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Relation of Early Repolarization (J Point Elevation) to Mortality in Blacks (from the Jackson Heart Study)

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Abstract

Conflicting data exist regarding the associations of early repolarization (ER) with electrocardiogram (ECG) and clinical outcomes in blacks. We examined the association of ER defined by J point elevation (JPE) and all-cause mortality, and heart failure (HF) hospitalization in blacks in the Jackson Heart Study (JHS) cohort. We included JHS participants with ECGs from the baseline visit coding JPE and excluded participants with paced rhythms or QRS duration ≥ 120 ms. We compared the cumulative incidence of 10-year all-cause mortality and 8-year HF hospitalization by presence of JPE ≥ 0.1 mV in any ECG lead at baseline using Kaplan-Meier estimates and multivariable Cox models. Of the 4,978 participants, 1,410 (28%) had JPE at baseline: anterior leads 97.8%, lateral leads 8.3%, and inferior leads 2.9%. Compared with participants without JPE, those with JPE were younger, more likely to be male and current smokers, and less likely to have hypertension. Over a median follow-up of 8 years, there were no significant differences in the cumulative incidence or multivariable-adjusted hazards of all-cause mortality or HF hospitalization in participants with and without JPE in any lead (adjusted hazard ratio 0.97, 95% confidence interval 0.89 to 1.52, and adjusted hazard ratio 1.18, 95% confidence interval 0.9 to 1.54, respectively). Of the 2,523 participants who completed Exam 3 without JPE at baseline, 246 (10%) developed JPE over follow-up. In conclusion, JPE on ECG was not associated with long-term mortality or HF hospitalization in a large prospective black community cohort, suggesting that ER may represent a benign ECG finding in blacks.

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Supplementary Data

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Early repolarization (ER) was historically considered a benign electrocardiographic finding defined as an upward concave elevation of the RS-T segment with a distinct J wave, a slurred QRS downstroke, and/or distinct J points.^{1,2} More recent evidence has revealed an increased prevalence of ER in participants with idiopathic ventricular fibrillation.³ Previous studies have also found conflicting results of the association of ER and cardiovascular mortality.^{4–6} Specifically, ER has been associated with higher mortality in Caucasians, but evidence in nonwhite populations is limited. Most studies have only included a small number of black participants but 2 studies with a large number of black participants demonstrated no association with mortality and a decrease in the prevalence of ER over 20 years of follow-up.^{5,6} Given multiple morphologic variants, there is some subjectivity in the diagnosis of ER without well-established consensus criteria. The J point, the junction at the end of the QRS complex and at the beginning of the ST segment, is crucial to the definition of ER and is easily ascertained by validated ECG coding programs that quantify measurements of ST-segment deviation leading to preferred use in the evaluation of ER.^{6–9} A recent position statement by an American Heart Association (AHA) working group recommended an umbrella definition of ER clearly stating and including any of the following: ST-segment elevation in the absence of chest pain, terminal QRS slurring, or terminal QRS notching.^{10,11} The primary purpose of this study was to better understand the association of ER and outcomes in the large middle-aged black population in the Jackson Heart Study (JHS).

Methods

The JHS is an ongoing, prospective community-based observational study that began enrolling participants in 2000 to study cardiovascular disease in a black population.^{12,13} Subjects were recruited from the Jackson, Mississippi metropolitan statistical area through random, volunteer, the Atherosclerosis Risk in Communities (ARIC) study participants, and family through a community-drive recruitment model with community representatives guiding recruitment. Since initiation, participants have completed 3 in-person examinations: Exam 1 (September 2000 to March 2004), Exam 2 (October 2005 to December 2008), and Exam 3 (February 2009 to January 2013). Participants complete annual follow-up telephone calls to determine vital status and occurrence of hospitalizations. All participants provided written informed consent, and study protocols were approved by local institutional review boards. Data collected include demographics, co-morbid conditions, medications, laboratory values, supine 12-lead digital electrocardiograms (ECGs) (Exams 1 and 3 only), and echocardiogram (Exam 1 only). The ECGs were recorded after overnight fast and transmitted using the Marquette MAC/PC digital ECG recorder (Marquette Electronics, Milwaukee, Wisconsin) to the Electrocardiographic Reading Center at the University of Minnesota for Exam 1 ECGs. The Exam 1 ECGs were then read using a computer algorithm developed using the Minnesota Code Modular ECG Analysis System developed for clinical trials and population studies and have been validated previously.⁷ For Exam 3, a supine 12-lead ECG at rest was obtained for JHS participants using the GE MAC 1200 (GE Healthcare, Jackson, Mississippi). An electrode locator was used to determine and standardize the positioning of chest electrodes. Digital ECG signals were sent through a phone modem to the JHS ECG reading center located at the Epidemiological Cardiology

Research Center, Wake Forest University, Winston-Salem, North Carolina, where ECGs were automatically processed using 2001 GE Marquette 12-SL software after visual inspection for technical errors. The automatic processing of ECGs included measurement ST amplitude at the J point. There were no manual over-reads or review of J point measurements at either visit.

For analysis of the primary end point of mortality, we created a cohort (Cohort A) of all patients with Exam 1 documentation of J point amplitude (JAMP) on electrocardiogram determined by the automated Minnesota Code Modular ECG Analysis System.⁷ There were no manual ECG over-reads performed. Patients with atrial or ventricular pacing, as noted by Exam 1 ECG atrioventricular Minnesota Code 6–8 or QRS complex duration ≥ 120 ms, were excluded from analysis.⁷ Secondary end point analyses were conducted in the following subgroups of Cohort A: (1) for the analysis of HF hospitalization, we included participants surviving to 2005, when HF hospitalization surveillance began (Cohort B); (2) for the analysis of factors associated with development of J point elevation (JPE), we included participants without JPE at Exam 1 that completed Exam 3 with documentation of JAMP on ECG (Cohort C).

The primary exposure variable was JAMP on ECG at clinical Exams 1 and 3. We examined JAMP in inferior (JAMP II, III, aVF), lateral (JAMP V6, I, aVL), anterior (JAMP V1, V2, V3, V4, V5), and JAMP aVR leads. For the primary analysis, JPE was defined as JAMP ≥ 0.1 mV found in any of the previously mentioned lead positions. We also examined JAMP ≥ 0.1 mV at inferior, lateral, and anterior lead positions. In secondary analyses, we examined high-risk JPE defined as JAMP ≥ 0.2 mV in any lead position given previous evidence revealing higher amplitude in subjects who had cardiovascular events.^{3,4} Although previous data suggest that inferior lead JPE is the primary lead associated with sudden cardiac death, other conflicting data exist and the AHA guideline statement recommending future studies classify ER using outcome-driven approaches to define meaningful and prevalent variant patterns led to our methodologic choices.¹⁰

The primary outcome was all-cause mortality within 10 years after Exam 1. Procedures to identify deaths in the JHS have been previously detailed.¹⁴ Data were generated from the following sources: annual follow-up including interviews with participants and next of kin, the National Death Index from the Centers for Disease Control and Prevention, and physician and coroner reports which were reviewed by a medical record abstraction unit. All diagnoses were adjudicated by trained medical staff. We also assessed HF hospitalization for 8 years among participants who survived to January 1, 2005 (beginning of surveillance for HF hospitalization) for Cohort B participants. HF hospitalizations were adjudicated by trained and certified HF abstractors through December 31, 2012 at the time of the analysis, and required (1) a discharge diagnosis of *International Classification of Diseases*, 9th Revision (ICD9) code 428 and/or underlying cause of death I50; and (2) radiographic, hemodynamic, or echocardiographic findings of HF; or (3) autopsy finding of pulmonary edema/HF.¹⁴ Any HF hospitalizations occurring in noncatchment area hospitals were validated by obtaining additional data after patient consent. Trained medical staff also reviewed and adjudicated primary diagnoses by their corresponding ICD-9-CM codes.

Development of JPE over the study period, defined as JAMP ≥ 0.1 mV in any lead at Exam 3, was assessed as a secondary outcome among Cohort C subjects.

Variables obtained from Exam 1 included demographics, co-morbid conditions, self-reported physical activity, alcoholic drink and caffeine consumption, physical examination findings, laboratory values, echocardiographic and ECG results, and medications. Among co-morbidities, hypertension (defined as systolic blood pressure/diastolic blood pressure $\geq 140/90$ mm Hg or use of blood pressure-lowering medications) and diabetes mellitus (fasting glucose ≥ 126 mg/dl, hemoglobin A1c $\geq 6.5\%$, or taking diabetes medications) were based on physician examination/laboratory values, atrial fibrillation was based on electrocardiographic evidence, and myocardial infarction, stroke, chronic lung disease, and smoking were self-reported. To determine presence of baseline HF, we applied modified Gothenburg criteria as developed and validated in the ARIC study.¹⁵ To ascertain left ventricular hypertrophy, we used quantitative left ventricular mass measurement from 2-dimensional or M-mode echocardiography when available (missing for 5% of participants); otherwise, left ventricular hypertrophy was based on a previously described qualitative assessment of mild, moderate, or severe hypertrophy.⁷ Baseline medication variables were ascertained using therapeutic classification codes recorded based on medications taken within 2 weeks of Exam 1.

We described Exam 1 baseline characteristics of the study population by presence of JPE in any lead position using frequencies with percentages for categorical variables and means with standard deviations or medians with interquartile range for continuous variables. We tested for differences between groups using the chi-square tests for categorical variables and Wilcoxon rank sum tests for continuous variables.

We assessed the associations of ER and outcomes. We calculated the cumulative incidence of all-cause mortality (Cohort A) and HF hospitalization (Cohort B) by presence of JPE using Kaplan-Meier estimates and tested for differences between the groups using log-rank tests. We estimated the unadjusted and adjusted associations of JPE and mortality and HF hospitalization using Cox proportional hazards models. Covariates from the baseline examination used as adjustment variables in the models were derived from previous JPE studies and clinical judgment and included age, gender, previous myocardial infarction, HF, hypertension, stroke, diabetes, atrial fibrillation, current smoking, previous smoking, physical activity hours/week, body mass index (BMI), systolic blood pressure, heart rate, estimated glomerular filtration rate, left ventricular hypertrophy, Cornell voltage criteria, left ventricular dimension, QRS duration, QTc duration, ACE-inhibitor/angiotensin receptor blocker, antiarrhythmic, β -blocker, calcium channel blocker, digoxin, and a variable for missing medication data.⁴⁻⁶ For all regression models, we restricted the total number of covariates based on a minimum of 10 events per variable and tested covariates for multicollinearity based on variance inflation factor >3 . We used a Kolmogorov-type Supremum test for proportional hazards assumption for the JPE study variable in both the mortality and the HF hospitalization outcome models. Study participants were censored at the time of (1) participant loss to follow-up or (2) end of study event surveillance follow-up on December 31, 2012. For HF hospitalization, we also censored participants at the time of death.

To examine the development of JPE in Cohort C, we used a modified Poisson model with an offset parameter to adjust for log of participant time between Exam 1 and Exam 3 (range 6 to 12 years).^{16,17} We used clinical judgment to select variables for the prediction model (including the same covariates as used in the Cox model listed previously in detail).

Most variables had very low missing rates. Among variables with <5% missing data, we imputed continuous variables to the overall median value, dichotomous variables to no, and multichotomous variables to the most frequent categorical value.¹⁸ For medication variables which were missing in 7% of participants, we assigned missing values to a separate category (coded as no, yes, or missing). We used a 2-tailed $\alpha = 0.05$ to establish statistical significance and we report 95% confidence intervals (CIs). We used SAS version 9.4 (SAS Institute Inc., Cary, North Carolina) for all analyses. The Institutional Review Board of the Duke University Health System approved the study.

Results

In total, 4,978 of 5,289 JHS participants (94.1%) who had documentation of JAMP on the baseline ECG and met other study criteria were included in this analysis. JPE at any lead was present in 28.3% of participants (1,410). The baseline characteristics of the study population stratified by presence or absence of JPE at any lead are presented in Table 1. Compared with participants without JPE, participants with JPE were younger (median age 52.0 years vs 56.3 years), more often male (63.5% vs 24.9%), more likely to be current smokers (17.4% vs 11.2%), and had lower BMI (median BMI 28.9 kg/m² vs 31.3 kg/m²) compared with those participants without JPE. The prevalence of most co-morbidities was similar, although participants with JPE less often had hypertension (50.4% vs 57.8%) and HF (4.8% vs 7.8%). Table 2 lists the frequency of baseline JPE by lead positions. Excluding leads V1 to V3 reduced the prevalence of JPE from 1,410 (28.3%) to 806 (16.2%) participants. JPE was found most frequently in the anterior lead position (27.7%), followed by the lateral leads (2.4%) and the inferior leads (0.8%).

Table 3 lists the cumulative incidence and multivariable-adjusted hazard ratios of all-cause mortality and HF hospitalization stratified by presence or absence of JPE at baseline. There was no significant difference in the cumulative incidence of all-cause mortality (11.1% vs 11.4%, $p = 0.9$) or HF hospitalization (6.9% vs 7.2%, $p = 0.88$) in participants who had JPE compared with those without JPE. Similarly, there was no significant difference in the adjusted hazard for all-cause mortality (hazard ratio [HR] 0.97, 95% CI 0.89 to 1.52, $p = 0.77$) or HF hospitalization (HR 1.18, 95% CI 0.90 to 1.54, $p = 0.24$). Interestingly, there was a significant difference in the cumulative incidence of all-cause mortality (8.9% vs 11.8%, $p = 0.02$) and HF hospitalization (4.4% vs 7.6%, $p = 0.003$) when leads V1 to V3 were excluded from analysis. However, there was no significant difference in the adjusted hazard ratio for all-cause mortality (HR 0.92, 95% CI 0.70 to 1.22, $p = 0.55$) or HF hospitalization (HR 0.85, 95% CI 0.58 to 1.26, $p = 0.42$). The cumulative incidence of mortality and HF hospitalization over the study period according to baseline JPE are presented in Figures 1 and 2, respectively. Defining JPE as ≥ 0.2 mV resulted in no differences by presence of JPE in the cumulative incidence of all-cause mortality or HF hospitalization for any lead (p -value = 0.51 and 0.99, respectively) or any lead excluding

leads V1 to V3 (p-value = 0.51 and 0.37, respectively) (Table 4). Tests indicated that the proportional hazards assumption was met for our primary JPE study variable for both the mortality and the HF hospitalization outcome models.

Participants who completed Exam 3 had a median age of 55 years (interquartile range 45.6 to 63.5), were 75.9% female, had similar rates of co-morbidities, physical examination and laboratory data, and medication use as participants that completed Exam 1 (Table S1). In the 2,523 participants without baseline JPE who had JAMP recorded on ECG in Exam 3 (Cohort C), 9.8% (n = 246) developed JPE in any lead. Of the 246 participants who developed JPE at Exam 3, 166 (67.5%) developed JPE in the anterior lead. As the majority of participants developed JPE in the anterior lead, we did not have sufficient power to examine the associations of the presence of JPE in a specific lead and outcomes. There were very few clinical differences between participants who did and did not develop JPE at Exam 3 (Table S2). In multivariable regression analyses, male gender was associated with a 59% higher risk of developing JPE compared with female gender (risk ratio 1.59, 95% CI [1.17, 2.17], p = .003). The only other factor that was associated with JPE development was use of antiarrhythmic medication at baseline (risk ratio 4.83, 95% CI [1.48, 15.7], p = .009).

Discussion

In this large cohort of blacks with available ECG data, JPE was not associated with all-cause mortality or HF hospitalization. The majority of JPE was localized to the anterior lead position and patients with JPE at baseline were younger, more likely to be male, have lower BMI, and are current smokers compared with those without JPE at baseline. Our results support previous findings from the ARIC study where JPE was not associated with sudden cardiac death or cardiac mortality in blacks.⁶ However, our results are contrary to other studies, which have reported that JPE was associated with increased risk of idiopathic ventricular fibrillation and death.^{3,4}

Previous studies have focused on JPE in the inferior and lateral lead positions.^{3–5} In the ARIC study, JPE was present in 12.3% of participants (44.3% male, 26.9% black), with blacks having a higher prevalence of JPE than whites (24.4% vs 7.9%, respectively). JPE was most common in the anterior lead (11.7%), followed by the inferior (0.8%) and lateral (0.6%) leads.⁶ The Finnish Mobile Clinic Health Survey demonstrated a prevalence of 5.8% with ER—inferior (3.5%), lateral (2.4%), and both leads (0.1%).⁴ The large outpatient VA Palo Alto Health Care System (87% male, 13% black, 6% Hispanic) revealed a prevalence of 2.3% for inferior or lateral ST-segment elevation with 0.6% in the inferior leads, 1.6% in the lateral leads, and 0.6% in both leads.⁵

The Finnish Mobile Clinic Health Survey was the first large study to identify ER as a risk factor associated with increased risk of death when seen in the inferior leads (adjusted relative risk 1.28, 95% CI 1.04 to 1.59, p-value = 0.03). Furthermore, 0.3% of participants had JPE more than 0.2 mV with even higher risk of death from cardiac causes (adjusted relative risk 2.98, 95% CI, 1.85 to 4.92, p < 0.001).⁴ The ARIC study revealed similar findings but also differences: JPE was not significantly associated with sudden cardiac death in the overall study (HR 1.23, 95% CI 0.87 to 1.75) but significant interactions were present

between race and JPE, as well as gender and JPE. Specifically, JPE was predictive of sudden cardiac death in whites (adjusted HR 2.03, 95% CI 1.28 to 3.21, $p = 0.006$) and female gender (adjusted HR 2.54, 95% CI 1.34 to 4.82, $p = 0.02$).⁶ The large VA Palo Alto Health Care System study found no association of ER evaluated as J waves, slurs, and ST elevation patterns and cardiac mortality (all p -values >0.1).⁵ Our findings from the JHS cannot be directly compared with the Finnish study findings given the difference in prevalence at the inferior lead position. Yet, our results do support the general findings of Pargoanker et al and the Palo Alto Health Care System study (no association between ER and mortality) and the specific findings from ARIC that ER in blacks is not associated with cardiovascular mortality.^{5,6,19,20} However, it may be that previous studies have not defined ER correctly and perhaps the definition of ER in blacks should be different. These results support the recent AHA recommendation that moving forward, ER should be defined using an outcome-driven approach to define meaningful and prevalent variant patterns.¹⁰

The change in ECG processing between Exams 1 and 3 may have contributed to discrepant findings. However, JPE at Exam 1 was determined by a computer algorithm using the Minnesota Code Modular ECG Analysis System that has been previously validated and that at Exam 3 was determined by a similarly validated algorithm at the Epidemiological Cardiology Research Center, Wake Forest University.^{8,9} There were no manual over-reads or review of J point measurements by physicians; however, the electronic ECG computer algorithms are well validated and previous studies have limited ECGs with over-read. Other studies have utilized physician ECG readers to define the amplitude of JPE from baseline: the Finnish Mobile Clinic Health Survey had physicians double-check all ECGs, with ER pattern demonstrating consensus among 542 of 630 total participants.⁴ The ARIC study utilized the Minnesota Code computer algorithm with a random sampling of tracings sent to be visually coded. The Palo Alto Health Care System study used a centralized, computerized ECG system (GE Healthcare, Wauwatosa, Wisconsin) and Minnesota Codes for J waves; however, all ECGs exhibiting ST-segment elevation were reread by 3 observers (4.5% updated and corrected). There are inconsistencies in how the ECGs were initially interpreted between studies, highlighting the importance of recent position papers recommending clear use of established terminology.^{10,11} The sports cardiology societies evaluating the use of ECG screening criteria to detect cardiac abnormalities in athletes have refined their criteria such that they have maintained sensitivity and increased specificity while reducing false-positive tests with consideration of characteristics specific to blacks.^{21–23}

A few key limitations should be considered from this analysis. This was a retrospective analysis from an observational cohort study of black patients in Jackson, Mississippi, that was not powered to assess the associations of JPE in specific lead positions and outcomes. We focused on the outcomes of mortality and HF hospitalizations, although future studies should explore major cardiovascular events including stroke and myocardial infarction related to JPE. In addition, these findings may not generalize to patients from different geographical locations or of other races and ethnicities. Although we adjusted for clinically relevant covariates, bias may have been introduced from unknown and unmeasured variables related to cardiovascular health. All ECGs were electronically interpreted and were not read by cardiologists, which may have under- or overrepresented the true incidence of JPE in our study. Although baseline JPE data were complete for $>99\%$ of JHS participants (5183/5289),

not all participants had Exam 3 data, and missingness of baseline and follow-up variables may have introduced bias related to nonrandom causes. In conclusion, JPE may be a benign finding in blacks and is not associated with all-cause mortality or HF. However, previous studies that included primarily Caucasian participants focused on inferior and lateral lead JPE 0.1 mV, which has low prevalence in black populations. Future studies are needed to better characterize differences in ER between blacks and participants of other races and ethnicities.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Cumulative incidence of mortality by absence or presence of J point elevation at any lead 0.1 mV.

Figure 2. Cumulative incidence of HF hospitalization by absence or presence of J-point elevation at any lead ≥ 0.1 mV.

Table 1

Baseline characteristics of the study population by absence or presence of J point elevation at any lead (primary cohort) *

Variable	J Point Elevation		p-value
	No N = 3,568	Yes N = 1,410	
Age, median (IQR)(Years)	56.3 (46.2, 65.0)	52.0 (43.2, 62.7)	< .001
Men	888 (24.9%)	895 (63.5%)	< .001
Prior Myocardial infarction	169 (4.7%)	72 (5.1%)	.58
Heart failure	280 (7.8%)	68 (4.8%)	< .001
Hypertension	2,063 (57.8%)	711 (50.4%)	< .001
Stroke	146 (4.1%)	62 (4.4%)	.63
Diabetes mellitus	758 (21.2%)	282 (20.0%)	.33
Chronic lung disease	254 (7.1%)	98 (7.0%)	.83
Atrial fibrillation	15 (0.4%)	2 (0.1%)	.13
Current smoker	401 (11.2%)	245 (17.4%)	< .001
Prior smoker	661 (18.5%)	285 (20.2%)	.17
Alcoholic drinks per week, median (IQR)	0.0 (0.0, 0.3)	0.0 (0.0, 1.5)	< .001 .004
Average number of hours of physical activity per week			
None	1,741 ± 49	623 ± 44	.003
<1	384 ± 11	144 ± 10	.57
1- < 2	575 ± 16	234 ± 17	.68
2- < 3	285 ± 8	128 ± 9	.21
3- < 4	217 ± 6	87 ± 6	.91
4 +	366 ± 10	194 ± 14	< .001
Caffeine consumption, (mg/day)	82.4 (20.6, 183.0)	87.4 (24.1, 192.2)	.04
Physical examination, median (IQR)			
Body Mass Index, (kg/m ²)	31.3 (27.4, 36.4)	28.9 (25.6, 33.0)	< .001
Neck circumference, (cm)	38.0 (35.0, 41.0)	39.0 (37.0, 42.0)	< .001
Systolic blood pressure, (mm Hg)	125.0 (115.6, 135.7)	125.7 (116.5, 137.6)	.05
Heart rate, (beats per minute)	64.0 (58.0, 71.0)	61.0 (56.0, 70.0)	< .001
Serum sodium, (mEq/L)	141.0 (139.0, 142.0)	141.0 (139.0, 142.0)	.23

Variable	J Point Elevation		p-value
	No N = 3,568	Yes N = 1,410	
eGFR, (ml/min/1.73 m ²)	86.0 (75.6, 96.2)	87.4 (77.2, 98.7)	<.001
Hemoglobin, (g/dL)	12.9 (12.1, 13.7)	13.6 (12.7, 14.6)	<.001
Baseline echocardiography and ECG			
Ejection Fraction, mean (SD), (%)	62.3 (7.1)	61.6 (7.4)	.004
Ejection Fraction, median (IQR), (%)	65.0 (55.0, 65.0)	65.0 (55.0, 65.0)	.004
LVEF <40%	21 (0.6%)	12 (0.9%)	.30
Left ventricular hypertrophy	279 (7.8%)	99 (7.0%)	.34
Cornell voltage criteria, median (IQR), (mm)	14.0 (11.0, 18.0)	15.0 (11.0, 20.0)	.03
LV dimension, median (IQR), (cm)	48.3 (45.5, 50.8)	48.5 (46.0, 51.4)	<.001
QRS duration, median (IQR), (msec)	90.0 (84.0, 98.0)	94.0 (86.0, 102.0)	<.001
QTc duration, median (IQR), (msec)	427.0 (410.5, 444.0)	417.0 (399.0, 434.0)	<.001
Medications			
ACE-inhibitor/Angiotensin receptor blocker	592 (16.6%)	207 (14.7%)	.10
Anti-arrhythmic	11 (0.3%)	3 (0.2%)	.57
Beta-blocker	355 (9.9%)	124 (8.8%)	.21
Calcium channel blocker	589 (16.5%)	196 (13.9%)	.02
Digoxin	50 (1.4%)	10 (0.7%)	.04
Any missing medications	241 (6.8%)	131 (9.3%)	.002

* Categorical variables are presented as frequencies, and continuous variables are presented as medians with interquartile ranges (IQR).

Table 2

Frequency of baseline (Exam 1) J point elevation and lead Position

Variable	Exam 1 (N = 4,978)
Any lead 0.1 mV*	1,410 (28.3%)
Any lead (excluding V1-V3) 0.1 mV	806 (16.2%)
Inferior lead 0.1 mV	41 (0.8%)
Lateral lead 0.1 mV	117(2.4%)
Anterior lead 0.1 mV	1,379 (27.7%)
Anterior lead (excluding V1-V3) 0.1 mV	770 (15.5%)
Any lead 0.2 mV	146 (2.9%)
Any lead (excluding V1-V3) 0.2 mV	55 (1.1%)

* One thousand three hundred seventy-nine of 1410 (97.8%) with JPE were found at an anterior lead (V1, V2, V3, V4, or V5).

Table 3

Cumulative incidence of all-cause mortality and HF hospitalization stratified by presence or absence of JPE
0.1 mV at any lead and excluding leads V1 to V3

Variable	J-Point Elevation		p-value
	No N = 3568	Yes N = 1410	
Mortality			
Cumulative Incidence	355 (11.4%)	140(11.1%)	.90
Unadjusted Hazard Ratio (95% CI) *	1.00 (referent)	0.99 (0.81, 1.20)	.90
Adjusted Hazard Ratio (95% CI) *, [†]	1.00 (referent)	0.97 (0.89, 1.52)	.77
Heart failure hospitalization			
Cumulative Incidence	220 (7.2%)	86 (6.9%)	.88
Unadjusted Hazard Ratio (95% CI) *	1.00 (referent)	0.98 (0.76, 1.26)	.88
Adjusted Hazard Ratio (95% CI) *, [†]	1.00 (referent)	1.18 (0.90, 1.54)	.24

	J-Point Elevation excluding V1-V3		p-value
	No N = 4172	Yes N = 806	
Mortality			
Cumulative Incidence (excluding lead V1-V3)	432 (11.8%)	63 (8.9%)	.02
Unadjusted Hazard Ratio (95% CI) *	1.00 (referent)	0.74 (0.56, 0.96)	.02
Adjusted Hazard Ratio (95% CI) *, [†]	1.00 (referent)	0.92 (0.70, 1.22)	.55
Heart failure hospitalization			
Cumulative Incidence (excluding lead V1-V3)	274 (7.6%)	32 (4.4%)	.003
Unadjusted Hazard Ratio (95% CI) *	1.00 (referent)	0.58 (0.40, 0.84)	.003
Adjusted Hazard Ratio (95% CI) *, [†]	1.00 (referent)	0.85 (0.58, 1.26)	.42

* Reference group is no JPE.

[†] Model adjusted for age, gender, myocardial infarction, diabetes, stroke, tobacco use (current smoker, former smoker), physical activity, systolic blood pressure, BMI, heart rate, renal function (eGFR), antiarrhythmic, β -blockers, calcium channel blockers, digoxin, ACE-inhibitors/ARB, QRS duration, QTc duration, Cornell voltage, LVH, left ventricular diastolic dimension, hypertension, heart failure, atrial fibrillation/atrial flutter.

Table 4

Cumulative incidence of all-cause mortality and HF hospitalization, by absence or presence of JPE at any lead 0.2 mV and any lead 0.2 mV excluding leads V1-V3

Variable	J-Point Elevation		p-value
	No	Yes	
Mortality	478 (11.3%) (10.3, 12.3)	17 (12.3%) (7.9, 19.3)	.51
Mortality (excluding leads V1-V3)	488 (11.3%) (10.4, 12.3)	7 (13.5%) (6.7, 27.0)	.51
Heart failure hospitalization	297 (7.1%) (6.4, 7.9)	9 (7.3%) (3.9, 13.7)	.99
Heart failure hospitalization (excluding leads V1-V3)	301 (7.1) (6.3, 7.9)	5 (10.2%) (4.4, 23.7)	.37

Presented as N (cumulative incidence %) (95% confidence Interval).