Prolonged $T_{peak-end}$ and $T_{peak-end}$/QT ratio as predictors of malignant ventricular arrhythmias in the acute phase of ST-segment elevation myocardial infarction: A prospective case-control study

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BACKGROUND Prolonged $T_{peak-end}$ (the interval from the peak of the T wave to the end of the T wave) and $T_{peak-end}$/QT ratio have been shown to be markers of arrhythmogenesis in various cardiac disorders.

OBJECTIVES The purpose of this study was to evaluate the utility of $T_{peak-end}$ and $T_{peak-end}$/QT ratio at admission in patients with acute ST-segment elevation myocardial infarction (STEMI) in predicting malignant ventricular arrhythmias.

METHODS The study group included 50 patients presenting with STEMI, in whom $T_{peak-end}$ and $T_{peak-end}$/QT ratio were measured at admission; these patients were monitored for arrhythmias with a continuous electrocardiogram in the intensive care unit for 48 hours, and 50 healthy individuals acted as controls.

RESULTS The $T_{peak-end}$ (0.11 ± 0.04 seconds vs 0.08 ± 0.006 seconds; $P < .0010$) and $T_{peak-end}$/QT ratio (0.30 ± 0.06 vs 0.21 ± 0.02; $P < .001$) were prolonged in patients with STEMI. Three patients with STEMI who sustained ventricular fibrillation (VF) within 24 hours of admission had prolonged corrected QT interval (0.39 ± 0.04 seconds vs 0.46 ± 0.13 seconds; $P = .019$), $T_{peak-end}$ (0.10 ± 0.02 seconds vs 0.20 ± 0.11 seconds; $P < .001$), and $T_{peak-end}$/QT ratio (0.26 ± 0.05 vs 0.41 ± 0.09; $P < .001$) as compared with patients with STEMI without VF. $T_{peak-end} > 0.1$ seconds and $T_{peak-end}$/QT ratio > 0.3 predicted VF with a sensitivity of 100%. However, the $T_{peak-end}$/QT ratio had a higher specificity (82.9% for $T_{peak-end}$/QT ratio vs 44.7% for $T_{peak-end}$) and accuracy (84% for $T_{peak-end}$/QT ratio vs 48% for $T_{peak-end}$).

CONCLUSION $T_{peak-end}$ and $T_{peak-end}$/QT ratio are prolonged in patients with STEMI compared with healthy individuals, and $T_{peak-end} > 0.1$ and $T_{peak-end}$/QT ratio > 0.3 predict malignant ventricular arrhythmias within 24 hours of STEMI.

KEYWORDS $T_{peak-end}$; $T_{peak-end}$/QT ratio; Ventricular arrhythmia in STEMI; Arrhythmia; ST-segment elevation myocardial infarction

ABBREVIATIONS **ECG** = electrocardiographic; **EF** = ejection fraction; **HR** = heart rate; **MI** = myocardial infarction; **QTc** = corrected QT; **SCA** = sudden cardiac arrest; **STEMI** = ST-segment elevation myocardial infarction; **$T_{peak-end}$ interval** = interval from the peak of the T wave to the end of the T wave; **VF** = ventricular fibrillation

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Introduction

Sudden cardiac arrest (SCA) is common and often the first manifestation of coronary artery disease; it is responsible for ≈50% of the mortality from cardiovascular disease.[1] Numerous studies have shown that ventricular tachyarrhythmias are the most common cause of SCA in patients with coronary artery disease.[2–4] Among patients admitted with acute ST-segment elevation myocardial infarction (STEMI), 2%–20% suffer from malignant ventricular arrhythmias[5,6] during first few hours of sustaining a myocardial infarction (MI). Identification of patients at increased risk of malignant ventricular arrhythmias is critical to the development of effective strategies to prevent SCA and also to identify patients requiring close monitoring and early and effective therapy to restore sinus rhythm. Various electrocardiographic (ECG) indices have been proposed as risk predictors of arrhythmias in patients with MI, such as T-wave alternans,[7,8] heart rate (HR) turbulence,[9] decreased HR variability,[10] prolonged corrected QT (QTc) interval, and increased QT dispersion.[11] However, these indices have prognostic values usually 6–8 weeks after MI. At present, there are no ECG markers that can predict malignant ventricular arrhythmias in patients presenting with STEMI.

Increased dispersion of repolarization, that is, the disturbance of the normal orderly pattern of ventricular

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recovery, is generally thought to predispose to ventricular arrhythmias. The interval from the peak of the T wave to the end of the T wave ($T_{peak-end}$ interval) has been proposed to represent dispersion of repolarization of the heart.[12,13] A prolonged $T_{peak-end}$ interval that indicates dispersion of repolarization has been shown to be associated with the risk of SCA in various cardiac disorders including long QT syndrome,[14] short QT syndrome, and Brugada syndrome.[15] The pattern of ST elevation in Brugada syndrome that mimics STEMI and $T_{peak-end}$/QT ratio has been shown to predict life-threatening arrhythmias; it has been hypothesized that prolonged $T_{peak-end}$ and $T_{peak-end}$/QT ratio may be able to predict malignant ventricular arrhythmias in patients with STEMI.[16] However, there have been no studies to prove or disprove the relation between prolonged $T_{peak-end}$ and $T_{peak-end}$/QT ratio and increased risk of arrhythmias in the acute phase of STEMI. This study was conducted to evaluate the utility of prolonged $T_{peak-end}$ and $T_{peak-end}$/QT ratio in patients with STEMI and its relation to malignant ventricular arrhythmias in the acute phase of STEMI.

Methods

The present study was a prospective case-control study conducted at the Sri Jayadeva Institute of Cardiovascular Sciences and Research, Bangalore, Karnataka, India, that enrolled patients between January 2013 and December 2013.

Study population

Fifty patients presenting with acute STEMI within 6 hours of chest pain were enrolled in the study. MI was defined as follows: the detection of a rise and/or fall in cardiac biomarkers, with at least 1 value above the 99th percentile of the upper reference limit, together with any one of the following: (1) any symptoms of ischemia or ECG changes suggestive of new ischemia, (2) development of pathological Q waves on ECG, or (3) imaging evidence of infarction. All the patients with STEMI were thrombolysed with 1.5 MU of streptokinase as per the institutional protocol. Patients were observed in the intensive coronary care unit for at least first 48 hours and then in the step-down unit for next 72 hours, and they were treated as per the American College of Cardiology/American Heart Association (ACC/AHA) guidelines for STEMI. Patients with a history of MI, arrhythmias, structural heart disease, and drug intake causing prolongation of the QT interval were excluded from the study. Subjects with a family history of sudden cardiac death were also excluded.

Control subjects were selected from people who attended the preventive health checkup program. Fifty healthy subjects who were normotensive, nondiabetic, and nonsmokers within the age group of 30–60 years without a history of ischemic heart disease were selected. The controls were examined clinically, and information on smoking status, alcohol usage, and a family history of sudden cardiac death and ischemic heart disease was obtained. A thorough physical examination was performed, and variables including their height, weight, body mass index and blood pressure were recorded. Investigations including ECG, 2-dimensional echo-Doppler study, and treadmill test were performed. Routine biochemical analysis was done, including fasting lipid profile, serum electrolyte levels (Na^+, K^+, Cl^-, Ca^{2+}, and Mg^{2+}), and fasting and postprandial blood sugar levels. Written informed consent was obtained from all participants. The study was approved by the institutional ethics committee.

Measurement of the $T_{peak-end}$ interval and QTc interval

A 12-lead ECG was obtained for each individual by using a MAC 5000 digital ECG system (GE Healthcare, Milwaukee, WI) at a paper speed of 25 mm/s, and a sampling rate of 1000 Hz. In the study group, the ECG obtained immediately after admission was used. In the control group, the ECG was obtained after resting for 15 minutes once the HR was <100 beats/min. The QT interval was measured from the earliest onset of the QRS complex to the end of the T wave. The peak of the T wave was defined as a point of the highest amplitude of the T-wave deflection, and the end of the T wave was defined as a point where the tangent on the descending limb of the T wave intersects the isoelectric line.[17] If a U wave followed the T wave, the nadir between the T wave and the U wave was considered T-wave offset. The QT interval was corrected for the HR using Bazett's formula. The precordial lead V_6 was selected because it best reflects the transmural axis of the left ventricle.[18] If lead V_6 was not suitable, leads V_5 and V_4 were measured. If the T-wave amplitude was <1.5 mm in a particular lead, then that lead was excluded from the analysis. The $T_{peak-end}$/QT ratio was calculated as the ratio of $T_{peak-end}$ in that lead to the corresponding QT interval. ECGs were digitized, and all variables including $T_{peak-end}$ interval were calculated manually after magnification. The measurement of each parameter was obtained by averaging 3 consecutive beats. All measurements were performed by a single operator (S.D.). In case of a difference of >20 ms in each measurement, an agreement was obtained after consulting 2 independent experts (J.S. and C.N.M.) who were blinded to the patients.

Statistical analysis

The statistical software SAS 9.2, SPSS 15.0, Stata 10.1, MedCalc 9.0.1, Systat 12.0, and R environment version 2.11.1 were used for the analysis of the data. The results of continuous measurements are presented as mean ± SD (min-max), and those of categorical measurements are presented as number (percentage). Significance is assessed at 5% level of significance. Either the χ^2 test or the Fisher exact test was used to find the significance of study parameters on a categorical scale between the 2 groups. A P value of $<.05$ was considered as significant, a P value between .01 and .05 was considered as moderately significant, and a P value of $\leq.01$ was considered as strongly significant. The Student t test (2-tailed, independent) was used to find the significance of study parameters on a continuous scale between the 2 groups (intergroup analysis). The 95% confidence interval was computed to find the significant features. A confidence