JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
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PUBLISHED BY ELSEVIER INC.

VOL. 65, NO. 25, 2015
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2015.04.042

ORIGINAL INVESTIGATIONS

Cumulative Blood Pressure in Early Adulthood and Cardiac Dysfunction in Middle Age

The CARDIA Study

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ABSTRACT

BACKGROUND Cumulative blood pressure (BP) exposure may adversely influence myocardial function, predisposing individuals to heart failure later in life.

OBJECTIVES This study sought to investigate how cumulative exposure to higher BP influences left ventricular (LV) function during young to middle adulthood.

METHODS The CARDIA (Coronary Artery Risk Development in Young Adults) study prospectively enrolled 5,115 healthy African Americans and whites in 1985 and 1986 (baseline). At the year 25 examination, LV function was measured by 2-dimensional echocardiography; cardiac deformation was assessed in detail by speckle-tracking echocardiography. We used cumulative exposure of BP through baseline and up to the year 25 examination (millimeters of mercury × year) to represent long-term exposure to BP levels. Linear regression and logistic regression were used to quantify the association of BP measured repeatedly through early adulthood (18 to 30 years of age) up to middle age (43 to 55 years).

RESULTS Among 2,479 participants, cumulative BP measures were not related to LV ejection fraction; however, high cumulative exposure to systolic blood pressure (SBP) and diastolic blood pressure (DBP) were associated with lower longitudinal strain rate (both $p < 0.001$). For diastolic function, higher cumulative exposures to SBP and DBP were associated with low early diastolic longitudinal peak strain rate. Of note, higher DBP (per SD increment) had a stronger association with diastolic dysfunction compared with SBP.

CONCLUSIONS Higher cumulative exposure to BP over 25 years from young adulthood to middle age is associated with incipient LV systolic and diastolic dysfunction in middle age. (J Am Coll Cardiol 2015;65:2679–87)

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Manuscript received October 23, 2014; revised manuscript received March 25, 2015, accepted April 20, 2015.

ABBREVIATIONS AND ACRONYMS

BP = blood pressure

CI = confidence interval

DBP = diastolic blood pressure

Ecc = circumferential peak systolic strain

Ecc_SRe = circumferential peak early diastolic strain rate

Ecc_SRs = circumferential peak systolic strain rate

Ell = 4-chamber longitudinal peak strain

Ell_SRe = 4-chamber longitudinal peak early diastolic strain rate

Ell_SRs = 4-chamber longitudinal peak systolic strain rate

Err = radial peak strain

Err_SRs = radial peak systolic strain rate

HF = heart failure

LV = left ventricular

LVEF = left ventricular ejection fraction

LVMI = left ventricular mass index

MAP = mean arterial pressure

OR = odds ratio

PP = pulse pressure

SBP = systolic blood pressure

STE = speckle-tracking echocardiography

Blood pressure (BP) at the higher end of the population distribution may represent a chronic exposure that injures the cardiovascular system. Cumulative BP exposure from young adulthood to middle age may adversely influence myocardial function and predispose individuals to heart failure (HF) and other cardiovascular disease later in life. The 2005 guidelines for the diagnosis and treatment of HF from the American College of Cardiology and American Heart Association highlighted the importance of early recognition of subclinical cardiac disease and of noninvasive tests in the clinical evaluation of HF (1).

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Speckle-tracking echocardiography (STE) offers the opportunity to evaluate subclinical markers of left ventricular (LV) dysfunction, and global myocardial strain assessed by STE has been described as a better predictor of future HF and other cardiovascular endpoints compared with left ventricular ejection fraction (LVEF) (2,3). Hypertension has been related to reduced global myocardial deformation as a precursor of HF (4,5), and, in turn, global myocardial deformation parameters (longitudinal and circumferential shortening and radial thickening) have been directly related to HF (6,7).

Our main objective was to investigate how cumulative exposure to high BP from young to middle adulthood influences LV function. In the CARDIA (Coronary Artery Risk Development in Young Adults) study, multiple repeated measures of BP and other cardiovascular risk factors were recorded over a 25-year timespan, starting during early adulthood (ages 18 to 30 years). In this report, we demonstrate the cumulative effect of BP exposure to conventional echocardiographic measures of LV systolic and diastolic function, as well as LV strain measures assessed by STE, also used as markers of subclinical LV dysfunction.

METHODS

PARTICIPANTS. The CARDIA study is a multicenter prospective investigation that enrolled 5,115 healthy African-American and white men and women in 1985 and 1986 (year 0) from 4 U.S. field centers (Birmingham, Alabama; Oakland, California; Chicago, Illinois; Minneapolis, Minnesota). Participants were followed prospectively in 7 subsequent examinations. The Institutional Review Boards at each study site approved the study protocols, and written informed consent was obtained from all participants. Of 3,498 participants attending the year 25 (2010 to 2011) examination, 3,474 underwent standard echocardiography and STE assessment. We excluded participants with incomplete BP measurement during 25 years of follow-up (n = 995). The remaining 2,479 participants with complete longitudinal datasets were included in the analyses. At baseline, the included participants were slightly older (25.3 vs. 24.5 years) and more female than male (1,409 vs. 1,070), and had a lower percentage of blacks (41.4% vs. 61.1%), higher educational attainment (14.2 vs. 13.4 years), and lower baseline systolic blood pressure (SBP) (109.8 vs. 110.9 mm Hg; all $p < 0.01$) compared with those not included in this study (n = 2,636) (Online Table 1).

Standardized protocols were used to measure height, weight, heart rate, BP, lipids, glucose, smoking status, educational level, and physical activity (8,9). Weight and height were measured using a standard balance beam scale. Body mass index was calculated as weight (kilograms) divided by height in meters squared. We used the average of the second and third of 3 BP measurements using random-zero sphygmomanometry performed at 1-min intervals after the participant had been sitting quietly for 5 min in a still room (year 0 to 15) and a BP monitor (year 20 to 25; Omron Healthcare Inc., Lake Forest, Illinois) (10). A calibration study was performed, and values calibrated to the sphygmomanometric measures were used for year 20 and year 25 BP measurements. We used recalibrated measures (10). Pulse pressure (PP) as the index of pulsatile component of BP was calculated as SBP minus diastolic blood pressure (DBP); mean arterial pressure (MAP) was calculated as: DBP + (1/3 PP). The presence of diabetes was assessed at each examination on the basis of a combination of medication use for diabetes (every examination), fasting plasma glucose ≥126 mg/dl (examination years 0, 7, 10, 15, 20, and 25), 2-h glucose ≥200 mg/dl (years 10, 20, and 25), or glycosylated hemoglobin ≥6.5% (years 20 and 25). Total cholesterol was measured in fasting plasma samples and determined by enzymatic procedures.

We calculated the cumulative exposure of BP for each participant over 25 years from age 18 to 30 years to age 43 to 55 years as millimeters of mercury × year at each clinic visit to represent long-term exposure to BP levels. We defined this BP product for each participant's accumulated exposure to BP. We used the area under the BP curve over 25 years as a covariate in the univariable and multivariable analyses. Calculations were performed for SBP, DBP, PP, and MAP.