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The relationship between QT interval and pain severity in trauma patients in the emergency department

Acil servise travma nedeniyle başvuran hastalarda ağrı şiddeti ile QT intervali arasındaki ilişki

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ABSTRACT

Aim: Cardiac depolarization occurs in patients experiencing pain from acute traumas, and changes in QT interval could indicate the state of ventricular depolarization. Thus, we aimed to determine the relationship between pain severity and QT interval in patients experiencing acute trauma.

Material and Method: Seventy patients, who were consecutively- admitted to the Emergency Department due to moderate or severe trauma (study group), and sixty healthy individuals (control group) were included in this study. The QT interval was calculated for each group before and after analgesia and visual analog scale pain levels were recorded. Statistical analyses were performed using SPSS for Windows software (ver. 21.0; SPSS Inc., Chicago, IL, USA). Data are presented as medians±interquartile range (IQR). Statistical significance was determined using Mann-Whitney U, Wilcoxon, and chi-square tests, with a p-value <0.05 considered significant.

Results: The mean age of patients with trauma and control patients was 31.50±25 years and 35.00±20 years, respectively. Among trauma patients, QT, RR and corrected QT (QTc) intervals were significantly different before and after analgesia (P<0.001). Similarly, the average pre-analgesia QT, RR and QTc values also differed between pre- and post-analgesia trauma patients (p=0.007, p<0.001, and p<0.001, respectively). However, no differences in QT values were observed before and after analgesia between patients experiencing moderate versus severe pain (p>0.05).

Conclusion: In trauma patients, acute pain prolonged the QT interval, which reverted to normal following the administration of nonsteroidal anti-inflammatory drugs. However, additional comparative studies on this topic are required.

Keywords: Emergency service, pain, trauma, electrocardiogram, QT interval

GİRİŞ

Amaç: Travmaya bağlı akut ağrıya maruz kalan hastalarda kardiyak depolarizasyon etkilenebilir. Dolayısıyla elektrokardiyografide QT değişikliği, ventriküler depolarizasyonun durumu ile ilgili bize bir fikir verebilir. Bu çalışmada travmaya maruz kalmış erişkin hastalarda ağrı şiddeti ile QT intervali arasındaki ilişkiyi araştırmayı amaçladık.

Gereç ve Yöntem: Acil Servise orta ve şiddetli travma nedeniyle ardışık olarak başvuran yetmiş hasta (çalışma grubu) ve altmış sağlıklı birey (kontrol grubu) bu çalışmaya dahil edildi. Analjezi öncesi ve analjezi sonrası grupların QT intervalleri hesaplandı. Çalışmaya katılan hastaların demografik özellikleri, klinik bulguları ve ağrı düzeyleri (Görsel Analog Skala ile) kaydedildi. İstatistiksel analizler SPSS programı (ver. 21.0; SPSS Inc., Chicago, IL, ABD) kullanılarak yapıldı. Veriler medyan±çeyrekler açıklığı (IQR) olarak sunulmuştur. Kullanılan istatistiksel yöntemler; Mann-Whitney U, Wilcoxon ve ki-kare testleridir. Anlamlılık sevisi; p <0,05 olarak kabul edildi.

Bulgular: Travma hastaları ve kontrol hastalarının yaş ortalaması sırasıyla 31,50±25 yıl ve 35,00±20 yıl idi. Travma hastaları arasında analjezi öncesi ve sonrası QT, RR ve düzeltilmiş QT (QTc) aralıkları anlamlı olarak farklıydı (P<0,001). Benzer şekilde, ortalama analjezi öncesi QT, RR ve QTc değerleri de analjezi öncesi ve sonrası travma hastaları arasında farklılık gösterdi (sırasıyla p=0,007, p<0,001, p<0,001). Ancak, orta ve şiddetli ağrı yaşayan hastalar arasında analjezi öncesi ve sonrası QT değerlerinde herhangi bir fark gözlenmedi (p>0,05).

Sonuç: Travmaya maruz kalan hastalarda gelişen akut ağrı QT intervalini uzatmakta, Non-steroid antiinflamatuar ilaç uygulaması sonrası ağrısı geçen hastalarda ise tekrar normale yaklaşmaktadır. Bu konuda daha ileri çalışmalara gereksinim vardır.Anahtar Kelimeler: Aerobik egzersiz nesfatin-1, Kreatin kinaz, Enerji düzenlenmesi

Anahtar Kelimeler: Acil servis, ağrı, travma, elektrokardiogram, QT aralığı

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INTRODUCTION

Acute pain is the most common complaint during emergency room admission and trauma is the most common cause of acute pain. In a recent French study, the ratio of patients admitted to the emergency department (ED) with pain was over 80% (1). Traumas can be mild to moderate, and include simple skin incisions, soft tissue injuries, extremity fractures, or life-threatening complications. The resultant acute pain depends on the severity of the trauma and can be classified by using visual analog scales (VASs). Pain management is based on the pain type, which is important for preventing further deterioration of the clinical situation, as well as the prevention of future chronic pain (2).

Changes in electrocardiograms (ECGs) in trauma patients are not specific and can be due to arrhythmias, ST-T wave alterations, sinus tachycardia, atrial flutter or atrial fibrillation, of which the most common are nonspecific ST-T changes following sinus tachycardias (3,4). QT intervals in ECGs indicate the period from ventricular depolarization to the completion of repolarization. In adults, the QT interval ranges from 0:35 to 0:44 sc (5); increased heart rate shortens the interval and decreased heart rate prolongs it. Therefore, QT intervals can be corrected using various formulas that account for heart rate. According to the formula of Bazett (1920), the corrected QT interval (QTc) is obtained by dividing the QT interval by the square root of the RR interval (6). In addition, another important ECG finding is the QT dispersion (QTd). It is calculated by subtracting the shortest QT interval from the longest QT interval in the leads in the ECG. Reported values of QTd vary widely, ranging from 10 to 71 msc in normal subjects. In general, a greater amount of QTd is associated with higher risk of cardiac events and mortality.

In trauma patients experiencing acute pain, cardiac depolarization can be affected. Thus, ECGs can detect QT changes and provide information about the status of ventricular depolarization in such patients. Currently, limited information regarding QT changes associated with trauma-induced acute pain is available (7,8); therefore, this study was aimed to investigate the relationship between pain severity and the QT interval in adult trauma patients.

MATERIAL AND METHOD

The study was carried out with the permission of Harran University Ethics Committee of Medical Faculty (Date: 29.03.2013, Decision no: B.30.2.HRÜ.0.20.05.00.050.01.04.65). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

In total, 70 patients aged over 18 years, admitted to the Harran University Faculty of Medicine Research or Application Hospital Emergency Clinic between May 2012 and June 2013, following moderate to severe trauma, were included in this study.

The pain severity of patients was evaluated using a VAS. Diclofenac sodium, a nonsteroidal anti-inflammatory drug (NSAID), was administered intramuscularly to patients with pain. ECGs were obtained prior to, and 60 minutes after, analgesic application. Venous blood, collected via the antecubital route using a sterile injector, was assessed for cardiac biomarkers including troponin I and creatine kinase-MB (CK-MB), as well as with respect to biochemical and hemogram parameters. Patient information, including age, sex, trauma type, blood collection time, and VAS pain score was also collected. From these data, cases were divided into moderate and severe groups. All patients provided informed written consent. For unconscious patients, consent was obtained from first-degree relatives.

Exclusion Criteria

Patients were excluded from this study if they were under 18 years of age, had received analgesia from another clinic, were admitted to the ED more than 3 hours after trauma, suffered from chronic diseases (e.g., rheumatoid arthritis, diabetes etc.) or abdominal pain, had drug sensitivities or addictions, used drugs within the past 7 days, suffered from active somatic or psychiatric illnesses, did not wish to participate, or withdrew from the study prematurely.

Control Group

The control group consisted of healthy individuals with similar demographic features who were admitted to the ED. In total, 60 healthy individuals over 18 years of age were included in this study; they all provided written informed consent. As with the study group, ECGs and blood samples were obtained and analyzed for cardiac biomarkers.

Sample Preparation and Measurements

ECGs were obtained from individuals prior to analgesia, and VAS pain scores were recorded. Approximately 6 cc of blood was also obtained for assessment of routine biochemistry and hemogram and cardiac biomarkers (including troponin I and CK-MB). Analgesia was applied within 10 minutes of patient admittance to the ED, and ECGs were obtained again after 60 minutes. QT intervals were calculated before and after analgesia using 12-channel ECG records that were obtained at 25 mm/sc and 10 mm/mV amplitude using a PETAS Kardioped 500 device. QT intervals were measured in mm/sc from the beginning of the Q wave until the end point of the T wave. In ECGs with a U wave, the lowest point between the T and U waves was considered as the end of the T wave.

On a numeric rating scale (NRS), pain was classified between 0 (no pain) and 10 (most severe pain). An NRS score of 1–3 indicated mild pain, while NRS scores of 4–7 and 8–10 represented moderate and severe pain, respectively (9).

Statistical Analysis

Statistical analyses were performed using SPSS for Windows software (ver. 21.0; SPSS Inc., Chicago, IL, USA). The data are presented as medians±interquartile range (IQR). For comparisons between groups, Mann-Whitney U tests and Wilcoxon tests were used. To assess the distribution of individuals by groups, chi-Square tests were used. A P-value <0.05 was considered significant.

RESULTS

Characteristics of patients are listed in **Table 1.**

Table 1. Characteristics of patients

	Trauma Patients (Median±ICR or N)	Control Group (Median±ICR or N)	P value
Age (years)	31.5±25	35.0±20	0.103
Sex (M/F)	56/14	47/13	0.183

No significant differences in age or sex were observed between the trauma patients and control groups. In total, 25 patients experienced trauma from falling (15 males, 10 females), 7 patients experienced gunshot wounds (GW) (6 males, 1 female), 6 patients were involved in motorcycle accidents (MA) (all males), 18 patients were involved in car accidents (CA) (16 males, 2 females), 6 patients experienced non-vehicle traffic accidents (5 males, 1 female), and 8 patients were assaulted (all males) (Table 2).

Table 2. Classification of trauma patients

	Male	Female	Total
Falling	15	10	25
Gunshot Wound	6	1	7
Motorcycle Accident	6	0	6
Car Accident	16	2	18
Non-Vehicle Traffic Accident	5	1	6
Assaulted	8	0	8
Total	56	14	70

Biochemical, hemogram and cardiac biomarkers were compared between trauma and control patients (Table 3).

Table 3. Comparison of laboratory results of trauma patients and control group

	Trauma Patients	Control Group	P value
Glucose (mg/dl)	127±39	104± 21	0.006
LDH (U/L)	329±257	216±99	0.001
CPK (U/L)	192.5±263	106.5±65	0.001
CK-MB (ng/ml)	1.73±2.56	1.94±2.58	0.084
Troponin (ng/ml)	0.01±0.02	0.06±0.43	0.675
WBC (µl)	14.07±6.81	9.10±2.60	<0.001
Hgb (mg/dl)	14.96±2.05	14.73±3.29	0.676
Hct (%)	43.25± 6.49	43.29±6.56	0.870
Platelet (K/mm³)	251.25±106.0	246.90±76.5	0.497

CK-MB: creatine kinase-MB, CPK: creatine phosphokinase, Hct: hematocrit, Hgb: hemoglobin, LDH: lactate dehydrogenase, Wbc: Leukocyte

Glucose, lactate dehydrogenase (LDH), and creatine phosphokinase (CPK) levels in trauma patients were 127±39 mg/dL, 329±257 U/L and 192.5±263 U/L, respectively, compared to 104±21 mg/dL, 216±99 U/L and 106.5±65 U/L, respectively patients in control group (p=0.006, p<0.001, and p<0.001, respectively). No differences in the levels of CK-MB and troponin between trauma (1.73±2.56 ng/mL and 0.01±0.02 ng/mL, respectively) and control patients (1.94±2.58 ng/mL and 0.06±0.43 ng/mL, respectively) were observed (both p>0.05).

QTd, QT, RR, and QTc intervals were compared in trauma patients before and after the application of analgesia (Table 4).

Table 4. Comparison of QTd, QT, RR and QTc intervals before and after analgesia in the trauma patient group

	Before analgesia	After analgesia	P value
QTd (mm/sc)	0.30±0.3	0.25±0.3	0.093
QT (mm/sc)	9.50±1.0	9.0±1	<0.001
RR (mm/sc)	14.5±9	17.5± 5	<0.001
QTc (mm/sc)	491.0±175	437.5±45	<0.001

QTd: QT Dispersion, QTc: Corrected QT, mm/sc: Millimeter/scond

The QTd value prior to analgesia in traumatic patients was 0.30±0.3 mm/sc, compared to 0.25±0.3 mm/sc after analgesia (p=0.093). QT, RR and QTd intervals in trauma patients prior to analgesia were 9.50±1.0 mm/sc, 14.5±9 mm/sc and 491.0±175 mm/sc, respectively, compared to 9.0±1 mm/sc, 17.5±5 mm/sc and 437.5±45 mm/sc, respectively, following analgesia (all p<0.001).

When comparing trauma patients before analgesia to control patients, no statistical difference in QTd values was observed (0.30±0.3 mm/sc and 0.30±0.3 mm/sc, respectively; p=0.157). Conversely, differences in QT, RR, and QTc values between trauma patients before analgesia (9.50±1.0 mm/sc, 14.5±9 mm/sc, and 491.0±171 mm/sc, respectively) and healthy controls (9.00±0.5 mm/sc, 19.5±5 mm/sc and 415.5±38 mm/sc, respectively) were observed (p=0.007, p<0.001, and p<0.001, respectively) (Table 5).

Table 5. Comparison of QTd, QT, RR and QTc intervals in control group and trauma patients before analgesia

	Trauma patients before analgesia	Control group	P value
QTd (mm/sc)	0.30±0.3	0.30±0.3	0.093
QT (mm/sc)	9.50±1.0	9.00±0.5	<0.001
RR (mm/sc)	14.5±9	19.5±5	<0.001
QTc (mm/sc)	491.0±175	415.5±38	<0.001

QTd: QT Dispersion, QTc: Corrected QT, mm/sc: Millimeter/scond

QTd, QT, RR, QTc intervals were also similar, between patients suffering from moderate or severe pain, before and after receiving analgesia (p>0.05; Table 6).

Table 6. According to visual analogue scale, relationship between moderate and severe pain and QTd, QT, RR and QTc intervals

	Moderate pain group (n:49)	Severe pain group (n:21)	P values
QTd before analgesia (mm/sc)	0.30±0.3	0.30±0.3	0.937
QTd after analgesia (mm/sc)	0.20±0.3	0.30±0.3	0.857
QT before analgesia (mm/sc)	9.50±0.63	9.00±1.50	0.189
QT after analgesia (mm/sc)	9.00±0.75	9.00±1.25	0.163
RR before analgesia (mm/sc)	14.00±9.0	15.50±7.3	0.608
RR after analgesia (mm/sc)	17.50±3.8	15.50±7.0	0.437
QTc before analgesia (mm/sc)	492.00±186	484.00±134	0.547
QTc after analgesia (mm/sc)	437.00±41	442.00±70	0.729

QTd: QT Dispersion, QTc: Corrected QT, mm/sc: Millimeter/scond

DISCUSSION

Following skeletal muscle injuries, CPK and CK-MB levels are elevated (10). In a study of chest trauma patients by Çobanoğlu, CPK level was found to increase significantly relative to that of control patients, while no increases in CK-MB were observed (11). In a related study, Karakuş et al., investigated cardiac enzymes in multi-trauma patients and found that CPK, CK-MB and troponin concentrations were elevated (12). In the current study, the average CPK value was significantly higher in trauma patients compared to controls; however, the average CK-MB and troponin levels did not change. Most patients in this study suffered extremity traumas, which may explain the lack of changes in cardiac-specific biochemical markers.

Trauma patients became relaxed upon receiving analgesia, and their anxiety levels decreased following administration of NSAIDs. Yang et al. reported that action potentials and the time to ventricular repolarization were shortened by NSAIDs (ibuprofen), causing a significant reduction in QT and QTc intervals. However, since NSAIDs cause ventricular arrhythmias, ibuprofen and other NSAIDs are

not recommended for traumatic-patients with heart disease (13). Kristof et al., found that diclofenac only increased repolarization times and QT intervals in patients with heart disease (14); however, since our study did not include patients with heart disease, we administered diclofenac sodium (diclomec) for analgesia. Contrary to the results of Kristof et al., a significant reduction in QT and QTc intervals was detected in patients receiving diclofenac in the present study. These findings are consistent with a study using ibuprofen (13); therefore, it is possible that the two drugs affect cardiac Na and Ca channels similarly.

The average QT and QTc values of trauma patients before analgesia were significantly higher than those of control patients, while the average RR values in trauma patients before analgesia was lower than that of the controls. Özdemir et al. detected an increase in QTc intervals and dispersion in children suffering from severe head traumas, especially those resulting in intracranial bleeding, and it was suggested that this could indicate poor cardiovascular outcomes (e.g., ventricular arrhythmias and sudden death) (15). Wittebole et al., detected wide negative T waves and prolonged QT intervals using ECGs after head trauma (16), similar to a study by Suzuki et al. In those studies, a significant relationship was observed between the severity of burns and increased QT dispersion. It was suggested that the increase in QT dispersion could be an important indicator of the magnitude of myocardial damage following burn injuries (7). Similarly, a study by Koturoglu et al., detected increased QT dispersion after acute stresses, including burn injuries and severe head trauma (8). Similarly, in the current study, a significant increase in QT and QTc intervals was observed in trauma patients without analgesia, while a decrease was observed following analgesia application. No significant difference in QTd interval was observed in either group.

CONCLUSION

Acute pain management: It is an important part of treatment both in terms of patients and in medical practice. The analgesia to be chosen in pain management should be effective, fast, reliable and appropriate for the patient's clinic. In our study, NSAI (diclofenac sodium) was used in the management of acute pain in patients exposed to moderate and severe trauma. In the trauma patients included in the study, the QT interval before analgesia was longer than the QT interval in the control group. 60 minutes after diclofenac sodium administration in trauma patients. Afterwards, shortening of the QT distance occurred. No significant correlation was found between moderate pain and QT intervals of severe pain before and after analgesia in trauma patients. Our study is one of the few studies on the relationship between pain intensity and QT distance in trauma patients. However, more research is needed on this topic.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Harran University Ethics Committee of Medical Faculty (Date: 29.03.2013 Decision no: B.30.2.HRÜ.0.20.05.00.050.01.04.65).

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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