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Original Article

Tpe/QT Variability Among Standard ECG Leads: How Not to Miss the Increase in the Tpe/QT Value?

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ABSTRACT

Background: The increased Tpe/QT ratio is a novel, promising predictor of cardiac arrhythmias. However, no consensus exists regarding the Tpe/QT measurement. This study aimed to evaluate Tpe/QT variability among standard ECG leads.

Methods: Tpe/QT magnitudes were analyzed in 8 standard ECG leads (I, II, V1–V6) in 33 patients with a definite diagnosis of arrhythmogenic right ventricular cardiomyopathy. Tpe/QT values were calculated in several ways: averaging against 1 or more leads over all the patients and searching the maximum value among all measured leads in each patient (the true maximum), followed by averaging over all the patients.

Results: Maximum and minimum Tpe/QT values were distributed among all the tested ECG leads. In each lead, minimum and maximum Tpe/QT values could be observed in different patients. The dispersion of Tpe/QT magnitudes calculated in various ways reached the value of 0.055.

Conclusions: The Tpe/QT magnitude depends on the method of determining the T-wave ending and the number of ECG leads used for its calculation. To detect the increased Tpe/QT ratio, the analysis of all available ECG leads against 1 or a few leads is preferable. ***(Iranian Heart Journal 2024; 25(2): 75-80)***

KEYWORDS: Tpe/QT ratio, Variability, Arrhythmic risk stratification, Arrhythmogenic right ventricular cardiomyopathy

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Tpe/QT (the interval from the peak to the end of the T-wave divided by QT) is a novel promising ECG index to predict cardiac arrhythmias. [1] It combines the duration of repolarization (the QT interval) and its spatial dispersion (the Tpe interval). Moreover, *in silico* studies have demonstrated that Tpe/QT reflects the dynamic balance between the longest and shortest action potentials in the heart ventricles. [2]

The magnitude of Tpe/QT does not need correction by heart rate since it almost has no variations between 60 and 100 beats per minute and remains relatively constant between a narrow range of values from 0.15

to 0.25, with a median value of 0.21. [1,3] The increased Tpe/QT magnitude is a useful stratificator of arrhythmic risks under the conditions of long QT syndrome, Brugada syndrome, short QT syndrome, Takotsubo syndrome, organic heart diseases (eg, acute myocardial infarction and coronary slow flow), and congenital and acquired channelopathies. [1, 4-7]

The problem is a substantial difference in the Tpe/QT magnitude between ECG leads, even in healthy subjects. [8] In cardiac disorders associated with repolarization disturbances (eg, arrhythmogenic right ventricular cardiomyopathy [ARVC]), this difference is expected to be more pronounced. In addition, the Tpe/QT magnitude depends on the method used for detecting the T-wave ending: tangent or tail (baseline) (Fig. 1). To date, no consensus has emerged concerning the Tpe/QT calculation, with most studies limited to 1 or several ECG leads. As a result, there is a discrepancy in the threshold values reported by clinical studies, rendering the use of Tpe/QT for risk stratification challenging.

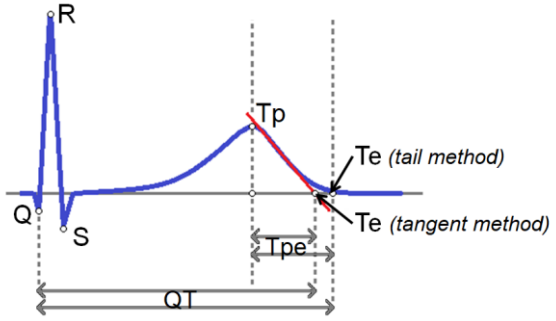

Figure 1: The image depicts the tail and tangent methods of determining Tpe, the interval from the peak to the end of the T-wave.

In the present study, we sought to analyze the variability of Tpe/QT magnitudes among standard ECG leads in patients with ARVC and to propose a reliable way to detect the increase in Tpe/QT.

METHODS

Study Population

The study group consisted of 33 patients with a definite diagnosis of ARVC (according to the 2010 TFC) at the Almazov National Medical Research Centre, Saint-Petersburg, Russia. Standard 12-lead ECG (10 mm/mV, paper speed 50 mm/s) was recorded in the supine position. Pacemaker-depended patients or those with complete bundle branch block, other cardiomyopathies, channelopathies, coronary artery disease, heart failure unrelated to ARVC, or a history of cardiac surgery were excluded from the study. In the depersonalized form, ECG data were provided for analysis to the Institute of Physiology, Syktyvkar, Russia.

ECG Analysis

The duration of QT and Tpe intervals in each lead was measured manually. Complex T-waves with difficult-to-determine endpoints were excluded from the analysis. The beginning of the QT interval was assessed as the first deflection of the QRS complex, and the end of the T-wave was defined as the intersection between the isoelectric line and the tangent to the steepest part of the descending portion (the tangent method) (Fig. 1). QT and Tpe intervals and the corresponding Tpe/QT ratios were calculated separately for each ECG lead.

RESULTS

The frequency of maximum and minimum Tpe/QT values among standard ECG leads

In different patients, maximum and minimum Tpe/QT magnitudes were observed in various ECG leads (Fig. 2). In half of the patients (52% of the cases), the maximum Tpe/QT occurred in leads V2–V4. At the same time, the same leads accounted for a quarter (24%) of the minimum values

of Tpe/QT. The absolute maximum (0.37) and the absolute minimum (0.11) were observed in the same lead (V6) in different patients. In general, both maximum and minimum Tpe/QT values were distributed among different ECG leads. In each lead, both minimum and maximum Tpe/QT values could be observed in different patients.

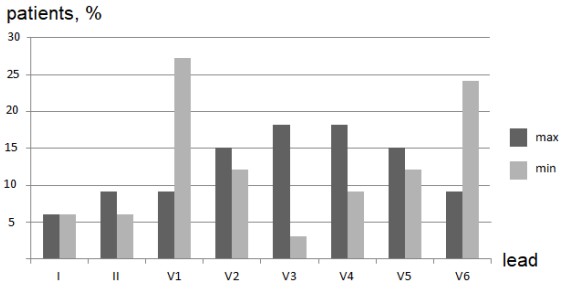

Figure 2: The graph illustrates maximum and minimum Tpe/QT values among standard ECG leads in patients with arrhythmogenic right ventricular cardiomyopathy.

The difference in Tpe/QT values calculated in various ways

Figure 3 presents Tpe/QT in patients with ARVC calculated in various ways, as follows:

- Averaged values for individual leads (I, II, V1–V6)
- The averaged "true" maximum calculated for each patient as the maximum Tpe/QT magnitude among all the leads and averaged over all the patients
- The averaged maximum among leads V1–V3,
- The averaged maximum among leads V4–V6
- Tpe/QT averaged over leads V1–V3
- Tpe/QT averaged over leads V4–V6

The dispersion of Tpe/QT magnitudes calculated in various ways reached the value of 0.055, comparable to the difference between the normal and threshold values reported by prior clinical studies.

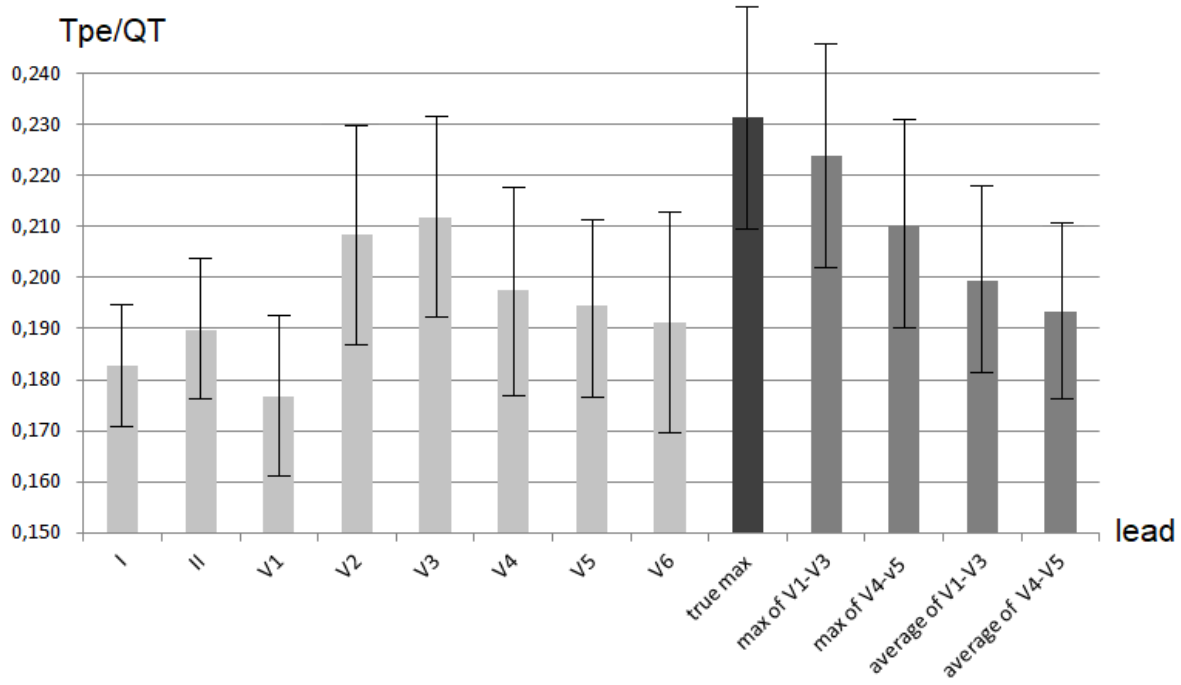

Figure 3: The graph demonstrates Tpe/QT values in patients with arrhythmogenic right ventricular cardiomyopathy averaging against 1 or more leads.
The "true" maximum was calculated for each patient as the maximum Tpe/QT magnitude among all the leads, and then averaged over all the patients.

DISCUSSION

In healthy subjects, maximum Tpe/QT magnitudes were observed in leads V3–V4. [8] In our study, in patients with ARVC, maximal Tpe/QT values could be observed in the right and left precordial leads, which is because ARVC is associated with action potential duration prolongation in the injured right ventricle, resulting in the redistribution of ventricular repolarization gradients. In different patients, these repolarization changes are expressed to varying degrees. The same ECG lead could yield both maximal and minimal Tpe/QT magnitudes in various patients with ARVC.

It is reasonable to assume that this is typical also for the other cardiac disorders associated with repolarization disturbances. Meanwhile, the hitherto reported threshold Tpe/QT values were obtained using a single or several leads. [8–13] The conclusion of our study is that all measured leads should be analyzed to find the true Tpe/QT maximum, and no information should be lost. Clinical confirmation for this conclusion is that in patients with ST-segment elevation myocardial infarction, the infarct-related-lead Tp-e/QT is a better predictor of poor prognosis than Tp-e/QT measured in the other leads. [14]

Tail or tangent?

The Tpe/QT ratio is sensitive to the method to determine the T-wave ending: the tail (the end of the T-wave is the point where the T-wave reaches the isoelectric baseline) or the tangent (the end of the T-wave is the point where a line from the peak of the T-wave through the steepest part of the descending limb intercepts the isoelectric baseline) (Fig. 1). The T-wave ending determined via the tail method is delayed by about 10 milliseconds compared with that determined via the tangent method. [15] For instance, if the tangent method yields a QT of 400 milliseconds, a Tpe value of 85 milliseconds, and a Tpe/QT value of 0.21, the tail method will lengthen both intervals by about 10 milliseconds and increase Tpe/QT to 0.23. For Tpe/QT, a difference in value of 0.02 is significant.

Heart rate correction

The Tpe/QT magnitude is affected by whether the QT interval and Tpe are rate corrected. We believe that heart rate correction when calculating Tpe/QT distorts the physiological meaning of this index since it reflects the dynamic relationship between the duration of repolarization (QT) and the dispersion of repolarization (Tpe) at each specific time point.

Limitations of the study

The salient limitation of this study is the lack of data on arrhythmic episodes in the patients. We could not assess which method of Tpe/QT calculating was the best for predicting life-threatening arrhythmias and mortality. Nonetheless, we showed that the maximum Tpe/QT value could occur in any lead without exception.

CONCLUSIONS

The Tpe/QT magnitude depends on the method for determining the T-wave ending and the number of ECG leads used for its calculation. To avoid discrepancies in threshold values reported by various researchers, a unified approach to the Tpe/QT measurement is needed. Detection of the increased Tpe/QT ratio requires the analysis of all available ECG leads against 1 or a few leads.

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Conflict of Interest

The author declares no competing interests.

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