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Evaluation of index of cardio-electrophysiological balance and Tp-e/QT ratio in patients with coronary artery ectasia

Koroner arter ektazisi olan hastalarda kardiyo-elektrofizyolojik denge indeksi ve Tp-e/QT oranının değerlendirilmesi

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Abstract
Aim: Index of cardiac electrophysiological balance (iCEB), calculated as QT interval divided by QRS duration, has been described as a novel risk marker for predicting malignant ventricular arrhythmia. Increased levels of iCEB predict to torsades de pointes (TdP) and decreased levels of iCEB predict to non-torsades de pointes mediated ventricular tachycardia or ventricular fibrillation. The aim of this study is to evaluate arrhythmogenic risk by using iCEB in patients with coronary ectasia (CAE).
Methods: Our study, designed as case-control, included 130 patients who were admitted to our outpatient clinic. 75 patients with isolated CAE (study group) and 55 healthy subjects (control group) were included in the study. Both groups underwent a standard 12-lead surface electrocardiogram and Tp-Te interval, QT interval, QRS interval, Tp-Te/QT ratio and QT/QRS ratio (iCEB) of patients were recorded and compared between groups.
Results: Tp-e intervals and Tp-e/QT ratio is significantly higher in study group (p=0.001). And, iCEB was found as tend to be numerically higher in study group, but we could not match a statistically difference between groups (p=0.118). Tp-e and Tpe/QT ratio were higher in patients with two or three vessels CAE than one vessel (p value; for Tp-e p=0.024 and Tpe/QT ratio p=0.028). Although iCEB was found as higher with affected number of coronary artery, there was no statistically difference between groups.
Conclusion: Our results demonstrate that CAE patients have significantly higher values of Tp-Te and Tp-Te/QT than controls. We need further studies to show increased arrhythmogenesis risk using iCEB for individuals with CAE.
Keywords: Arrhythmia, Coronary artery ectasia, iCEB, QT/QRS ratio

Öz
Amaç: QRS süresine bölünmüş QT intervali olarak hesaplanan, kardiyak elektrofizyolojik denge indeksi (iCEB), malign ventriküler aritmileri öngörmek için yeni bir risk belirleyicisi olarak tanımlanmıştır. iCEB'nin artmış seviyeleri torsades de pointes (TdP) ve azalan iCEB düzeylerinin ise torsades de pointes olmayan ventriküler taşikardi veya ventriküler fibrilasyona neden olduğunu öngörmektedir. Bu çalışmanın amacı koroner ektazisi (KAE) olan hastalarda iCEB kullanılarak, bu hastalardaki aritmojenik riski değerlendirmektir.
Yöntemler: Vaka kontrolü olarak tasarlanan çalışmamıza polikliniğimize başvuran 130 hasta dahil edildi. İzole KAE'si olan 75 hasta (çalışma grubu) ve 55 sağlıklı birey (kontrol grubu) çalışmaya dahil edildi. Her iki gruba da 12 adet standart elektrokardiyografi çekildi. Tp-Te intervali, QT intervali, QRS intervali, Tp-Te / QT oranı ve QT / QRS oranları (iCEB) kaydedilerek gruplar arasında karşılaştırma yapıldı.
Bulgular: Tp-e intervalleri ve Tp-e / QT oranı çalışma grubunda anlamlı olarak daha yüksek saptandı (p=0,001). Ayrıca iCEB'in, çalışma grubunda sayısal olarak daha yüksek olma eğilimi olduğu bulunmuştur, ancak gruplar arasında istatistiksel olarak anlamlı bir fark bulunamamıştır (p=0,118). Tp-e ve Tpe / QT oranı, iki veya üç damar KAE'si olan hastalarda, tek damar ektazisi olanlardan daha yüksekti (Tp-e için p≤0,024 ve Tpe/QT oranı için p=0,028). iCEB, etkilenen koroner arter sayısı ile daha yüksek bulunmasına rağmen, gruplar arasında istatistiksel olarak fark saptanmadı.
Sonuç: Bulgularımız, KAE hastalarının sağlıklı kontrollere göre daha yüksek Tp-Te ve Tp-Te / QT değerlerine sahip olduğunu göstermektedir. KAE'li bireyler için iCEB kullanılarak artmış aritmojenik riski göstermek için daha fazla çalışmaya ihtiyacımız vardır.
Anahtar kelimeler: Aritmi, Koroner arter ektazisi, iCEB, QT/QRS oranı

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Introduction

Coronary artery ectasia (CAE) is considered as an atypical form of coronary atherosclerosis which characterized by impairment of the internal and external elastic lamina and also thought to be a rare congenital or acquired coronary anomaly [1,2]. The clinical and prognostic significance of CAE is not clearly understood. CAE may be a cause of coronary rupture, spasm, dissection, thrombosis, myocardial ischemia and even sudden cardiac death eventually [3,4]. As a result this condition may not be accepted completely benign as it is associated with adverse coronary events [5].

In addition, it has been demonstrated that diffuse coronary ectasia without any obstructive lesion may trigger myocardial ischemia due to increased lactate levels in the coronary sinus with incremental atrial pacing [6]. Besides it is well known that myocardial ischemia is thought to be the important cause of sudden cardiac death in most cases due to malignant arrhythmias [7]. Previously published studies showed that Tp-Te and Tp-Te/QT ratio, which are accepted as marker of increased ventricular repolarization and dispersion, are significantly higher in patients with coronary ectasia than control group [8]. Moreover, prolonged QT interval and increased QT dispersion was also detected in patients with coronary artery ectasia [3]. It has been suggested that these findings may indicate increased arrhythmogenic risk in individuals with coronary artery ectasia.

Index of cardiac electrophysiological balance (iCEB), calculated as QT interval divided by QRS duration, has been described as a novel risk marker for predicting malignant ventricular arrhythmias [9]. It was shown that increased iCEB level is a predictor of torsades de pointes (TdP) whereas decreased iCEB level is associated with non-torsades de pointes ventricular tachycardia or ventricular fibrillation [10].

In this study, we aimed to investigate the iCEB and its association between Tp-Te and Tp-Te/QT ratio in patients with CAE, to evaluate pro-arrhythmogenic effect of this benign disease.

Materials and methods

Study population

Our study, designed as case-control, included 130 patients who were admitted to our outpatient clinic of the Necmettin Erbakan University, Meram Faculty of Medicine, Department of Cardiology, Konya, Turkey. The patients who underwent elective coronary angiography (positive cardiac stress test, ischemia in myocardial perfusion scintigraphy, patients with recently detected left ventricular wall motion abnormalities or patients with stable angina pectoris) between February 2017 and May 2018 were prospectively included in this study. Participants were divided into two groups as study group (patients with CAE) (n = 75) and control group that age/sex-matched individuals with a normal coronary angiogram (n = 55). Exclusion criteria were determined as elevated serum creatinine levels, any kind of bundle branch blocks, previously documented atrial fibrillation, atrial, ventricular or atrioventricular pre-excitations, acute or chronic inflammatory disease, electrolyte abnormalities or a known receiving any drugs that may have an effect on the cardiac conduction (antiarrhythmic drugs, digitalis, β-blocker, or calcium-channel blocker medication). Demographic characteristics, cardiovascular risk factors (diabetes mellitus, smoking, hypertension, family history of coronary artery disease, hyperlipidemia) and routine blood tests results were recorded.

A power analysis for sample size was performed with an online calculator (https://clincalc.com/stats/samplesize.aspx) by a professional statistician. According to analyses, assuming a power of 90 % and α= 0.05, a study population including at least 52 individuals were needed. Ethics committee approval was received for this study from the local ethics committee.

Coronary angiography

6F sheath was inserted to femoral artery with Seldinger method and coronary angiography was performed with Judkins method, 20% of angiogram was performed via the radial access. Angiography results were evaluated by at least two cardiologists blinded to the patients. Isolated CAE was defined as an enlargement of coronary vessel's segment 1.5 times or higher that of an adjacent normal parts of the same vessel without any stenotic lesion [11]. Coronary artery ectasia without coronary artery stenosis was accepted as isolated CAE and Markis classification system was used to define the severity of isolated coronary artery ectasia [12]. According to this system; diffuse ectasia of two or three vessels was classified as Type 1, diffuse disease in one vessel and localized disease in another vessel as Type 2, diffuse ectasia of only one vessel as Type 3, and localized segmental ectasia as Type 4.

Electrocardiographic parameters

The standard 12-lead surface ECGs of study population were recorded after a 30-min resting period in the supine position (filter range; 10 mV/mm and a paper speed of 25 mm/s and machine of Marquette Case, Hellige Medical System, Cardiosmart Hellige Instrument Company, Freiburg, Germany). Heart rate, QT interval, QRS interval, T wave, Tpeak-Tend interval were recorded from their electrocardiograms. All ECGs were scanned and transferred to a digital platform to decrease margin of error during measurement and then a software (Adobe Photoshop) was used for x300% magnification.

The Tp-Te interval was calculated from the peak of the T wave to the end of the T wave. Measurements of the Tp–e interval were performed from precordial leads [13,14]. QT interval was calculated from the beginning of the QRS complex to the end of the T-wave that defined as the return to the T–P is electric line and corrected for heart rate using the Bazett formula: cQT = QT√(R–R interval). The measurements were executed on lead II and lead V5 and then the longest QT interval was used for analysis (14). The Tp-Te/QT ratio was defined as Tp-Te in lead V5 divided by QT interval in the same lead. Patients with U waves on their ECGs were excluded from the study. iCEB was calculated as QT interval divided by QRS interval in the same leads.

Statistically analysis

We used SSPS version 16.0 (SPSS, Inc., Chicago, IL, USA) for statistical analyses. Quantitative variables with a normal distribution were specified as the mean ± standard deviation, and those with non-normal distribution were specified with median (Interquartile range (IQR) 25-75); categorical variables were specified with number and percentage values.

Kolmogorov Smirnov test was used to test normality of distribution. Mean values of continuous variables were compared between groups using the t-test, one way ANOVA test, or Kruskal-Wallis test where appropriate. The chi-square test was performed to compare the differences between categorical variables. The Spearman rank correlation was used to assess the correlation between iCEB levels and Tp-Te/QT ratio. P values below 0.05 were considered statistically significant in our study.

Results

The demographic features, laboratory parameters and electrocardiographic characteristics of the study population are summarized in Table 1. A total of 130 patients were aged 57.7±11.3 years and 60 (46.2%) were women in study population. There was no statistically significant difference between study group and the control group in terms of, age, sex, body mass index and lipid profile, percent of smokers, current of diabetes mellitus or hypertension. Heart rate, QT and QTc values were similar between groups. Although QRS interval was shorter in study group than control group, without statistical difference (p=0.452). Tp-e intervals and Tp-e/QT ratio is significantly higher in study group (p=0.001). And, iCEB or iCEBc values were tend to be numerically higher in study group, but there was no statistical difference between groups (p values 0.118 and 0.105, respectively).

In subgroup analysis, we did not find any relationship between CAE localization (left anterior descending, circumflex or right coronary artery) or ECG parameters like Tp-Te/QT ratio, Tp-Te and iCEB. Moreover, Tp-e and Tpe/QT ratio were higher in patients with two or three vessels CAE (type 1) than one vessel (p value; for Tp-e p=0.024 and Tpe/QT ratio p=0.028). But the same parameters did not differ between two and three vessels CAE (p=0.289). In addition, there was higher iCEB level as affected number of coronary artery increase, but there was no statistically difference between groups (p=0.811) (Figure 1).

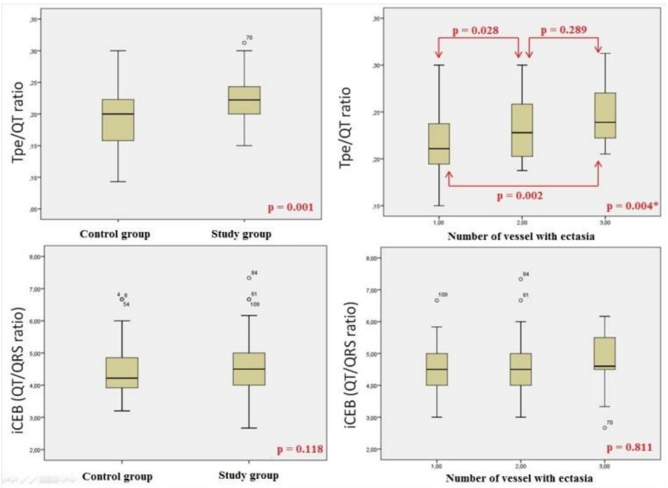

Figure 1: Comparing of Tpe interval, Tpe/QT ratio and index of cardio-electrophysiological balance (iCEB) between groups

In Markis classification, Tp-Te/QT ratio was significantly higher in Type IV compare to other types, but it did not showed statistically significant difference due to limited number of patients with Type IV. And iCEB and iCEBc levels were not different in groups according to Markis classification. Electrocardiographic characteristics of the ectasia and subgroups are summarized in Table 2.

Table 1: Demographic, clinical and laboratory characteristics of study population

	Control group (n: 55)	Study group (n: 75)	p
Age (years)	56.5±11.4	58.6±11.4	0.316
BMI (kg/m^2)	26.7±4.5	27.0±3.7	0.661
Sex (female), n (%)	26 (47.3)	34 (45.3)	0.822
DM, n (%)	16 (29.1)	20 (26.7)	0.763
Hypertension, n (%)	28 (50.9)	38 (50.7)	0.971
Smoking, n (%)	18 (32.7)	29 (38.7)	0.482
LVEF (%)	56.6±6.2	54.6±8.6	0.209
Creatinine (mg/dl)	0.77±0.12	0.78±0.12	0.630
Hb (g/dl)	13.8±1.6	13.9±1.7	0.765
Platelet (10^3/mm3)	266.4±79.1	245.3±75.1	0.139
Leukocyte (10^3/mm3)	6.76 (5.57-8.08)	7.85 (6.36-9.30)	0.006
FBG (mg/dl)	97 (87-121)	102 (90-113)	0.534
Total cholesterol (mg/dl)	201.8±43.8	192.4±46.3	0.256
LDL-C (mg/dl)	123.9±36.9	117.9±38.5	0.388
HDL-C (mg/dl)	47.9±12.9	43.9±10.5	0.067
Triglyceride (mg/dl)	155.0±97.6	160.7±91.6	0.732
Electrocardiographically findings			
Heart rate (bpm)	74.7±11.1	74.6±15.5	0.989
QT interval (ms)	379.9±34.3	384.2±42.3	0.541
QTc interval (ms)	421.3±34.6	423.1±38.1	0.784
QRS interval (ms)	87.2±12.6	84.9±20.3	0.452
Tp-e interval (ms)	73.5±17.7	85.9±14.6	0.001
Tp-e/QT ratio	0.20±0.05	0.23±0.03	0.001
iCEB (QT/QRS)	4.45±0.78	4.72±1.1	0.118
iCEBc (QTcB/QRS)	4.92±0.73	5.21±1.2	0.105

* BMI; Body Mass Index, DM; diabetes mellitus, FBG; fasting plasma glucose, Hb; hemoglobin, HDL-C; high-density lipoprotein cholesterol; iCEB; index of cardio-electrophysiological balance, iCEBc; corrected index of cardio-electrophysiological balance, LVEF; left ventricular ejection fraction, LDL-C; low-density lipoprotein cholesterol.

Table 2: Tpe interval, Tpe/QT ratio and iCEB according to characteristics of coronary ectasia

Ectasia Location	n (%)	Tp-e	Tp-e/QT	iCEB (QT/QRS)
LAD	44 (58.6)	88.5±15.4	0.23±0.03	4.70±1.15
RCA	49 (65.3)	86.6±15.6	0.23±0.04	4.81±1.07
LCx	28 (37.3)	91.5±13.1	0.24±0.03	4.62±0.98
Number of Vessel	n (%)			
One-vessel	38 (50.6)	80.7±12.7	0.21±0.03	4.65±1.01
Two-vessel	24 (32)	88.9±14.7*	0.23±0.03*	4.77±1.02
Three-vessel	13 (17.3)	95.7±14.2*	0.25±0.03*	4.82±1.19
Markis classification	n (%)			
Type I	2 (2.6)	85.0±7.07	0.24±0.05	4.44±0.62
Type II	16 (21.3)	86.9±15.7	0.23±0.04	4.85±1.40
Type III	13(17.3)	80.6±14.6	0.23±0.03	4.53±0.79
Type IV	44 (58.6)	87.2±14.6	0.20±0.04	4.75±1.03

+CAE; coronary artery ectasia, iCEB; index of cardio-electrophysiological balance, LAD; left anterior descending artery, LCX, left circumflex artery, RCA; right coronary artery, * a significant difference for Tp-e; p = 0.024 between one and two vessel ectasia, p = 0.001 between one and three vessel ectasia, * a significant difference for Tp-e/QT; p = 0.028 between one and two vessel ectasia, p = 0.002 between one and three vessel ectasia

Discussion

In the current study, we failed to demonstrate a positive or negative association between CAE and iCEB (QT/QRS)/iCEBc (QTc/QRS). We also found a higher Tp-e interval and Tp-e/QT ratio that known as a predictor for malignant ventricular arrhythmias in patients with CAE and we showed that these values tend to elevate as the number of affected coronary artery by ectasia increases.

Recently, a novel non-invasive marker named as iCEB, calculated as QT interval divided by QRS duration, has been defined as a potential risk marker for drug-induced ventricular arrhythmias in an animal study model [9]. And it has been demonstrated that iCEB is equal to the cardiac wavelength λ (λ = effective refractory period (ERP) x conduction velocity) and that an increased or decreased ratio of iCEB might potentially predict TdP or non-TdP mediated VT/VF, respectively [9,10]. Previously, the association between malignant ventricular arrhythmias and cardiac wavelength λ was well described [15]. Therefore, Robyns T and colleges, as a result of their human study, speculated that iCEB may be a noninvasive and easy to measureable marker of increased arrhythmogenesis considering that the iCEB is equivalent of cardiac wave length [10].

Based on these findings, Yumurtacı O et al. [16] found that iCEB and heart rate-corrected QT(QTc)/QRS ratio was higher in patients with acute myocarditis who had ventricular arrhythmic episodes compare to uneventful control group. Recently, Ucar FM et al. [17] have investigated the balance of ventricular depolarization and repolarization in patients with rheumatoid arthritis by using iCEB. And they found that iCEB (QT/QRS) is higher in patients with rheumatoid arthritis than in healthy subjects. Moreover, they have found a positive correlation between iCEB and hsCRP levels. Finally, they speculated that the increased frequency of sudden cardiac death due to ventricular arrhythmias in patients with rheumatoid arthritis may be TdP-related and can be clarified by the new index of balance between depolarization and repolarization [17]. Another study demonstrated that higher iCEB is associated with higher pericardial fat volume which is related with subclinical atherosclerosis and increased inflammatory response and atrial fibrillation or other cardiac conduction problems [18,19]. But interestingly, Nafakhi H et al. [18] have not found a statistically significant relationship between iCEB and coronary artery calcification values. Another remarkable feature of these studies are that Tp-e/QT ratio was compatible with iCEB where higher values are useful in predicting ventricular arrhytmias in patients with myocarditis, rheumatoid arthritis and thicker pericardial fat.

Tp-Te interval is considered as an index of transmural dispersion of left ventricular repolarization and Tp-Te/QT ratio is also used as a novel electrocardiographic index of ventricular arrhythmogenesis. Previously published studies demonstrated that a prolonged Tp-Te interval and higher Tp-Te/QT ratio has been associated with an increased risk of ventricular arrhythmias [20,21]. Karaagac and collegues [8] found a significantly higher value of Tp-Te and Tp-Te/QT ratio in patients with CAE than healtly individuals and they suggested that these parameters may predict an increased risk of arrhythmogenesis in patients with CAE. Our findings were not different from this study and we also did not find a correlation between iCEB and Tp-Te/QT ratio. One of the most remarkable results of our study is that increased number of ecstatic coronary arteries is associated with higher Tp-e and Tp-Te/QT ratio.

The frequency of CAE may increase with routine use of conventional coronary angiography or other imaging methods. Angina pectoris is a frequent complaint of patients with isolated CAE and several mechanism have been proposed to explain of myocardial ischemia due to CAE such as microvascular dysfunction, impaired coronary flow reserve, delayed coronary blood flow [22], increased coronary spasm phenomenon [23], micro thrombi and coronary dissections [24], epicardial and microvascular perfusion failure [25]. Moreover, interestingly isolated coronary ectasia may cause ischemia even without significant coronary stenosis [6]. Ischemia is a well-known risk factor for malignant arrhythmias and it is reasonable to think that the risk of arrhythmia is attributable to above mentioned mechanisms in patients with coronary artery ectasia. Therefore, sudden cardiac death may occur in these patients.

This study has some limitations like a relatively small-sized prospective study conducted in a single center without follow up period. Diagnostic electrophysiological studies were not performed each of patients. And another major limitation of our study is the lack of comparison in patients with CAE with and without a history of malignant arrhythmia.

Conclusion

In the present study, our findings indicate that QT/QRS (iCEB) measurement, which is easily-obtainable from surface ECG, is tend to be higher in patients who have CAE than healthy controls. Higher iCEB is associated with TdP ventricular tachycardia and CAE may be associated with sudden cardiac death as a result of TdP. A prospective long term follow-up study with the same population may give us more information about the role of iCEB to predict ventricular arrhythmias and/or sudden death. Further prospective studies are needed to conceive exact role of iCEB in identifying high risk patients with coronary ectasia.

References

1. Sultana R, Sultana N, Ishaq M, Samad A. The prevalence and clinical profile of angiographic coronary ectasia. J Pak Med Assoc. 2011;61:372-5.
2. Demopoulos VP, Olympios CD, Fakiolas CN, Pissimissis EG, Economides NM, Adamopoulou E, et al. The natural history of aneurysmal coronary artery disease. Heart. 1997;78(2):136-41.
3. Karakaya O, Saglam M, Barutcu I, Esen AM, Turkmen M, Kargin R, et al. Effects of isolated coronary artery ectasia on electrocardiographic parameters reflecting ventricular heterogeneity. J Electrocardiol. 2007;40(2):203-6.
4. Doi T, Kataoka Y, Noguchi T, Shibata T, Nakashima T, Kawakami S, et al. Coronary Artery Ectasia Predicts Future Cardiac Events in Patients With Acute Myocardial Infarction. Arterioscler Thromb Vasc Biol. 2017;37(12):2350-5.
5. Amit Malviya, Pravin K.Jha, Animesh Mishra. Isolated coronary artery ectasia: Clinical, angiographic, and follow up characteristics. Indian Heart Journal. 2017;69:619–23.
6. Kruger D, Ulrich S, Herrmann G, Simon R, Sheikhzadeh A. Exercise-induced myocardial ischemia in isolated coronary artery ectasia and aneurysms (dilated coronopathy). J Am Coll Cardiol. 1999;34:1461-70.
7. Davies MJ. Pathological view of sudden cardiac death. Br Heart J. 1981;45:88-97.
8. Karaagac K, Yontar OC, Tenekecioglu E, Vatansever F, Ozluk OA, Tutuncu A, et al. Evaluation of Tp-Te interval and Tp-Te/QTc ratio in patients with coronary artery ectasia. Int J Clin Exp Med. 2014;15;7(9): 2865-70.
9. Lu HR, Yan GX, Gallacher DJ. A new biomarker–index of cardiac electrophysiological balance (iCEB)–plays an important role in drug-induced cardiac arrhythmias: Beyond QT-prolongation and torsades de pointes (TdPs). J Pharmacol Toxicol Methods. 2013;68:250–9.
10. Robyns T, Lu HR, Gallacher DJ, Garweg C, Ector J, Willems R, et al. Evaluation of Index of Cardio-Electrophysiological Balance (iCEB) as a New Biomarker for the Identification of Patients at Increased Arrhythmic Risk. Ann Noninvasive Electrocardiol. 2016;21(3):294-304.
11. Hartnell GG, Parnell BM, Pridie RB. Coronary artery ectasia, its prevalence and clinical significance in 4993 patients. Br Heart J. 1985;54:392-5.
12. Markis JE, Joffe CD, Cohn PF, Feen DJ, Herman MV, Gorlin R. Clinical significance of coronary arterial ectasia. Am J Cardiol. 1976;37:217-22.
13. Castro Hevia J, Antzelevitch C, Tornés Bárzaga F, Dorantes Sánchez M, Dorticós Balea F, Zayas Molina R, et al. Tpeak-Tend and Tpeak-Tend dis¬persion as risk factors for ventricular tachycar¬dia/ventricular fibrillation in patients with the Brugada syndrome. J Am Coll Cardiol. 2006;47:1828-34.
14. Shimizu M, Ino H, Okeie K, Yamaguchi M, Nagata M, Hayashi K, et al. T-peak to T-end interval may be a better predictor of high-risk patients with hypertrophic cardiomyopathy associated with a cardiac troponin I mutation than QT dispersion. Clin Cardiol. 2002;25(7):335-9.
15. Girouard SD, Rosenbaum DS. Role of wavelength adaptation in the initiation, maintenance, and pharmacologic suppression of reentry. J Cardiovasc Electrophysiol. 2001;12(6):697-607.
16. Yumurtacı O, Kurt C, Ucar MF, O Cihan. Usefulness Of Electrocardiographic Markers To Predict Ventricular Arrhythmias In Acute Myocarditis Patients. Turkish Med. Stud. J. 2017;4:6-10.
17. Ucar FM, Yılmaztepe MA, Taylan G. Evaluation of Index of Cardioelectrophysiological Balance (iCEB) in Patients with Rheumatoid Arthritis. Erciyes Med J. 2018;40(1):8-12.
18. Nafakhi H, Al-Mosawi AA, Alareedh M, Al-Nafakh HA. Index of cardiac electrophysiological balance and transmural dispersion of the repolarization index relationships with pericardial fat volume and coronary calcification. Biomark Med. 2018;12(4):321-8.
19. Sengul C, Özveren O. Epicardial adipose tissue: a review of physiology, pathophysiology, and clinical applications. Anadolu Kardiyol Derg. 2013;13(3):261-5.
20. Hetland M, Haugaa KH, Sarvari SI, Erikssen G, Kongsgaard E, Edvardsen T. A novel ECG-index for prediction of ventricular arrhythmias in patients after myocardial infarction. Ann. Noninvasive Electrocardiol. 2014;19;330–7.
21. Gupta P, Patel C, Patel H, Narayanaswamy S, Malhotra B, Green JT, et al. T(p-e)/QT ratio as an index of arrhythmogenesis. J. Electrocardiol. 2008;41:567–74.
22. Akyurek O, Berkalp B, Sayin T, Kumbasar D, Kervancioğlu C, Oral D. Altered coronary flow properties in diffuse coronary artery ectasia. Am Heart J. 2003;145:66-72.
23. Suzuki H, Takeyama Y, Hamazaki Y, Namiki A, Koba S, Matsubara H, et al. Coronary spasm in patients with coronary ectasia. Cathet Cardiovasc Diagn. 1994;32:1-7.
24. Perlman PE, Ridgeway NA. Thrombus and anticoagulation therapy in coronary ectasia. Clin Cardiol. 1989;12:541-2.
25. Güleç S, Atmaca Y, Kılıçkap M, Akyürek O, Aras O, Oral D. Angiographic assessment of myocardial perfusion in patients with isolated coronary artery ectasia. Am J Cardiol. 2003;91:996-9.