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Correlation of High-Sensitivity Troponin-T with QTc Interval among Patients Diagnosed with Acute Coronary Syndrome

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Abstract

The authors aimed to prove that an increase in high-sensitivity Troponin (hsTnT) levels correlates with the corrected QT (QTc) interval measured during a standard 12-lead ECG. From the literature, we know that various drugs, stress, psychological states, and diseases prolong or lengthen the QT interval. The QTc interval, calculated according to the frequency, provides a more accurate result and is used in clinical practice and certain research studies. The QTc interval can be calculated using several formulas, among which the Bazett formula, the oldest mathematical model, shows the most distorted result. This publication demonstrates and proves that higher troponin levels correlate with, and therefore prolong, the QTc interval, which has relevance in clinical practice.

Keywords

hsTnT, QTc, QT Prolongation, QTc Formula

1. Research Location, Brief Hospital Overview

Our research was conducted in Budapest, the capital of Hungary, at the Emergency Care Center of the North Pest Centrum Hospital (Honvédkórház), a multidisciplinary, world-class, and well-equipped hospital with Level III progressivity. The hospital includes all medical specialities and offers a broad range of imaging diagnostics (X-ray, ultrasound, computed tomography, MRI, PET-CT). Both outpatient and inpatient care are provided. Some of the key departments include the emergency department, internal medicine, cardiology, surgery, thoracic surgery, cardiac surgery, vascular surgery, neurosurgery, gynecology, ophthalmology, otorhinolaryngology and head and neck surgery, urology, diabetology, hematology,

angiology, neurology, nephrology, and psychiatry. Additionally, the hospital features a state-of-the-art central laboratory department, where most essential tests are performed.

2. Introduction

A prolonged QT interval can lead to malignant arrhythmias and sudden cardiac death. The precise QT interval is expressed as the corrected QT interval (QTc), which can be calculated using several mathematical formulas (e.g., Bazett, Framingham, Fridericia, Hodges, Rautaharju). The QTc interval largely depends on heart rate, medication effects, and stress conditions. Certain drugs (antiarrhythmic agents, antipsychotics, antibiotics), stress, mental state, and various pathological conditions or diseases can also affect the QTc interval, prolonging it and potentially leading to malignant arrhythmias. From international literature, we know that depression, non-ST elevation myocardial infarction (NSTEMI), and certain medications are proven to prolong the QTc interval [1].

This publication does not provide a physiological and pathophysiological overview but briefly outlines the precise focus of our research to ensure transparency. Our study was retrospective and used non-random data collection, for which the necessary research ethics approval was obtained. Data were extracted from the MedWorks database, which is regularly used in the hospital. The study was conducted at the Emergency Care Center of the North Pest Central Hospital, Honvéd Hospital in Budapest. Data collection began in January 2020 and ended in December 2023. We included all patients who underwent a standard 12-lead ECG and had high-sensitivity Troponin-T (hsTnT) measured during blood sampling. Laboratory parameters included renal function (e-GFR), white blood cell count, C-reactive protein (CRP), D-dimer, and sodium and potassium levels. Exclusion criteria were if the patient had undergone pacemaker implantation, had a QRS duration greater than 120 ms, had atrial fibrillation on the ECG, or other rhythm disorders associated with QT prolongation. Exclusion criteria also included patients taking medications that cause QT prolongation (e.g., sodium channel, digitalis preparations, antibiotics, SSRIs).

The ECGs were performed using the EDAN SE-1201 device, which is certified and regularly used in the Emergency Department, and ECGs recorded by other devices were excluded.

This publication presents the correlation between the QTc (corrected QT) interval and high-sensitivity Troponin-T (hsTnT) levels. The QTc interval (corrected QT interval) is a parameter measured on an electrocardiogram (ECG) that measures the duration of the heart's electrical activity. The length of the QT interval can vary depending on heart rate, and the QTc interval represents the value that corrects for fluctuations caused by heart rate. The QT interval is critical for clinicians because certain medications can prolong it, significantly lengthening the QT interval, which can lead to malignant arrhythmias. The QTc interval is calculated by dividing the QT interval by the square root of the RR interval length.

The most accepted formulas include the Bazett, Framingham, and Hodges (Fridericia) formulas.

> "The most widely used correction formula was described by Bazett in 1920 based on a sample of 72 subjects, including both sexes and children. Unlike all other formulas, the Bazett formula is purely empirical: the author did not perform any mathematical modeling when determining the QT/RR relationship. Thus, it is not surprising that the Bazett formula performs the worst in all comparisons; the QTc value contains significant distortion due to the remaining frequency dependence, which is greater the more the frequency deviates from the reference value of 60 beats per minute. Although the Bazett formula can be well applied in everyday clinical practice, its use in research requires far-reaching caution." (Andrássy, 2007)

Rana Al-Zakhari and colleagues demonstrated during the COVID pandemic that troponin levels were significantly elevated in patients infected with SARS-CoV-2. The increase in troponin levels in patients served as a marker of the viral infection [1].

In his study, Adnan Bashir Bhatti demonstrated that cardiac-related liver cirrhosis causes QTc prolongation [2].

Gábor Andrássy elaborated in his PhD thesis on the effects of smoking and mental stress on QTc prolongation. Smoking had no direct impact on the QTc interval, but mental stress, through its adrenergic effects, did [3]. Carrara also mentioned the troponin molecule in his PhD defense. We present a troponin molecule from his work for better visualization [4].

A study has shown that there is a correlation between the monocyte/HDL ratio and the thrombus burden in the coronary arteries, indicating that these laboratory markers also predict the risk of cardiovascular events [5].

It is commonly assumed that all ST-segment destruction causes QTc prolongation. Nathan Henrie provided a counterexample to this assumption. They analyzed data from patients with ST-elevation and non-ST-elevation myocardial infarction and found that patients in the NSTEMI group had longer QTc intervals and lower Troponin-I levels [6].

Katrukha and colleagues investigated the troponin molecule. Despite over 40 years of research, the complete mechanism of the troponin molecule is still not fully understood. The destruction of troponin subunits (Troponin T, I, C) is responsible for the development of various cardiac diseases. They published a review article on this topic in 2013, summarizing the current physiological knowledge about troponin [7].

It is well-documented in the literature that certain medications significantly prolong the QTc interval. Non-cardiovascular QT-interval-prolonging drugs, which often cause less significant QT-interval prolongation compared to antiarrhythmic agents, are associated with an increased mortality rate in patients with a significantly lower de novo risk of sudden cardiac death [8].

As highlighted in Luengo's publication, "Several studies have consistently demonstrated that 34% to 54% of patients with NSTEACS do not show ST-segment changes upon arrival at the hospital. Therefore, the assessment of other ECG parameters, such as the length of the QRS complex, T-wave abnormalities, or the duration of the corrected QT interval (QTc), may provide additional information to supplement the analysis of the ST-segment." [9]

Minoretti and his team conducted a survey investigating the correlation between neuroticism and QTc prolongation. They demonstrated that QTc interval was prolonged not only in depressed men but also in predisposed groups, which is associated with an increased risk of arrhythmia [10].

In the article published by Michael Psallas and his research group in 2005, the age-adjusted QT interval showed no difference between patients with type 1 and type 2 diabetes. In the present study, we were able to refute this finding [11].

According to the research by Routray and his group, the average troponin I value was significantly higher in patients with multi-vessel disease on angiography ($p = 0.005$) compared to those with single-vessel disease, and it did not show a significant difference based on the culprit artery. The average QTc interval did not differ significantly between males and females, but it varied significantly according to the age of the patients. In patients under 70 years of age, the average QTc was significantly lower ($p = 0.01$). The QTc interval also differed significantly in patients with diabetes ($p < 0.001$) or dyslipidemia ($p < 0.001$). We were able to confirm the latter finding in our study as well, although the correlation was not strong [12].

Bert Vandenberk and colleagues published their results in 2016, comparing different QTc mathematical formulas. A total of 6609 patients were included (mean age: 59.8 ± 16.2 years; 53.6% male, average heart rate: 68.8 ± 10.6 bpm). The best heart rate correction results were shown by the Fridericia and Framingham formulas, while Bazett's performed the worst. The Fridericia and Framingham formulas demonstrated the best rate correction and significantly improved the prediction of 30-day and 1-year mortality. The Bazett formula overestimated the number of potentially dangerous QTc prolongation cases, which could lead to unnecessary safety measures, such as withdrawing the patient's first-choice medication [13].

In our work, we aimed to find out whether there is a correlation between QTc interval prolongation and elevated troponin levels. Due to this correlation and the statistically significant association, our results can be applied to cardiovascular risk stratification [10].

The purpose of risk stratification is:

1) Optimization of patient care: By classifying patients into low, medium, or high-risk groups, physicians can direct treatment resources more efficiently. High-risk patients may require more attention, more intensive treatment, and more frequent monitoring.

2) Support for treatment decision-making: Risk stratification helps determine

the appropriate treatment strategy, such as the need for invasive interventions, the use of medication, or the recommendation of lifestyle changes.

3) Prevention and intervention: Early identification of high-risk patients allows for proactive intervention, preventing disease progression or the development of complications.

Overall, risk stratification is a critical tool in medical decision-making, facilitating personalized patient care, treatment effectiveness, and the optimization of preventive strategies. By knowing the troponin level and the QTc interval, and if the troponin level exceeds 5 ng/ml and the QTc interval is prolonged (over 450 ms in men, and over 460 ms in women), the patient can be classified into any cardiovascular risk group.

In 2004, Hiroto Ito and colleagues published an article in which they explained that women with mental illness had significantly longer QTc intervals. "The mean QTc interval was 0.408 (SD = 0.036). The QTc interval for women was significantly longer than for men. Women without comorbidities had significantly longer QTc intervals than men [4]."

The normal QTc values for adult men range between 350 and 450 ms, while for adult women, they range between 360 and 460 ms; however, 10% - 20% of otherwise healthy individuals may have QTc values outside of these ranges [8].

A renowned Hungarian physician-researcher and cardiologist, Gábor Andrássy, published his PhD thesis in 2009, in which he examined, among other things, the effect of mental stress on the QTc interval. We do not intend to go into detail about Andrássy's research at this time, as it is available in the literature [2], but it is certainly worth mentioning. Every patient who comes into contact with any segment of healthcare is exposed to stress. The effects of stress activate the sympathetic nervous system, which causes an increase in heart rate and blood pressure, thereby affecting the cardiovascular system and potentially influencing the QTc interval [2]. We consider this fact important, and therefore, it would be most optimal if patients receiving healthcare services remained calm and stress-free.

3. Study Procedure

All patients treated in our Emergency Department were included in the study. The study commenced in January 2020. We used the hospital's electronic database for retrospective data collection. Among the demographic data, the patients' age and gender were recorded.

During the non-randomized sample collection, we recorded the patients' relevant comorbidities, such as diabetes mellitus (type I-II), hypertension, chronic lung disease, and heart disease. Our database also indicated whether patients were regularly taking medications that prolong the QT interval. During data analysis, we selected and subsequently excluded patients whose EKG recordings showed atrial fibrillation, complete left bundle branch block, complete right bundle branch block, or pacemaker activity.

The patients were positioned lying down, and in cases of anxiety or restlessness,

they were psychologically guided. In all cases, an intravenous cannula was inserted into the most optimal forearm vein. Blood samples were taken, and the data were extracted from the hospital's electronic database (MedWorks). From the laboratory tests, the following values were recorded: serum sodium (Se Na), serum potassium (Se K), e-GFR, Troponin T, D-dimer, white blood cell count, and C-reactive protein.

Upon admission, a standard 12-lead EKG was performed on the patients. During EKG analysis, we recorded heart rate and parameters calculated by the department's standardized and calibrated 12-lead EKG device (e.g., QRS, QTcBazett). During EKG recording, internationally applied electrode placements were used, as follows:

- The V1 lead was placed on the right side of the chest, between the 4th and 5th ribs.
- The V2 lead was placed on the left side of the chest, between the 4th and 5th ribs.
- The V4 lead was placed on the left side of the chest, between the 5th and 6th ribs, at the midclavicular line.
- The V3 lead was placed in a median position between V2 and V4.
- The V5 lead was placed in line with V4, at the anterior axillary line.
- The V6 lead was placed in line with V4 and V5, at the midaxillary line.

The limb leads were also applied in a standardized manner, with the red electrode placed on the right arm, yellow on the left arm, black on the right leg, and green on the left leg.

In our research, no alternative or so-called supplemental ECG examinations were performed. These include right-sided chest leads, lateral leads, and dorsal leads. The scope of these examinations exceeds the framework of the current study, and therefore, we did not discuss these ECG images in our work.

For medication classification, we based our analysis on the internationally accepted Vaughan-Williams classifications (Classes I-VI). This database was used to filter out patients taking antiarrhythmic drugs that prolong the QTc interval.

During echocardiography, performed by a cardiologist, the following measurements were taken and recorded: ejection fraction and any dysfunction of the left ventricular walls (septal, anterior, inferior, basal, lateral). If acute coronary angiography was performed on the patient, we recorded which coronary artery branch was occluded, whether PCI was performed, and whether a stent was implanted. During the study, we only recorded large coronary occlusions, such as CX, LAD, and RCA. During data analysis, we ensured that patients with ion imbalances affecting action potentials were excluded. For laboratory results, the following reference values were used: serum sodium (135 - 145 mmol/l), serum potassium (3.7 - 4.9 mmol/l), Troponin T (5 ng/ml), and e-GFR (65 - 90 ml/min/1.73m^2).

4. Exclusion of Non-Standard ECG Recordings

It often happens that ECG leads are not placed according to the protocol, *i.e.*, in a non-standardized manner. In these cases, the ST segment, the height of the R

wave, and even the R axis can change, leading to completely misleading results. In some instances, we highlighted pre-hospital ECG recordings and compared them with the 12-lead standard recordings taken in our department. We compared the ECG images of 10 patients. For the calculation of the QTc, we used a one-sample T-test, which did not reveal a significant difference (p-value: 0.091). However, for the QRS axis, we found a significant statistical difference (p-value: 0.00056). The two attached ECG recordings clearly and unambiguously visualize that significant discrepancies occurred in the limb leads. If the limb leads are not placed correctly, *i.e.*, not on the distal parts of the limbs, the heart's electrical axis changes completely (**Figure 1**).

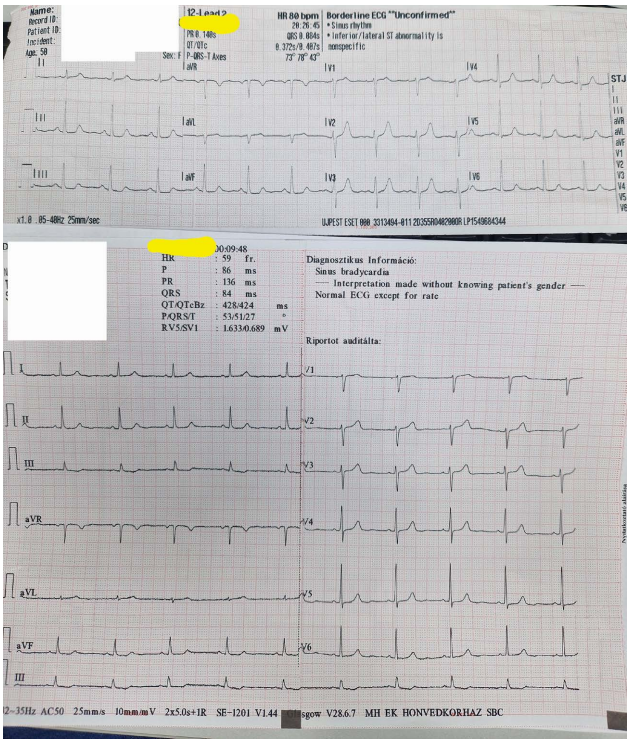

Figure 1. Lead ECG recorded using non-standard limb electrodes; below: standard ECG. A significant difference in cardiac axis can be observed.

5. Brief Physiological Summary of Troponin-T Protein

Katrukha and colleagues investigated the troponin molecule. Despite over 40 years of research, the complete mechanism of the troponin molecule is still not fully understood. The destruction of troponin subunits (Troponin T, I, C) is responsible for the development of various cardiac diseases. They published a review article on this topic in 2013, summarizing the current physiological knowledge about troponin [7]. During myocardial contraction, the cell membrane depolarizes, and the resulting increase in intracellular Ca^{2+} levels lead to cardiomyocyte stimulation, generating mechanical force. The regulation of muscle contraction is primarily associated with the troponin complex, a component of the thin filament. This protein consists of three subunits: troponin C (TnC), which binds Ca^{2+};

troponin I (TnI), which inhibits the ATPase activity of the actomyosin complex; and troponin T (TnT), which interacts with tropomyosin. Structural changes in troponin following Ca^{2+} binding allow for ATP-dependent interaction between myosin and actin, leading to muscle contraction (Figure 2).

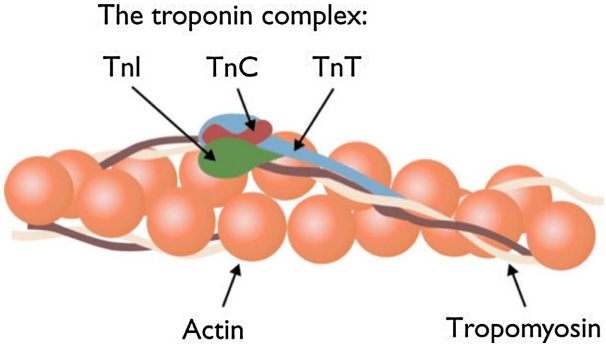

Figure 2. Troponin complex: Carrara, S. (2017.apr.). Towards new efficient nanostructured hybrid materials for ECL applications.

Troponin T is expressed by three genes in human cells: TNNT1 (slow skeletal muscle troponin), TNNT2 (cardiac troponin), and TNNT3 (fast skeletal muscle troponin). The gene for cardiac troponin T (TNNT2) is located on chromosome 1 (1q32.3), and this isoform is the only one expressed in cardiac muscle cells. The amino acid sequences of troponins in cardiac muscle differ from those in skeletal muscle, making cardiac troponin I and T distinguishable with high specificity. High-sensitivity Troponin-T is significant because it is released in large amounts during myocardial injury, making it suitable for diagnosing myocardial infarction. An increase in troponin levels can be detected 5 - 8 hours after cell apoptosis and remains detectable for 7 - 14 days.

Numerous studies have confirmed that elevated TnT levels are significantly associated with cardiovascular mortality and the occurrence of heart failure. Since 2014, it has also been accepted as a predictor of myocardial infarction. As a key regulator of cardiac contraction, the troponin complex plays an essential role in the management of heart failure. One cause of this pathology is a decrease in myocardial Ca^{2+} sensitivity, leading to a reduction in contractile force and systolic cardiac function. The TnC affinity for Ca^{2+} and the interactions between TnI and TnC play a crucial role in the Ca^{2+} sensitivity of the thin filament. Currently, several compounds are known to interact with the subunits of the troponin complex and enhance the sensitivity of the thin filament to calcium. These include bepridil and levosimendan [4].

6. Results

The statistical analysis was performed using Python and SPSS software. Out of a total sample of 842, five cases had incomplete data and were excluded from the study due to technical errors. Additionally, 171 individuals did not meet the inclusion criteria and were excluded. The final representative sample consisted of

671 individuals: 319 men (mean age 53.671 ± 17.963 years) and 352 women (mean age 60.078 ± 20.375 years). Among 41 patients diagnosed with ACS, 12 cases involved RCA occlusion, 13 cases involved LAD occlusion, and 2 cases involved CX occlusion. The average ejection fraction is 48% (±15). Of the 671 patients, 134 had diabetes, 76 had chronic obstructive pulmonary disease (COPD), 397 had hypertension, and 62 had hypothyroidism.

An independent sample t-test performed on the entire sample showed a significant difference (p-value: 0.000152) between the control group and hsTnT values above 5 ng/ml. ACS was diagnosed in 41 patients. In the entire sample, Pearson correlation analysis showed a very weak relationship (0.046368) between hsTnT and QTc interval. Among patients diagnosed with confirmed acute coronary syndrome, Pearson correlation analysis showed a weak but positive result (0.106851). Based on the independent two-sample t-test, the mean QTc was 440.51 ms (±32.07 ms). We found a highly significant statistical difference ($p < 0.000152$) between the control group and the study sample. Our study confirmed our hypothesis that QTc prolongation correlates with elevated hsTnT levels.

As a secondary finding, we discovered an interesting and important factor that influences the heart's electrical axis, known as its axis orientation. We compared the ECG images of 10 patients. For the calculation of the QTc, we used a one-sample T-test, which did not reveal a significant difference (p-value: 0.091). However, for the QRS axis, we measured a significant statistical difference (p-value: 0.00056).

We examined whether the elevated troponin levels and prolonged QTc time in 134 known diabetic patients show any correlation. The result indicated that the Pearson correlation coefficient between troponin levels and QT time is 0.106, indicating a weak positive correlation. The corresponding p-value is 0.223, which means the correlation is not significant ($p > 0.05$). This result also suggests that diabetes, when associated with prolonged QTc time, is already a warning sign and indicates cardiovascular risk.

7. Conclusions

In our study, we demonstrated that the high-sensitivity hsTnT level shows a correlation and significant difference with the corrected QT interval (QTc) measured on a standard 12-lead ECG recording. Our results successfully proved that elevated troponin levels are associated with QTc prolongation.

We consider our results to be relevant in the field of clinical sciences. From the literature, we know that prolonged QT intervals can be either acquired or congenital. Congenital prolonged QT interval is known as long QT syndrome, which is based on genetic disruption. The acquired forms, which are often iatrogenic, occur because many medications can cause prolongation of the QTc interval (e.g., antiarrhythmic drugs, antibiotics, antipsychotics, chemotherapeutic agents). In our study, we did not examine whether the prolonged QT interval was of congenital or acquired etiology. We believe it is important that for every patient admitted

to the hospital, their routine lab tests should be supplemented with troponin measurement before starting treatment, and a standardized 12-lead EKG should be performed in all cases. If elevated troponin levels (above 5 ng/ml) and a QTc interval exceeding the reference values are detected on the EKG (450 ms in men, 460 ms in women), and the patient has cardiovascular risk factors (e.g., smoking, hypertension, diabetes, heart diseases), a cardiological evaluation should be considered. It is important that standardized ECG recordings are always made, and the position of the electrodes should not be altered, as otherwise, we may obtain incorrect and misleading ECG results.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Bashir Bhatti, A., Ali, F. and Akbar Satti, S. (2014) Prolonged QTc Interval Is an Electrophysiological Hallmark of Cirrhotic Cardiomyopathy. *Open Journal of Internal Medicine*, **4**, 33-39. https://doi.org/10.4236/ojim.2014.41006

[2] Al-Zakhari, R., Atere, M., Lim, W., Abdulrahman, M., Akhtar, S., Sheets, N., *et al.* (2021) Corrected QT Interval Prolongation, Elevated Troponin, and Mortality in Hospitalized COVID-19 Patients. *Cardiology Research*, **12**, 258-264. https://doi.org/10.14740/cr1276

[3] Andrássy, G. (2007). Különböző stresszorok hatása a QT időre és a T hullámra. *Orvosi Hetilap*, **150**, 447-457.

[4] Carrara, S. (2017) Towards New Efficient Nanostructured Hybrid Materials for ECL Applications. Master's Thesis, Université de Strasbourg.

[5] Soltan, G.M., Samy, N.I., Ahmed, S.E. and ELShafey, W.E.H. (2019) Association of the Monocyte to HDL Cholesterol Ratio with Thrombus Burden in Patients with Acute Coronary Syndrome. *World Journal of Cardiovascular Diseases*, **9**, 746-758. https://doi.org/10.4236/wjcd.2019.910067

[6] Henrie, N., Harvell, B., Ernst, A.A., Weiss, S.J., Oglesbee, S., Sarangarm, D., *et al.* (2017) Comparison of QTc and Troponin Levels in ST Elevation Mis Compared with Non-ST Elevation Mis. *Southern Medical Journal*, **110**, 210-216. https://doi.org/10.14423/smj.0000000000000623

[7] Katrukha, I.A. (2013) Human Cardiac Troponin Complex. Structure and Functions. *Biochemistry* (*Moscow*), **78**, 1447-1465. https://doi.org/10.1134/s0006297913130063

[8] Li, E.C., Esterly, J.S., Pohl, S., Scott, S.D. and McBride, B.F. (2010) Drug-Induced Qt-Interval Prolongation: Considerations for Clinicians. *Pharmacotherapy*: *The Journal*

of Human Pharmacology and Drug Therapy, **30**, 684-701. https://doi.org/10.1592/phco.30.7.684

[9] Jiménez Candil, J. and Martín Luengo, C. (2008) Intervalo QT e isquemia miocárdica aguda: viejas promesas, nuevas evidencias. *Revista Española de Cardiología*, **61**, 561-563. https://doi.org/10.1157/13123059

[10] Minoretti, P., Politi, P., Martinelli, V., Emanuele, E., Bertona, M., Falcone, C., *et al.* (2006) QT Interval Duration in Apparently Healthy Men Is Associated with Depression-Related Personality Trait Neuroticism. *Journal of Psychosomatic Research*, **61**, 19-23. https://doi.org/10.1016/j.jpsychores.2006.01.001

[11] Psallas, M., *et al.* (2006)). QT Dispersion Comparison between Participants with Type 1 and 2 Diabetes and Association with Microalbuminuria in Diabetes. *Journal of Diabetes and Its Complications*, **20**, 88-97.

[12] Routray, S.N., *et al.* (2019) Correlation of Corrected QT Interval with Quantitative Cardiac Troponin-I Levels and Its Prognostic Role in Non-ST-Elevation Myocardial Infarction. *International Journal of Advanced Research*, **7**, 1274-1281. https://doi.org/10.21474/ijar01/8950

[13] Vandenberk, B., Vandael, E., Robyns, T., Vandenberghe, J., Garweg, C., Foulon, V., *et al.* (2016) Which QT Correction Formulae to Use for QT Monitoring? *Journal of the American Heart Association*, **5**, e003264. https://doi.org/10.1161/jaha.116.003264