CLINICAL RESEARCH STUDY

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The Systolic Blood Pressure Difference Between Arms and Cardiovascular Disease in the Framingham Heart Study

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ABSTRACT

BACKGROUND: An increased interarm systolic blood pressure difference is an easily determined physical examination finding. The relationship between interarm systolic blood pressure difference and risk of future cardiovascular disease is uncertain. We described the prevalence and risk factor correlates of interarm systolic blood pressure difference in the Framingham Heart Study (FHS) original and offspring cohorts and examined the association between interarm systolic blood pressure difference and incident cardiovascular disease and all-cause mortality.

METHODS: An increased interarm systolic blood pressure difference was defined as ≥10 mm Hg using the average of initial and repeat blood pressure measurements obtained in both arms. Participants were followed through 2010 for incident cardiovascular disease events. Multivariable Cox proportional hazards regression analyses were performed to investigate the effect of interarm systolic blood pressure difference on incident cardiovascular disease.

RESULTS: We examined 3390 (56.3% female) participants aged 40 years and older, free of cardiovascular disease at baseline, mean age of 61.1 years, who attended a FHS examination between 1991 and 1994 (original cohort) and from 1995 to 1998 (offspring cohort). The mean absolute interarm systolic blood pressure difference was 4.6 mm Hg (range 0-78). Increased interarm systolic blood pressure difference was present in 317 (9.4%) participants. The median follow-up time was 13.3 years, during which time 598 participants (17.6%) experienced a first cardiovascular event, including 83 (26.2%) participants with interarm systolic blood pressure difference ≥10 mm Hg. Compared with those with normal interarm systolic blood pressure difference, participants with an elevated interarm systolic blood pressure difference were older (63.0 years vs 60.9 years), had a greater prevalence of diabetes mellitus (13.3% vs 7.5%,), higher systolic blood pressure (136.3 mm Hg vs 129.3 mm Hg), and a higher total cholesterol level (212.1 mg/dL vs 206.5 mg/dL). Interarm systolic blood pressure difference was associated with a significantly increased hazard of incident cardiovascular events in the multivariable adjusted model (hazard ratio 1.38; 95% CI, 1.09-1.75). For each 1-SD-unit increase in absolute interarm systolic blood pressure difference, the hazard ratio for incident cardiovascular events was 1.07 (95% CI, 1.00-1.14) in the fully adjusted model. There was no such association with mortality (hazard ratio 1.02; 95% CI 0.76-1.38).

CONCLUSIONS: In this community-based cohort, an interarm systolic blood pressure difference is common and associated with a significant increased risk for future cardiovascular events, even when the absolute difference in arm systolic blood pressure is modest. These findings support research to expand clinical use of this simple measurement.

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KEYWORDS: Cardiovascular disease; Cardiovascular risk; Interarm blood pressure difference

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An increased interarm systolic blood pressure difference is usually defined as 10 mm Hg or greater[1,2] and can be found in up to 24% of healthy individuals.[3-6] It has been suggested that identification of interarm systolic blood pressure difference is crucial for appropriate identification and treatment of hypertension,[7-9] for clinical decision-making and surveillance.[1,10-13] Interarm systolic blood pressure differences have been studied in patients in primary care settings,[14-16] in patients with various manifestations of vascular disease,[17-19] and in population-based cohorts.[3,6,16] It has been found to correlate with classic and novel cardiovascular risk factors and may be predictive of cardiovascular events. Nevertheless, data on the epidemiology of interarm systolic blood pressure difference are relatively scarce.[3,6,16,17] While an association between interarm systolic blood pressure difference and mortality was noted in 3 small prospective studies and a meta-analysis that pooled data from 20 older studies,[14,15,17,18,20] the evidence for an association with cardiovascular disease is less consistent.[20] The objectives of this study were to describe the distribution of interarm systolic blood pressure difference and risk factor correlates in the Framingham Heart Study (FHS) original and offspring cohorts and to determine the association between interarm systolic blood pressure difference and incident cardiovascular events and all-cause mortality.

CLINICAL SIGNIFICANCE

- Interarm systolic blood pressure difference (ISBPD) is associated with incident cardiovascular events independent of traditional cardiovascular risk factors in a large community-based cohort.
- Measurement of blood pressure in both arms is important both for accurate blood pressure detection and for cardiovascular risk stratification.

METHODS

Study Participant Sample

Methods of recruitment have been described previously for participants from the original cohort and the offspring study cohort of the FHS.[21,22]

From the original FHS cohort of 5209 that was recruited in 1948,[23] 1026 men and women attended an FHS examination between 1991 and 1994. There also were 3532 men and women from the offspring study cohort who attended the sixth offspring cycle examination from 1995 to 1998. Of the 4558 total original and offspring cohort participants, 494 were excluded because they did not have a blood pressure measurement in both arms. Of the remaining participants, 66 participants <40 years old and 608 with prevalent cardiovascular disease were excluded. The Institutional Review Board at Boston University Medical Center approved the examination content, and informed consent was obtained from study participants at the time of their examination.

Interarm Systolic Blood Pressure Measurement

For the purpose of calculating the interarm systolic blood pressure difference, brachial systolic blood pressure measurements were obtained as part of an ankle-brachial index measurement by trained technicians according to a standard protocol after participants lay supine for at least 5 minutes. Measurements were taken in the sequence of right arm, left arm, right ankle, and left ankle and repeated twice. If the initial and repeat blood pressure differed by >10 mm Hg at any site, a third measurement was taken. When 2 blood pressure measurements were obtained in the same arm, the average blood pressure in that arm was used. The interarm systolic blood pressure difference was defined as the absolute difference between the single or average blood pressure measurements in each arm. An increased interarm systolic blood pressure difference was defined as interarm systolic blood pressure difference ≥10 mm Hg.[14,18] The maximal difference between arms was used.

Definition of Incident Cardiovascular Disease Events and Mortality

Participants were followed through 2010 for the first incident cardiovascular event, defined as coronary heart disease (ie, a fatal coronary event, recognized myocardial infarction and unrecognized myocardial infarction, coronary insufficiency, or angina), a cerebrovascular event (ie, ischemic stroke or transient ischemic attack), intermittent claudication,[24] or congestive heart failure.[25] An unrecognized myocardial infarction was adjudicated when serial changes on the electrocardiogram showed development of pathologic Q waves and neither the participant nor the physician considered the possibility of a myocardial infarction. Mortality data were obtained by review of all medical records including the last hospitalization, nursing home records, personal physical records, and if needed, next-of kin interviews along with death certificate evaluation. All cardiovascular events and deaths in both the original cohort and offspring participants were adjudicated by an end-point committee of 3 senior investigators using the same criteria and all available medical records. Ischemic stroke and transient ischemic attack events were reviewed by a panel of study neurologists.

Definition of Risk Factor Covariates

Covariates were obtained at the same time as the interarm systolic blood pressure difference measurement. Hypertension was defined as a blood pressure ≥140/90 mm Hg or the use of antihypertension medications. Body mass index was calculated as the participants' weight in kilograms divided by the participants' height in meters squared. Diabetes mellitus was considered present if the fasting glucose was ≥126 mg/100 mL (offspring), a nonfasting glucose of ≥200 mg/dL (original cohort), or if the participant was receiving