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Research Article

Prevalence of electrocardiographic abnormalities based on hypertension severity and blood pressure levels: the Reasons for Geographic and Racial Differences in Stroke study

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Abstract

We evaluated the prevalence of major and minor electrocardiographic (ECG) abnormalities based on blood pressure (BP) control and hypertension (HTN) treatment resistance. We analyzed data from the Reasons for Geographic and Racial Differences in Stroke study of 20,932 participants who were divided into presence of major (n = 3782), only minor (n = 8944), or no (n = 8206) ECG abnormalities. The cohort was stratified into normotension (n = 3373), pre-HTN (n = 4142), controlled HTN (n = 8619), uncontrolled HTN (n = 3544), controlled apparent treatment-resistant HTN (aTRH, n = 400), and uncontrolled aTRH (n = 854) groups, and the prevalence ratios (PRs) of major and minor ECG abnormalities were assessed separately for each BP group. The full multivariable adjustment included demographics, risk factors, and HTN duration. Compared with normotension, the PRs of major ECG abnormalities for pre-HTN, controlled HTN, uncontrolled HTN, controlled aTRH, and uncontrolled aTRH groups were 1.01 (0.90–1.14), 1.30 (1.16–1.45), 1.37 (1.23–1.54), 1.42 (1.22–1.64), and 1.44 (1.26–1.65), respectively ($P < .001$), whereas the PRs of minor ECG abnormalities among each of the above BP groups were similar. Detection of major ECG abnormalities among hypertensive persons with poor control and treatment resistance may help improve their cardiovascular risk stratification and early intervention. J Am Soc Hypertens 2016;10(9):702–713.

Keywords: Apparent treatment-resistant hypertension; blood pressure control; major electrocardiographic abnormalities; minor electrocardiographic abnormalities.

Introduction

The presence of major and minor electrocardiographic (ECG) abnormalities has been associated with an increased risk for coronary heart disease (CHD), stroke, cardiovascular (CV) mortality and sudden cardiac death.[1–12] Given its relatively low cost and widespread availability, ECG serves as a valuable adjunctive tool to facilitate CV risk

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stratification and predict adverse CV outcomes, especially in asymptomatic individuals.[1–4,9,11] The Minnesota coding system, commonly used to codify ECG abnormalities in epidemiologic studies, was classified into major and minor abnormalities.[13–15] Black race and male gender has been associated with a greater prevalence of ECG abnormalities.[8,16–20] The association of both major and minor ECG abnormalities with traditional CV risk factors, including hypertension (HTN), has been previously reported.[17,21,22]

Pre-HTN, defined as systolic blood pressure (SBP) 120–139 mm Hg and/or diastolic blood pressure (DBP) of 80–89 mm Hg, has been associated with the development of frank HTN and adverse CV events.[23–26] However, the association of pre-HTN and ECG abnormalities remains unknown. Resistant HTN, an extreme phenotype of HTN, is defined as SBP $\geq$140 mm Hg and/or DBP $\geq$90 mm Hg on $\geq$3 antihypertensive medication classes.[27] The term apparent treatment-resistant HTN (aTRH) has been used in epidemiologic studies to describe cases of resistant HTN in which pseudoresistance (ie, falsely labeled as having resistant HTN) is not reliably excluded. Apparent TRH is further classified into controlled aTRH (SBP $<$ 140 mm Hg and DBP $<$ 90 mm Hg on $\geq$ 4 antihypertensive medications) and uncontrolled aTRH (SBP $\geq$ 140 mm Hg and/or DBP $\geq$ 90 mm Hg with $\geq$3 antihypertensive medications).[28,29] Although elevated SBP has been associated with a greater prevalence of ECG abnormalities, the prevalence of ECG abnormalities among hypertensive persons based on treatment resistance and blood pressure (BP) control has not been previously reported.

In this study, using data from the Reasons for Geographic and Racial Differences in Stroke (REGARDS) study, we determined the cross-sectional association between major and minor ECG abnormalities and BP levels and HTN severity (defined by the number of antihypertensive medication used). We hypothesized that the prevalence of ECG abnormalities would be greater with increasing HTN severity and poorer BP control; we further investigated the interaction of age, gender, race, and geographical region on this association.

Methods

REGARDS is a longitudinal study designed to investigate factors contributing to excess stroke mortality across the southeastern United States and among blacks. The REGARDS study includes a cohort of 30,239 black and white adults $\geq$45 years old recruited from the 48 continental US states between January 2003 and October 2007. The study was designed to balance on gender and race, with oversampling from regions in the Southeastern United States with high stroke incidence. The final cohort included 55% women, 42% blacks, and 55% in the stroke belt (defined as North Carolina, South Carolina, Georgia, Alabama, Mississippi, Arkansas, Tennessee, and Louisiana). The details of REGARDS sample and study recruitment have been previously described.[30] Briefly, the participants were recruited via mail and telephone. Baseline demographic information and medical history were obtained by trained personnel using computer-assisted telephone interview. The anthropometric and BP measurements, venous blood samples, brief physical examination, ECG, and pill bottle review were conducted during the in-home visits 3–4 weeks after the telephone interview. All participants provided written informed consent, and the study protocol was approved by the participating Institutional Review Boards.

Blood Pressure Measurements

BP was taken by trained examiners using an android sphygmomanometer. BP was measured twice following a standard protocol. All participants were asked to sit for 5 minutes with feet on floor prior to BP measurement, and there was a 30-second interval between measurements. The average of two readings was calculated. BP quality was monitored by central examination of digit preference and retraining of personnel as needed.

Definition of Groups Based on BP and Antihypertensive Treatment

The presence of HTN was determined based on self-reported history and in-home review of antihypertensive medication bottles. We stratified our cohort into six mutually exclusive groups based on BP control and number of antihypertensive medications used. We defined normotension as SBP $<$120 mm Hg and DBP $<$80 mm Hg without antihypertensive medication use; pre-HTN as SBP 120–139 mm Hg and/or DBP 80–89 mm Hg without antihypertensive medication use[12]; controlled HTN as SBP $<$140 mm Hg and DBP $<$90 mm Hg on $\leq$3 classes of antihypertensive medications[31]; uncontrolled HTN as SBP $\geq$140 mm Hg and/or DBP $\geq$90 mm Hg on none or $<$3 antihypertensive medications; controlled aTRH as SBP $<$140 mm Hg and DBP $<$90 mm Hg on $\geq$ 4 classes of antihypertensive medications; and uncontrolled aTRH as SBP $\geq$140 mm Hg and/or DBP $\geq$90 mm Hg on $\geq$3 classes of antihypertensive medications.

ECG Abnormalities

A standard 12-lead ECG was obtained during the in-home visit. All ECGs were centrally read and coded by trained physician electrocardiographers, and all abnormalities were over-read by a second physician electrocardiographer. The ECG variables including Minnesota codes (MC) have been described previously.[13–15] We defined major ECG abnormalities as: major Q waves (MC: 1.1, 2.12), minor Q waves and STT abnormalities (MC: 1.3 + 4.1 or 4.2 or 5.1 or 5.2), major isolated STT abnormalities (MC: