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Ethnic Difference in Proximal Aortic Stiffness

An Observation From the Dallas Heart Study

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ABSTRACT

OBJECTIVES This study aims to compare ethnic difference in proximal aortic pulse wave velocity (PWV) and characteristic impedance (Zc).

BACKGROUND Increased aortic stiffness is an independent predictor of target organ damage, incident hypertension, and all-cause mortality. However, previous studies have not directly assessed proximal aortic function in Blacks, the ethnic population with disproportionately high risk for incident hypertension and target organ complications.

METHODS We evaluated the multiethnic, population-based Dallas Heart Study participants (N = 2,544, 54.2% women, 49.7% Black) who underwent cardiac magnetic resonance at 1.5-T. Aortic stiffness and Zc were determined from aortic arch PWV and lumen area measurements. Linear regression was used to evaluate ethnic differences in proximal aortic wall stiffness using aortic arch PWV and Zc as dependent variables with and without adjustment for traditional cardiovascular risk factors. Because cardiac output was significantly higher in Blacks compared to Whites and Hispanics, additional comparisons of PWV and Zc were performed after adjustment for cardiac output and peripheral vascular resistance.

RESULTS Compared with Whites, both Blacks and Hispanics had higher levels of aortic arch PWV (4.25, 95% confidence interval [CI]: 4.15 to 4.35 m/s, vs. 4.72, 95% CI: 4.64 to 4.81 m/s, vs. 4.48, 95% CI: 4.33 to 4.63 m/s, respectively, both $p < 0.05$ vs. White), and Zc (64.9, 95% CI: 63.3 to 66.6 dyne*s/cm^5, vs. 75.6, 95% CI: 74.0 to 77.2 dyne*s/cm^5, vs. 70.1, 95% CI: 67.6 to 72.8 dyne*s/cm^5, respectively, both $p < 0.01$ vs. White) after adjustment for age, age squared, sex, body mass index, height, mean arterial blood pressure, antihypertensive treatment, heart rate, total cholesterol, diabetes mellitus, and smoking. Compared with Hispanics, Blacks also had higher level of both PWV and Zc (both $p < 0.01$). Ethnic differences in PWV and Zc persisted after adjustment for cardiac output and peripheral vascular resistance.

CONCLUSIONS In a multiethnic population-based-sample, Blacks and Hispanics had higher proximal aortic stiffness compared with Whites independent of blood pressure and relevant risk factors. (J Am Coll Cardiol Img 2016;■:■–■)
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Blacks suffer a disproportionately increased risk for hypertension and hypertensive target organ damage (1). The mechanisms underlying these ethnic differences have been explored but remain incompletely elucidated. Properties of the arterial system, such as aortic stiffness, may contribute to risk for developing hypertension (2). Increased aortic stiffness may also represent a consequence of

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ABBREVIATIONS AND ACRONYMS

BP = blood pressure

CMR = cardiac magnetic resonance

DHS = Dallas Heart Study

PWV = proximal aortic pulse wave velocity

Zc = characteristic impedance

long-standing hypertension. Blacks have higher pulse pressure (3) which is a measure of arterial pressure pulsatility and is closely related to arterial stiffness. Various measures have been developed to assess aortic stiffness directly, with the best-characterized noninvasive measurement being pulse wave velocity (PWV) (4). PWV is an independent risk predictor of target organ damage (5,6), cardiovascular events (7,8), incident hypertension (2), and all-cause-mortality (4). Characteristic impedance of the proximal aorta (Zc) is another useful measure of arterial stiffness that is related to clinical outcomes (9). Zc is related to PWV but is also highly sensitive to aortic lumen area, which also influences arterial pressure pulsatility. For some subgroups of patients, such as diabetics, Zc is a more sensitive measure of central aortic stiffness than PWV (10). Because of differing relations with aortic wall stiffness and diameter, PWV and Zc each provide distinct insights and can change discordantly under certain circumstances. If the aortic wall stiffens and diameter is unchanged, PWV and Zc will change proportionately. On the other hand, if stiffness and diameter both change, the resulting change in PWV and Zc can differ dramatically and may even change in opposite directions. Between young adulthood and midlife, aortic diameter is expected to increase while the wall stiffens; PWV could therefore increase while Zc and pulse pressure decrease (11).

Prior population-based studies assessing ethnic differences in aortic stiffness (12,13) used measures derived from radial artery tonometry, which are indirect and less precise than PWV (14). Carotid and femoral artery applanation tonometry is the most widely used technique for measuring aortic PWV; however, the proximal arch (proximal to the origin of the brachiocephalic artery) cannot be assessed with this technique (4). In this regard, cardiac magnetic resonance (CMR) has the potential advantage of being able to measure stiffness in multiple user-specified segments of the aorta, including measurement of aortic arch PWV (15). Further, with the advent of automated post-processing techniques, CMR-derived aortic arch PWV is readily obtained during routine CMR with minimal additional scan time (16).

Accordingly, our study aimed to use CMR-derived aortic arch PWV and Zc in a large multiethnic, population to assess ethnic differences in proximal aortic stiffness across different ages. To understand these relationships we will also adjust for risk factors that may influence stiffness as well as potential contributions of aortic lumen area. As a secondary aim, we evaluate ethnic differences in pulse pressure.

METHODS

STUDY SAMPLE. Written informed consent was obtained from all participants. The study was approved by the Institutional Review Board of the University of Texas Southwestern Medical Center. Participants were enrolled in the Dallas Heart Study (DHS), a multiethnic, population-based probability sample of Dallas County. The study design and methodology have been described previously (17). Briefly, the DHS phase 1 consisted of 3 sequential visits, including 2 home visits and a clinical visit. During the first 2 visits, a survey was administered through a face-to-face interview and self-reported ethnicity was obtained. In the third visit, 2,971 participants returned for various imaging studies, including CMR. Participants were excluded from analysis if CMR image quality was insufficient for interpretation (n = 340) or if self-reported ethnicity was not Black, White, or Hispanic (n = 84). A total of 2,544 participants (54.2% women, 49.7% Black) ages 19 to 67 years comprised the analysis cohort.

COVARIATE DEFINITIONS. Brachial blood pressure was measured noninvasively using a nonferromagnetic arm blood pressure cuff and automated blood pressure monitor. Four separate blood pressure measurements were acquired at various time points: 1) before scanning, outside the magnet; 2) before scanning, inside the magnet; 3) after scanning, inside the magnet; and 4) immediately after scanning, outside the magnet. The second and third blood pressure measurements were averaged for each subject. Hypertension was defined as systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or use of blood pressure lowering medication. Pulse pressure was defined as the difference between systolic and diastolic blood pressure. Mean arterial pressure was defined as (2 × diastolic blood pressure + systolic blood pressure)/3. Diabetes mellitus was defined as a fasting glucose ≥125 mg/dl or use of hypoglycemic medications. Body mass index (BMI) was calculated using the equation weight/height^2 (kg/m^2). Ethnicity, cigarette smoking, and use of antihypertensive medication were determined by self-report.

CMR. Participants underwent CMR using a 1.5-T whole-body system (Intera, Philips Medical Systems, Best, the Netherlands). All CMR studies were acquired with a 4-element surface array coil. Aortic arch PWV was assessed using a breath-hold, velocity-encoded, phase-contrast gradient echo sequence acquired perpendicular to the course of the ascending aorta 4 cm above the aortic valve plane. The ascending and