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İskemik Dilate Kardiyomiyopati Hastalarında Ventriküler Taşikardi Ablasyonunun Qt Dispersiyonu, Tp-Te İntervali Ve Tp-Te/Qt Oranı Üzerine Akut Etkilerinin Araştırılması

Evaluation Of Acute Effect Of Ventricular Tachycardia Ablation On Qt Dispersıon, Tp-Te Interval And Tp-Te/Qt Ratio In Patients With Ischemic Dilated Cardiomyopathy

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ÖZ

GİRİŞ ve AMAÇ: *Literatürde kardiyomiyopati hastalarında skar dokusunun sol ventrikül repolarizasyon süreci üzerine etkileri ile ilgili sınırlı veri bulunmaktadır. Mevcut çalışmada amaç ventrikül taşikardi (VT) ablasyonunun aritmi başlangıcı ve sürdürülmesinde rolü olduğu iddia edilen sol ventrikül repolarizasyon dispersiyonu üzerine akut etkisinin araştırılmasıdır.*

YÖNTEM ve GEREÇLER: *İskemik kardiyomiyopatisi olan ve VT ablasyonu yapılan sıralı 27 hasta çalışma popülasyonumuzu oluşturdu. Hastaneye yatış esnasında ve işlemden sonra elde edilen elektrokardiyografik kayıtlar retrospektif olarak ventrikül repolarizasyon dispersiyonunun noninvaziv göstergeleri oldukları iddia edilen QTc dispersiyonu, Tp-Te intervali ve Tp-Te/QT oranı açısından değerlendirildi. VT ablasyonu öncesi ve sonrasında elde edilen parametreler arasındaki farkın önemi araştırıldı.*

BULGULAR: *Ablasyon öncesi ve sonrası dönem arasında QTc dispersiyonu (47.8 ± 28.3 msn vs 42.4 ± 16.0 msn, p: 0.42), Tp-Te intervali (derivasyon V5; 92.2 ± 26.6 msn vs 96.4 ± 24.9 msn, p: 0.40) ve Tp-Te/QT oranı (derivasyon V5; 0.21 ± 0.06 vs 0.22 ± 0.06, p: 0.43) açısından önemli farklılık yoktu.*

TARTIŞMA ve SONUÇ: *VT ablasyonu işlemin hemen sonrasında repolarizasyon heterojenitesini ve transmural dispersiyonunu yansıttığı iddia edilen elektrokardiyografik parametrelerde değişikliğe neden olmadı.*

Anahtar Kelimeler: *Ventrikül taşikardisi, ventriküler taşikardi ablasyonu, ventriküler repolarizasyonun transmural dispersiyonu, QT dispersiyonu, Tp-Te intervali*

ABSTRACT

INTRODUCTION: *There is limited data in the literature regarding the effect of scar tissue on left ventricular (LV) repolarization process in patients with cardiomyopathy. The aim of present study is to evaluate the acute effect of ventricular tachycardia (VT) ablation on dispersion of LV repolarization which is suggested to play a role in initiating and sustaining arrhythmia.*

METHODS: *A total of 27 consecutive patients with ischemic cardiomyopathy who had undergone VT ablation constituted our study population. Electrocardiographic recordings obtained at the time of hospitalization and after the procedure were retrospectively evaluated for the QTc dispersion, Tp-Te interval and Tp-Te/QT ratio which are suggested to be noninvasive markers of dispersion of ventricular repolarization. Significance of difference between electrocardiographic parameters obtained before and after VT ablation was evaluated.*

RESULTS: *There was no significant difference between pre- and post ablation state regarding QTc dispersion (47.8 ± 28.3 msec vs 42.4 ± 16.0 msec, p: 0.42), Tp-Te interval (derivation V5; 92.2 ± 26.6 msec vs 96.4 ± 24.9 msec, p: 0.40) and Tp-Te/QT ratio (derivation V5; 0.21 ± 0.06 vs 0.22 ± 0.06, p: 0.43).*

DISCUSSION AND CONCLUSION: *VT ablation did not alter electrocardiographic parameters that are assumed to represent heterogeneity and transmural dispersion of repolarization in the immediate post procedure state.*

Keywords: *Ventricular tachycardia, ventricular tachycardia ablation, transmural dispersion of ventricular repolarization, QT dispersion, Tp-Te interval*

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INTRODUCTION

Ventricular tachycardia (VT) is the major cause of mortality and morbidity in patients with cardiomyopathy. Ischemic dilated cardiomyopathy provides a suitable milieu for development of VT where a region of fibrosis and areas of surviving cardiomyocytes within scar tissue facilitate development of reentry.

There is limited data regarding the effect of scar tissue on action potential duration (APD) and repolarization time (1). Transmural dispersion of repolarization is known to play important role in pathophysiology of arrhythmia, however alteration of dispersion in scar or scar borderzone is not clear (1,2). A recent study has reported increased action potential duration in areas of myocardial scar (1). Authors have also demonstrated heterogeneity of regional transmural APD which caused localized dispersion of repolarization (1).

Electrocardiographic QT dispersion has been suggested to reflect dispersion of ventricular repolarization (3). QT dispersion has also been suggested to correlate with but not direct measure of heterogeneous ventricular action potential duration (3,4). Electrocardiographic Tp-Te interval has been suggested to be a marker of transmural dispersion of ventricular repolarization (5). Ratio of Tp-Te/QT has been reported to reflect VT susceptibility and it has been shown to be associated with ventricular arrhythmia or sudden death in Brugada syndrome, long QT syndrome, short QT syndrome and obstructive hypertrophic cardiomyopathy (2,6,7).

We could not find any information in the literature regarding the effect of VT ablation on cardiac repolarization abnormalities in patients with ischemic cardiomyopathy. Our aim in this study is to evaluate the acute effect of VT ablation on electrocardiographic parameters which have been suggested to represent dispersion of ventricular repolarization.

MATERIAL AND METHODS

Study population and Design:

A total of 27 consecutive patients (23 male, age: 35.0 ± 12.7 years) with ischemic cardiomyopathy who had undergone VT ablation between 01.01.2017 and 01.05.2019 constituted our study population. VT ablation was performed due to resistance to medical therapy and/or recurrent implantable cardioverter-defibrillator shocks. Electrocardiographic recordings obtained at the time of hospitalization and after the procedure were retrospectively evaluated for the QTc dispersion, Tp-Te interval and Tp-Te/QT ratio. Significance of difference between electrocardiographic parameters obtained before and after VT ablation was evaluated. The study was approved by the local ethics committee.

VT Ablation:

Endocardial mapping was perfomed to all patients and epicardial mapping was performed when endocardial mapping failed to identify desired ablation sites. Substrate mapping was performed using Ensite Precision 3D mapping system (Abbott, St Paul, Minnesota, USA). Substrate mapping and ablation was the preferred strategy for the majority of patients. Normal tissue was defined as tissue with bipolar voltage > 1.5 mV, dense scar was defined as bipolar voltage < 0.5 mV and scar borderzone was defined as a bipolar voltage 0.5-1.5 mV on voltage mapping. Activation map during tachycardia was performed if the tachycardia was hemodynamically tolerated. Late systolic potentials and local abnormal ventricular activities (LAVA) during sinus rhythm and mid diastolic potentials during VT were tagged as the potential ablation sites (Figure 1). Pacemapping was used to identify the exit site of clinical VT. Entrainment maneuvers were performed to identify isthmus if VT was hemodynamically tolerated. Irrigated tip catheters were used during ablation.

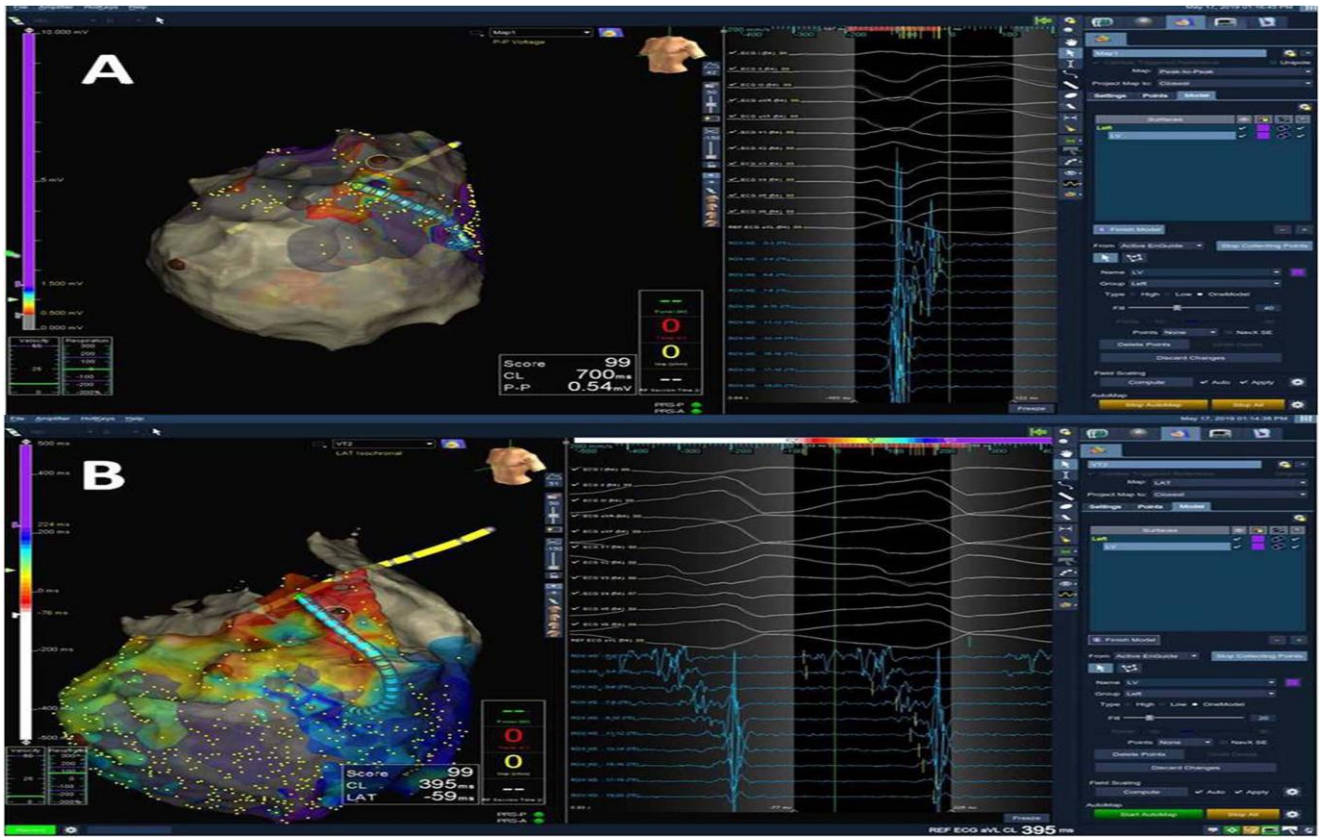

Figure 1. A) Local abnormal ventricular activities (LAVA) during sinus rhythm in a patient with ischemic dilated cardiomyopathy B) Mid diastolic potentials are recorded close to region during ventricular tachycardia where LAVA were observed in sinus rhythm

VT stimulation was performed with one to three extrastimuli at two sites in right ventricle at the end of the procedure to assess the effectiveness of ablation. Procedural success was assessed by non-inducibility of clinical VT during ventricular stimulation and abolishment of all late systolic potentials and LAVA's.

Electrocardiographic measurements:

All standard 12-lead ECGs were obtained before and at the end of VT ablation procedure using a recorder (Schiller AT-2 plus, Switzerland) set at a 50 mm/s paper speed and 1 mV/cm standardization. Electrocardiographic recordings were scanned for online analysis using the CardioCalipers program (Version 3.3 for Windows, Iconico, www.iconico.com). Twenty randomly selected ECGs were reexamined by the same cardiologist and another blind cardiologist for calculation of intraobserver and interobserver variability.

The QT interval was measured from the beginning of the QRS complex to the end of the T wave. The end of the T wave was defined as the intersection of the tangent to the down slope of the T wave. If there was a U wave following the T wave, the end of the T wave was measured as the nadir between the T and U waves. Recordings with less than eight analyzable leads were excluded from the analysis. QT maximum was determined as the longest QT interval and QT minimum was determined as the shortest QT interval in any analyzed electrocardiographic lead. Measured QT intervals were corrected for heart rate with Bazett's formula ($QTc = QT/\sqrt{RR}$). Corrected QTd (QTcd) was defined as the difference between corrected maximum (QTcmax) and minimum QT (QTcmin) interval among the 12 ECG leads. Tp-Te interval was measured from Tpeak to Tend on lead V4, V5 and V6. T waves with amplitude less than 1.5 mm or T waves with distorted morphology were excluded from analysis. Tp-Te/QT ratio was calculated separately on V4, V5 and V6.

Statistical Analysis

Statistical tests were performed with a statistical analysis program (SPSS 16.0 for windows, SPSS Inc., Chicago, Illinois, United States). The distribution of the data was tested by using one-sample Kolmogorov-Smirnov test. Values

displaying normal distribution were expressed as the mean ± SD and values not displaying normal distribution were expressed as median with interquartile range. Categorical variables were expressed in ratio. Significance of difference regarding ECG parameters obtained at the time of hospitalization and after the procedure was tested with paired Student's t test. p value < 0.05 was interpreted as statistically significant.

RESULTS

Demographic and clinical characteristics of patients are shown on table 1. Sixteen (59.2%) patients underwent endocardial ablation and 11 (40.8%) patients underwent combined endocardial and epicardial ablation. VT was noninducible at the end of procedure in 23 (85.2%) patients. Ablation sites of patients are shown on Table 2.

Table 1. Baseline characteristics of patients who had undergone ventricular tachycardia ablation

Gender, male (%)	23 (82.1)
Age, years	35.0 ± 12.7
Ejection fraction , %	34.2 ± 9.9
Hypertension, n (%)	19 (67.9)
Diabetes Mellitus, n (%)	12 (42.9)

Table 2. Ablation sites of patients with ischemic cardiomyopathy

Ablation Site	**Number of patients**
LV apicoseptal + inferoseptal	1 (3.7%)
LV basalseptal + posterobasal	1 (3.7%)
LV anterior + anteroapical	3 (11.1%)
LV anteroapical	1 (3.7%)
LV anteroseptal + anteroapical	3 (11.1%)
LV anterolateral	3 (11.1%)
LV anteroseptal	1 (3.7%)
LV anteroapical +apical	1 (3.7%)
LV apicoseptal	2 (7.4%)
LV posterobasal	6 (22.2%)
LV posteroinferior	1 (3.7%)
LV posterolateral + inferior basal	1 (3.7%)
LV posterolateral + midapical	1 (3.7%)
LV posteroseptal	2 (7.4%)
LV: Left ventricle	

Electrocardiographic QTc dispersion, QT and Tp-Te and Tp-Te/QT ratio values measured before and after VT ablation are shown on Table 3. There was no significant difference regarding any of the measured variables before and after ablation procedure.Intraobserver and interobserver intraclass correlation coefficients (ICC) for QTc dispersion, and Tp-Te were as follows: 0.78 and 0.70 and 0.76 and 0.72, respectively.

Table 3. Comparison of electrocardiographic repolarization parameters before and after ventricular tachycardia ablation

(n: 27)	**Preablation**	**Postablation**	**p value**
QTc maximum (msec)	513.4 ± 64.3	519.1 ± 41.2	0.61
QTc minimum (msec)	445.3 ± 71.3	441.6 ± 60.1	0.54
QTc dispersion (msec)	47.8 ± 28.3	42.4 ± 16.0	0.42
QT V4 (msec)	447.1 ± 61.8	457.0 ± 59.6	0.37
QT V5 (msec)	448.7 ± 62.6	449.6 ± 59.8	0.94
QT V6 (msec)	432.3 ± 58.2	447.6 ± 56.4	0.17
V4 tp-te (msec)	98.3 ± 28.2	104.0 ± 28.9	0.30
V5 tp-te (msec)	92.2 ± 26.6	96.4 ± 24.9	0.40
V6 tp-te (msec)	86.9 ± 17.4	92.4 ± 21.0	0.20
V4 tp-te/qt	0.22 ± 0.05	0.23 ± 0.05	0.51
V5 tp-te/qt	0.21 ± 0.06	0.22 ± 0.06	0.43
V6 tp-te/qt	0.20 ± 0.05	0.21 ± 0.05	0.62

QTc: **Corrected QT interval**
Tp-Te: **T peak to T end**

DISCUSSION

In the present study VT ablation did not lead to any alteration in electrocardiographic parameters which reflect heterogeneity of action potential duration and transmural dispersion of repolarization.

Voltage gradient between endocardium and epicardium during repolarization have been suggested to contribute to the recording of T wave (5). The beginning of the T wave is constituted by a more rapid decline of the phase 2 (plateau) of the epicardial action potential compared to endocardial action potential. Difference between duration of

phase 2 of endocardial and epicardial action potential has been suggested to create a voltage gradient across the myocardium (5). The gradient progressively increases during epicardial action potential repolarization, reaching a maximum with full repolarization of epicardium which coincides with the peak of the T wave (5). Endocardial repolarization corresponds to the initial descending limb of the upright T wave and complete repolarization of the M region coincides with the end of the T wave (5). The time interval between the peak and the end of the T wave has been supposed to represent the transmural dispersion of repolarization (5). There is not much data in the literature regarding alteration of action potential duration and transmural dispersion of repolarization in failing hearts with scar. Glukhov et al have reported heterogeneous prolongation of APD in failing hearts, which significantly reduced the transmural and local APD gradients (8). Authors have suggested that alterations in APD might increase dispersion of repolarization and contribute to arrhythmogenesis in patients with myocardial scar. Srinivasan et al have shown prolonged APD in areas of myocardial scar compared with normal tissue (1). They suggested that heterogeneity of transmural and planar APD might result in localized dispersion of repolarization which may be important for initiation of VT. Yalın et al. have evaluated the association between left ventricular scar size and infarct heterogeneity with T wave alternans in patients with a history of prior myocardial infarction (9). Scar characteristics were evaluated with cardiac magnetic resonance imaging and patients had relatively preserved left ventricular ejection fraction with non-sustained VT. Authors could not find any association between scar size and infarct heterogeneity and T wave alternans which was assumed to be a marker of abnormal repolarization.

Based on above mentioned observations we retrospectively investigated the effect of VT ablation on electrocardiographic parameters which have been suggested to be markers of heterogeneity and transmural dispersion of repolarization. To the best of our knowledge there is no data in the literature related with this issue. Modification of scar and scar borderzone during VT ablation might affect the assumed localized dispersion of repolarization. This effect might also be operative in suppression of VT after VT ablation. We did not observe any effect of VT ablation on electrocardiographic parameters reflecting dispersion of repolarization which is in disagreement with the hypothesis that dispersion of repolarization might be important for initiation of scar-related VT. However, we retrospectively evaluated ECG's which were obtained at the end of procedure. Further prospective studies are needed to evaluate the chronic effect of VT ablation on dispersion of repolarization. Heterogeneity regarding the ablation sites and extent of ablation in our study population with limited number of patients might have contributed to failure to observe significant differences.

Study Limitations:

Retrospective design and small sample size are the main limitations of our study. We retrospectively evaluated ECG's that were obtained just after the procedure. Chronic effect of VT ablation on repolarization cannot be inferred from present study.

CONCLUSION

VT ablation did not alter electrocardiographic parameters that are assumed to represent heterogeneity and transmural dispersion of repolarization in the immediate post procedure state. Results of prospective studies are needed to evaluate the chronic effect of VT ablation on myocardial repolarization abnormalities that has the potential to increase tendency for VT initiation.

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