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Research Article

The association of renal artery calcification with hypertension in community-living individuals: the multiethnic study of atherosclerosis

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Abstract

Hypertension (HTN) is a modifiable risk factor for cardiovascular disease (CVD). Renal artery calcium (RAC) may signal the presence of flow-limiting atherosclerotic disease that may contribute to changes in the kidney's regulation of blood pressure. We hypothesized that RAC is independently associated with HTN. We examined a multiethnic cohort of 1285 participants who underwent abdominal computed tomography scans in five US communities. After adjustment for age, gender, race/ethnicity, CVD risk factors, abdominal aortic calcium score, and kidney function, the presence of RAC was associated with a 50% higher odds of HTN (odds ratio: 1.54; 95% confidence interval 1.11–2.13). Similarly, the presence of RAC was associated with a 8.5 mm Hg higher systolic blood pressure, a 2.1 mm Hg higher diastolic blood pressure, and a 7.4-mm Hg higher pulse pressure. In conclusion, independent of CVD risk factors, abdominal aortic calcium, and kidney function, the presence of RAC is associated with HTN prevalence. J Am Soc Hypertens 2016;10(2):167–174.

Keywords: Hypertension; Renal artery calcification; Multiethnic; Atherosclerosis.

Introduction

Cardiovascular disease (CVD) remains the leading cause of mortality among Americans, accounting for one-third of all deaths in the United States.[1] Of the modifiable risk factors for CVD, hypertension (HTN) has been estimated to account for 18% of the population attributable risk for first myocardial infarction.[2,3] Furthermore, chronic kidney disease is a strong risk factor for both HTN and CVD,[4] and HTN is a leading cause of chronic kidney disease in the United States, second only to diabetes as a factor in the progression to end-stage renal disease.[5–7]

Renal mechanisms appear to play a primary role in the pathophysiology of blood pressure (BP) elevation.[8] Calcified atherosclerotic plaques can be detected and quantified using computed tomography (CT).[9–12] In the coronary arteries, the degree of arterial calcification is highly correlated with atherosclerotic plaque burden.[13–15] Although significant atherosclerosis of the renal artery can lead to flow-limiting stenosis and the development of renovascular HTN, subclinical atherosclerosis of the renal arteries may also be associated with changes in BP regulation. Even if not flow limiting, it is possible that calcification within the renal arteries marks the burden of small vessel vascular

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Conflict of interest: The authors have no conflicts of interest to declare.

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disease within the kidney, which in turn may lead to salt and water retention and resultant HTN. However, whether renal artery calcium (RAC) is associated with HTN is uncertain.

To our knowledge, only two prior studies have examined the relationship of RAC with HTN. Both showed that RAC was associated with a higher prevalence of HTN.[16,17] However, these studies evaluated predominantly Caucasian populations; whether these associations extend to different race/ethnicities is uncertain. Furthermore, it remains uncertain if the association of RAC with HTN is independent of kidney function in a multiethnic cohort. Given this, the present study aimed to examine the cross-sectional association of RAC with HTN in a community-living, multiethnic cohort and to determine if such associations persist when accounting for traditional CVD risk factors, calcification of nonrenal vasculature, and kidney function. As a secondary objective, this study aims to examine the association of RAC with different components of BP, including systolic blood pressure (SBP), diastolic blood pressure (DBP), and pulse pressure (PP).

Methods

Participants

Between August 2000 and July 2002, 6814 men and women aged 45–84 years were recruited from six US communities to participate in the Multi-Ethnic Study of Atherosclerosis (MESA), a population-based longitudinal study aimed at examining subclinical CVD and the progression to clinical disease. Men and women were eligible to participate if they self-identified as African-American, Chinese-American, Caucasian, or Hispanic and had no known clinical CVD at baseline. Complete methods have been previously published.[18]

Participants for this analysis consisted of 1959 MESA subjects who were randomly selected from five of the MESA field centers (Chicago, Illinois; Forsyth County, North Carolina; Los Angeles County, California; New York, New York; and St. Paul, Minnesota) to participate in the MESA Abdominal Aortic Calcium Study during which abdominal CT scans were conducted at clinic examinations 2 or 3 (July 2002–July 2005).[19] This study was approved by the institutional review boards at all field centers, and all participants gave informed consent before participation.

Procedures

Data for this study were collected during clinic visits 2 or 3 (corresponding to the visit when the abdominal CT was conducted). Demographic and behavioral information, including age and smoking, were collected via a self-administered questionnaire, although trained interviewers collected information on medication usage and medical history.

Trained study staff took BP and anthropometric measurements. Three BP measurements were taken after the participant was seated quietly for 5 minutes using a Dinamap automated blood pressure device (Dinamap Monitor Pro 100, Critikon, Inc, Tampa, FL, USA); the average of the second and third measurements was used for analysis. PP was calculated as SBP–DBP. HTN was defined as SBP $\geq$140 mm HG or DBP $\geq$90 mm HG, or current use of antihypertensive medication. Pack years of smoking was calculated as (the number of cigarettes smoked per day, 20) multiplied by the number of years smoked. Anthropometric measurements were taken with participants wearing light clothes and no shoes. Body mass index (BMI) was calculated as weight (kg)/height (m^2).

Blood sample collection and processing was performed according to a standardized protocol. Venipuncture was conducted by trained phlebotomists among participants in a 12-hour fasting state for measurement of serum creatinine and lipid profiles. Dyslipidemia was defined as total cholesterol-to-high-density lipoprotein ratio>5 or use of a lipid-lowering medication.[20,21] Diabetes status was determined based on 2003 American Diabetes Association criteria: fasting blood glucose of $\geq$7 mmol/L (126-mg/dl) or current insulin or oral hypoglycemic medication usage.[22] Estimated glomerular filtration rate (eGFR) was calculated from serum creatinine and demographic variables using the Chronic Kidney Disease Epidemiology Collaboration equation.[23] Urine was collected for albumin and creatinine, which were used to calculate the urinary albumin to creatinine ratio (UACR).

Given its anatomic proximity to the renal arteries and its association with CVD mortality and calcification in other vascular beds, abdominal aorta calcification was included as a marker of system vascular atherosclerotic calcification.[24,25] The presence and extent of calcification in the abdominal aorta and the left and right renal arteries were measured using abdominal CT scans conducted using electron-beam CT scanners (Imatron C-150; Imatron, Inc, San Francisco, CA, USA) or prospective electrocardiogram-triggered scanners (Siemens S4+ Volume Zoom; Siemens, Erlanger, Germany; and General Electric Hi Speed LX, GE Medical Systems, Milwaukee, WI, USA). The distal 15 cm of the abdominal aorta terminating at the aortic bifurcation was scanned. The L5-S1 intervertebral disc space was identified on scout films to approximate the level of the aortic bifurcation.

CT images were centrally reviewed by trained study technologists at the MESA CT Reading Center (Los Angeles, CA, USA). Calcified foci were defined as those regions with a density of >130 Hounsfield units and an area of $\geq$3 contiguous pixels (1.0 mm^2). Total RAC scores were calculated by summing left and right renal ostia Agatston scores and left and right renal artery Agatston scores. Calcium in the abdominal aorta was scored using an 8-cm segment of the distal abdominal aorta ending at the aortic bifurcation. Calcium in the descending thoracic aorta was