

Clinical significance of Tp-e interval, Tp-e/QT ratio, and Tp-e/QTc ratio in patients with renal colic

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Abstract

Background: Renal colic is a frequently encountered condition in the emergency department (ED), characterized by the sudden and severe onset of flank pain. To assess the risk of cardiac arrhythmia in patients with renal colic, electrocardiography (ECG) was used to investigate several ventricular arrhythmia characteristics, such as the Tp-e interval, Tp-e/QT ratio, and Tp-e/QTc ratio.

Objective: This study aimed to investigate the role of the Tp-e interval, Tp-e/QT ratio, and Tp-e/QTc ratio as cardiac arrhythmia stimulators in patients with renal colic. By evaluating these parameters, the risk of developing cardiac arrhythmia in individuals with renal colic could be better understood.

Methods: The study included patients who presented to the tertiary emergency department with renal colic over a period of six months, from June 10, 2022, to December 31, 2022. Upon admission, all patients underwent an ECG, and measurements of QT interval and Tp-e interval were conducted in leads D2 and V5. These measurements served as indicators for assessing the potential risk of cardiac arrhythmia in patients with renal colic.

Results: The levels of D2 TPE were significantly elevated in patients experiencing renal colic attacks compared to both the pain-free period and the control group ($p=0.036$). Additionally, the levels of D2 Tpe and QTc were significantly higher during the renal colic attack period as well as the pain-free period when compared to the control group ($p=0.041$).

Conclusions: The Tp-e interval, Tp-e/QT ratio, and Tp-e/QTc ratio may potentially be associated with fatal ventricular arrhythmias in patients who present to emergency departments with renal colic pain.

Keywords: Tp-e interval, Tp-e/QT ratio, Tp-e/QTc ratio, Renal colic.

Introduction

Renal colic is a frequently encountered condition in the emergency department (ED), where patients typically present with intense and abrupt flank pain.¹ This terrible pain is mostly caused by increased pressure due to a urinary tract obstruction, and the severity of the pain is directly proportional to the degree of pressure.² The prevalence of this condition in European countries is approximately 16% per year, with a higher occurrence in males. Research indicates that the lifetime prevalence of renal colic is 10%, and exacerbation rates reach 25%.³ Recent years have witnessed a potential rise in incidence due to changes in individuals' living circumstances. Pain is

a widespread issue that impacts various segments of society, and studies have established its correlation with cardiovascular disease.^{4,5}

The significance of the sympathetic nervous system in regulating cardiovascular functions cannot be overstated due to its impact on heart rate, venous capacitance, and arteriolar resistance. Heightened sympathetic activity has been associated with elevated mortality and morbidity rates. Research has established a correlation between increased sympathetic activity and the occurrence of myocardial infarction and ventricular arrhythmias. Furthermore, specific ventricular repolarization dispersions, such as the QT interval (an electrocardiogram

marker) and its corrected form, QTc, as well as the Tpe interval, have been identified as possible indications of life-threatening arrhythmias.⁶⁻⁸ Furthermore, recent research has demonstrated that the Tp-e/QT and Tp-e/QTc ratios can serve as reliable markers for ventricular arrhythmias, regardless of any fluctuations in heart rate. These findings emphasize the need to assess ventricular arrhythmia characteristics such as the Tp-e interval, Tp-e/QT ratio, and Tp-e/QTc ratio on electrocardiograms (ECGs) of patients with renal colic.^{9,10} However, there remains a scarcity of studies in the existing literature that specifically investigate these parameters in patients with renal colic.

Objectives

This study aimed to evaluate the possible risk of cardiac arrhythmia in people with renal colic through an examination of the Tp-e interval, tp-e/QT ratio, and Tp-e/QTc ratio as potential cardiac arrhythmia stimulators.

Methods

This study was conducted as a prospective case-control study at a single center. Patients who presented with renal colic at the tertiary emergency department between June 10, 2022, and December 31, 2022, were included in the study.

Participants

The study included patients who arrived at the emergency department experiencing flank pain and were diagnosed with renal colic through an abdominal computed tomography (CT) scan. These patients had previously been diagnosed with clinical renal colic and had similar symptoms of back pain and dysuria. Patient information, such as age and sex, was recorded for analysis. However, certain criteria were used to exclude specific groups from the study. Patients under the age of 18, those with arrhythmia, hypertension, cardiovascular disease, chronic kidney or liver disease, diabetes mellitus, hyperthyroidism or hypothyroidism, pacemakers, drug use, heavy caffeine consumption and stimulant use, tachycardia (>100 beats/minute) or bradycardia (<60 beats/minute), and pregnant women were not included. To form a control group, healthy volunteers who visited the emergency department for reasons unrelated to

cardiac pathology and had similar demographic characteristics were randomly selected.

Study protocol

The severity of flank pain was assessed using the visual analog scale (VAS) score. The VAS score ranged from "0" for individuals experiencing no pain to "100" for those with the most intense pain ever. Participants were requested to rate their pain on the VAS scale between 0 and 100. The VAS score was documented during both the period of pain and the pain-free period. ECGs were recorded from all participants using a paper velocity of 10 mm/mV and a speed of 50 mm/s for the 12-lead ECG. Two ECGs were analyzed: the first upon admission and the second after administration of analgesic therapy. A second ECG was examined in patients whose VAS score decreased by 30 or more within the first hour following treatment. Patients who did not achieve a reduction of 30 or more in their VAS score after treatment were excluded from the study. A cardiologist, who was unaware of the patients' clinical and demographic information, manually performed all ECG measurements.

Electrocardiographic analysis, QTc and Tpe measurement

Upon admission, patients underwent an ECG procedure. Mindray's BeneHearth R12 device, produced in Shenzhen, China, was used to record the 12-lead ECG. The ECGs were recorded with a velocity of 25 mm/sec and an amplitude of 10 mm/mV. The ECGs from the case and control groups were then digitized, and the QT and TPE intervals were measured in leads D2 and V5. For the Tpe interval measurement, the distance between the peak and end point of the T wave was calculated, with the end point defined as the point where the T wave reached the isoelectric line. The corrected QT interval (QTc) was then calculated using the Bazett formula based on the measured QT intervals.

$$QT \text{ corrected (Bazett)} = QT/\sqrt{RR}$$

Statistical analysis

The analysis of all data was conducted using SPSS version 20.0 (SPSS Inc., Chicago, IL). Graphs were created using Prism version 8 (Graphpad Software). Continuous variables were assessed for minimum, maximum, mean,

and standard deviation, while categorical variables were examined for frequency and percentage distribution. The normality distribution of continuous variables was determined using the Shapiro-Wilk normality test. Paired t-tests and ANOVA tests were employed to analyze data that conformed to the normality distribution. P value less than 0.05 was considered statistically significant.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki. The Ethics Committee of Antalya Training and Research Hospital approved the research protocol. The present study did not interfere with the process of diagnosis and treatment of patients and all participants signed an informed consent form.

Results

The case group of the study consisted of 29 patients, while the control group included 30 patients, all of whom were diagnosed with renal colic. The mean age of the patients in the case group was 46.55±14.80 years. Among the patients in the control group, 15 (50%) were female. On the other hand, 14 (48.3%) of the patients in the case group were female. Detailed information about the patients in the control group can be found in Table 1.

The study findings revealed that D2 Tpe levels were significantly higher in patients experiencing renal colic attacks compared to both the pain-free period and the control group (p=0.036). Additionally, D2 Tpe/QTc levels were found to be significantly higher during the renal colic attack period as well as the pain-free period when

compared to the control group (p=0.041). A comprehensive comparison of ECG parameters between the patients and controls can be found in Table 2 and Figure 1.

Table 1. Control and case groups descriptive information

Gender	Control	Case	P Value
Female, n(%)	15 (50)	14 (48.3)	>0.99
Male, n(%)	15 (50)	15 (51.7)	
Age, year	50.73±18.25	46.55±14.80	0.338

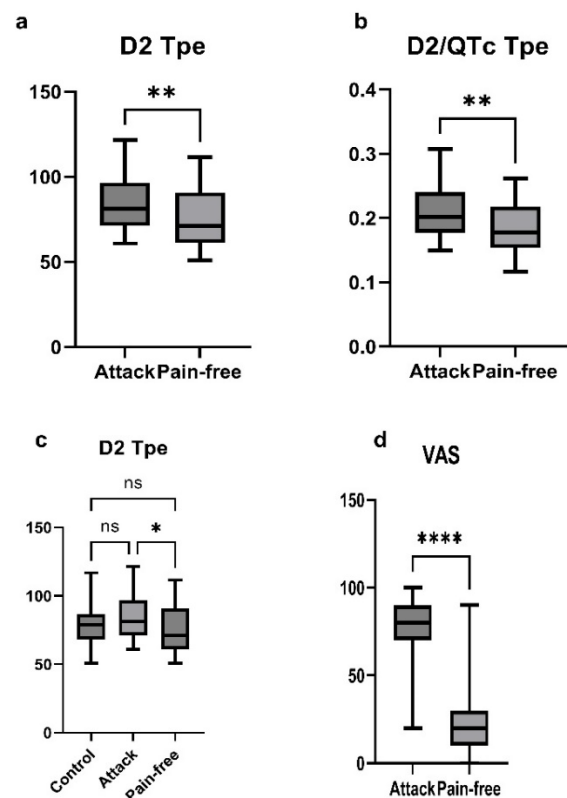


Figure 1. Comparison of groups in terms of Tpe, Tpe/QTc and pain scores

Table 2. Comparison of groups in terms of parameters

	Control	Attack	Pain-free	P value*	P value**
QTc	412.1±21.72	406.83±16.40	408.97±19.50	0.605	0.576
D2 Tpe	80.15±16.00	86.52±16.14	75.70±15.18	0.002	0.036
V5 Tpe	74.93±19.63	80.61±19.76	77.17±20.54	0.307	0.55
D2 Tpe /QTc	0.19±0.04	0.21±0.04	0.18±0.03	0.003	0.041
V5 Tpe /QTc	0.18±0.05	0.19±0.05	0.18±0.05	0.208	0.501
VAS		76.90±17.75	24.83±19.75	<0.001	ns

*; Paired t-Test Attack vs Pain-free, **; ANOVA, Control vs Attack vs Pain-free

Discussion

In various studies, the correlation between pain and cardiac rhythm disorders, specifically arrhythmia, has

been established.¹¹ Our study, however, revealed noteworthy findings regarding patients with renal colic. We observed that levels of Tpe and Tpe/QTc were

significantly elevated in these patients compared to both control subjects and pain-free periods.

The correlation between alterations in the 12-lead ECG and severe arrhythmias has been established through various research studies. Among the frequently employed measures are the ratios of Tpe, QT, and their respective corrected forms in relation to one another.¹² The process of ventricular depolarization initiates from the endocardium and progresses towards the epicardium, while repolarization is distributed across both regions.¹³

The Tpe distance and the Tpe/QT ratio have garnered significant attention in numerous studies investigating arrhythmia and sudden cardiac death. Furthermore, studies have shown that increasing the Tpe distance might slow the dispersion of conduction during repolarization, affecting the incidence of arrhythmias.^{14,15}

Ceci et al. conducted a study that highlighted the correlation between premature ovarian failure and ventricular arrhythmia characteristics. This finding shed light on the potential impact of ovarian dysfunction on cardiac health.¹⁶ Additionally, another study focused on the elevation of the TPE/QT ratio in cases of acute myocardial infarction. This study further explored the prognostic value of this ratio in patients undergoing coronary angiography.

Studies have provided evidence of an elevation in the Tp-e/QT and Tp-e/QTc ratios among individuals diagnosed with acute myocardial infarction. Furthermore, these ratios have been found to be associated with the occurrence of arrhythmias. Additionally, research has indicated a correlation between these parameters and an increase in levels of cardiac enzymes.¹⁷

The impact of pain on the cardiovascular system has been extensively studied, revealing its influence through neuroendocrine mechanisms and alterations in electrophysiological processes.¹⁸ Research has demonstrated that severe pain can lead to imbalances in the autonomic system, thereby elevating the susceptibility to coronary disease. The impact of enhanced autonomic efficiency on the cardiovascular and gastrointestinal systems is well documented, and individuals may seek medical attention at emergency departments due to heightened effects.^{19,20} Studies have shown that Tpe, QT

interval, and Tpe/QT ratio are associated with sudden death and arrhythmias.⁶ Maury et al., found that higher TPE increases the chance of developing arrhythmias in individuals with Brugada syndrome.²¹

Bilge et al. found an association between elevated TPE, QT, and tpe/qt ratios and the development of arrhythmias in individuals with ischemic stroke.²² In our own study, we have found evidence suggesting that the elevation of tpe, qt, and tpe/qt levels in patients experiencing exacerbations of renal colic may serve as a potential indicator for cardiovascular events. However, it is important to acknowledge the limitations of our study. Firstly, it was conducted in a single-center setting, which may limit the generalizability of our findings. Additionally, our study lacked long-term follow-up, as the patients were only monitored with a Holter recording or a monitor. Therefore, further research involving prospective multicenter studies with Holter monitoring or monitored follow-up is necessary to better understand the impact of renal colic and pain on arrhythmias.

Conclusions

The Tp-e interval, Tp-e/QT ratio, and Tp-e/QTc ratio could potentially be associated with fatal ventricular arrhythmias in individuals who arrive at emergency departments with renal colic pain.

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Competing interests

The authors declare that they have no competing interests.

Abbreviations

Emergency department: ED; Electrocardiography: ECG; Computed tomography: CT; Visual analog scale: VAS.

Authors' contributions

All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

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Availability of data and materials

The data used in this study are available from the corresponding author on request.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. The Ethics Committee of Antalya Training and Research Hospital approved the research protocol. All participants signed an informed consent form.

Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

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