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The Effect of QT, QTc, and Tpe Interval on Outcome and Mortality in Syncope Patients

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Abstract

Introduction Syncope is a transient condition associated with disturbance of cerebral perfusion. Mortality is higher in cases of syncope of cardiac origin, which is observed in patients with arrhythmogenic findings on electrocardiogram (ECG). In this study, we plan to investigate the relationship of QT interval (QT), Corrected QT Interval (QTc), T peak end (Tpe), Tpe/QT, and Tpe/QTc measured on 12-lead ECGs of patients with mortality and outcomes of patients.

Materials and Methods Our study was conducted prospectively with syncope patients older than 18 years presenting to the emergency department of a tertiary teaching and research hospital. The demographic data, ECGs, laboratory data, and outcomes of the syncope patients were recorded and analyzed.

Results Of the 80 syncope patients who participated in the study, 36% were women. The V5 interval of the syncope patients was significantly longer than that of the control group. When comparing the TpeV5/QTc rates of the patients, the syncope patients had significantly higher rates. In a categorical comparison, the Tpe times of the syncope patients were more frequently prolonged than those of the control group.

Conclusion The measurement of Tpe interval, which is prolonged in patients, appears as a parameter for syncope. The prolongation of the Tpe time observed in lead V5 of the ECG requires a closer follow-up of the patients, especially during the follow-up in daily practice, which represents an important part of the emergency admissions.

Keywords
- syncope
- emergency service
- Tpe interval

Introduction

Syncope is a condition in which there is a temporary loss of consciousness due to cerebral hypoperfusion, followed by spontaneous recovery, most commonly due to a fall in systemic blood pressure.[1] Cardiac syncope is considered the most common cause of syncope. A structural heart problem and/or a condition that can cause electrocardiographic (ECG) changes (systemic disease, pre-excitation, conduction disorders, short or long QT, Brugada's syndrome) is the basis for cases of syncope of cardiac origin.[1,2] Although they may seem like an imitation of a death-like situation for patients and their families, they often occur with benign conditions. It is most commonly encountered with vasovagal, that is, neurocardiological, volume defect or drug-triggered

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etiologies. In addition, dysrhythmias, valve problems, ventricular tachycardia, atrioventricular block, and critical aortic stenosis are among the cardiac causes.[2–4]

QT distribution, corrected QT distribution, and transmural repolarization distribution have recently been used in the literature to assess myocardial repolarization. In addition, the T peak end (Tpe) interval is determined by measurements on the 12-lead ECG.[3] It appears to be a predictor of increased risk of sudden cardiac death. Changes in Tpe and Tpe/QT and Tpe/QTc ratios are indicative of the distribution of repolarization in myocardial tissue and have been associated with ventricular arrhythmias.[4,5] This study will investigate the association of QT, QTc, Tpe, Tpe/QT, and Tpe/QTc measured on a 12-lead ECG with mortality and outcomes.

Patients and Methods

Study Population

This prospective cross-sectional study was conducted on patients who were admitted to the emergency department (ED) of a tertiary hospital (Health Science University Antalya Training and Research Hospital, Antalya, Turkey). This study was approved by the ethics committee of the hospital (Ethics code: 2022-196). All patients consented to participate in the study, and the data were recorded by ED physicians. Patients with syncope who presented to the ED and agreed to participate in the study were enrolled. Patients were selected from a third level education and research emergency between June 2022 and June 2023. Twelve-lead ECGs were obtained at the time of admission. Demographic data, laboratory findings, and patient outcomes were recorded. Patients who presented to the ED and whose diagnosis of syncope was confirmed by the senior faculty member were targeted to be included in the study and the findings were analyzed. Patients with syncope older than 18 years who presented to the ED of the hospital concerned were included in the study. Patients who did not agree to participate in the study were defined as those who did not give consent, those with a diagnosis other than syncope, and those with a pathological condition that would affect the ECG Tpe index. A group of healthy persons was used as the control group in the study. When selecting these participants, it was taken into account that they did not have any additional cardiac diseases or any pathology that would affect Tpe. All examinations were taken within the first 30 minutes of admission to the ED.

Sample Size

In the power analysis based on the prevalence value we obtained according to the studies in the literature, the amount of type I error (alpha) was 0.05, the power of the test (1-beta) was 0.8, the effect size was 0.4, and the alternative hypothesis (H1) was two-sided. While using this test, there was no significant difference. The required minimum sample size was 52.[6]

Tpe and QTc Measurement

After the patients' 12-lead ECGs were digitally recorded at high resolution using a scanning system, their measurements were performed manually in an electronic environment. The measurement was performed with a digital meter by a cardiologist and an emergency physician who were both blind to the patients. The Tpe and QTc intervals obtained from leads DII and V5 of the ECGs were recorded.[7,8]

The distance from the beginning of the Q wave to the isoelectric line of the T wave was measured, and the corrected QT interval was calculated from the heart rate using the Bazett formula ($QT/\sqrt{RR}$). Tpe was calculated as the distance between the projection of the peak of the T wave on the isoelectric line and the projection of the line connecting the descending branch of the T wave to the isoelectric line, and Tpe/QTc ratios were also recorded.

Statistical Analysis

Data were analyzed using SPSS 27 statistical analysis software. For categorical data, the descriptive statistical methods used to evaluate the data were number and percentage; for numerical data, the mean, standard deviation (SD), median, and minimum–maximum were used. In the statistical analysis, the Kolmogorov–Smirnov or Shapiro–Wilks test was first used to test whether the groups were suitable for normal distribution. Student's *t*-test and Mann–Whitney *U* test were used to evaluate the numerical data, and the chi-squared test was used to evaluate the categorical data. Linear regression analysis was used to assess the relationship between data. The receiver operating characteristic (ROC) analysis was used to examine the effect of categorical distribution on the results. Results with a *p*-value below 0.05 were considered statistically significant.

Results

In our study, 80 patients were included in the syncope group, in which patients with syncope were followed. While 36 (45%) of the patients were females, 28 (56%) participants in the control group were females. The mean age of the patients in the syncope group was 44.92 ± 18.48 years, but there was no significant difference between them and the control group ($p = 0.47$). The demographic data and general characteristics of the syncope patients and the control group are shown in ►**Table 1**. A comparison of the Tpe measurements and TpeV5/QTc ratio in the QTc, DII, and V5 leads on the ECGs of patients in the syncope and control groups included in the study are shown in ►**Table 2**. Compared with the control group, the Tpe value in lead V5 and the TpeV5/QTc ratio were significantly increased in the syncope group ($p < 0.001$ in both).

The outcome values of the patients in the syncope group were categorically divided into two groups, normal and prolonged, according to the mean Tpe ratio for healthy subjects previously reported in the literature. In the categorical analysis of the V5 lead Tpe value for the control and syncope patients, a significant prolongation was observed in the syncope patients, the odds ratio was 12.17, and there was moderate agreement between them (Kappa = 0.535, $p < 0.001$). When comparing DII and V5 leads in syncope patients, a discordant relationship was found for the

Table 1 Descriptive statistics in syncope and control group

Parameter	Syncope ($n = 80$)	Control ($n = 50$)	p-value
Male, n (%)	44 (55)	22 (44)	0.149
Age (y)	53.93 ± 20.47	44.92 ± 18.48	0.47
Height (cm)	167.21 ± 9.35	167.92 ± 8.44	0.19
Weight (kg)	71.91 ± 15.48	90.16 ± 12.07	0.77
Hearth rate (/min)	85.35 ± 18.55	130.66 ± 22.94	0.31
Systolic arterial pressure (mm Hg)	124.44 ± 22.39	98.28 ± 1.51	<0.001
Diastolic arterial pressure (mm Hg)	78.06 ± 19.40	87.90 ± 16.14	0.93
Biochemical data			
White blood cell	9.00 ± 3.87	7.20 ± 1.21	0.211
Hemoglobin	12.55 ± 2.32	13.65 ± 1.24	0.672
Platelets	231.44 ± 92.81	210.44 ± 54.6	0.512
Neutrophil	6.14 ± 3.33	4.22 ± 1.26	0.846
Hs troponin I	30.61 ± 169.41	1.24 ± 0.24	<0.001
Outcome			
Exitus, n (%)	4 (5)		

categorical score (Kappa = –0.05 for DII, $p = 0.213$; Kappa = –0.059 for V%, $p = 0.354$). In the ROC analysis performed between QTc, DII, and V5 leads' Tpe value, TpeV5/QTc value, high-sensitivity (Hs) troponin I results in syncope patients, the Hs troponin I value demonstrated a statistically significant discrimination ratio (area = 0.841), indicating a good and reliable result (SD = 0.058; $p < 0.001$). The ROC analysis is shown in ►**Tables 1**–**3** (►**Fig. 1**). There was no significant difference in the correlation analysis between the Tpe value in the QTc, DII, and V5 leads and the TpeV5/QTc ratio according to the Hs troponin I value in syncope patients (►**Tables 3**–**5**).

Discussion

Syncope is a temporary loss of consciousness following cerebral hypoperfusion. It is a common presentation in EDs. It accounts for 1% of all ED visits.[9] Syncope of cardiac origin is often the result of arrhythmia.[10] While tachycardic syncope is associated with speed, specific arrhythmias, conditions that alter preload conditions, left ventricular function, and syncope due to poor adaptation are observed.[11,12] In this study, we investigated the relationship between QT, QTc, Tpe, Tpe/QT, and TP-e/QTc in patients with syncope.

In one study, 8.8 of syncope patients were followed in the hospital. While mortality was observed in 3.6% of the patients, the mortality rate due to arrhythmic causes was found to be 2.8%.[13] In a study by Ince et al, 421 syncope patients were examined. While it was observed that 20.2% of the patients required hospitalization and follow-up, the mortality rate was 5.5%.[14] While the mortality rate in our study was 5%, this finding was similar to the studies in the literature.

In a study by Maury et al investigating the effects of arrhythmic conditions on Tpe, 325 participants were included. These participants were divided into patients with unexplained syncope, sudden death, and those requiring cardioversion defibrillation. It was found that there was a

Table 2 QTc, Tpe, and Tpe/QTc comparison by groups

Groups		Mean	SD	p-value
QTc	Control	406.38	20.75	0.337
	Syncope	421.17	22.92	
TpeDII	Control			
	Syncope	84.57	21.79	
TpeV5	Control	64.98	11.36	<0.001
	Syncope	88.06	22.37	
TpeV5/QTc	Control	0.16	0.02	<0.001
	Syncope	0.21	0.05	

Abbreviation: SD, standard deviation.

Table 3 Categorical comparison by outcome

V5	Outcome					
	Outpatient		Inpatient			
	N	%	*N*	%	Odds ratio	*p*-value
Normal	7	11.3	4	22.2	0.445	0.2136
Elongated	55	88.7	14	77.8	Kappa	
	62	100.0	18	100.0	−0.05	
DII	**Outcome**					
	Outpatient		**Inpatient**			
	N	%	*N*	%	Odds ratio	*p*-value
Normal	14	22.6	6	33.3	0.583	0.354
Elongated	48	77.4	12	66.7	Kappa	
	62	100.0	18	100.0	−0.059	

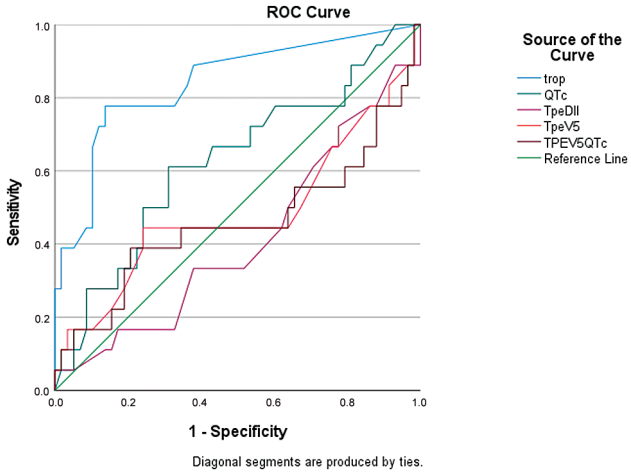

Fig. 1 Receiver operating characteristic (ROC) analysis.

significant prolongation of Tpe measurements in hospitalized cases of syncope and sudden death. It has been observed to be an independent risk factor for arrhythmic events in patients whose measurements exceed 100 milliseconds.[15]

One of the important conditions observed in acute myocarditis cases is arrhythmia. Block formations may occur with complicated ventricles or atrial arrhythmias.[16] In the study conducted by Ucar et al in which the Tpe interval of 56 patients with myocarditis was evaluated, heart rate, QT, and QTc values were found to be similar between the groups. The QRS interval was found to be lower in the acute myocarditis group than in the control group ($p < 0.001$). Tpe, Tpe/QT, and Tpe/QTc values were significantly higher in the acute myocarditis group ($p < 0.001$, <0.001, and 0.03, respectively). Transient ventricular tachyarrhythmias occurred in four patients and death from cardiac arrest in one patient.[4]

According to the data obtained in our study, it was calculated that the QTc duration in patients with syncope was not significantly different from that in the control group. In patients with syncope, the Tpe interval in lead V5 was found to be significantly higher than that in the control group, and the TpeV5/QTc ratio was found to be significantly higher. As seen in studies in the literature, this is an indicator of increased Tpe time and increased ventricular arrhythmia in patients with syncope.

In a study conducted by Koca and Koç in which the normal Tpe index was determined, the mean value was calculated to be 76.1 ± 12.3 milliseconds.[17] In the categorical evaluation above this limit, the number of people with prolonged Tpe was significantly higher in syncope patients than in the control group. No significant difference was found when grouped by outcome. Prolonged Tpe interval measurement in patients emerges as a parameter for syncope. The

Table 4 ROC analysis in electrocardiogram parameters

ROC analysis					
Variable	AUC	SD	*p*-value	95% confidence interval	
				Low	High
QTc	0.626	0.078	0.107	0.473	0.779
TpeDII	0.413	0.079	0.272	0.257	0.568
TpeV5	0.484	0.090	0.861	0.307	0.662
TpeV5/QTc	0.460	0.092	0.662	0.279	0.640
Hs troponin I	0.841	0.058	0.000	0.728	0.954

Abbreviations: AUC, area under the curve; ROC, receiver operating characteristic curve; SD, standard deviation.

Table 5 Hs troponin I correlation analysis in syncope patients

Hs troponin I	QTc	Tpe D2	Tpe V5	TpeV5/QTc
r	0.195	0.04249	0.1329	0.07968
95% CI	−0.03186 to 0.4027	−0.1832 to 0.2640	−0.09385 to 0.3466	−0.1484 to 0.2998
R^2	0.03802	0.001805	0.01767	0.006349
p-value	0.0914	0.7137	0.2492	0.4938

Abbreviations: CI, confidence interval; Hs, high-sensitivity.

prolongation of the Tpe time observed in lead V5 of the ECG requires closer follow-up of patients, especially during the follow-up in daily practice, which is an important part of emergency admissions.

This was a single-center and prospective study. Future studies with a multicenter approach, larger prospective sample size, and a higher number of patients with a fatal course will help further in determining the Tpe interval that can show mortality.

Conclusions

Increased Tpe interval measurement and a high TpeV5/QTc value in patients appear to be useful parameters in relation to syncope. The prolongation of Tpe time observed in lead V5 of the ECG requires closer follow-up of patients, especially during the follow-up in daily practice, which is an important part of ED admissions.

Authors' Contributions

All authors contributed to collecting the data, writing the article, reviewing, and approving the final article.

Compliance with Ethical Principles

This study was approved by Ethics Committee of Antalya training of Research Hospital on June 16, (2022-196).

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Conflict of interest

None declared.

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