ORIGINAL ARTICLE

Evaluation of Tp-e interval, Tp-e/QT ratio and Tp-e/QTc ratio in blunt chest trauma patients

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ABSTRACT

BACKGROUND: After blunt chest trauma, life-threatening arrhythmias may occur in the early post-injury period, as well as a few days after the injury. This study aimed to evaluate the risk of arrhythmias in blunt chest trauma patients using Tp-e interval, Tp-e/QT ratio and Tp-e/QTc ratio.

METHODS: In this study, patients who applied to the emergency department due to blunt chest trauma were examined prospectively. The 12-lead ECG was performed to both blunt chest trauma and control group. ECG measurements of QT and Tp-e intervals were performed from both groups.

RESULTS: A total of 81 participants; 41 blunt chest trauma patients and 40 healthy volunteers were included in this study. Tpe, Tpe/QT, Tpe/QTc values were statistically significant in the trauma group compared to the control group ($p<0.001$). Although Tpe/QTc, max QT and min QT were statistically significant ($p<0.05$) in patients with a rib fracture, no difference was detected concerning Tpe, Tpe/QT compared to no-rib fracture group ($p>0.05$).

CONCLUSION: Tp-e interval, Tp-e/QT ratio and Tp-e/QTc ratio in ECG predict the arrhythmias that may occur in blunt cardiac trauma, especially in blunt chest trauma patients.

Keywords: Arrhythmia; blunt chest trauma; emergency department.

INTRODUCTION

Blunt chest trauma develops after severe trauma to the chest wall and may cause injury to crucial structures, such as the lung, diaphragm, heart, pleura or pericardium.[1] Blunt chest trauma has an approximately 15% rate among all emergency trauma cases, and a considerable part of this type of trauma results in mortality.[2] Also, many complications may occur after blunt chest trauma.[3] The development of rare cardiac arrhythmias is an indirect indicator of the presence of cardiac involvement.[4,5] In addition to this, when an arrhythmia due to blunt chest trauma is detected, all types of arrhythmias, such as supraventricular tachycardia, atrial fibrillation, ventricular tachycardia and ventricular fibrillation, have been reported to develop from the atrium and ventricle of the heart.[6]

The QT interval (QT), corrected QT interval (QTc), QT dispersion and transmural dispersion of repolarization (TDR) are accepted as determinants of myocardial repolarization.[7] Tp-e, the interval between peak and end of T wave on electrocardiogram (ECG), is known to be a predictor of ventricular repolarization with transmural dispersion.[8] The Tp-e/QT ratio and the Tp-e/QTc ratio are also used as determinants for the development of ventricular arrhythmia on electrocardiography and it is thought to be the most important determinant of the increased mortality risk. The Tp-e/QT ratio and the Tp-e/QTc ratio are also known as electrocardiographic markers for the development of ventricular arrhythmia.[8–10]

After blunt chest trauma, life-threatening arrhythmias may occur in the early post-injury period, as well as a few days

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after the injury.[6] In literature, there are not enough data to evaluate Tp-e interval, Tp-e/QT ratio and Tp-e /QTc ratio as markers of cardiac arrhythmogenesis in patients with blunt chest trauma. In this study, we aimed to evaluate the risk of arrhythmias in blunt chest trauma patients using Tp-e interval, Tp-e/QT ratio and Tp-e/QTc ratio.

MATERIALS AND METHODS

Study Design

In this study, patients who applied to the emergency department due to blunt chest trauma within six months were examined prospectively. This study included a total of 81 participants, 41 patients with blunt chest trauma, and 40 healthy volunteer as a control group. The control group participants were randomly selected from patients over 18 years old who applied to the emergency department. This study was carried out in the Bozok University Faculty of Medicine, Department of Emergency Medicine after the approval of our institution's local ethics committee (2018-KAEK-189_2018.01.25_25) and informed consent was obtained from each participant.

Study Population

Medical history, weight and height measurements of the participants were taken and body mass index (BMI) was calculated as weight/height^2 ratio (kg/m^2). ECG records, heart rate, BMI, systolic blood pressure (SBP), diastolic blood pressure (DBP), age values and findings were evaluated in both patient and control groups. Patients with a history of cardiac arrhythmia, hypertension, atrial fibrillation, coronary artery disease, chronic kidney and liver disease, coronary artery disease, diabetes mellitus, hyperthyroidism or hypothyroidism history which may cause arrhythmia, and patients with electrolyte abnormalities, moderate and severe heart valve disease, history of arrhythmia, heart failure, permanent pacemaker, any cardiac branch block, any other signs of intraventricular conduction defect, antiarrhythmic (digoxin, B-Blocker, Ca antagonist) drug usage, smoking history and patients who had tachycardia (>100 beats/minute) or bradycardia (<60 beats/minute) on ECG recordings were excluded from this study.

Electrocardiography

The 12-lead ECG was performed to both blunt chest trauma and control group. Nihon Kohden ECG 1250 Cardiofax S (2009, Tokyo, Japan) was used at a paper speed of 50 mm/s. ECG was performed while the participants at rest in the supine position while the heart was in a resting period. Measurements of QT and Tp-e intervals were performed manually. Patients with U wave on ECG data were excluded from this study. The average of three data obtained from the ECG of each lead was used. The QT interval is the area from the beginning of the QRS wave to the end of the T wave[11] and was evaluated according to the corrected heart rate using the Bazett formula: QTc = QTd/√ (RR). The QTd was defined as the calculation of the difference between the maximum (QTmax) and the minimum QT (QTmin). Calculation of the difference between corrected QTmax (cQTmax) and corrected QTmin (cQTmin) detected the corrected QTd (cQTd).[12] All data were collected by an emergency medical physician, QT and Tp-e interval measurements were performed by two cardiologists who were blinded to clinical and symptoms of the patients.

Statistical Analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, USA) version 20.0 software. The obtained data were expressed as mean±standard deviation. Visual (histograms, probability graphs) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk test) were used to determine whether the variables distributed normally. An independent sample t-test was used to compare variables with normal distribution, and the Mann-Whitney U test was used to compare variables without normal distribution. Chi-square test or Fischer's exact test (when the chi-square test assumptions are not made due to low expected cell counts) were used to compare rates in different groups when it was available. P<0.05 was considered statistically significant.

RESULTS

A total of 81 participants, 41 blunt chest trauma patients and 40 healthy volunteers were included in this study.

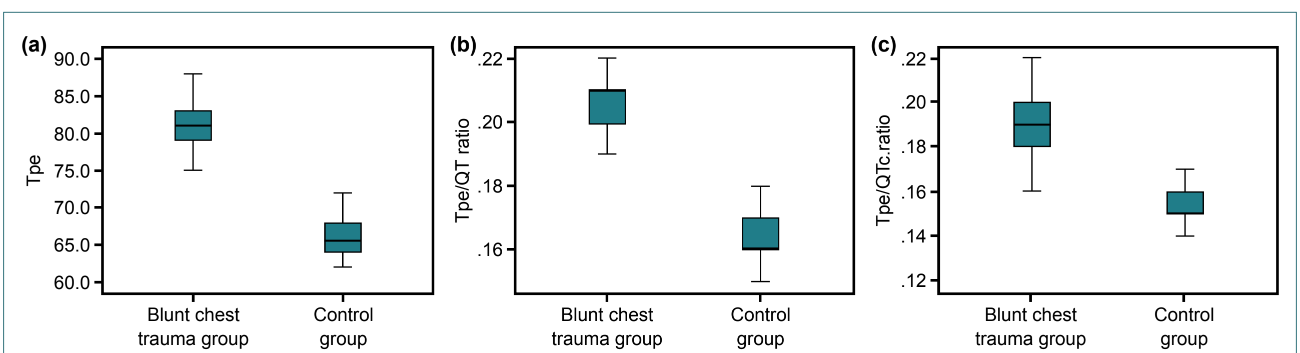

Figure 1. Comparison of the Tp-e interval **(a)**, Tp-e/QT ratio **(b)** and Tp-e/QTc ratio **(c)** between the blunt chest trauma and control groups.

Clinical data and variables of patients with blunt chest trauma and control group are shown in Table 1. In the trauma group, there were 30 male and 11 female patients; and the control group consisted of 30 male and 10 female. Age distribution of the groups was as follows: 41.37±16.15 in blunt chest trauma group and 37.78±14.62 in the control group. Age, BMI, SBP, DBP, HR, RR parameters were not found to be statistically significant in trauma cases compared to the control group ($p>0.05$).

Tpe (trauma 80.71±3.55, control 65.83±2.69, $p<0.001$), Tpe/QT (Trauma 0.21±0.01, control 0.17±0.01, $p<0.001$) Tpe/QTc (Trauma 0.19±0.01, control 0.15±0.01, $p<0.001$) values were statistically significant in the trauma group compared to the control group. cTpe (trauma 89.17±6.31, control 71.52±4.73, $p<0.001$), maxQT (trauma 400.30±12.79, control 410.83±10.86, $p<0.001$), minQT (Trauma 373.69±10.24, contol 385.18±10.35, $p<0.001$), QT (Trauma 387.10±11.29, control 398.00±10.35, $p<0.001$) were also found to be statistically significant. QT dispersion and QTc dispersion values were not found to be statistically significant ($p>0.05$) in trauma cases compared to the control group.

Table 1. Statistical analysis of the data and variables

Variables	Trauma (n=41)	Control (n=40)	p
Age (years)	41.37±16.15	37.78±14.62	0.335
BMI (kg/m^2)	26.46±4.19	26.35±3.07	0.757
SBP (mmHg)	130.00±11.46	127.13±12.96	0.262
DBP (mmHg)	75.98±8.38	75.63±8.78	0.926
HR (bpm)	73.46±8.07	70.98±7.10	0.145
RR (ms)	0.83±0.09	0.85±0.08	0.167
Tpe (ms)	80.71±3.55	65.83±2.69	<0.001
cTpe (ms)	89.17±6.31	71.52±4.73	<0.001
maxQT (ms)	400.30±12.79	410.83±10.86	<0.001
minQT (ms)	373.69±10.24	385.18±10.35	<0.001
QT (ms)	387.10±11.29	398.00±10.35	<0.001
QTc (ms)	429.20±28.11	431.70±23.73	0.666
maxQTc (ms)	443.58±28.92	445.40±24.99	0.764
minQTc (ms)	414.02±25.67	417.50±23.22	0.525
QTdispersion (ms)	26.85±5.67	25.65±4.73	0.258
QTc dispersion (ms)	29.80±7.10	27.90±5.33	0.177
Tpe/QT	0.21±0.01	0.17±0.01	<0.001
Tpe/QTc	0.19±0.01	0.15±0.01	<0.001

Variable are presented as mean±standard deviation. BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; HR: Heart rate; Tp-e: Transmural dispersion of repolarization; cTpe: Corrected transmural dispersion of repolarization; QTmax: QTmaximum; QTcmax: Corrected QT maximum; QTmin: QT minimum; QTcmin: Corrected QT minimum; QTd: QT dispersion; QTcd: Corrected QT dispersion; Tp–e/QT: Transmural dispersion of repolarization; Tp–e/QTc: Transmural dispersion of repolarization/corrected QT.

The etiology of blunt chest trauma cases is shown in Table 2. When the etiology of blunt chest trauma was examined, it was found that 20 patients had fallen from heights, six patients had motor vehicle accidents, three patients had pedestrian injuries, five patients had blunt forced trauma, and seven patients had other reasons.

Evaluation of trauma severity and ECG parameters are shown in Table 3. Patients with blunt chest trauma were divided into two groups, with six patients with a rib fracture, and 35 patients with no-rib fracture. In statistical analysis results, although Tpe/QTc, max QT and min QT were statistically significant ($p<0.05$) in patients with a rib fracture, no difference was detected concerning Tpe, Tpe/QT compared to no-rib fracture group ($p>0.05$).

Table 2. The etiology of blunt chest trauma cases

Patient groups	Etiology	n
Blunt chest trauma	Fall from height	20
	Motor vehicle accident	6
	Pedestrian injury	3
	Blunt forced trauma	5
	Other reasons	7
	Totally	41
Control	Totally	40
Totally		81

Table 3. Evaluation of the trauma severity and electrocardiogram parameters

Variables	Rib fracture (n=6)	No fracture (n=35)	p
Tpe (ms)	83.68±2.88	80.20±3.44	0.220
maxQT (ms)	410.67±10.80	398.51±12.37	0.030
minQT (ms)	381.17±9.68	372.40±9.90	0.037
QT (ms)	396.17±10.30	385.54±10.83	0.031
QTc (ms)	448.17±28.89	425.94±27.07	0.073
maxQTc(ms)	464.67±32.16	439.97±27.21	0.052
minQTc (ms)	431.50±30.85	411.03±23.92	0.071
QTdispersion (ms)	29.50±2.43	26.40±5.96	0.481
QTcdispersion (ms)	33.17±2.56	29.23±7.48	0.230
Tpe/QT	0.21±0.01	0.21±0.01	0.984
Tpe/QTc	0.19±0.01	0.19±0.01	0.028
cTpe (ms)	94.63±6.16	88.24±5.921	0.020

Variable are presented as mean±standard deviation. Tp–e: Transmural dispersion of repolarization; cTpe: Corrected transmural dispersion of repolarization; QTmax: QTmaximum; QTcmax: Corrected QT maximum; QTmin: QT minimum; QTcmin: Corrected QT minimum; QTd: QT dispersion; QTcd: Corrected QT dispersion; Tp–e/QT: Transmural dispersion of repolarization; Tp–e/QTc: Transmural dispersion of repolarization/corrected QT.

DISCUSSION

Cardiac injury due to blunt chest trauma and cardiac arrhythmia, as a result, is related to the violence of the impact on the chest wall, where it is applied, and which stage of the cycle during heart beat occurred.[13]

When the study data is examined, it is possible to provide early diagnosis of arrhythmias caused by blunt chest trauma and indirect blunt cardiac trauma by determining Tp-e interval, Tp-e/QT ratio and Tp-e/QTc ratios.

Several mechanisms have been proposed to identify traumatic cardiac arrhythmias, such as ischemia and hypoxia, perfusion disorders, increased vagal sympathetic stimulation, and excessive conduction of damaged myocardial cells. Ismailov et al.[6] showed that blunt chest trauma and blunt heart injury might be the cause of many kinds of arrhythmias, especially atrial fibrillation.

Increased Tp-e interval has been found to be a risk predictor for the development of malignant arrhythmias. These arrhythmias have not been affected by the presence or absence of structural heart disease in the patient.[14] The time interval between the T wave and the end of the T wave is generally expected to indicate the difference in repolarization time between subendocardial and subepicardial myocardial cells, and this interval leads to the evaluation of the transmural dispersion of the precordial repolarization as a marker of ECG.[15,16] Recently, the elongated interval of Tp-e appears to be a valuable sign for predicting ventricular arrhythmia and cardiovascular disorders. Tp-e interval and Tp-e/QT ratio have been reported to be associated with increased ventricular repolarization distribution. Elongation of the Tp-e interval has been reported to be related to ventricular arrhythmia and sudden cardiac death. These values are also expressed as new electrocardiographic markers.[17] The Tp-e/QT ratio measured from precordial leads is 0.21 ms in healthy adults with normal heart rate (60–100 beats/min).[18] In this study, Tp-e interval, Tp-e/QT ratio and Tp-e/QTc ratio values in ECG were determined and predictability of ventricular arrhythmogenesis via ECG was evaluated.

Cardiac arrhythmia as a result of blunt chest trauma is a rare condition.[19] Although it seems rare, various arrhythmias, such as atrial flutter and fibrillation, extrasystoles and ventricular tachycardia, may develop secondary to blunt chest trauma.[6,18–20] Kilicaslan et al.[7] reported that Tp-e/QT, Tp-e/QTc values increased in Obstructive Sleep Apnea Syndrome, and it was possible to determine the possibility of arrhythmia development in patients with Obstructive Sleep Apnea Syndrome by looking at these markers. In many studies with a similar perspective, it has been reported that Tp-e interval, Tp-e/QT ratio and Tp-e/QTc ratio can predict the development of arrhythmia in many diseases, such as diabetes mellitus, ankylosing spondylitis, hypothyroidism, hypertrophic cardiomyopathy.[7–9,21,22] In our study, the Tp-e interval, which is one of the arrhythmia markers, was found to be higher in the patient group than the control group, and Tp-e/QT, Tp-e/QTc values were statistically significant in the trauma group compared to control group. However, when the cases of blunt chest trauma were divided into subgroups, it was found that the presence of rib fracture did not affect all the markers of arrhythmia, even if it showed statistically significant results in some markers.

Limitations

Although there are some limitations in our study, the most important limitation is the limited number of patients. In addition, the obligation of evaluation only in selected trauma cases is another limitation. Although arrhythmia development has been reported in patients with blunt chest trauma, even in pos-traumatic follow-up, in our study, long-term clinical follow-ups and rhythm holter follow-up could not be performed. Long-term rhythm Holter monitoring and large patient groups are needed to emphasize the importance of Tp-e interval, Tp-e/QT and Tp-e/QTc ratios in predicting the risk of cardiac dysrhythmia in patients with blunt chest trauma.

Conclusion

Although there are many studies about arrhythmia development in patients with blunt chest trauma, to our knowledge, the Tp-e interval, Tp-e/QT ratio and Tp-e/QTc ratio of blunt chest trauma cases were not investigated in any study. In conclusion, Tp-e interval, Tp-e/QT ratio and Tp-e/QTc ratio in ECG predict the arrhythmias that may occur in blunt cardiac trauma, especially in blunt chest trauma patients.

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Authorship Contributions: Concept: İ.Ç., Ş.H.; Design: İ.Ç., Ş.H.; Supervision: Ş.H.; Fundings: İ.Ç., Ş.H.; Materials: İ.Ç., Ş.H.; Data: İ.Ç.; Analysis: İ.Ç., Ş.H.; Literature search: İ.Ç., Ş.H.; Writing: İ.Ç.; Critical revision: Ş.H.

Conflict of Interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZET*

Künt göğüs travması hastalarında Tp-e aralığı, Tp-e/QT oranı ve Tp-e/QTc oranının değerlendirilmesi

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AMAÇ: Künt göğüs travmasından sonra, yaralanma sonrası erken dönemde ve yaralanmadan birkaç gün sonra hayati tehlike oluşturan aritmiler ortaya çıkabilir. Bu çalışmada, künt göğüs travma hastalarında Tp-e aralığı, Tp-e/QT oranı ve Tp-e/QTc oranı kullanılarak aritmi riskini değerlendirmeyi amaçladık.
GEREÇ VE YÖNTEM: Bu çalışmada künt göğüs travması nedeniyle acil servise başvuran hastalar ileriye yönelik olarak incelendi. Künt göğüs travması ve kontrol gruplarına 12 derivasyonlu EKG uygulandı. Her iki gruptan da QT ve Tp-e aralıklarının EKG ölçümleri yapıldı.
BULGULAR: Kırk bir künt göğüs travmalı hasta ve 40 sağlıklı gönüllü olmak üzere, toplamda 81 katılımcı çalışmaya dahil edildi. Tpe, Tpe/QT, Tpe/QTc değerleri travma grubunda kontrol grubuna göre istatistiksel olarak anlamlıydı ($p<0.01$). Her ne kadar Tpe/QTc, maksimum QT ve min QT, kaburga kırığı olan hastalarda istatistiksel olarak anlamlı olsada ($p<0.05$) kaburga kırığı olmayan gruba göre Tpe, Tpe/QT açısından fark bulunmadı ($p>0.05$).
TARTIŞMA: EKG'de Tpe aralığı, Tp-e/QT oranı ve Tp-e/QTc oranı, künt kardiyak travmada, özellikle künt göğüs travma hastalarında oluşabilecek aritmileri öngörmektedir.
Anahtar sözcükler: Acil servis; aritmi; künt göğüs travması.

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