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Tp-e Interval, Tp-e/QT and Tp-e/QTc Ratios in Female Patients with Small Heart Syndrome

Küçük Kalp Sendromlu Kadın Hastalarda Tp-e Aralığı, Tp-e/QT ve Tp-e/QTc Oranları

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Abstract

Objective: The relevance of Tp-e, QT dispersion and the ratios between these two as predictive variables of ventricular arrhythmias, particularly ventricular prematurity depolarization and sudden cardiac death, were assessed in this study of patients who were identified with small heart syndrome.

Method: The study included 94 female patients, as 47 small-heart and 47 normal-heart patients, by calculating their cardiothoracic ratios. We measured QT_{max}, QT_{min}, QRS, JT and Tp-e intervals, Tp-e/QT_{max}, Tp-e/QTc_{max}, Tp-e/JT and Tp-e/JTc rates and estimated QTc_{max}, QTc_{min}, cQTd and JTc intervals.

Results: cQTd, Tp-e, Tp-e/QTc_{max}, and Tp-e/JTc values were significantly higher in the small heart patient group. QTc_{min} and QTcmin values were significantly lower.

Conclusion: Tp-e and QT dispersion values are important markers in patients with small heart syndrome in terms of predicting ventricular repolarization and a possible ventricular arrhythmia.

Keywords: Electrocardiogram, small heart syndrome, ventricular repolarization

Öz

Amaç: Tp-e, QT dispersiyonu ve bu ikisi arasındaki oranlar ventriküler aritmilerin, özellikle ventriküler prematürite depolarizasyonunun ve ani kardiyak ölümün öngörücü değişkenleri olarak, bu çalışmada küçük kalp sendromu ile tanımlanan hastalarda değerlendirildi.

Yöntem: Kardiyotorasik oranları hesaplanarak 47'si küçük kalpli, 47'si normal kalpli 94 kadın hasta çalışmaya alındı. QT_{maks}, QT_{min}, QRS, JT ve Tp-e intervalleri, Tp-e/QT_{maks}, Tp-e/QTc_{maks}, Tp-e/JT ve Tp-e/JTc oranları ölçüldü ve QTc_{maks}, QTc_{min}, cQTd ve JTc intervalleri hesaplandı.

Bulgular: Küçük kalp hasta grubunda cQTd, Tp-e, Tp-e/QTc_{maks} ve Tp-e/JTc değerleri anlamlı olarak daha yüksekti ve QTc_{min} değerleri anlamlı olarak daha düşüktü.

Sonuç: Küçük kalp sendromlu hastalarda Tp-e ve QT dispersiyon değerleri ventriküler repolarizasyonu ve olası bir ventriküler aritmiyi öngörme açısından önemli belirteçlerdir.

Anahtar Kelimeler: Elektrokardiyografi, küçük kalp sendromu, ventriküler repolarizasyon

Introduction

Small heart syndrome, also known as neurocirculatory asthenia, is related to a small heart shadow on chest X-rays. Fatigue or exhaustion, tachycardia, pain in the abdomen, difficulty in breathing, anxiousness, shaking, sweating, and loss of consciousness are the most common conditions which are also the most detectable symptoms of cardiac arrhythmia patients (1,2).

As clinical manifestations of cardiac arrhythmias like palpitations and chest pain, fatigue may also occur in our clinical routine. While arrhythmias could be reported with 24-hour electrocardiography (ECG) reading during rhythm

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follow-up, these arrhythmias can also be difficult to identify. Therefore, ECG results may also be helpful (3,4).

The repolarization process offers useful knowledge as an indicator of arrhythmia in cardiac electrophysiology relating to the chance of having an arrhythmia. As it involves the depolarization step, the QT distance is important, so the JT distance belongs to the repolarization step. Recently, in terms of sensitivity of ventricular arrhythmias and the chance of sudden cardiac death, Tp-e values, one of the determinant criteria for ventricular arrhythmias, and their association with QT and JT distances are useful measurements (5,6).

The relevance of Tp-e, QT dispersion and the ratios between these two as predictive variables of ventricular arrhythmias, particularly ventricular prematurity depolarization and sudden cardiac death, were assessed in this study of patients who were identified with small heart syndrome.

Materials and Methods

The study complies with the Declaration of Helsinki. University of Health Sciences Turkey, Gazi Yaşargil Training and Research Hospital approved the study protocol on 15/01/2021 with the number of 625 and informed consent was obtained from participants participating in the study in this article.

Study Design and Population

Ninety-four female patients, including 47 small-heart and 47 normal-heart patients, who registered between March 2018 and February 2020, were included in the study for evaluating their chest X-ray cardiothoracic ratios (CTR) (Figure 1), after obtaining the ethical committee approval. The patients were selected from those who presented to the cardiology outpatient clinic with the complaint of chest pain. None of patients have a history of coronary artery disease or another cardiac disease. Exercise test was applied to all patients and no pathology was found in the effort test. Patients and hospital registrations provided the required demographic and clinical features. Patients with metabolic or electrolyte abnormalities, systemic heart failure, acute or chronic infections, or those taking drugs that might affect the P wave, PR segment, QT and QTc intervals were not involved in the study. Complete blood count and biochemical assessments on all patients were previously carried out and the outcomes of each patient were reported.

Chest Roentgenograms

In the posteroanterior projection on the chest roentgenogram, the calculated CTR was described as small heart of ≤42% (7-9). Throughout the right-to-left projection of the lateral view on the chest X-ray, the existence or lack of narrow chest indications, involving the posterior-anterior chest and straight back, was evaluated. Once the anteroposterior diameter was measured laterally less than 40% of the transversal diameter at the level of the diaphragm of the thoracic cavity, a narrow chest was identified.

ECG Analysis

After resting for 10 minutes, twelve leading ECGs were collected with a magnitude of 10 mm/mV and a frequency of 25 mm/s with typical lead positions in the standard position with a commercially available instrument. The ECG duration is 10 s, so there were 4 to 6 beats per lead, based on the heart rate. ECG measurements were taken manually by using a magnifying glass (TorQ 150 mm Optical Caliper LCD) by two random cardiologists who had no patient data. By measuring the Pearson's correlation coefficient (r=0.93), interobserver agreement for PWPT was assessed. The QT interval of the surface ECG was calculated as the period between the starting of the QRS and the termination of the T wave. The Hodges formula was used to calculate the QTc intervals.

QT Indices

From the beginning of the QRS complex to the end of the T wave, which was described as its returning to the TP baseline, QT intervals were collected. The QT interval to the lowest point of the curve between the T and U waves

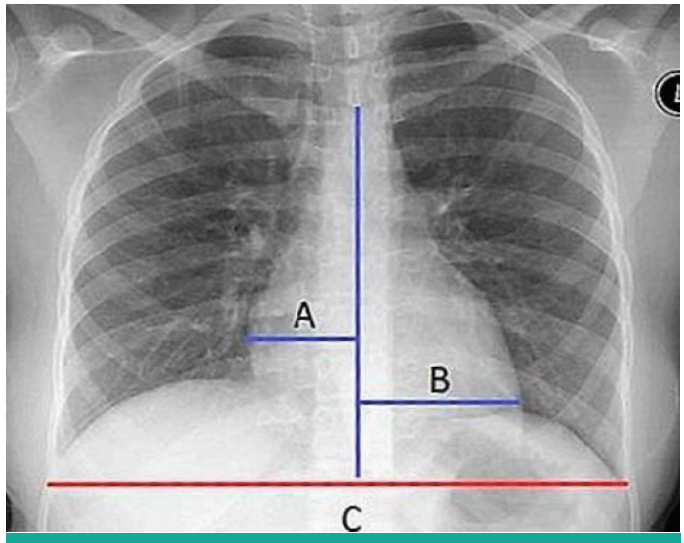

Figure 1. Measurement of cardiothoracic ratio

was calculated when U waves were present. To determine the heart rate and compensate for the QT interval (QTc), the R-R interval was calculated and used with the Hodge's equation (10,11). QT dispersion (QTd) was defined as the difference in separate leads between the longest and shortest QT intervals. From the T wave peak to the end of the T wave, the Tp-e interval was described. Tp-e interval calculations were conducted from precordial points. The Hodge's formula [QTc=QT+0.00175 × (HR-60)] was used to measure the rate of QTc and the corrected QT dispersion (cQTd). JT intervals were calculated from the endpoint of the QRS complex (J point) through the ending of the T wave (JTend interval). In order to calculate JTc, the Hodge's formula [JTc=JT+0.00175 × (HR-60)] was used. The ratios of Tp-e/QT, Tp-e/QTc, Tp-e/JT, and Tp-e/JTc were also measured. No patient had an observable lead of less than nine. For assessments, the intra- and interobserver variations were <5%.

Statistical Analysis

The analysis was carried out using the SPSS 23.0 Statistical Package Software for Windows (SPSS Inc., Chicago, Illinois, USA). Quantitative variables were presented as mean ± standard deviation, and qualitative variables were expressed as numbers and percentages. Variations within independent variables were evaluated by the Student's t-test for normally distributed numerical variables and the Mann-Whitney U test for non-normal distributed variables and the chi-square analysis for qualitative variables. The Kolmogorov-Smirnov test was used to determine the normality of the data. The Levene's test was employed to assess the variance homogeneity. A p-value <0.05 was regarded as statistically significant.

Results

There was no significant difference between the patients in the study and the control group in terms of age, weight, height, platelet, hemoglobin, creatinine, urea, alanine aminotransferase, troponin, or aspartate aminotransferase. The body mass index in the small heart group was detected as low (Table 1). In the small heart patient group, significantly higher values were recorded for cQTd (24.246±9.046 ms vs. 35.495±14.358 ms, p<0.001), Tp-e (67.32±11.661 ms vs. 72.67±11.028 ms, p=0.04), Tp-e/QTc_{max} (0.166±0.028 vs. 0.181±0.027, p=0.012), Tp-e/JTc (0.214±0.038 vs. 0.232±0.034, p=0.022). Also, the values of the small heart group for QTc_{min} (379.34±20.064 ms vs. 364.71±23.149 ms, p=0.004) were significantly lower. No significant difference was found in the heart rate (87.81±15.532 bpm vs. 83.81±14.372 bpm, p=0.223), QRS (83.23±6.948 ms vs. 81.91±10.052 ms, p=0.206), QT_{max} (354.93±26.796 ms vs. 358.54±28.434 ms, p=0.528), QT_{min} (330.68±26.611 ms vs. 323.04±30.829 ms, p=0.202), JT (265.7±25.16 ms vs. 271.88±23.104 ms, p=0.218), QTc_{max} (403.59±18.208 ms vs. 400.20±18.336 ms, p=0.371), JTc (314.37±21.325 ms vs. 313.55±22.526 ms, p=0.856) Tp-e/QT_{max} (0.190±0.034 vs. 0.203±0.031, p=0.063), Tp-e/JT (0.255±0.047 vs. 0.267±0.036, p=0.295) between the small heart group and control group (Table 2). For the JT, QT, and Tp-e measurements, the intra-observer difference between cardiologists was 2.5%, 3.4%, and 4.3%, respectively. Both the small heart group and control group shared a similar systematic error between the cardiologists.

Discussion

In this research, it has been found that there is a significant association between elevated cQTd, Tp-e interval, Tp-e/QTc_{max}, and Tp-e/JTc ratios on surface ECG and small heart patients, in which they were considered to be correlated with ventricular arrhythmias and sudden death. We found that our literature review revealed no current study on the relationship between small heart syndrome and ventricular arrhythmia.

A variety of cardiac problems associated with low output syndrome are caused by small heart syndrome. In the assessment of those patients, diagnostic methods are particularly relevant, specifically chest radiography and ECG. The outcome of myocardial damage is low output

Table 1. Demographic and laboratory characteristics

	Control group (n=47)	Small heart group (n=47)	p
Cardio-thoracic ratio	46.413+3.007	38.530+2.642	<0.001*
Age; years	24.74+4.989	22.87+5.029	0.073
Height; cm	1.600+0.058	1.622+0.063	0.086
Weight; kg	59.51+13.592	54.15+8.041	0.061
Body mass index; kg/cm^2	23.122+4.448	20.597+3.031	0.002*
Systolic tension; mmHg	98.53+5.120	98.36+4.775	0.868
Diastolic tension; mmHg	65.57+3.781	67.43+4.596	0.052
Alanine aminotransferase; IU/mL	16.94+14.039	15.43+6.746	0.847
Aspartate aminotransferase; IU/mL	18.60+7.039	18.98+4.528	0.146
Creatinine; mg/dL	0.726+0.143	0.757+0.219	0.950
Urea, mg/dL	22.515+5.568	22.134+5.627	0.309
Platelet; 10^3/µL	261.04+74.246	255.30+59.553	0.563
Hemoglobin; mg/dL	13.670+1.233	13.832+1.064	0.498

and it can end up causing ventricular arrhythmias. In patients with low output, malignant arrhythmias have been confirmed to be present (12).

The repolarization process offers valuable knowledge as a marker of arrhythmia in cardiac electrophysiology within the context of the probability of developing arrhythmia. QT range is significant in this regard in the 12-lead ECG. The QT interval is predominantly defined by the repolarization duration that refers to the JT interval. Thus, as a more acceptable indicator of ventricular repolarization than the QT, the JT interval has been suggested (13). In addition, through the analysis of the JT instead of the QT interval, the probability of incident cardiovascular episodes was better estimated (14,15). In addition to the value of QT and JT intervals, useful parameters in terms of sensitivity to ventricular arrhythmias are Tp-e measurements, which are the predictors of ventricular arrhythmias, and their interaction with QT and JT distances (16-18). Cardiac screening should be carried out in younger patients with palpitations, chest pressure, and difficulty of breathing, by considering chest radiographs (19). Based on disorders like anxiety and panic attacks, the symptoms of these patients are normally dismissed by cardiologists. Furthermore, panic disorder patients demonstrated even greater ventricular repolarization parameters than healthy controls (20). Nevertheless, as our research indicates, these patients should bear in mind that, as they appear to have ventricular arrhythmias, supervision should be continued for more than 24 hours.

Table 2. Electrocardiographic findings

	Control group (n=47)	Small heart group (n=47)	p
Heart rate, bpm	87.81+15.532	83.81+14.372	0.223
QRS; ms	83.23+6.948	81.91+10.052	0.206
QT max; ms	354.93+26.796	358.54+28.434	0.528
QT min; ms	330.68+26.611	323.04+30.829	0.202
JT; ms	265.7+25.16	271.88+23.104	0.218
QTc max; ms	403.59+18.208	400.20+18.336	0.371
QTc min; ms	379.34+20.064	364.71+23.149	0.004*
JTc; ms	314.37+21.325	313.55+22.526	0.856
cQTd; ms	24.246+9.046	35.495+14.358	<0.001*
Tp-e; ms	67.32+11.661	72.67+11.028	0.04*
Tp-e/QT max	0.190+0.034	0.203+0.031	0.063
Tp-e/QTc max	0.166+0.028	0.181+0.027	0.012*
Tp-e/JT	0.255+0.047	0.267+0.036	0.295
Tp-e/JTc	0.214+0.038	0.232+0.034	0.022*

bpm: Beat per minute, ms: millisecond, QTc_{max}: Corrected QT_{max}, QTc_{min}: Corrected QT_{min}, JT interval (JT): Were measured from the end of the QRS complex (J point) to the end of the T wave (JTend interval), JTc: Corrected JT interval, cQTd: cQT dispersion (QTd) was determined as the difference between the maximum and minimum QTc interval, Tp-e: T peak and end interval

This idea is supported by the connection between this condition and chronic fatigue syndrome. Previous studies have identified the association between chronic fatigue syndrome and low output syndrome (21,22). A widespread and complex chronic pain disorder, impacting 1% to 5% of the population, Fibromyalgia (FM) is defined as a chronic systemic pain that lasts for more than 3 months without any apparent organic lesion (23-25). Furthermore, it is known that chronic fatigue syndrome is connected with fibromyalgia, which is one of the leading symptoms of abnormal chest pain. The susceptibility of this group of patients with anxiety and depression to ventricular arrhythmias is also established (26,27).

Study Limitations

A significant drawback is to make manual calculations rather than computer-based calculations for the quantities. For calculating QT values, automated measurement programs have been designed. Nevertheless, there have been still some challenges present with these systems (28). Based on several parameters, especially coronary artery disease and hormones, ventricular repolarization may differ (29). Since we did not get coronary angiography, we did not have adequate evidence to explain this concern. Analyses were conducted on the ECGs of the patients and echocardiography did not support these results.

Conclusion

As in the result of this retrospective study, it should be noted that when any arrhythmias are detected, patients having small hearth syndrome with improved prediction levels of ventricular arrhythmia should be monitored more closely through sequential ECG shots and reconfiguration. With this monitoring, the possibility of hemodynamic dysfunction that can lead to arrhythmia or cardiac arrest that can contribute to death can be reduced. To validate our findings, long term monitoring and extensive prospective investigations are necessary.

Ethics

Ethics Committee Approval: The study complies with the Declaration of Helsinki. University of Health Sciences Turkey, Gazi Yaşargil Training and Research Hospital approved the study protocol at 15/01/2021 with number of 625.

Informed Consent: Informed consent was obtained from participants participating in the study in this article.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: E.İ., Design: E.İ., Data Collection or Processing: B.B., Analysis or Interpretation: B.B., Drafting Manuscript: E.İ., Critical Revision of Manuscript: B.B., Final Approval and Accountability: E.İ.

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