Impact of ethnicity on aortic root dimensions in patients without atherosclerotic lesions in coronary arteries or the ascending aorta assessed by computed tomography angiography

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INTRODUCTION

There is substantial computed tomography angiography (CTA) data on aortic root anatomy in patients with aortic valve stenosis, but much less information is available on normal aortic anatomy as evaluated by CTA. CTA is regarded as the most accurate imaging modality for quantification of aortic valve apparatus [1–4]. Given the growing number of transcatheter aortic valve replacement (TAVR) procedures in younger populations and the anticipated need for re-interventions, the knowledge of potential ethnical differences may allow for a more individualized approach to appropriate aortic valve selection.

We studied Caucasian and Asian subjects without CTA-detectable atherosclerosis in either the coronary arteries or the ascending aorta to evaluate the ethnic factors affecting these dimensions.

METHODS

A consecutive series of 196 Caucasian (Polish) patients in whom coronary artery disease was excluded by coronary CTA were matched with 440 Asian (Korean) patients without any CTA coronary artery atherosclerotic changes. The details of group selection have been described previously [5]. Subjects were matched by 1) body-surface area (BSA), with ± 0.01 m^2 allowance; 2) age, with ± 15 years allowance; and 3) sex. Eventually, 115 Caucasian-Asian pairs were created. Each CTA examination was evaluated for the presence of a bicuspid aortic valve, atherosclerotic plaque in the aortic root, or the presence of aortic valve prosthesis, and patients with any of these pathologies were excluded.

Demographic and co-morbidity data were obtained from medical records. In the Caucasian (Polish) group, CTA was performed from 2012 to 2014 at the National Institute of Cardiology (Warsaw, Poland) using a dual-source scanner (Somatom Definition; Siemens Healthcare, Forchheim, Germany). In the Korean group, CTA was performed from 2014 to 2018 at the Chung-Ang Hospital University (Seoul, Korea) using a Philips Brilliance 64 scanner (Philips, Best, the Netherlands). Approvals of both Polish and Korean institutional review boards were obtained. The research was done in accordance with the Declaration of Helsinki. Written consent was waived due to the retrospective nature of the study.

Image acquisition, contrast dosage, and CTA protocol were described in our previous article [5]. Only diastolic reconstructions of the aortic root were used for measurements. The analysis was done retrospectively by a single experienced observer (JS) using the same dedicated workstation and software (iNtuition, Terarecon, Foster City, CA, US).

Measurements were performed according to the standard pre-TAVR evaluation [6].

Table 1. Basic patient demographics and comparison of aortic root dimensions of Caucasian (n = 86) vs. Asian (n = 86) patients

Variable	Caucasian (n = 86)	Asian (n = 86)	*P*-value
Mean age, years, mean (SD)	46.9 (7.9)	47.3 (11.8)	0.68
Men, n (%)	40 (47)	40 (47)	1
Diabetes mellitus, n (%)	3 (4)	2 (2)	0.64
Hypertension, n (%)	40 (47)	14 (16)	<0.001
Hyperlipidemia, n (%)	44 (52)	53 (62)	0.26
Active smoking or a history of n (%)	10 (12)	32 (37)	<0.001
Weight, kg, mean (SD)	71.0 (13)	71.3 (13)	0.59
Height, cm, median (IQR)	168 (162–176)	167 (161–176)	0.13
BMI, kg/m^2, median (IQR)	24.2 (22.0–27.4)	25.0 (22.9–26.8)	0.15
BSA, m^2, mean (SD)	1.81 (0.20)	1.81 (0.20)	0.32
AV annulus CSA, cm^2, median (IQR)	4.1 (3.6–4.8)	4.1 (3.6–4.7)	0.31
AV annulus diameter, mm, median (IQR)	22.7 (21.4–24.6)	23.0 (21.5–24.4)	0.42
AV annulus perimeter, mm, mean (SD)	75.0 (7.1)	74.0 (6.6)	0.16
Aortic bulb CSA, cm^2, median (IQR),	7.8 (6.9–9.3)	7.5 (6.3–8.3)	0.003
Aortic bulb diameter, mm, mean (SD)	31.1 (3.5)	29.7 (2.9)	0.006
Aortic bulb perimeter, mm, median (IQR)	102.0 (96.5–113.0)	101.5 (94.3–107.0)	0.02
STJ CSA, cm^2, median (IQR)	5.6 (5.0–6.9)	5.4 (4.8–6.2)	0.02
STJ diameter, mm, median (IQR)	26.7 (25.3–29.6)	26.3 (24.6–28.0)	0.02
STJ perimeter, mm, median (IQR)	84.3 (79.9–93.7)	82.8 (77.9–88.6)	0.01
STJ height to AV annulus, mm, median (IQR)	23.4 (21.9–25.7)	21.9 (20.9–23.4)	<0.001
AV to LCA ostium height, mm, mean (SD)	15.4 (3.0)	14.5 (2.3)	0.01
AV to RCA ostium height, mm, mean (SD)	17.6 (3.4)	15.9 (2.9)	<0.001

Abbreviations: AV, aortic valve; BMI, body mass index; BSA, body surface area; CSA, cross-sectional area; IQR, interquartile range; LCA, left coronary artery; RCA, right coronary artery; SD, standard deviation; STJ, sino tubular junction

The first measurement point was at the level of the aortic valve annulus, just below the plane of the hinge points of the aortic valve leaflets; the second parallel plane was at the greatest aortic bulb cross-section area (CSA); the third parallel plane was at the sino-tubular junction (STJ). In all planes, CSA, perimeter, and diameter were measured. Moreover, STJ height and the heights of the right coronary artery (RCA) and the left coronary artery (LCA) ostium were evaluated.

Statistical analysis

Statistical evaluation was done with MedCalc 9.3.8.0 software (MedCalc, Merierkerke, Belgium). Categorical variables were analyzed using the χ^2 test. Continuous data were evaluated first with the Kolmogorov-Smirnov test for normal distribution. The Mann-Whitney U test was used in cases of non-parametric distribution, and data were presented as medians with interquartile ranges (IQR). The t-test was employed in cases of normal distribution and data were presented as means with standard deviations (SD). The Spearman test was used for correlation analysis. A *P*-value of less than 0.05 was recognized as significant.

RESULTS AND DISCUSSION

Of 115 case-control-matched Polish-Korean pairs, 27 pairs were rejected because of the presence of defined pathologies, and two pairs were rejected because of non-diagnostic CTA. As shown in Table 1, there were no differences in basic demographics except for hypertension and smoking.

Whereas the dimensions of the aortic valve (AV) annulus (median [IQR] CSA: 4.1 [3.6–4.8] cm^2 vs. 4.1 [3.6–4.7] cm^2; *P* = 0.31) were not significantly different between the two ethnicities, Caucasians had larger dimensions of the aorta at the level of the aortic bulb (median [IQR] CSA: 7.8 [6.9–9.3] cm^2 vs. 7.5 [6.3–8.3] cm^2; *P* = 0.003) and the STJ (median [IQR] CSA: 5.6 [5.0–6.9] cm^2 vs. 5.4 [4.8–6.2] cm^2; *P* = 0.02) than Asians. Also, the distances from the coronary ostia and the STJ to the aortic valve were greater in Caucasians than in Asians (23.4 [21.9–25.7] mm vs. 21.9 [20.9–23.4] mm for median [IQR] STJ height; *P* <0.001; 15.4 [3.0] mm vs. 14.5 [2.3] mm for mean [SD] LCA ostium height; *P* = 0.01; 17.6 [3.4] mm vs. 15.9 [2.9] mm for mean [SD] RCA ostium height; *P* <0.01).

After combining Caucasians and Asians, the strongest correlation with aortic dimensions was found for BSA (from R = 0.32 for RCA ostium height to R = 0.75 for AV annulus perimeter; *P* <0.01 for all correlations), followed by height (from R = 0.31 for STJ CSA to R = 0.71 for AV annulus perimeter all *P* <0.01), and weight (from R = 0.27 for AV to LCA ostium height to R = 0.69 for AV annulus perimeter all *P* <0.01).

The main findings of our study in individuals without CTA-detectable coronary or ascending aorta atherosclerosis were as follows: 1) Caucasians had larger aortic root dimensions by an average of 3.6%–4.6% for diameter and by 7.2%–9.4% for CSA than Asians, even after matching for body size. 2) The height of the coronary artery ostia was greater in Caucasian than Asian subjects. Consequently, our results suggested that ethnic differences should be taken into account when setting thresholds for reference values defining normal aortic root anatomy.

Ribeiro et al. [7] found that a lower height of the coronary ostia and smaller aortic bulb diameter increased the risk for coronary obstruction after TAVR and that coronary obstructions were more frequent in females; however, ethnic data were not evaluated. Significantly, coronary occlusions after TAVR and, especially, after redoing TAVR have been serious and potentially lethal. This was recently underlined by Buzzatti et al. [8] who showed that the risk after redoing TAVR exceeded 10%. Our data suggest that the risk of coronary occlusion during re-TAVR may be higher in the Asian population.

Yoon et al. [9] performed a comparison of diseased pre-TAVR aortic root anatomy in a multiethnic, four-center study. The authors found that the dimensions of the aortic root structures and LCA ostium height were smaller in Asians than in Caucasian patients [9]. However, this study lacked a matching protocol; and BSA was significantly different between ethnic groups.

Pham et al. [10] presented CTA data on aortic root anatomy in healthy individuals living in Denmark. The authors admitted that lack of data on patient ethnicity was a limitation; this limitation has been addressed in our report. Indeed, we have concluded that ethnicity affected all dimensions of the aortic root and should be taken into account when planning future studies.

There are some limitations of this study. CTA scans were performed with coronary protocol focused on the coronary tree and, therefore, did not include the whole ascending aorta. Only the diastolic phase of the cardiac cycle was used for measurements. In the matching protocol, there was a substantial allowance for age — 15 years.

In conclusion, Caucasians have larger aortic root structures and higher coronary ostia than Asians even after matching for body size.

Article information

Conflict of interest: None declared.

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