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Investigation of the effect of tens treatment on cardiac electrical activity using proarrhythmogenic markers

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ABSTRACT

Aim: It was aimed to investigate the effect of transcutaneous electrical nerve stimulation (TENS) treatment, which is widely used for pain, on cardiac electrical activity by using new proarrhythmogenic markers that give an idea on cardiac arrhythmia.

Material and Method: Forty patients (21 females, 19 males, mean age 56.60±10.38) who applied to our outpatient clinic with the complaint of pain in the left shoulder or limitation of motion were included in our study. A fifteen-session physical therapy program was applied to the patients. Twelve-lead electrocardiography (ECG) was performed before treatment, at the end of the first day of treatment, and after treatment; and heart rate, QT interval (cQT) corrected according to Bazett's formula, Tp-e/QT and electrophysiological balance index (iCEB) ratio were measured. The relationship of the measurements before treatment-first day after treatment, before treatment-fifteenth day after treatment and first day after treatment-fifteenth day after treatment was evaluated by Paired-Samples T test analysis.

Results: In our study, when heart rate, cQT, Tp-e/QT and iCEB values were statistically analyzed, no significant difference was observed between measurements, since $p>0.05$.

Conclusion: In our study, when the heart rate, new proarrhythmogenic markers cQT, Tp-e/QT and iCEB values were examined in patients who received physical therapy to the left shoulder region, it was seen that TENS treatment did not have a significant effect on cardiac rhythm.

Keywords: TENS, ECG, rhythm, cQT, Tp-e/QT ratio and iCEB

INTRODUCTION

Transcutaneous electrical nerve stimulation (TENS) is a widely used noninvasive, non-pharmacological treatment for pain (1). TENS, a clinical application of the gate control theory defined by Melzack and Wall in 1965, is a low-voltage electrical current in which large-diameter sensory fibers are stimulated by electrons on the skin in order to reduce nociceptive input (2, 3). TENS has been used to treat a wide variety of acute and chronic painful conditions since the 1970s. TENS is a relatively safe, noninvasive and easy to use treatment option (4). TENS has no serious side effects and contraindications, except for skin irritation, pacemaker, bleeding disorders, pregnancy, and epilepsy (5).

The standard superficial electrocardiogram (ECG) is a simple and widely used diagnostic tool that shows cardiac electrical activity. The prolongation of the QT interval, a marker for electrical instability, is the best known ECG sign for arrhythmia (6). In addition, in the twelve-lead ECG, Tp-e, defined as the distance between the peak and the end of the T wave, and iCEB, formulated as the Tp-e/QT ratio and the QT interval/QRS duration, are new proarrhythmogenic markers that give an idea about cardiac arrhythmia (7-10).

In this study, it is aimed to investigate whether the treatment has a negative effect in terms of cardiac arrhythmia by evaluating heart rate, cQT, Tp-e/QT and iCEB measurements on ECG in patients who received conventional TENS treatment in the left shoulder area, which is the body part closest to the anterior chest wall.

MATERIAL AND METHOD

A total of 40 patients, 21 women and 19 men, who applied to the Physical Medicine and Rehabilitation outpatient clinic of Amasya University Sabuncuoğlu Şerefeddin Training and Research Hospital, between October 2019 and February 2020, between the ages of 18 and 80 with

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complaints of left shoulder pain or limitation of motion, were included in the study. Ethics committee approval of the study was obtained from the Ethics Committee of Amasya University (Date: 03.09.2020, Decision No: 105). For the patients included in our study, infrared (20 min), TENS (20 min), ultrasound (5 min) and 15 min exercise program were planned as fifteen sessions. Physical therapy sessions were administered daily, Monday through Friday, for 3 weeks. Patients with heart rhythm disorders, pacemaker, pregnancy and neuroendocrine diseases such as diabetes, and hypo/hyperthyroidism were not included in our study. Conventional TENS was applied with four standard electrodes placed in the anterior and upper regions of the left shoulder with an amplitude width of 0.2 ms and a frequency of 80 Hz. The intensity of the stimulation was increased until a perceptible tingling sensation was experienced by the patient. ECGs were recorded with a standard 12-lead ECG at 25 mm/s paper speed and 10 mm/mV amplification. ECG measurements were made three times in total, before the treatment, after the first session and after the fifteenth session. ECGs were evaluated by a single physician who had no knowledge of clinical findings.

In the ECG, the QT interval was accepted as the time elapsed from the beginning of the QRS complex to the end of the T wave. Derivation II and V5 were used to measure the QT interval. Then, with Bazett's formula, the corrected QT interval (cQT) was calculated: cQT=QT $\surd$ (R-R interval) (11). In the chest leads, the Tp-e interval was determined by measuring the time between the peak of the T wave and the end of the T wave (12,13). The Tp-e/QT ratio was calculated as the ratio of Tp-e time in lead V5 to the QT interval in the same lead, and the cardiac electrophysiological balance index (iCEB=QT/QRS) was calculated by evaluating derivation II or V5 (14).

Statistical analysis

SSPS® version 21.0 statistical package program (SPSS Inc., Chicago, IL, United States) was used for statistical analysis. Continuous variables were expressed as mean±standard deviation. Relationships between heart rate, cQT, Tp-e/QT and iCEB measurements before, on the first day after treatment and on the fifteenth day after treatment were calculated using the Paired-Samples T test. P<0.05 values were considered statistically significant.

RESULTS

The average age of the study population is 56.60±10.38 and it consists of 19 male (47.5%) and 21 female (52.5%) patients. The demographic characteristics of the patients are shown in **Table 1**.

Table 1. Demographic characteristics

	Total 40	
Age	56.60	±10.38
Gender		
Male	19	%47.5
Female	21	%52.5
BMI	31.0225	±5.38819

Average and standard deviations of the measurements of heart rate, cQT, Tp-e/QT and iCEB values before treatment, on the first day after treatment and on the fifteenth day after treatment in ECG are shown in **Table 2**. The values of the measurements before the treatment and after the treatment on the first day, before the treatment and on the fifteenth day after the treatment, on the first day after the treatment and on the fifteenth day after treatment were compared with the Paired-Samples T test and it is shown that no significant difference was observed between them, in **Table 3**.

Table 2. Heart rate, cQT, Tp-e/QT and iCEB average values

	Before treatment	First day after treatment	Fifteenth day after treatment
Heart rate	71.95±8.21	70.80±10.41	70.72±10.83
cQT (ms)	433.25±40.84	433.30±32.52	424.70±33.03
Tp-e/QT ratio	0.126±0.04	0.127±0.040	0.131±0.030
iCEB (QT/QRS)	4.52±0.10	4.58±0.11	4.64±0.09

Table 3. P values of heart rate, cQT, Tp-e/QT and iCEB measurements

	Heart Rate	cQT (ms)	Tp-e/QT Ratio	iCEB (QT/QRS)
Before treatment-First day after treatment	.289	.990	.728	.613
Before treatment-Fifteenth day after treatment	.290	.253	.230	.152
First day after treatment-Fifteenth day after treatment	.941	.095	.302	.587

DISCUSSION

In this study, the effects of TENS on cardiac rhythm were evaluated by measuring heart rate and proarrhythmogenic markers in patients without cardiac disease who presented to our outpatient clinic with pain or limitation in the left shoulder. TENS treatment applied to the left shoulder, the region closest to the heart, did not have a significant effect on ECG parameters.

TENS is a simple, reliable and reusable treatment method applied in daily clinical practice in the treatment of many acute or chronic painful conditions (15). Since the 19th century, although TENS has been reported to have analgesic and anesthetic effects and has been used

for a long time by some clinicians, the mechanisms that reduce pain or provide analgesia have only recently been explained. Various theories explaining peripheral and central mechanisms support the use of TENS to provide analgesic effect (16-19). While adrenergic receptors are part of the peripheral mechanism, endogenous opioid release and gate control are part of the central mechanism. In clinical practice, TENS types are available that are obtained by modulating the stimulation frequency, amplitude and wavelengths. We included patients who received high frequency (50-100 Hz), low-intensity conventional TENS therapy, which is more commonly used in physical therapy protocols.

The autonomic nervous system plays an important role in the nervous control of the cardiovascular system. When previous studies were reviewed, regarding the effects of TENS on the sympathetic and parasympathetic nervous system, Wong et al. reported an increase in sympathetic tonus (20). However, Sanderson et al. showed a decrease in sympathetic activity after TENS use (21), and Buonocore et al. showed that there was no change in autonomic nerve control of the heart (22). This shows that a definite judgment cannot be made about the effect of TENS on heart rate changes through sympathetic and parasympathetic modulation (23).

In addition, another possible TENS application area that can affect heart rhythm is the back area. This area is the paravetebral ganglion area where the sympathetic nerve innervation of the heart, adrenal gland and vessels is located (24). In the study of Cinara et al. (23), they hypothesized that TENS application to this area may cause sympathetic modulation and a decrease in circulating catecholamine levels.

There are a limited number of studies in the literature examining the effects of TENS treatment on heart rhythm. Ağırman and Aydın stated that the effects of TENS treatment on cardiac rhythm were not statistically significant in their study on 41 patients (26 women, 15 men), which included heart rate and QTc measurements (25). However, except for heart rate and QTC values, Tp-e/QT and iCEB ratios are used as new proarrhythmogenic markers to determine cardiac arrhythmia (10).

The main limitation of this study is that it was performed on healthy individuals who do not have any cardiac problems and who do not have any additional disease that may disrupt the heart rhythm. Also, manual evaluation of ECG parameters can be considered as another limitation. However, these shortcomings can be overcome with further studies. Not applying TENS to other areas close to the heart can be considered as an additional limitation in evaluating its effect on the cardiac rhythm.

CONCLUSION

In conclusion, by evaluating heart rate, cQT, Tp-e/QT and iCEB measurements, which can be easily obtained from ECG parameters, it was observed that TENS treatment applied to the left shoulder area, which is the closest to the heart, did not have negative effects on heart rhythm in patients without heart disease. Lastly, further studies are needed to examine the effects of TENS amplitude and frequency changes on heart rhythm and pro-arrhythmogenic markers.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Research Ethics Committee of Amasya University (Date: 03.09.2020, Decision No: 105).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

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 approved the final version.

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