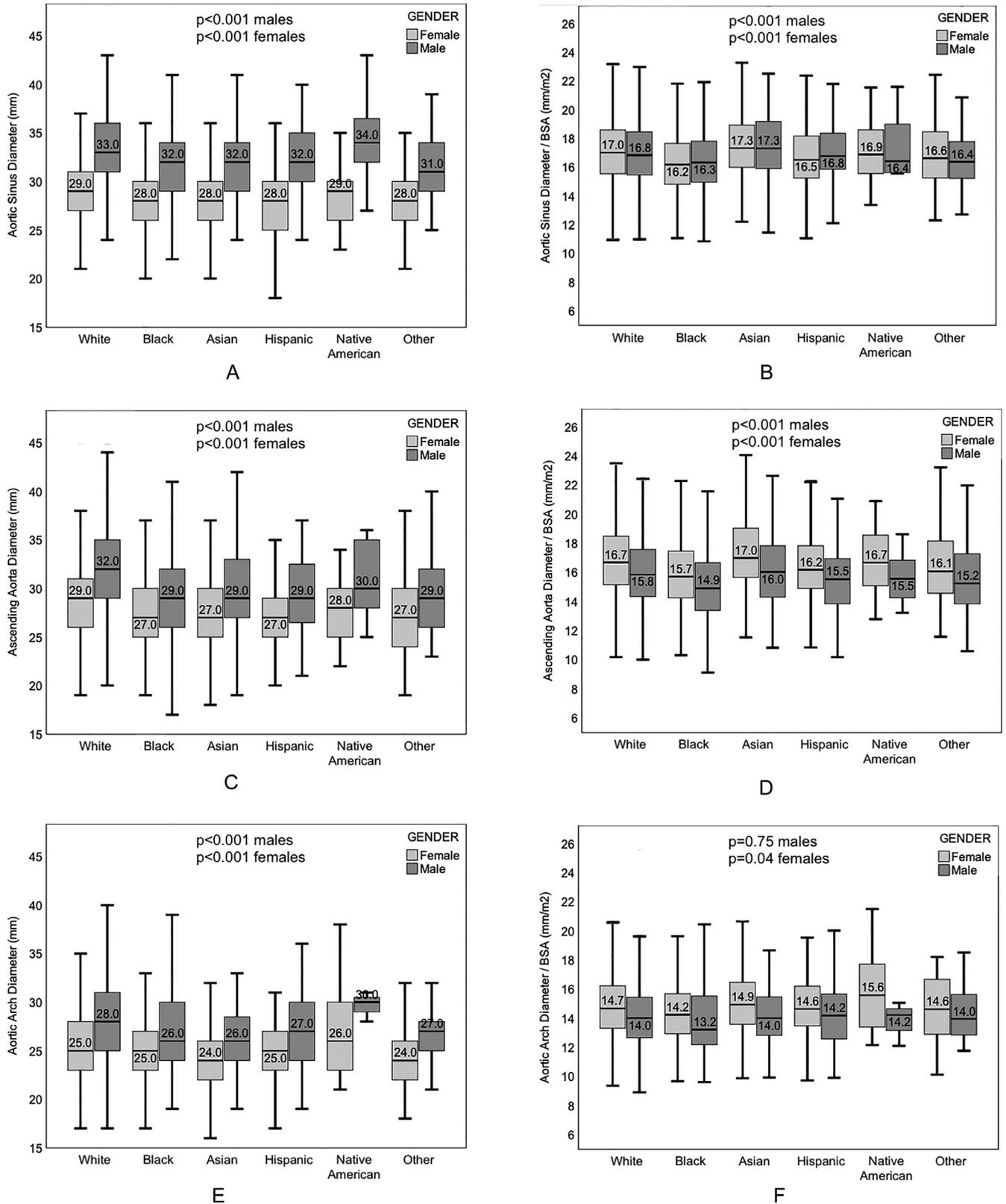


Figure 1. (A to F) Aortic size by gender and race. Gender-specific comparisons of aortic dimensions are provided for the nonindexed and BSA-indexed aortic sinus (A and B), ascending aorta (C and D), and aortic arch diameters (E and F). Values represent inner edge-to-inner edge measurements. p Values for gender-specific comparisons are provided on the figures. The black horizontal lines represent median values which are numerically labelled on the figure, the box the interquartile range, and the vertical lines extend up to 1.5 times the interquartile range and represent nonoutlier cases. BSA, body surface area.

Table 2
Adjusted differences in blacks versus whites

	Adjusted difference	95% CI	p
Overall			
Aortic sinus (mm)	-0.72	-0.50 to -0.95	<0.001
Aortic sinus/BSA (mm/m ²)	-0.34	-0.20 to -0.48	<0.001
Ascending aorta (mm)	-0.95	-0.69 to -1.22	<0.001
Ascending aorta/BSA (mm/m ²)	-0.43	-0.27 to -0.60	<0.001
Aortic arch (mm)	-	-	0.79
Aortic arch/BSA (mm/m ²)	-	-	0.76
Females			
Aortic sinus (mm)	-0.60	-0.34 to -0.87	<0.001
Aortic sinus/BSA (mm/m ²)	-0.49	-0.30 to -0.67	<0.001
Ascending aorta (mm)	-0.79	-0.47 to -1.12	<0.001
Ascending aorta/BSA (mm/m ²)	-0.53	-0.32 to -0.75	<0.001
Aortic arch (mm)	-	-	0.88
Aortic arch/BSA (mm/m ²)	-	-	0.29
Males			
Aortic sinus (mm)	-0.88	-0.49 to -1.27	<0.001
Aortic sinus/BSA (mm/m ²)	-	-	0.30
Ascending aorta (mm)	-1.14	-0.71 to -1.57	<0.001
Ascending aorta/BSA (mm/m ²)	-0.29	-0.05 to -0.53	0.02
Aortic arch (mm)	-	-	0.80
Aortic arch/BSA (mm/m ²)	-	-	0.35

BSA, body surface area.

Values represent inner edge-to-inner edge measurements. Variables adjusted for age, gender (when appropriate), and mean arterial blood pressure.

larger BSA-indexed aortic sinus diameters and aortic arch diameters in Asians, and larger BSA-indexed aortic arch diameters in Hispanics. We also observed differences in BSA-adjusted aortic arch dimensions in both Native Americans and multiracial/other cohorts.

Although we observed differences in aortic dimensions by race, we sampled only a small number of races from a limited geographic area, and it is not known whether these findings would be durable in other geographic areas and in other racial subgroups. Potential interactions between race

Table 3
Adjusted differences in Asians versus whites

	Adjusted difference	95% CI	p
Overall			
Aortic sinus (mm)	-0.41	-0.29 to -0.53	<0.001
Aortic sinus/BSA (mm/m ²)	0.36	0.28 to 0.43	<0.001
Ascending aorta (mm)	-0.33	-0.19 to -0.47	<0.001
Ascending aorta/BSA (mm/m ²)	0.41	0.33 to 0.50	<0.001
Aortic arch (mm)	-0.51	-0.29 to -0.73	<0.001
Aortic arch/BSA (mm/m ²)	0.20	0.07 to 0.33	0.002
Females			
Aortic sinus (mm)	-0.38	-0.24 to -0.53	<0.001
Aortic sinus/BSA (mm/m ²)	0.32	0.22 to 0.42	<0.001
Ascending aorta (mm)	-0.22	-0.04 to -0.40	0.02
Ascending aorta/BSA (mm/m ²)	0.45	0.34 to 0.57	<0.001
Aortic arch (mm)	-0.47	-0.20 to -0.73	0.001
Aortic arch/BSA (mm/m ²)	0.20	0.04 to 0.37	0.02
Males			
Aortic sinus (mm)	-0.46	-0.25 to -0.66	<0.001
Aortic sinus/BSA (mm/m ²)	0.41	0.29 to 0.53	<0.001
Ascending aorta (mm)	-0.49	-0.26 to -0.72	<0.001
Ascending aorta/BSA (mm/m ²)	0.35	0.23 to 0.48	<0.001
Aortic arch (mm)	-0.56	-0.18 to -0.93	0.004
Aortic arch/BSA (mm/m ²)	-	-	0.06

BSA, body surface area.

Variables adjusted for age, gender (when appropriate), and mean arterial blood pressure. Values represent inner edge-to-inner edge measurements.

Table 4
Adjusted differences in Hispanics versus whites

	Adjusted difference	95% CI	p
Overall			
Aortic sinus (mm)	-0.23	-0.11 to -0.35	<0.001
Aortic sinus/BSA (mm/m ²)	-	-	0.23
Ascending aorta (mm)	-0.27	-0.13 to -0.41	<0.001
Ascending aorta/BSA (mm/m ²)	-	-	0.42
Aortic arch (mm)	-	-	0.95
Aortic arch/BSA (mm/m ²)	0.15	0.03 to 0.27	0.01
Females			
Aortic sinus (mm)	-0.26	-0.12 to -0.40	<0.001
Aortic sinus/BSA (mm/m ²)	-	-	0.91
Ascending aorta (mm)	-0.23	-0.06 to -0.40	0.008
Ascending aorta/BSA (mm/m ²)	-	-	0.54
Aortic arch (mm)	-	-	0.90
Aortic arch/BSA (mm/m ²)	-	-	0.13
Males			
Aortic sinus (mm)	-	-	0.07
Aortic sinus/BSA (mm/m ²)	-	-	0.06
Ascending aorta (mm)	-0.36	-0.13 to -0.59	0.002
Ascending aorta/BSA (mm/m ²)	-	-	0.62
Aortic arch (mm)	-	-	0.92
Aortic arch/BSA (mm/m ²)	0.22	0.04 to 0.41	0.02

BSA, body surface area.

Variables adjusted for age, gender (when appropriate), and mean arterial blood pressure. Values represent inner edge-to-inner edge measurements.

and socioeconomic status¹¹ cannot be examined in the present study. We included a multiracial/other cohort in this study due to calls for inclusion of this understudied population in research studies.¹²

One limitation is that we excluded individuals with known risk factors for aortic dilatation, but unmeasured variables or unidentified risk factors may be present. In addition, we examined individuals referred for clinically

Table 5
Adjusted differences in Native Americans versus whites

	Adjusted difference	95% CI	p
Overall			
Aortic sinus (mm)	-	-	0.53
Aortic sinus/BSA (mm/m ²)	-	-	0.23
Ascending aorta (mm)	-	-	0.59
Ascending aorta/BSA (mm/m ²)	-	-	0.96
Aortic arch (mm)	0.51	0.08 to 0.93	0.02
Aortic arch/BSA (mm/m ²)	0.32	0.07 to 0.57	0.01
Females			
Aortic sinus (mm)	-	-	0.80
Aortic sinus/BSA (mm/m ²)	-	-	0.61
Ascending aorta (mm)	-	-	0.39
Ascending aorta/BSA (mm/m ²)	-	-	0.96
Aortic arch (mm)	0.24	0.02 to 0.95	0.04
Aortic arch/BSA (mm/m ²)	0.38	0.09 to 0.66	0.01
Males			
Aortic sinus (mm)	-	-	0.23
Aortic sinus/BSA (mm/m ²)	-	-	0.20
Ascending aorta (mm)	-	-	0.82
Ascending aorta/BSA (mm/m ²)	-	-	0.88
Aortic arch (mm)	-	-	0.23
Aortic arch/BSA (mm/m ²)	-	-	0.82

BSA, body surface area.

Variables adjusted for age, gender (when appropriate), and mean arterial blood pressure. Values represent inner edge-to-inner edge measurements.

Table 6
Adjusted differences in multiracial/other cohort versus whites

	Adjusted difference	95% CI	p
Overall			
Aortic sinus (mm)	−0.15	−0.05 to −0.25	0.004
Aortic sinus/BSA (mm/m ²)	—	—	0.11
Ascending aorta (mm)	−0.14	−0.02 to −0.25	0.03
Ascending aorta/BSA (mm/m ²)	—	—	0.21
Aortic arch (mm)	—	—	0.50
Aortic arch/BSA (mm/m ²)	0.11	0.01 to 0.21	0.03
Females			
Aortic sinus (mm)	—	—	0.17
Aortic sinus/BSA (mm/m ²)	—	—	0.36
Ascending aorta (mm)	−0.16	−0.01 to −0.32	0.04
Ascending aorta/BSA (mm/m ²)	—	—	0.84
Aortic arch (mm)	—	—	0.65
Aortic arch/BSA (mm/m ²)	—	—	0.20
Males			
Aortic sinus (mm)	−0.22	−0.05 to −0.38	0.009
Aortic sinus/BSA (mm/m ²)	—	—	0.17
Ascending aorta (mm)	—	—	0.31
Ascending aorta/BSA (mm/m ²)	—	—	0.07
Aortic arch (mm)	—	—	0.56
Aortic arch/BSA (mm/m ²)	—	—	0.06

BSA, body surface area.

Variables adjusted for age, gender (when appropriate), and mean arterial blood pressure. Values represent inner edge-to-inner edge measurements.

indicated echocardiography, which may introduce selection bias. Some racial cohorts were small in size, which limits our ability to detect differences. Further, studies were not blindly interpreted, which could also introduce bias. Finally, as noted in the methods, we used inner edge-to-inner edge measurements for aortic size; although these might be expected to differ^{9,10} from leading edge-to-leading edge measurements supported by some guidelines,⁸ we do not anticipate that this would affect the overall study findings in terms of differences between racial groups.

In a cohort without known risk factors for cardiovascular disease or aortic dilatation, race is associated with significant differences in aortic dimensions independent of age, gender, and BSA. Although the observed differences were small, they could result in incorrect classification of aortic size in some individuals. These findings suggest that reference ranges for aortic size should be established using racially diverse cohorts to prevent misdiagnosis of aortic dilatation based on race.

Disclosures

The authors have no conflicts of interest to disclose.

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