DOI: 10.4274/jarem.galenos.2025.84803
J Acad Res Med 2025;15(1):42-45

Evaluation of Changes in Ventricular Repolarization Parameters After Surgical Mitral Valve Repair in Patients with Mitral Valve Prolapse

Ümeyir Savur, Aysel Akhundova, Aykun Hakgör

İstanbul Medipol University Faculty of Medicine, Department of Cardiology, İstanbul, Türkiye

Cite this article as: Savur Ü, Akhundova A, Hakgör A. Evaluation of changes in ventricular repolarization parameters after surgical mitral valve repair in patients with mitral valve prolapse. J Acad Res Med. 2025;15(1):42-45

ABSTRACT

Objective: To evaluate the changes in ventricular repolarization parameters in preoperative and postoperative electrocardiograms (ECGs) of patients who underwent mitral valve repair (MVR) for mitral valve prolapse (MVP).

Methods: Patients who underwent MVR due to MPV with severe mitral regurgitation were included in the study. A resting 12-lead ECG was recorded both preoperatively and 6 months postoperatively. QT, QTc, cQTd, JT, JTc, and Tp-e were measured; Tp-e/QT and Tp-e/QTc ratios were calculated.

Results: The study included 53 patients (58.5% male), with a mean age of 52.7±13 years. The durations of PR, QRS, QT, cQT, cQTd, JT, cJT, and Tp-e were reduced significantly ($p<0.001$) six months after repair.

Conclusions: The repolarization parameters changed after MVR surgery. Shortening of the QT, cQT, cQTd, JT, cJT, and Tp-e durations after the repair procedure may reduce the risk of sudden cardiac death, and arrhythmias in MVP.

Keywords: Mitral valve prolapse, mitral valve regurgitation, mitral valve repair, sudden cardiac death, ventricular arrhythmia, ventricular repolarization

INTRODUCTION

In developed countries, mitral valve prolapse (MVP) is the leading cause of primary mitral regurgitation (MR) (1). However, rheumatic mitral valve disease continues to be more common in developing countries (2). MVP is associated with several significant complications, including severe MR, heart failure, transient ischemic attacks, cerebrovascular events, ventricular arrhythmias (VAs), infective endocarditis, and sudden cardiac death (SCD) (3). While several studies have indicated that MVP may increase the risk of SCD, the exact incidence remains undefined. Research has shown a reduction in VAs following mitral valve surgery (4,5). VAs are a leading cause of SCD in MVP (6). Furthermore, alterations in the electrocardiogram (ECG) repolarization phase have been associated with VAs and SCD (7). Parameters such as JT, QT, and Tp-e intervals, when measured and compared on an ECG, are valuable indicators for assessing the risk of VAs and SCD. While the QT interval reflects overall repolarization, the JT interval is more specific to repolarization, and the Tp-e interval reflects the dispersion of ventricular repolarization. This study aimed to assess preoperative and postoperative differences in the JT, QT, and Tp-e intervals on 12-lead ECGs of patients with MVP undergoing mitral valve repair (MVR).

METHODS

In accordance with the Declaration of Helsinki, the study was conducted after obtaining approval İstanbul Medipol University Non-Interventional Clinical Research Ethics Committee (decision no: 954, date: 10.11.2022), and written informed consent was secured from all participants. The 53 patients who underwent MVR for MVP with severe MR between January 2019 and December 2022 were included in the study. Baseline characteristics were recorded for all patients. Patients with persistent atrial fibrillation before or after surgery, chronic ischemic heart disease, decreased left ventricular ejection fraction (LVEF), right or left bundle block or atrioventricular blocks, structural heart disease, valve pathology other than MVP, and decreased LVEF function after surgery were excluded. A 12-lead ECG was recorded at rest before surgery and 6 months after surgery.

ORCID IDs of the authors: Ü.S. 0000-0003-1320-9033, A.A. 0000-0002-4066-6822, A.H. 0000-0001-8252-0373

Corresponding Author: Ümeyir Savur, MD,
E-mail: drumeyirsavur@hotmail.com

Received Date: 02.03.2025 **Accepted Date:** 22.04.2025
Publication Date: 06.05.2025

ECG recordings of all patients were obtained with a standard machine (Nihon Kohden Cardiofax ECG-1950 VET) with an amplitude of 10 mm/mV and using all 12 leads: I–III, aVR, aVF, V1-V6, at a speed of 25 mm/s in the supine position. ECG samples were evaluated by two different cardiologists. QT, QTc, cQTd, JT, JTc, and Tp-e were measured. Corrected QT dispersion was calculated by subtracting the minimum corrected QT interval (QTc) from the maximum QTc interval. The PR interval was calculated from the beginning of the P wave to the commencement of the QRS complex. The QRS duration was determined from the onset of the Q wave to the end of the S wave. The Tp-e interval was manually measured from the peak of the T wave to the lowest point of the wave in the precordial leads (V4, V5, and V6). The QT interval was measured from the onset of the QRS complex to the end of the T wave, or from the onset of the QRS complex to the point where the T wave returned to baseline in cases where a U wave was present. The QTc interval was calculated using the Bazett formula.

Normal QTc values range from 360 to 460 ms in women and from 350 to 450 ms in men (8). The JT interval was measured from the J point to the end of the T wave in the precordial leads. Measurements were taken until the nadir of the Tp-e, and the QTc ratios were subsequently calculated.

MR severity, anatomy of the mitral leaflets, left ventricular function, left ventricular diameters, and left atrial diameter were evaluated with GE Philips Health Care Vivid T8 cardiovascular ultrasound machines, with transthoracic transducers.

Statistical Analysis

The normality of continuous variables was assessed using the Kolmogorov-Smirnov test and analyzing histogram plots. Normally distributed variables were given as the mean and standard deviation. The other categorical variables were shown as absolute numbers and percentages. The paired-sample t-test was used to investigate whether there was a statistically significant difference in the preoperative and postoperative values of the electrocardiographic and echocardiographic parameters for the normally distributed variables. The threshold of statistical significance in the study results was established as a p-value <0.05. The IBM Statistics, version 26, program was used for all statistical analyses (IBM Corporation, NY, USA).

RESULTS

The mean age of the patients included in the study was 52.7±13 years. Table 1 summarizes the clinical, echocardiographic, and procedural features of the patients. There were 31 (58.5%) male and 22 (41.5%) female patients. Anterior prolapse was observed in 7 (13.2%), posterior prolapse in 27 (50.9%), and bileaflet prolapse in 19 (35.8%) patients. Tricuspid valve prolapse was observed in 29 patients (54.7%), and tricuspid annuloplasty was performed in addition to MVR in 18 of these patients (34%). Mitral chordal and leaflet augmentation was performed in 47 (88.7%) patients, and mitral ring annuloplasty was performed in 34 (64.2%) patients.

There were significant improvements in the left ventricular end-systolic, end-diastolic diameters, left atrial diameter, and pulmonary artery systolic pressure 6 months after the operation. Pre-operative and postoperative electrocardiographic findings of patients are shown in Table 2. The mean heart rate of patients was 82.2±15.8 beats per minute (bpm) before the operation and was reduced to 70.2±10.5 bpm after six months of MVR. The mean PR duration was 162.1±30.9 ms before, 142.6±28.8 in 6 months after the operation (p<0.001). Similar to the shortening of the PR interval, the duration of the QRS (from 91.1±11.2 to 86.9±9.3), the QT (from 424.8±40.1 to 394.4±34.3 ms), the constant Q transform

Table 1. Clinical, echocardiographic and procedural features of the study population (n=53)

	Mean±SD / n (%)		
Age, years	52.7±13.1		
Gender (male)	31 (58.5%)		
Hypertension	22 (41.5%)		
Diyabetes mellitus	5 (9.4%)		
Dyslipidemia	8 (15.1%)		
Coronary artery disease	10 (18.9%)		
Anterior/posterior/bi-leaflet prolapse	7 (13.2%)/27 (50.9%)/19 (35.8%)		
Tricuspid valve prolapse	29 (54.7%)		
Tricuspid ring annuloplasty	18 (34%)		
Mitral cordal augmentation	47 (88.7%)		
Mitral ring annuloplasty	34 (64.2%)		
	Pre-op	**Post-op**	**p-value**
LVEF (%)	61.1±5.7	57.4±7.7	<0.001*
LVESD (mm)	40.1±4.9	36.1±3.1	<0.001*
LVEDD (mm)	58.3±4.8	45.7±7.5	<0.001*
LAD (mm)	47.1±5.2	42.8±5.7	<0.001*
sPAP (mmHg)	40.2±13.9	27.3±7.6	<0.001*

*Paired-sample t-test was used
LVEF: Left ventricle ejection fraction, LVESD: Left ventricle end-systolic diameter, LVEDD: Left ventricle end-diastolic diameter, LAD: Left atrial diameter, sPAP: Systolic pulmonary artery pressure

Table 2. Pre-operative and postoperative comparison of the electrocardiographic findings

	Pre-op	Post-op	p-value
Heart rate, bpm	82.2±15.8	70.2±10.5	<0.001*
PR, ms	162.1±30.9	142.6v28.8	<0.001*
QRS, ms	91.1±11.2	86.9±9.3	0.001*
QT, ms	424.8±40.1	394.4±34.3	<0.001*
cQT, ms	439.6±39.6	419.2±22.9	0.002*
cQTd, ms	42.9±7.9	36.7±7.9	<0.001*
JT, ms	331.1±46.1	311.7±29.4	0.01*
cJT, ms	351.2±35.9	336.1±18.1	<0.001*
Tp-e, ms	87.9±13.1	81.2±9.2	<0.001*

*Paired-sample t-test was used

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(cQT) (from 439.6±39.6 to 419.2±22.9 ms), the cQTd (from 42.9±7.9 to 36.7±7.9 ms), the JT (from 331.1±46.1 to 311.7±29.4 ms), the cJT (from 351.2±35.9 to 336.1±18.1 ms), and the Tp-e (from 87.9±13.1 to 81.2±9.2 ms) were reduced significantly after MVR (p<0.001).

DISCUSSION

In this article, we analyzed QT, cQT, cQTd, JT, cJT, and Tp-e interval durations of MVP patients before and at six months after MVR surgery. A significant reduction in these parameters was observed following successful MVR.

According to our study, MVR appears to exert a beneficial effect on the regression of ventricular repolarization parameters, potentially lowering the incidence of VAs. However, data regarding repolarization changes following cardiac surgery remain limited. A short-term prolongation of the QT interval is observed postoperatively. General anesthetic agents, antibiotic agents, cardioactive drugs, antiarrhythmic drugs, or increased inflammatory activation after surgery are among the causes. The ventricular repolarization parameters reach normal values, 3-6 months after surgery (9).

The prevalence of MVP is 2-3% (10). Although MVP is usually described as a benign disease, it is associated with SCD. Humphries and McKusick (11) first described inferior T wave inversions (TWI) in patients with mitral valve disease, which was later defined as MVP. The SCD was higher in patients with inferior TWI (12). In case reports, the VAs were suppressed, and inferior (TWI) improved after MVR, due to MVP (13). The study aimed to evaluate changes in ventricular repolarization parameters following surgical MVR for MVP, which have not been previously assessed in the literature. Unfortunately, there is no definitive treatment option to prevent SCD in MVP patients. Despite their widespread use in managing VAs associated with MVP, the evidence supporting the efficacy of beta-blockers remains insufficient. A recent study demonstrated that ventricular ectopic impulses of fascicular and papillary muscle can trigger ventricular fibrillation (VF). This study indicates that catheter ablation may play a role in mitigating the complications associated with symptomatic arrhythmias and reducing the necessity for implantable cardioverter defibrillators (14).

Arrhythmogenesis in MVP is significantly influenced by the Purkinje system. Suppression of VA after MVR has been shown in limited case reports (15,16). Vaidya et al. (17) revealed that after surgical correction of bileaflet MVP, the surgical correction reduced the malignant arrhythmia and appropriate shocks.

The exact mechanism of VAs in patients with MVP and their relationship with mechanical, electrical, or hemodynamic factors is yet to be clearly established. It is believed that arrhythmias in MVP may arise from myocardial stretching or endocardial friction lesions due to the retraction of the valve leaflet over the papillary muscle (18). The presence of late gadolinium enhancement at the papillary muscle level or adjacent free wall has been associated with the origin of VAs. In MVP, SCD is generally attributed to VF, with some studies suggesting that VF may be caused by excessive leaflet motility, which leads to mechanical stretching of the valve apparatus, followed by stretch-induced fibrosis and ectopic foci.

Variations in the QT interval, QT dispersion, and J-point elevation may be implicated in the pathogenesis of VAs in MVP patients. By demonstrating improvements in ventricular repolarization parameters post-surgery, this study provides valuable insights to the existing literature on MVP. It has been shown in previous studies that the QT interval, JT interval, and Tp-e measurements are important predictors of Vas (19-21). In our findings, repolarization abnormalities reverted to normal after MVP surgery. In a published case, TWIs, one of the key ventricular repolarization parameters, were observed to return to normal on the first day after surgery, a change attributed to hemodynamic factors rather than structural modifications.

The prolapse of the mitral valve induces mechanical stress on the left atrium. Theoretically, timely MVR prevents the development of scar tissue and may reduce the risk of VAs. Following MVR, left ventricular volume decreases due to hemodynamic effects. Because QRS duration correlates with left ventricle end-diastolic volume, prolonged QRS duration has been associated with elevated cardiovascular mortality (22). Consequently, MVR may improve ventricular repolarization parameters by reducing mechanical stretch, decreasing left ventricular volume, and potentially preventing the development of VAs.

Study Limitations

The retrospective design of our study and the limited number of cases included are notable limitations. One of the key factors contributing to this is the small number of centers in our country where MVP repair can be performed. ECG changes were compared before the operation and 6 months after the operation; and follow-ups of ECGs were not performed during this period. however

CONCLUSION

Ventricular repolarization parameters were altered following MVR surgery. Shortening of QT, cQT, cQTd, JT, cJT and Tp-e intervals after repair of MVP may reduce the risk of SCD and arrhythmia in these patients. Surgical repair of MVP plays a crucial role in normalizing ventricular repolarization parameters and preventing SCD.

Ethics

Ethics Committee Approval: Approval was obtained for this study from the İstanbul Medipol University Non-Interventional Clinical Research Ethics Committee (decision no: 954, date: 10.11.2022).

Informed Consent: Written informed consent was secured from all participants.

Footnotes

Author Contributions: Surgical and Medical Practices - Ü.S, A.A., A.H.; Concept - Ü.S.; Design - Ü.S. A.H.; Data Collection and/or Processing - Ü.S.; Analysis and/or Interpretation - A.A.; Literature Search - Ü.S.; Writing - Ü.S.

Conflict of Interest: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Financial Disclosure: The author(s) received no financial support for the research, authorship, and/or publication of this article.

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