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Elevated blood pressure and electrocardiographic frontal T axis and spatial QRS-T angle changes in postmenopausal women

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Abstract

Introduction: Frontal T axis and spatial QRS-T angle are both measures of disturbances in ventricular repolarization and depolarization. We determined whether increased blood pressure is a risk factor for changes in these parameters in postmenopausal women free of left ventricular hypertrophy.
Materials and Methods: This cross-sectional study included 969 women. A standard 12-lead electrocardiogram (ECG) was recorded, and frontal T axes and spatial QRS-T angles were computed from vectorcardiography. Logistic regression analysis was used to assess the relationship between systolic and diastolic blood pressures on the one hand and both ECG parameters on the other.
Results: Odds ratios were 1.08 (95% confidence interval [CI], 0.99-1.18) and 1.12 (95% CI, 1.03-1.23) per 10 mm Hg systolic blood pressure for frontal T axis and QRS-T angle, respectively. These values were 1.05 (95% CI, 0.95-1.16) and 1.12 (95% CI, 1.02-1.23) per 5 mm Hg diastolic blood pressure for frontal T-axis and QRS-T angle, respectively.
Conclusion: Elevated blood pressure may lead to ventricular depolarization and repolarization disturbances before overt ECG left ventricular hypertrophy has developed.

Keywords: Blood pressure; Heart; Electrocardiography; Women

Introduction

Elevated blood pressure is an important risk factor for sudden death, of which cardiac arrhythmias are the main cause. In systemic hypertension, left ventricular hypertrophy (LVH) is one of the most common manifestations of end-organ damage.[1] Left ventricular hypertrophy leads to disturbances in ventricular depolarization and repolarization, which promote arrhythmias and mortality.[2]

Hypertension causes LVH through changes in heart shape and mass.[3,4] Early changes in cardiac geometry, before overt LVH has developed, may already result in changes of ventricular depolarization and repolarization. These abnormalities may become visible on the electrocardiogram (ECG) by changes in the frontal T axis and spatial QRS-T angle.[5,6] These ECG abnormalities appear to be particularly related to subsequent fatal cardiac events rather than to nonfatal events. Consequently, abnormalities in frontal T axis and spatial QRS-T angle have been suggested to reflect an increased risk of nonischemic cardiac arrhythmias.[6-8] Moreover, the QRS-T angle is a strong predictor of new-onset heart failure, combined fatal and nonfatal events, and all-cause mortality in multivariate adjusted ECG risk models in large groups of postmenopausal women free from cardiovascular disease as well as in women with prior cardiovascular disease.[8-10]

In view of the effect of sustained blood pressure elevation on geometry and ventricular dimensions, hypertension may lead to changes in the ECG T axis and QRS-T angle even before overt LVH; but currently, no data on this association are available.

The aim of the present cross-sectional study was to determine whether blood pressure is a risk factor for frontal T axis and spatial QRS-T angle changes in postmenopausal women free of ECG LVH.

Materials and methods

Study population

Participants were recruited from the Prospect study, one of the 2 Dutch cohorts participating in the European

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Prospective Investigation into Cancer and Nutrition (EPIC).[11] In Prospect, a total of 17 357 healthy breast cancer screening participants, aged 49 to 70 years and living in Utrecht and surrounding areas, were enrolled between 1993 and 1997. The purpose of the Prospect-EPIC study is to assess the relation between nutrition and cancer and other chronic diseases.

Of the 17 357 women, 6612 were excluded because of death, unavailability due to participation in other studies, absence of written informed consent, or emigration. Because the present study was part of a study on the role of age at menopause in cardiovascular risk stratification, 4901 participants were excluded on the basis of incomplete data on menopause-related factors. Out of 5844 eligible women, a random selection of 1996 women was invited by the principal investigator of Prospect-EPIC for a single visit to our outpatient clinic; and 1000 (50.1%) answered positively. Twenty-nine women with ECG evidence of LVH were excluded. Two participants were excluded because of missing ECG records. Therefore, the final population consisted of 969 subjects.

The study was approved by the Institutional Review Board of the University Medical Center Utrecht, and written informed consent was obtained from all participants. Data collection took place between October 2002 and April 2004.

Blood pressure measurements

Systolic and diastolic blood pressures were measured after lying in supine position for 10 minutes. All measurements were performed twice with a Dinamap (DINAMAP XL; Critikon, Johnson & Johnson, Tampa, FL) at the right and left arm. The mean of the duplicate measurements was calculated, and the highest value between both arms was used. Blood pressure values from PROSPECT measured between 1993 and 1997 were also available.

ECG interpretation and measurements

A standard 12-lead ECG was recorded with the women lying in supine position using Cardio Perfect equipment (Cardio Perfect Resting ECG; Welch Allyn Cardio Control, Delft, the Netherlands). The ECGs were recorded at a sampling frequency of 300 Hz and stored digitally. All ECGs were processed by the modular ECG analysis system (MEANS).[12] The MEANS computes a representative averaged beat for each of the 12 leads from which ECG measurements and a diagnostic interpretation are derived.

Mean QRS and T axes were computed from vectorcardiographic X, Y, and Z leads, which can, in good approximation, be constructed from the standard ECG leads.[13] The mean spatial axes are based on the areas of the wave components of the QRS complex and the T wave. The mean frontal T axis is the angle between the X axis and the projection of the mean spatial T axis on the frontal XY plane. The spatial QRS-T angle is the angle between the mean spatial QRS axis and the mean spatial T axis.

Electrocardiographic LVH was defined by using voltage and repolarization criteria, in which the age-adjusted Sokolow criterion[14] and T-wave abnormalities are the main parts. Women with a MEANS interpretation of possible, probable, or definite LVH were considered to have evidence of LVH and were excluded.[15]

Cardiovascular risk factors

All participants filled in a questionnaire including information on date of birth, cardiovascular disease history, and established risk factors for cardiovascular disease. Fasting venous blood samples were drawn. Plasma total cholesterol, triglycerides, and glucose were measured using standard enzymatic procedures. High-density lipoprotein (HDL) cholesterol was measured by the direct method (inhibition, enzymatic). Height and weight were measured, and the body mass index was calculated as weight divided by height squared (in kilograms per square meter). Body fat distribution was assessed by measuring waist to hip circumference ratio. Finally, current medication use was recorded. Diabetes *mellitus* was defined as a fasting blood glucose ≤7.0 mmol/L and/or use of antidiabetic medication. Smoking was defined as current, past, and never smoking.

Data analyses

The frontal T axis and spatial QRS-T angle were categorized into 2 classes: normal and abnormal. In the absence of generally accepted criteria and to achieve sufficient statistical power, arbitrary cutoff values were chosen that resulted in an abnormal category comprising approximately 15% of the subjects. The frontal T axis was categorized as follows: normal (25° to 65°) and abnormal (−180° to 24° and 66° to 180°). The spatial QRS-T angle was categorized as follows: normal (0° to 87°) and abnormal (88° to 180°).

First, the cross-sectional data collected in the year 2002 to 2004 were analyzed. Logistic regression analysis was used to assess the relationship between systolic and diastolic blood pressure on the one hand and frontal T axis and spatial QRS-T angle on the other. The strength of the relationship between systolic blood pressure and ECG parameters was expressed as an odds ratio (OR) and corresponding 95% confidence interval (95% CI) per 10 mm Hg systolic blood pressure and per 5 mm Hg diastolic blood pressure. We investigated age, glucose, diabetes, total to HDL cholesterol ratio, triglycerides, body mass index, waist to hip ratio, smoking, and antihypertensive drug use as potential confounders. First, we adjusted for one variable at the time to assess its influence on the crude relationship between blood pressure and abnormal frontal T axis and spatial QRS-T angle (bivariate analyses). In addition to age, we eventually adjusted simultaneously for those characteristics that changed the crude OR in one of the models.

Second, we investigated whether systolic and diastolic blood pressures measured during the Prospect study (1993-1997) were associated with changes in ECG parameters measured in the present study (2002-2004).

Subgroup analysis was carried out for antihypertensive drug use to determine whether the results differed in women who used antihypertensive drugs compared with women who did not.