

ST-segment depression in atrioventricular nodal reentrant tachycardia: Preliminary results

Jakub Szymon Mercik^{1,A–F}, Jadwiga Radziejewska^{2,A–F}, Katarzyna Pach^{3,A–F}, Dorota Zyśko^{1,A–F}, Jacek Gajek^{4,A–F}

¹ Department of Emergency Medicine, Wrocław Medical University, Poland

² Kłodzko County Hospital, Poland

³ Students' Scientific Association, Department of Emergency Medical Service, Wrocław Medical University, Poland

⁴ Department of Emergency Medical Service, Wrocław Medical University, Poland

A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation;

D – writing the article; E – critical revision of the article; F – final approval of the article

Advances in Clinical and Experimental Medicine, ISSN 1899–5276 (print), ISSN 2451–2680 (online)

Adv Clin Exp Med. 2021;30(12):1323–1328

Address for correspondence

Jakub Mercik

E-mail: jakub.mercik@wp.pl

Funding sources

This research was financially supported by the Ministry of Health subvention (No. STM.A280.20.107 from the IT Simple system of Wrocław Medical University).

Conflict of interest

None declared

Received on November 9, 2020

Reviewed on November 26, 2020

Accepted on November 22, 2021

Published online on December 13, 2021

Cite as

Mercik JS, Radziejewska J, Pach K, Zyśko D, Gajek J. ST-segment depression in atrioventricular nodal reentrant tachycardia: Preliminary results. *Adv Clin Exp Med.* 2021;30(12):1323–1328. doi:10.17219/acem/144161

DOI

10.17219/acem/144161

Copyright

© 2021 by Wrocław Medical University

This is an article distributed under the terms of the Creative Commons Attribution 3.0 Unported (CC BY 3.0) (<https://creativecommons.org/licenses/by/3.0/>)

Abstract

Background. The ST-segment is part of the electrocardiogram and physiologically, it forms an isoelectric line. The ST-segment depression is often observed in young, healthy people with paroxysmal tachycardia with narrow QRS complexes. In this group of patients, the 'mysterious tachycardia-induced ST-segment depression', 'subendocardial myocardial ischemia' and other not fully understood terms are used to explain this phenomenon.

Objectives. To assess the presence and possible mechanisms of ST-segment depression during atrioventricular nodal reentrant tachycardia (AVNRT) in patients undergoing radiofrequency (RF) ablation of the underlying arrhythmia.

Materials and methods. The study included 50 patients (35 women and 15 men) aged about 49 years with clinically relevant paroxysmal narrow QRS complex tachycardia. During electrophysiological study (EPS), all patients had measured QRS components – QR, RS and RJ during the tachycardia and during the sinus rhythm. All of the measurements were done in lead V5.

Results. There was a statistically significant difference in cycle length during sinus rhythm and tachycardia (707.0 ± 137.8 ms compared to 327.5 ± 29.1 ms, $p = 0.000$), the RJ component (0.819 ± 0.381 mV compared to 0.878 ± 0.376 mV, $p = 0.003$) and the difference RJ-QR (0.081 ± 0.083 mV compared to 0.163 ± 0.108 mV, $p = 0.000$). The differences in RS and QR components during sinus rhythm and tachycardia did not reach the statistical significance. The difference RJ-QR during tachycardia correlated negatively with tachycardia cycle length ($R = -0.39$, $p = 0.0049$). The tachycardia cycle length correlated positively with the age of the studied patients ($R = 0.28$, $p = 0.043$).

Conclusions. In patients with AVNRT, there is a ST-segment depression during the episodes of tachycardia and the degree of this change is related to tachycardia cycle length. The most probable explanation of the ST-segment depression is the overlap of the QRS complex on the preceded T wave. Some intrinsic properties of individual electrocardiogram (ECG) also influence this phenomenon. The ischemic origin of the presented ST-segment change can be excluded.

Key words: tachycardia, AVNRT, ST-segment depression

Background

The ST-segment is a part of the electrocardiogram located between the QRS complex and the T wave. There are 2 types of ST-segment changes. First ones, depending on repolarization, appear in the absence of depolarization changes of the action potential.^{1,2} The causes may include ischemia, myocarditis, drugs and electrolyte disturbances.^{3,4} The secondary changes of ST-segment are related to the depolarization phase aberrations. They are present in bundle branch blocks, ventricular pre-excitation and ventricular QRS complexes including pacing. The ST-segment changes constitute part of electrocardiogram (ECG) assessment for myocardial ischemia; therefore, it is important to understand causes leading to the incorrect interpretation and diagnosis.^{5,6} The ST-segment changes could be observed in people with paroxysmal narrow QRS complex tachycardia, with no overt evidence of an ischemic heart disease.^{7–9}

In the atrioventricular nodal reentrant tachycardia (AVNRT), we are concerned with a retrograde P wave, which occurs within the QRS complex. Our hypothesis is that if the tachycardia is rapid enough, the QRS complex follows the preceded T wave, which in turn changes the reference point by raising the isoelectric baseline. An example of such changes is presented in Fig. 1.

Objectives

The purpose of the study was to assess the presence and possible mechanisms of ST-segment depression during AVNRT in patients undergoing radiofrequency (RF) ablation of the underlying arrhythmia.

Materials and methods

The study included 50 patients (35 females and 15 males) approx. 49 years old, presenting with a clinically relevant paroxysmal tachycardia. In all studied individuals, the electrophysiological testing was performed, the diagnosis of AVNRT was established and the arrhythmia was successfully eliminated through RF ablation. The clinical and demographic characteristics, as well as laboratory tests are presented in Table 1.

Table 1. Clinical, demographic and biochemical characteristics of studied patients

Parameters	Mean/number	SD/%
Age [years]	49.1	14.2
Sex (female)	35	70.0
Hypertension	22	44.0
Diabetes mellitus	8	16.0
Heart failure	1	2.0
Ischemic heart disease	2	4.0
Hemoglobin [g/dL]	14.0	1.4
K ⁺ [mmol/L]	4.4	0.4
Glucose [mg/dL]	101.9	16.5
TSH [mIU/L]	1.644	0.918

SD – standard deviation; TSH – thyroid-stimulating hormone.

During electrophysiological study (EPS), the cycle length of the sinus rhythm and tachycardia, as well as the amplitudes of QRS components – QR, RS and RJ during the tachycardia and during the sinus rhythm with a paper speed of 200 mm/s and an enhancement of $\times 64$ –128 were measured. The described measurements of the particular QRS components in an exemplary patient with a pronounced ST-segment depression are depicted in Fig. 2.

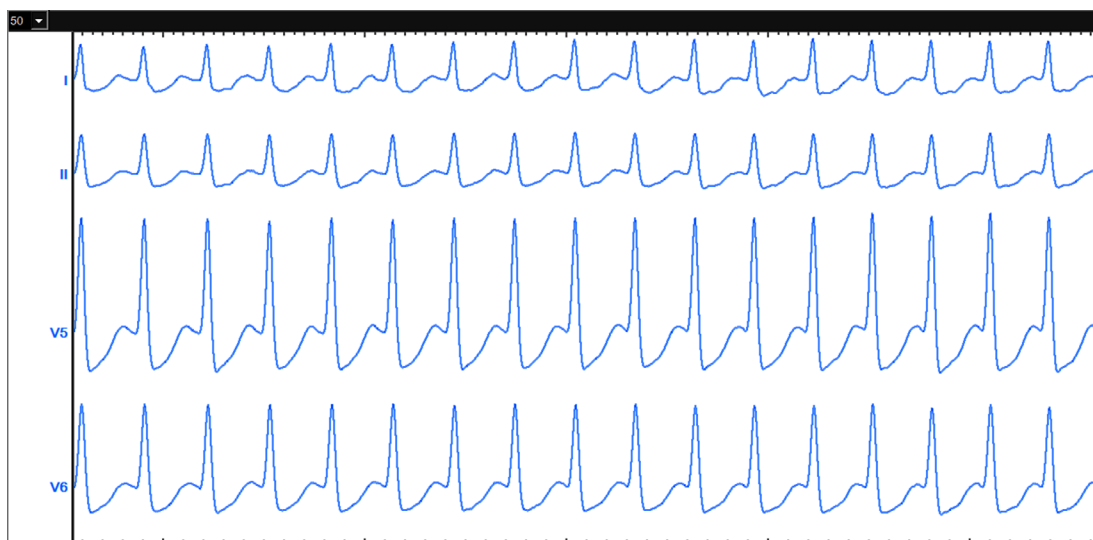


Fig. 1. The example of ST-segment depressions during atrioventricular nodal reentrant tachycardia (AVNRT) in selected electrocardiogram (ECG) leads in 40-year-old male (CL – 279 ms, delta ST in lead V5 – 0.641 mV). Paper speed 50 mm/s

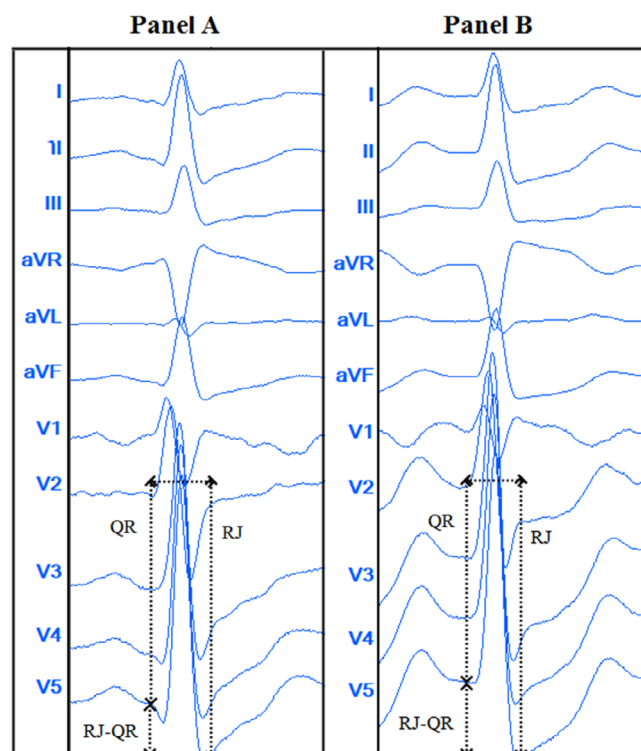


Fig. 2. Measurements of the particular QRS components in an exemplary patient. Panel A: sinus rhythm QR – 1.26 mV, RJ – 1.46 mV, RJ–QR – 0.20 mV; panel B: tachycardia QR – 1.21 mV, RJ – 1.59 mV, RJ–QR – 0.38 mV

Statistical analysis

The statistical analysis was performed using the computer program STATISTICA v. 13.3 (StatSoft Inc., Tulsa, USA). For quantitative variables, basic descriptive statistics were calculated and the compliance of their distributions with the theoretical normal distribution was

checked using the Shapiro–Wilk W test. Comparisons were performed with the Wilcoxon signed-rank test for dependent groups. The correlations between the studied parameters were performed using Spearman's rank correlation coefficient. A value of $p < 0.05$ was considered significant.

The study was approved by the local Bioethical Committee at Wrocław Medical University (approval No. KB 213/2020).

Results

The electrocardiographic measurements in sinus rhythm and tachycardia are presented in Table 2.

The tachycardia-related changes in patients with AVNRT include the elevation of the reference point as indicated by a diminished QR amplitude, as well as by the depression of the J point. This influenced the difference RJ–QR resulting in the ECG ST-segment depression.

The difference RJ–QR during tachycardia negatively correlated with the tachycardia cycle length ($R = -0.39$, $p = 0.0049$). This relationship is depicted in Fig. 3.

Table 2. Electrocardiographic parameters in sinus rhythm and atrioventricular nodal reentrant tachycardia (AVNRT)

Parameters	Sinus rhythm	Tachycardia	p-value
Cycle length [ms]	707.0 ± 137.8	327.5 ± 29.1	0.000
QR [mV]	0.738 ± 0.315	0.715 ± 0.289	0.143
RS [mV]	0.982 ± 0.385	1.007 ± 0.386	0.375
RJ [mV]	0.819 ± 0.381	0.878 ± 0.376	0.003
RJ–QR [mV]	0.081 ± 0.083	0.163 ± 0.108	0.000

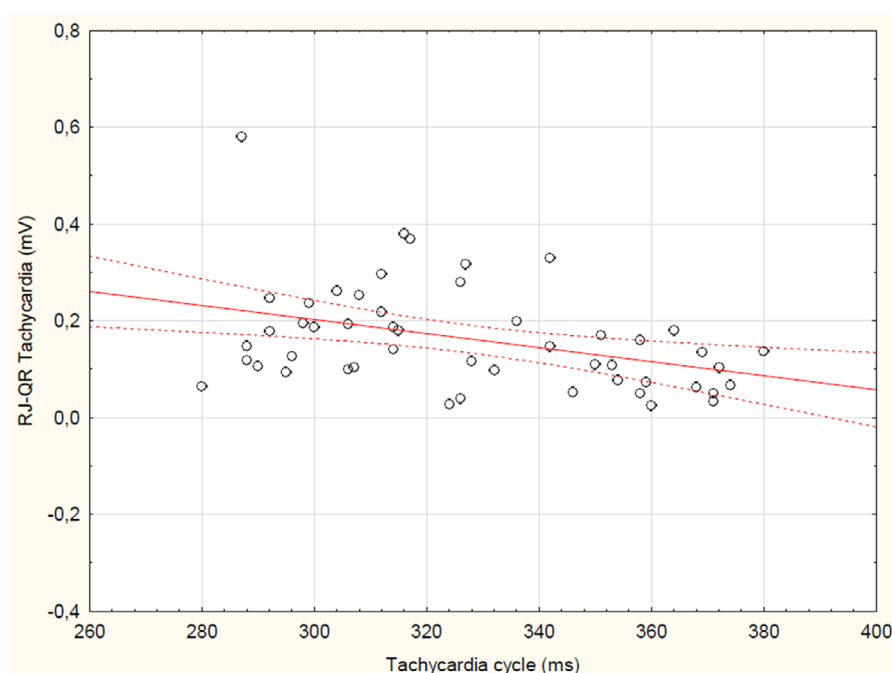


Fig. 3. Negative correlation between the RJ–QR difference during tachycardia and the tachycardia cycle length

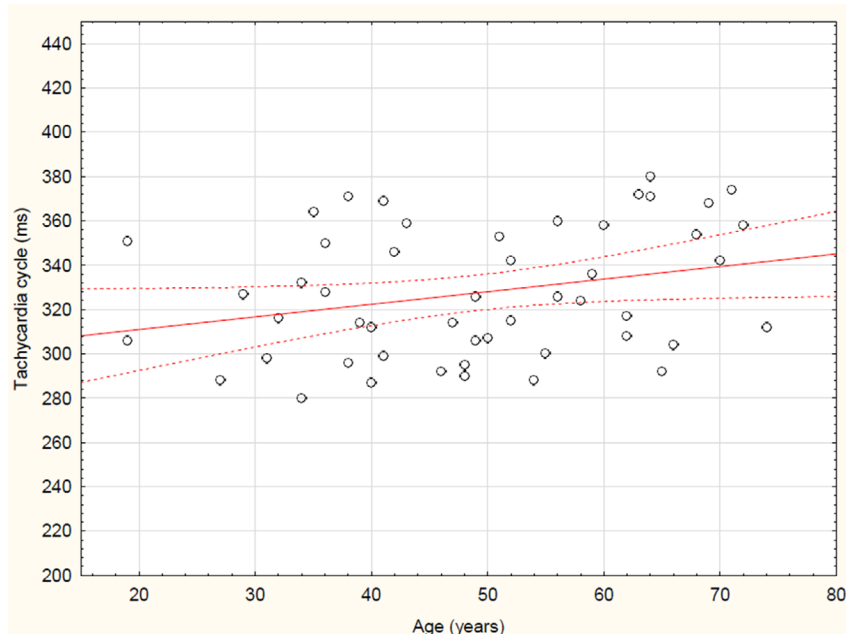


Fig. 4. Positive correlation between the tachycardia cycle length and the age of the studied patients

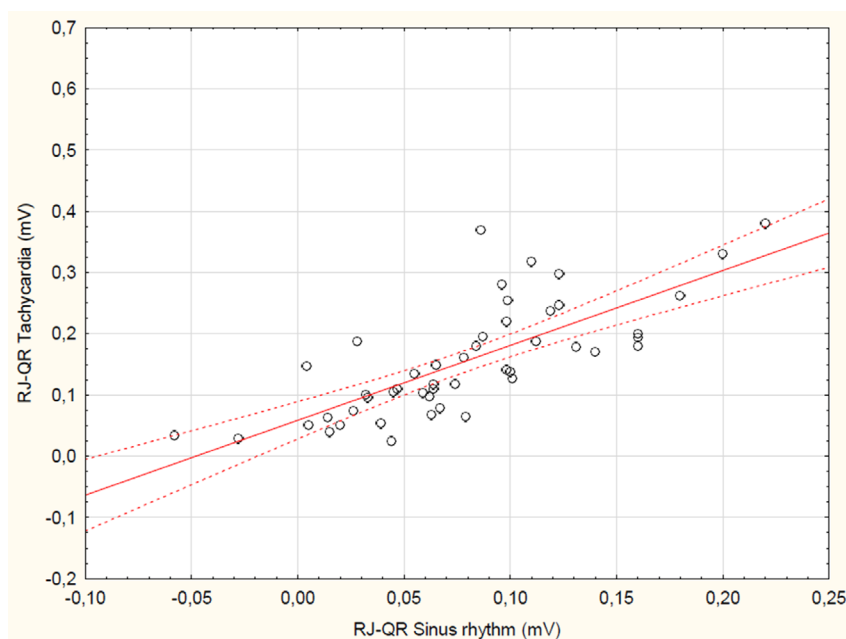


Fig. 5. High positive correlation between RJ-QR in tachycardia and RJ-QR in sinus rhythm

The tachycardia cycle length positively correlated with the age of the studied patients ($R = 0.28$, $p = 0.043$), as depicted in Fig. 4.

To examine the individual intrinsic properties of ECG, the correlation between RJ-QR in sinus rhythm and RJ-QR in tachycardia was assessed. Those parameters correlated with each other at high statistical significance ($R = 0.8$, $p = 0.000$), as depicted in Fig. 5.

No correlation between the degree of ST-segment changes and the age of the studied subjects was revealed. The gender of the patients did not affect the studied parameters, nor did the laboratory parameters and comorbidities. The age distribution curve of the studied patients was consistent with the Gaussian distribution.

Discussion

In patients with paroxysmal supraventricular tachycardias, the ST-segment depression is a common finding. At first glance, ST-segment depression is an ischemia-related change. Petsas et al. assessed the role and significance of the ST-segment depression in supraventricular tachycardia in terms of the coexistence of a myocardial ischemia, utilizing an exercise test. Fifteen out of 16 subjects with ST-segment depression during supraventricular tachycardia had no changes on tests.¹⁰ In another study, the concentration of troponin I and ST-segment depression were taken as indicators for myocardial damage. Non-invasive examinations (myocardial scintigraphy, exercise

echocardiography and exercise test) and coronary angiography were used for confirmation. The authors concluded that elevated troponin I levels and the ST-segment depression are not significant markers of myocardial damage in patients with paroxysmal tachycardia.¹¹

In many studies, the duration of an arrhythmia episode is not associated with an increase in troponins. However, in the case of longer-lasting tachycardia, the instability of the circulation may occur, resulting in troponin release.^{12–14}

During the exercise-related sinus tachycardia, there is a gradual QT-interval shortening, which is associated with adrenergic activation. It is not a linear process, but according to the latest research there is a type of hysteresis in which, when accelerating, the heart shortens the QT-interval depending on the heart rate, first slowly, then increasingly faster. After the exertion, the QT-interval lengthens more slowly at first, then it gets faster until it returns to the primary duration. This phenomenon occurs because of the slow responsiveness of QT-interval to changes in the heart rate.^{15,16} The patient's gender also constitutes an important aspect that may affect the QT length. It has been proven that women of a given age have a significantly longer corrected QT-interval than men. Additionally, the correlation between the change in the QT-interval and a patient's age was demonstrated. The older the patient is, the shorter the QT-interval gets.^{17,18}

The activation of the sympathetic system leads to the acceleration of the heart rate, decrease of the PR interval, the ST-segment depression and, in some cases, to the inversion of the T waves, while the parasympathetic activation slows down the heart rate and elevates the ST-segment.¹⁹ It was also observed in some healthy people. Their baseline ECG was showing slight changes in the ST-segment (<1 mm), often referred to as nonsignificant. This is in line with our results, as the initial J-point depression correlated with depression during tachycardia.

The ST-segment changes could be caused by projection of the retrograde P wave onto the ST-segment, more common in patients with atrioventricular reentrant tachycardia, due to longer ventriculoatrial interval (usually exceeding 100 ms). In AVNRT, the interval is usually below 70 ms, affecting only the QRS complex.²⁰

The most probable explanation of the findings

In our study group, the myocardial ischemia was unlikely to occur, due to the short-lasting arrhythmia paroxysms, relatively young age of the subjects and lack of patients' complaints. In AVNRT, the overlapping of retrograde P waves could not be explained. The most probable reason of the ST change is the overlapping of R wave on the preceded T wave with shortening of QT-interval with tachycardia, and something that could be referred to as intrinsic characteristics of ECG. This combination

might be explained by our results: a decrease of the amplitude of the QR component concomitantly with an increase of the RJ component, and a strong correlation between initial RJ–QR and tachycardia RJ–QR differences. Those conclusions are further supported by the correlation between the ST-segment depression and the tachycardia cycle length, as well as by the correlation between this last parameter and the age. As the tachycardia gets slower with age while the ST-depression is not related to age, the ST-segment depression in those settings is purely electrocardiographic and not an ischemic one.

Limitations

The study is observational, hence the causality cannot be directly derived from the results. The study group was relatively small. The mechanisms of ST-segment depression could also be different across the age groups. All these factors could have influenced the obtained results. Nevertheless, it does not make our conclusions less important.

Conclusions

1. In patients with AVNRT, the ST-segment is lowered during the episodes of tachycardia, and the degree of this change is related to the tachycardia cycle length.
2. The most probable explanation of the ST-segment depression is the overlapping of the QRS complex on the preceded T wave.
3. Some intrinsic properties of an individual ECG have been observed to be influential in this aspect.

ORCID iDs

Jakub Szymon Mercik  <https://orcid.org/0000-0002-5627-7071>
 Jadwiga Radziejewska  <https://orcid.org/0000-0001-9153-9754>
 Katarzyna Pach  <https://orcid.org/0000-0002-3643-9467>
 Dorota Zyśko  <https://orcid.org/0000-0001-9190-0052>
 Jacek Gajek  <https://orcid.org/0000-0002-0038-1750>

References

1. Shapiro E. The first textbook of electrocardiography. Thomas Lewis: Clinical Electrocardiography. *J Am Coll Cardiol*. 1983;1(4):1160–1161. doi:10.1016/s0735-1097(83)80120-x
2. Rautaharju PM, Surawicz B, Gettes LS, et al. AHA/ACCF/HRS recommendations for the standardization and interpretation of the electrocardiogram. *J Am Coll Cardiol*. 2009;53(11):982–991. doi:10.1016/j.jacc.2008.12.014
3. Ghaffar A. Clinical electrocardiography. *Pak J Health*. 1953;3(1):6–12. PMID:13063999.
4. Kenny BJ, Brown KN. *ECG T Wave*. Treasure Island, USA: StatPearls Publishing; 2020.
5. Coppola G, Carità P, Corrado E, et al. ST segment elevations: Always a marker of acute myocardial infarction? *Indian Heart J*. 2013;65(4):412–423. doi:10.1016/j.ihj.2013.06.013
6. Kozłowski D. Method in the chaos: A step-by-step approach to ECG interpretation. *Eur J Transl Clin Med*. 2018;1(1):76–92. doi:10.31373/ejtc/92255
7. Arya A, Kottkamp H, Piorkowski C, et al. Differentiating atrioventricular nodal reentrant tachycardia from tachycardia via concealed accessory pathway. *Am J Cardiol*. 2005;95(7):875–878. doi:10.1016/j.amjcard.2004.12.020

8. Dorenkamp M, Zabel M, Sticherling C. Role of coronary angiography before radiofrequency ablation in patients presenting with paroxysmal supraventricular tachycardia. *J Cardiovasc Pharmacol Ther.* 2007;12(2):137–144. doi:10.1177/1074248407300775
9. Jastrzębski M. ST-segment depression and elevation during supraventricular tachycardias [in Polish]. *Kardiol Pol.* 2012;70(3):291–293. PMID:22430416.
10. Petsas AA, Anastassiades LC, Antonopoulos AG. Exercise testing for assessment of the significance of ST segment depression observed during episodes of paroxysmal supraventricular tachycardia. *Eur Heart J.* 1990;11(11):974–979. doi:10.1093/oxfordjournals.eurheartj.a059637
11. Bukkapatnam RN, Robinson M, Turnipseed S, Tancredi D, Amsterdam E, Srivatsa UN. Relationship of myocardial ischemia and injury to coronary artery disease in patients with supraventricular tachycardia. *Am J Cardiol.* 2010;106(3):374–377. doi:10.1016/j.amjcard.2010.03.035
12. Ben Yedder N, Roux JF, Paredes FA. Troponin elevation in supraventricular tachycardia: Primary dependence on heart rate. *Can J Cardiol.* 2017;27(1):105–109. doi:10.1016/j.cjca.2010.12.004
13. Miranda RC, Machado MDN, Takakura IT, et al. Elevated troponin levels after prolonged supraventricular tachycardia in patient with normal coronary angiography. *Cardiology.* 2006;106(1):10–13. doi:10.1159/000092449
14. Zellweger MJ, Schaer BA, Cron TA, Pfisterer ME, Osswald S. Elevated troponin levels in the absence of coronary artery disease after supraventricular tachycardia. *Swiss Med Wkly.* 2003;133(31–32):439–441. PMID:14562187.
15. Gravel H, Jacquemet V, Dahdah N, Curnier D. Clinical applications of QT/RR hysteresis assessment: A systematic review. *Ann Noninvasive Electrocardiol.* 2018;23(1):e12514. doi:10.1111/anec.12514
16. Kannankeril PJ, Harris PA, Norris KJ, Wasy I, Smith PD, Roden DM. Rate-independent QT shortening during exercise in healthy subjects: Terminal repolarization does not shorten with exercise. *J Cardiovasc Electrophysiol.* 2008;19(12):1284–1288. doi:10.1111/j.1540-8167.2008.01266.x
17. Królik M, Milnerowicz H. The effect of using estrogens in the light of scientific research. *Adv Clin Exp Med.* 2012;21(4):535–543. PMID:23240460.
18. Pearl W. Effects of gender, age, and heart rate on QT intervals in children. *Pediatr Cardiol.* 1996;17(3):135–136. doi:10.1007/BF02505201
19. Friedman HS. Determinants of the total cosine of the spatial angle between the QRS complex and the T wave (TCRT): Implications for distinguishing primary from secondary T-wave abnormalities. *J Electrocardiol.* 2007;40(1):12–17. doi:10.1016/j.jelectrocard.2006.05.008
20. Rivera S, De La Paz Ricapito M, Conde D, Verdu MB, Roux JF, Paredes FA. The retrograde P-wave theory: Explaining ST segment depression in supraventricular tachycardia by retrograde AV node conduction. *Pacing Clin Electrophysiol.* 2014;37(9):1100–1105. doi:10.1111/pace.12394