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Utility of nonspecific resting electrocardiographic features for detection of coronary artery stenosis by Computed Tomography in acute chest pain patients: from the ROMICAT trial

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Abstract

Twelve-lead surface electrocardiography (ECG) and computed tomography (CT) are used to evaluate for myocardial ischemia and coronary artery disease (CAD), respectively. We aimed to

determine features on resting ECG that predict coronary artery stenosis by cardiac CT. In 309 acute chest pain patients, we compared the initial triage resting ECG to contrast-enhanced 64-slice cardiac CT angiography. We assessed for 6 quantitative (QT interval, QTc interval, QTc > 440 ms, gender-specific QTc, QT dispersion and QRS duration) and 4 qualitative ECG parameters (ST depression >0.05 to ≤0.1 mV, T wave inversion ≥0.1 mV, T wave flattening, and any T wave abnormalities) and for the presence of coronary stenosis by CT (>50% luminal narrowing). Specificities of these ECG parameters were excellent (83.6–97.0%) while sensitivities were poor (12.2–29.3%). For coronary stenosis detection, the ECG features with the greatest performance were the presence of ST depression (positive likelihood ratio [LR+] 4.09) and T wave inversion (LR+ 4.58). In multivariable analyses, the risk for coronary stenosis increased by 33–41% for every 20 ms prolongation of the QTc interval after adjusting for age, gender, and cardiac risk factors or adjustment for Framingham risk score. Similarly, there was an increase of fourfold with the presence of ST depression >0.05 to ≤0.1 mV or T wave inversion ≥0.1 mV. In acute chest pain patients, resting ECG features of QTc interval prolongation, mild ST depression, and T wave inversion are independently associated with the presence of CT coronary stenosis and their presence suggests an increase risk of CAD.

Keywords

Electrocardiography; Coronary artery stenosis; Computed tomography; Acute chest pain; Emergency department

Introduction

The twelve-lead surface electrocardiogram (ECG) is an inexpensive modality used in daily practice for the evaluation of myocardial ischemia in patients with suspected coronary artery disease (CAD). Nonspecific resting ECG findings have been associated with the presence of CAD and adverse clinical outcomes [1–7]. Quantitative parameters include prolongation of QT interval, QTc interval correcting for heart rate, QT dispersion and QRS duration, [1–5,8,9] while qualitative measures include T wave abnormalities [6,7] and ST depression of ≥0.05 mV and <0.1 mV [10]. QTc intervals of practical importance include the dichotomized categories of QTc interval prolongation >440 ms and gender-specific QTc interval of >450 ms for men and >470 ms for women and have been associated with increase risk of sudden death [11]. T wave abnormalities encompassing T wave inversion ≥0.1 mV depression, [6,7] T wave flattening (not upright and <0.1 mV inversion) [12,13] and biphasic T waves [14,15] have been used in the differential diagnosis in chest pain and have long-term prognostic implications after myocardial infarction. Coronary computed tomography angiography (CT) has been shown to be an accurate noninvasive imaging modality for the detection of coronary artery stenosis, defined as >50% luminal narrowing, when compared to invasive coronary angiography [16–18].

The “Rule Out Myocardial Infarction Using Computer Assisted Tomography” (ROMICAT) trial included a large collective patient cohort without known history of CAD who presented to the emergency department with acute chest pain and had initial negative biomarkers and non-diagnostic ECG prior to admission [19]. These patients had both resting triage ECG and cardiac CT done within 24 h of each other, allowing for the comparison of nonspecific ECG features to coronary artery stenosis by CT. The significance of these ECG features to coronary artery stenosis as determined by CT remained uncertain.

In this ROMICAT substudy, we sought to determine the diagnostic performance and association of these quantitative and qualitative ECG parameters to coronary artery stenosis by CT in ED patients with acute chest pain who had initial non-diagnostic ECG.

Methods

Study population

The study design and results have been previously reported [19]. Briefly, the ROMICAT trial is a double-blinded, single site prospective observational cohort study of consecutive adult patients at low-to-intermediate likelihood of acute coronary syndrome who presented to the emergency department of a tertiary-care hospital with acute chest pain and were awaiting hospital admission. Patients must have an initial electrocardiogram (ECG) without new diagnostic ECG changes, including ST-segment elevation or depression ≥ 1 mm or T wave inversion >4 mm in >2 anatomical contiguous leads, as previously described [19]. Additionally, patients must have normal initial troponin and in sinus rhythm. All eligible patients who consented underwent ECG-gated contrast-enhanced 64-slice multi-detector CT. Our institutional review board approved the study protocol and all patients provided written informed consent.

In this analysis, we included patients where we had both initial triage ECG and CT available for analysis. The ECG analyzed was obtained prior to and within 24 h of the CT scan. From the 368 patients in ROMICAT which excluded patients with coronary artery bypass graft or percutaneous coronary stents, we excluded an additional 20 patients with self-report of CAD and 25 patients in whom the electronic ECG was not available for review. In addition, we excluded patients with left bundle branch block ($n = 5$), right bundle branch block (RBBB, $n = 6$), and on digoxin therapy ($n = 3$). Our final analysis included a total cohort of 309 patients where both CT and ECG were available for interpretation.

CT data acquisition and measurements

CT imaging was performed using a standard 64-slice multi-detector CT coronary angiography (Sensation 64, Siemens Medical Solutions, Forchheim, Germany) protocol that was acquired at end inspiration and included the administration of sublingual nitroglycerin (0.6 mg) and intravenous beta-blocker (metoprolol 5–20 mg) for those with the baseline heart rate >60 beats per minute and no other contraindications. A test bolus protocol was employed and contrast agent (Iodixanol 320 g/cm³, Visipaque, General Electric Healthcare, Princeton, NJ, USA) used based on scan range at 5 ml/s. CT images were acquired in spiral mode, gantry rotation time of 330 ms, 64×0.6 mm slice collimation, tube voltage of 120 kV, effective tube current of 850–950 mAs, with ECG-correlated tube current modulation when appropriate, resulting in a mean estimated radiation dose of 13.8 ± 3.6 millisievert.

For coronary artery assessment, transaxial images were reconstructed using a medium sharp convolution kernel with a slice thickness of 0.75 mm and increment of 0.4 mm. Coronary artery assessment was performed offline using the Leonardo workstation (Siemens Medical Solutions, Forchheim, Germany). The coronary stenosis interpretations were performed by joint reading of two readers by consensus with disagreement resolved by a third reader, as previously validated [20]. The CT readers were blinded to the ECG results. The presence of coronary stenosis was defined as luminal narrowing of $>50\%$ diameter or if stenosis could not be excluded on a per patient basis.

ECG measurements

All ECG readers were blinded to the CT imaging results. Quantitative assessments were performed using electronic caliper (Cardio Calipers, Iconico, Inc., New York, NY) for QT dispersion and computerized reads for QT interval, QTc interval, and QRS duration. QT dispersion was calculated as the difference between electronically measured maximum QT interval and minimum QT interval. The QTc interval, which corrected for heart rate, was obtained and from the computerized read. In addition, the QTc interval was dichotomized by

two separate criteria: the first defined as QTc interval prolongation >440 ms and the second gender-specific QTc interval of >450 ms for men and >470 ms for women [11].

Qualitative assessments of ECG readings were performed by consensus from two independent cardiologists with disagreement resolved by adjudication from a third cardiologist. Qualitative ECG changes were considered positive if present in at least two contiguous leads. ST depression was defined as ≥ 0.05 and < 0.1 mV. T wave inversion was defined as ≥ 0.1 mV depression. T wave flattening was defined as not upright and < 0.1 mV inversion. Any T wave changes included T wave inversion, flattening, and biphasic T wave changes.

Covariates of interests

Cardiovascular risk factors and medical history were assessed at the time of subject's enrollment based on self-report or obtained from the medical records during the index hospitalization. Body mass index (BMI) was defined as weight (kilograms) divided by the height squared (meters). Hypertension was defined as systolic blood pressure of at least 140 mm Hg or diastolic blood pressure of at least 90 mm Hg or current antihypertensive treatment. Diabetes mellitus was defined as a fasting plasma glucose ≥ 126 mg/dl or treatment with a hypoglycemic agent. Hyperlipidemia was defined as total cholesterol of > 200 mg/dl or treatment with a lipid lowering medication. Subjects were classified as smokers if they had smoked at least one cigarette per day in the year prior to the study.

Statistical analysis

Descriptive statistics were expressed as mean $\pm$ standard deviation (SD) for continuous variables and as frequency and percentages for nominal variables. The differences in means between two groups were determined using Student's *t* test for continuous variables and differences in proportions were determined by Fisher's Exact or Chi-square test for categorical variables. In determining the diagnostic test characteristics of the ECG parameters to the presence of CT coronary artery stenosis, we calculated the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and test-positive and test-negative likelihood ratios (LR+ and LR-). We used logistic regression to determine the association between the ECG parameters and CT coronary stenosis. To determine whether an ECG parameter remained independently associated with coronary stenosis, we performed multivariable logistic regression models and adjusted for potential confounders based on a priori knowledge, with $P < 0.10$ on univariate screen. Covariates adjusted included age, hypertension, diabetes mellitus, and hyperlipidemia in addition to gender which was forced into the models for face validity. Additionally, we performed similar multivariable analyses with adjustment for Framingham risk score (FRS). Hosmer and Lemeshow Goodness-of-Fit Test were tested for all the models and demonstrated good model fit. The interobserver reproducibility for the electronic ECG measurements was determined for 20 randomly selected studies and assessed using intraclass correlation coefficient (ICC). The interobserver ICC was 0.96 for the maximum QT interval and 0.95 for the minimum QT interval. For the detection of presence of coronary stenosis on a per patient basis, Cohen's Kappa was 0.82, as previously reported [20]. A 2-tailed *P* value of < 0.05 was considered to indicate statistical significance. All analyses were performed using SAS (Version 9.2, SAS Institute Inc., Cary, North Carolina) and SPSS (Version 16.0, Chicago, Illinois).

Results

Characteristics of study subjects

The baseline characteristics of these 309 patients are shown in Table 1. Their quantitative and qualitative ECG measurements are depicted in Table 2. In this cohort, 185 (59.9%) were men, with a mean age of 52 years, and BMI of 29 kg/m². The mean ECG heart rate was 69.8 ± 14.5 bpm and the mean CT heart rate was 65.2 ± 11.9 bpm. Overall, there were 41 (13.3%) patients with presence of any coronary artery stenosis by CTA. As compared to patients without coronary stenosis, those with coronary stenosis were older by 10 years, had higher proportion of hypertension, diabetes mellitus, hyperlipidemia, and higher Framingham risk score (all $P \leq 0.01$). There were no differences in gender, BMI, and current smoking history when comparing patients with and without coronary stenosis ($P \geq 0.30$).

Quantitative ECG parameters comparison with CT stenosis

We compared the differences between patients with and without CT coronary stenosis to the 6 quantitative ECG parameters, as shown in Table 2. Patients with coronary stenosis had longer QTc interval by 30.8 ms ($P = 0.036$) than those without. When stratified by prolonged QTc > 440 ms, there were more patients with coronary stenosis with prolonged QTc > 440 ms than those without stenosis (24.4 vs. 12.7%, $P = 0.046$). The other four quantitative ECG parameters evaluated, including QT interval, gender-specific QTc, QT dispersion, and QRS duration were not significantly different between the two groups (all $P \geq 0.15$).

Qualitative ECG parameters comparison with CT stenosis

Table 2 also showed the difference in proportions between patients with and without stenosis based on qualitative ECG parameters. We compared the two groups based on the presence of ST depression, T wave inversion, T wave flattening, and any T wave changes. More patients with coronary stenosis had ST depression (12.2%) than those without stenosis (3.0%, $P = 0.02$). With respect to T wave abnormalities, T wave inversion was present in more patients with coronary stenosis (17.1%) than those without (3.7%, $P = 0.003$), while there was no difference between the two groups with respect to T wave flattening ($P = 0.33$). There were two patients with biphasic T waves, neither of which had CT stenosis. When combining the 3 T wave changes of T wave inversion, T wave flattening, and biphasic T waves, presence of any of these 3 T wave changes had higher occurrence in patients with coronary stenosis than those without (29.3 vs. 16.4%, $P = 0.047$).

Diagnostic accuracy of ECG findings for coronary stenosis by CT

Table 3 depicts the diagnostic accuracy of the dichotomized ECG parameters for both quantitative and qualitative measures to detect CT coronary artery stenosis. While the specificity was excellent (ranged from 83.6–97.0%), the sensitivity was poor (ranged from 12.2–29.3%). Similarly, the NPV was high (ranged from 87.5–88.5%), while the PPV was lower and more variable (ranged from 17.8–41.2%). A positive ECG finding had greater diagnostic yield to change the post-test probability of having coronary stenosis than that of a negative ECG result. The ECG parameters with the best diagnostic performance were the qualitative measures of T wave inversion (LR+ of 4.58) and ST depression (LR+ of 4.09). The ECG parameters of QTc > 440 ms, gender-specific QTc, and any T wave changes had a twofold increase in the positive likelihood test (LR+ range of 1.78–2.33). The positive finding of T wave flattening performed the worst with the LR+ of 1.41. For all the ECG parameters, a negative ECG test finding had little change in the post-test probability for coronary stenosis (LR– range of 0.86–0.93).

Association between ECG parameters to CT stenosis

Figure 1 illustrates the association between the quantitative ECG parameters and the presence of coronary artery stenosis on CT. In crude analysis, both QTc interval and prolonged QTc > 440 ms were associated with coronary stenosis (both $P \leq 0.05$), while neither QT interval nor gender-specific QTc were associated with coronary stenosis (both $P \geq 0.70$). For every 20 ms increment in QTc interval, there was a 33% increase in odds for having coronary stenosis after adjusting for age, gender, and cardiac risk factors (adjusted odds ratio [OR] 1.33, $P = 0.027$) and a 41% increase after adjusting for FRS (adjusted OR 1.41, $P < 0.0001$). There remained a twofold increase in odds of having coronary stenosis in those with prolonged QTc > 440 ms after adjustment for FRS (adjusted OR 2.44, $P < 0.0001$) but the association was no longer significant after adjustment for age, gender, and cardiac risk factors ($P = 0.16$).

For the qualitative ECG parameters, the associations to CT coronary stenosis are shown in Fig. 2. In univariate analysis, ST depression, T wave inversion, or any T wave changes was associated with coronary stenosis ($P \leq 0.05$), while T wave flattening was not ($P = 0.34$). Patients with ST depression had over fourfold increase in risk of coronary stenosis as compared to those without ST depression after adjustment for age, gender, and cardiac risk factors (adjusted OR 4.23, $P = 0.048$) and over sevenfold increase after adjusting for FRS (adjusted OR 7.89, $P < 0.0001$). In patients with T wave inversion, there was a near fourfold increase in risk for coronary stenosis as compared to patients without this ECG finding after adjustment for age, gender, and cardiac risk factors (adjusted OR 3.85, $P = 0.019$) and over fourfold increase after adjusting for FRS (adjusted OR 4.82, $P < 0.0001$). There remained a twofold increase in odds for stenosis in those with any T wave changes after adjusting for FRS (adjusted OR 2.42, $P < 0.0001$), but the association was no longer significant for age, gender, and cardiac risk factors ($P = 0.28$).

Discussion

In this ED cohort of 309 patients with acute chest pain but normal or non-diagnostic ECG, we assessed 6 quantitative and 4 qualitative resting ECG parameters for their association with the presence of coronary artery stenosis as determined by cardiac CT. Patients with stenosis had longer QTc interval as well as higher proportions of QTc > 440 ms, ST depression between 0.05 and 0.1 mV, T wave inversions ≥ 0.1 mV, and any T wave changes as compared to those without stenosis. The qualitative parameters of T wave inversion and ST depression had the best diagnostic performance for detecting coronary artery stenosis, followed by the quantitative ECG parameters of QTc > 440 ms and gender-specific QTc, and then any T wave changes. Moreover, QTc interval, ST depression, and T wave inversion were independently associated with the presence of coronary artery stenosis.

Cardiac CT is a cutting edge technology that can be used to non-invasively and accurately detect coronary artery stenosis [16,19,21]. While the “nonspecific” ECG parameters are quite specific with high specificities ranging from 83.6 to 97.0%, their sensitivities are poor. The two ECG parameters that have the greatest positive test performance are presence of ST depression and T wave inversion (LR+ of 4.09 and 4.58, respectively). The presence of the remaining ECG parameters had less impact in changing the post-test probabilities for stenosis. Furthermore, the absence of these ECG findings had little effect on the post-test probability for stenosis (LR– range 0.85–0.93). Thus, while the absence of these ECG findings may not be a reliable method to exclude stenosis, the presence of these ECG parameters, particularly ST depression and T wave inversion, may allow for re-stratification of patients to a higher risk category for coronary stenosis.

With respect to quantitative ECG parameters assessed in our study, QT and QTc interval have been reported to serve as a marker for subclinical atherosclerotic disease, [4] with prolonged QTc interval associated to coronary stenosis by invasive coronary angiography [22]. QTc interval, [23] gender-specific QTc, [11] and QT dispersion [3] have been shown to be independent risk factors for sudden cardiac death. While QT dispersion [8] has been found to correlate strongly with coronary artery calcium, we did not find an association between QT dispersion to coronary stenosis in our cohort. A potential explanation for this discrepancy is that we used CT angiography which allows for assessment of non-calcified lesions in addition to calcified ones. Moreover, we did not find an association of QT interval and QRS duration to coronary stenosis. However, while the gender-specific QTc and QTc > 440 ms was not associated with stenosis, we found that there was a 33–41% increase in risk of stenosis for every 20 ms increment of QTc interval, even after adjusting for age, gender, and cardiovascular risk factors or adjustment for FRS. These findings suggest that QTc interval is the only independent quantitative parameter associated with coronary stenosis, raising doubt in the clinical utility of the other quantitative measures.

Among the qualitative parameters, we found that ST depression and T wave inversion were independent predictors of coronary stenosis on CT, with over around a fourfold increase in risk of stenosis. ST depression during exercise ECG testing has been shown to be associated with coronary stenosis [24] and even with coronary artery plaque as determined by CT [25]. Our study differs from these exercise ECG studies in that we demonstrated the value of ST depression on a resting 12-lead ECG for detecting stenosis on CT. Our result also confirms and strengthens the importance of ST depression >0.05 mV but $\leq$ 0.1 mV for the detection of coronary artery stenosis. This is in accordance with the major society guidelines that ST depression >0.05 mV corresponds to CAD and is associated with increased risk of poor outcome [10]. Similarly, we found that the presence of T wave inversion $\geq$ 0.1 mV is associated with coronary stenosis on CT. Our findings may explain the higher risk of death or nonfatal myocardial infarction in patients with T wave inversion $\geq$ 0.1 mV, as they may be attributed to coronary stenosis [6,10]. Interestingly, while T wave flattening [12,13] is also associated with higher rates of 30-day cardiovascular events in patients with potential acute coronary syndrome, we did not find a relation between this ECG parameter and CT stenosis. When evaluating the performance of any T wave changes (which are comprised of T wave inversion, T wave flattening, and biphasic T wave) for the detection of stenosis, despite a significant association after adjusting for FRS, there was no longer a significant association with coronary stenosis after multivariable adjustment of age, gender, cardiac risk factors. One potential explanation is that the presence of T wave inversion is the driving force behind the main effect while T wave flattening attenuates the overall impact for detecting stenosis by CT. Although biphasic T waves are characteristically associated with stenosis, [14,15] we only had two patients with this finding, which is too small a number to make any substantial influence in our results.

The results from our study have potential clinical implications. Several ECG parameters from the resting 12-lead ECG may be helpful for ED physicians in triaging of patients with acute chest pain. Not surprisingly, the presence of ST depression >0.05 mV but $\leq$ 0.1 mV and presence of T wave inversion $\geq$ 0.1 mV are independently associated with coronary stenosis of >50% luminal narrowing by cardiac CT. Both these ECG findings are in the major society guidelines for detecting acute coronary syndrome secondary to CAD [10] and if present should forewarn physicians of the high potential for underlying coronary artery stenosis. The more subtle finding of QTc prolongation is also indicative of coronary stenosis. Such patients with these “nonspecific” ECG findings may benefit from further evaluation and possibly coronary imaging. If coronary heart disease is detected, then intensification of therapy is warranted to reduce mortality [26].

Limitations

There are several limitations in the interpretation of our study. This is a substudy of the ROMICAT trial, which consists of emergency department chest pain patients with low-to-intermediate risk for suspected acute coronary syndrome and no known history of CAD and inconclusive ECGs. The generalizability of our results may be limited to this study population. Our analysis includes a single initial triage resting ECG, which precludes the assessment of dynamic ECG changes. Since serial ECGs are typically performed in the ED, this information would provide supplemental value. Lastly, while QTc interval prolongation was associated with coronary stenosis, using pre-defined binary cutpoints did not yield a significant association and hence this parameter may be less useful in clinical practice.

Conclusion

In summary, both resting ECG and cardiac CT are non-invasive modalities used to evaluate for CAD in acute chest pain patients. QTc interval prolongation, mild ST depression, and T wave inversion are independently associated with the presence of CT coronary stenosis and their presence suggests an increase risk of CAD.

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Abbreviations

CT	Computed tomography
ECG	Electrocardiography
CAD	Coronary artery disease
BMI	Body mass index
PPV	Positive predictive value
NPV	Negative predictive value

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Fig. 1. Logistic regression analysis of the association between any coronary stenosis and quantitative ECG parameters. ECG parameters that remained significantly associated in the multivariable models are shown. *Multivariable models were adjusted for Framingham risk score. **Multivariable models were adjusted for covariates in Table 1 where $P < 0.10$, which included age, hypertension, diabetes, and hyperlipidemia. Gender was included in the model for face validity

Fig. 2.

Logistic regression analysis of the association between any coronary stenosis and qualitative ECG parameters. ECG parameters that remained significantly associated in the multivariable models are shown. *Multivariable models were adjusted for Framingham risk score.

**Multivariable models were adjusted for covariates in Table 1 where $P < 0.10$, which included age, hypertension, diabetes, and hyperlipidemia. Gender was included in the model for face validity

Table 1

Baseline characteristics of the study group

	Total <i>n</i> = 309	Stenosis <i>n</i> = 41	No stenosis <i>n</i> = 268	<i>P</i> value
Demographics				
Age, years	51.8 ± 11.3	60.7 ± 12.8	50.7 ± 10.7	<0.0001
Men	185 (59.9%)	28 (68.3%)	157 (58.6%)	0.30
Body mass index, kg/m ²	29.1 ± 6.2	29.7 ± 6.9	28.9 ± 5.9	0.41
Risk factors				
Hypertension	108 (35.0%)	28 (68.3%)	80 (29.9%)	<0.0001
Diabetes mellitus	26 (8.4%)	11 (26.8%)	15 (5.6%)	<0.0001
Hyperlipidemia	110 (35.6%)	22 (53.7%)	88 (32.8%)	0.01
Smoking	80 (25.9%)	13 (31.7%)	67 (25.0%)	0.35
Framingham risk score				
Low (<10%)	213 (69.6%)	15 (36.6%)	198 (74.7%)	<0.0001
Intermediate (10–20%)	64 (20.9%)	11 (26.8%)	53 (20.0%)	
High (>20%)	29 (9.5%)	15 (36.6%)	14 (5.3%)	

Table 2

Quantitative and qualitative ECG parameters in the total cohort and comparison between those with and without CT stenosis

	Total	Stenosis	No stenosis	P value
Quantitative ECG measures				
QT interval, ms	396.4 ± 41.7	398.7 ± 58.0	400.7 ± 38.8	0.77
QTc interval, ms	421.0 ± 27.5	452.0 ± 50.6	421.2 ± 21.2	0.036
QTc >440 ms	44 (14.2%)	10 (24.4%)	34 (12.7%)	0.046
Gender-specific QTc	19 (6.2%)	5 (12.2%)	14 (5.2%)	0.15
QT dispersion, ms	34.6 ± 20.7	40.4 ± 29.9	33.7 ± 18.8	0.17
QRS duration, ms	90.5 ± 10.7	89.7 ± 9.7	90.6 ± 10.9	0.62
Qualitative ECG measures				
ST depression	13 (4.2%)	5 (12.2%)	8 (3.0%)	0.02
T wave inversion	17 (5.5%)	7 (17.1%)	10 (3.7%)	0.003
T wave flattening	45 (14.6%)	8 (19.5%)	37 (13.8%)	0.33
Any T wave changes	56 (18.1%)	12 (29.3%)	44 (16.4%)	0.047

ECG electrocardiographic, CT computed tomography, QTc corrected QT interval

Table 3
Diagnostic accuracy and likelihood ratios of dichotomized ECG parameters to CT stenosis

	Sensitivity	Specificity	PPV	NPV	LR+	LR-
Quantitative ECG measures						
QTc >440 ms	24.4% (10/41)	87.3% (234/268)	22.7% (10/44)	88.3% (234/265)	1.92	0.87
Gender-specific QTc	12.2% (5/41)	94.8% (254/268)	26.3% (5/19)	87.6% (254/290)	2.33	0.93
Qualitative ECG measures						
ST depression	12.2% (5/41)	97.0% (260/268)	38.5% (5/13)	87.8% (260/296)	4.09	0.91
T wave inversion	17.1% (7/41)	96.3% (258/268)	41.2% (7/17)	88.4% (258/292)	4.58	0.86
T wave flattening	19.5% (8/41)	86.2% (231/268)	17.8% (8/45)	87.5% (231/264)	1.41	0.93
Any T wave changes	29.3% (12/41)	83.6% (224/268)	21.4% (12/56)	88.5% (224/253)	1.78	0.85

ECG electrocardiographic, CT computed tomography, QTc corrected QT interval, PPV positive predictive value, NPV negative predictive value, LR+ likelihood ratio of a positive test, LR- likelihood ratio of a negative test