Evaluation of cardiac functions after catheter ablation of atrioventricular nodal reentrant tachycardia

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1. Introduction
Radiofrequency catheter ablation (RFA) is an effective and accepted treatment strategy in supraventricular tachyarrhythmias [1–3]. Recurrent supraventricular tachycardia causes systolic dysfunction and dilated cardiomyopathy [4]. RFA could improve ventricular functions in patients with arrhythmic cardiomyopathies [5]. Speckle tracking echocardiography techniques, including strain, strain rate (SR), and torsion measurements, provide more precise assessment of systolic and diastolic function of the heart than conventional parameters [6]. We have shown previously that RFA of atrioventricular nodal reentrant tachycardia (AVNRT) improved left atrial functions soon after the procedure [7]. However, to our knowledge, reports of the long-term alterations of cardiac functions after AVNRT RFA are lacking in the literature. We aimed to assess the long-term variation of atrial and ventricular functions after RFA AVNRT by using speckle tracking echocardiography.

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2. Methods
2.1. Patients
This was a cross-sectional study including 55 consecutive patients who underwent an invasive electrophysiology study and RFA between April 2018 and August 2018 due to symptomatic drug-resistant typical slow-fast AVNRT. Patients with atrioventricular block, atrial tachycardia, atrioventricular reentrant tachycardia, paroxysmal atrial fibrillation, bundle branch block, chronic renal failure (estimated glomerular filtration rate <60 mL/min/1.73m²), hypertension, a history of coronary artery disease, left ventricular hypertrophy, heart failure with reduced ejection fraction, diabetes mellitus, or moderate to severe valvular heart disease were excluded from the study. The study protocol was approved by our university ethics committee. This study conforms to the principles of Helsinki Declaration. Written informed consent was obtained from all patients.

A Vivid E-9 cardiovascular ultrasound system (General Electric, Horten, Norway) was used for transthoracic

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Background/aim: Radiofrequency catheter ablation (RFA) is the most effective method of supraventricular tachycardia therapy. Recurrent supraventricular tachycardia may cause systolic dysfunction and dilated cardiomyopathy. The aim of this study was to evaluate the long-term alterations of atrial and ventricular functions after RFA of typical atrioventricular nodal reentrant tachycardia (AVNRT).

Materials and methods: This cross-sectional study included 55 consecutive patients with symptomatic drug-resistant AVNRT who had had an invasive electrophysiology study and RFA. Speckle-tracking–based echocardiographic assessment was performed shortly before and 1 year after the operation. Left ventricle (LV) and right ventricle (RV) peak systolic strain (PSS) and atrial strain measurements were performed.

Results: RFA successfully eliminated tachyarrhythmia in all patients. LV apical 4-chamber PSS –20.8% (–24.7 to –16.0) vs. –22.8% (–26.6 to –17.0, P < 0.001), LV apical 2-chamber PSS –21.5% (–26.8 to –10.1) vs. –22.0% (–27.8 to –13.7, P < 0.001), LV global PSS –20.4% (–26.4 to –14.4) vs. –23.0% (–27.1 to –2.3, P < 0.001), RV global PSS –26.0% (–30.0 to –18.0) vs. –26.5% (–32.1 to –19.7, P < 0.001), and peak left atrial longitudinal strain 41.0% (19.0–71.8) vs. 54.0% (25.6–82.0, P < 0.001) were significantly improved 1 year after RFA.

Conclusion: RFA of AVNRT not only provides relief of palpitations but also improves cardiac functions.

Key words: Speckle tracking, AVNRT, tachycardia, strain, ablation

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echocardiographic examination. Echocardiography assessment was performed 24 h before and 1 year after the RF Aoperation. Atrialelectromechanical coupling times, left ventricular peak systolic strain (LV PSS), and right ventricle peak systolic strain (RV PSS) measurements were evaluated [8]. The images were acquired at a frame rate of 70–100 frame/s. Modified biplane Simpson's method was used for the evaluation of the left ventricular ejection fraction.

The apical 4-chamber view was selected for the evaluation of left atrial deformation; peak positive longitudinal strain at the reservoir phase was determined. Right and left ventricular global longitudinal peak systolic strains were measured. EchoPAC dimension 2010 software (GE Healthcare, Chicago, IL, USA) was used by 2 experienced cardiologists to analyze echocardiographic data. The measurements of left atrial and right ventricular speckle tracking imaging are shown in Figures 1a and 1b, consecutively.

2.2. Electrophysiological study and ablation procedure

Conventional electrophysiology study and RFA were performed on all patients [9]. Antiarrhythmic drugs were stopped for more than 7 days prior to RFA and discontinued thereafter. Conventional quadripolar catheter (Medtronic 6F; Medtronic, Minneapolis, MN, USA), decapolar coronary sinus catheter (Abbott Inquiry CS-5Fr; Abbott Laboratories, Abbott Park, IL, USA), His catheter (Webster His catheter; Biosense Webster, Irvine, CA, USA), and ablation catheter (7F Marinr multicurve steerable catheter; Medtronic) were introduced. A Micropace electrophysiology recorder and stimulator (Micropace SureTouch 4.0; Micropace Inc., Tustin, CA, USA) was used for programmed stimulation techniques. Typical slow-fast AVNRT was diagnosed and ablated according to standard criteria [9]. After the administration of 1 mg i.v. atropine, programmed stimulation protocols were repeated after RFA in order to confirm elimination of tachyarrhythmia.

To standardize the frequency of AVNRT episodes, we used a scale based on history of AVNRT occurrence (1 = less than once a month; 2 = at least once a month; 3 = at least once a week).

2.3. Statistical analysis

The distribution of continuous variables was evaluated with the Shapiro–Wilk test. Continuous variables were expressed as mean ± standard deviation or median (minimum-maximum), whichever was appropriate. To analyze dependent variables, the Wilcoxon signed rank test was used. Bland–Altman and intraclass observer agreement tests were used for the evaluation of inter- and intraobserver agreement. A two-tailed P < 0.05 was considered statistically significant. IBM SPSS 21.0 was used for statistical analysis (IBM Corp., Armonk, NY, USA).

3. Results

Programmed electrical stimulation induced AVNRT in all patients. RFA successfully eliminated AVNRT in all patients and recurrence was not observed. Thirty-three patients were using beta blockers and 22 patients were using calcium channel blockers before the RFA. After the RFA, no patient used any antiarrhythmic drug. The mean age of the patients was 35.67 ± 6.95 years and the mean body mass index was 26.48 ± 2.54 kg/m². Clinical characteristics of the patients are presented in Table 1.

The duration of palpitations was 10 (2–20) years and the scale of AVNRT occurrence was 2 (1–3). Apical 4-chamber LV PSS –20.8% (–24.7 to –16.0) vs. –22.8% (–26.6 to –17.0),

Figure 1. A) Measurement of left atrial strain imaging. B) Measurement of right ventricular free wall strain imaging.
Table 1. The characteristics of the patients.

| Variable             | Basal        | 1 year follow-up | P    |
|----------------------|--------------|------------------|------|
| Age, year            | 35.67 ± 6.95 | –                 |      |
| Male, n (%)          | 17 (30.9%)   | 17 (30.9%)       |      |
| BMI, kg/m²           | 26.48 ± 2.54 | –                 |      |
| Scale of AVNRT occurrence | 2 (1–3)     | 1 (1–2)          |      |
| Palpitation duration, year | 10 (2–20)   | 10 (2–20)        |      |
| Systolic blood pressure, mmHg | 123.49 ± 8.89 | 123.49 ± 8.99 |      |
| Diastolic blood pressure, mmHg | 75.00 ± 6.20 | 75.00 ± 6.20     |      |
| Procedure time, min  | 48 (7–80)    | –                 |      |
| Fluoroscopy time, min| 10 (1–21)    | –                 |      |

P < 0.001), apical 2-chamber LVPSS –21.5% (–26.8 to –10.1) vs. –22.0% (–27.8 to –13.7, P < 0.001), apical long axis LVPSS –19.2% (–21.9 to –15.6) vs. –21.7% (–26.9 to –18.0, P < 0.001), global LVPSS–20.4% (–26.4 to –14.4) vs. –23.0% (–27.1 to –2.3, P < 0.001), global RV-G-S–26.0% (−30.0 to −18.0) vs. –26.5% (−32.1 to −19.7, P = 0.008), peak left atrial longitudinal strain 41.0% (19.0–71.8) vs. 54.0% (25.6–82.0, P < 0.001) were significantly improved 1 year after RF catheter ablation (Table 2). Left ventricle diastolic filling velocities and left atrial volume index were also significantly improved after the procedure.

Table 2. Echocardiographic outcomes of patients before and 1 year after the procedure.

| Variable             | Basal        | 1 year follow-up | P    |
|----------------------|--------------|------------------|------|
| A4C-S, %             | –20.8 [−24.7]−(−16.0) | –22.8 [−26.6]−(−17.0) | <0.001|
| A2C-S, %             | –21.5 [−26.8]−(−10.1) | –22.0 [−27.8]−(13.7) | <0.001|
| LAX-S, %             | –19.2 [−21.9]−(15.6) | –21.7 [−26.9]−(−18.0) | <0.001|
| LV-G-S, %            | –20.4 [−26.4]−(14.4) | –23.0 [−27.1]−(−2.3) | <0.001|
| RV-G-S, %            | –26.0 [−30.0]−(18.0) | –26.5 [−32.1]−(−19.7) | <0.001|
| LA-S-r %             | 41.0 (19.0–71.8) | 54.0 (25.6–82.0) | <0.001|
| TPA, ms              | 52.0 (25.2–71.9) | 45.7 (8.0–77.0) | 0.020 |
| SPA, ms              | 41.0 (29.2–56.0) | 47.0 (30.5–56.0) | 0.078 |
| LPA, ms              | 58.0 (28.3–73.0) | 51.0 (23.0–69.0) | 0.001 |
| E, cm/s              | 65.0 (49.0–85.0) | 72.0 (55.0–91.0) | <0.001|
| A, cm/s              | 72.0 (50.0–95.0) | 60.0 (42.0–90.0) | <0.001|
| DT, ms               | 215.0 (164.0–263.0) | 170.0 (154.0–245.0) | <0.001|
| LAVI, mL/m²          | 28.0 (20.0–35.0) | 25.0 (21.0–31.0) | <0.001|
| LVEF, %              | 63.0 (55–70) | 66.0 (60–70) | <0.001|

A4C-S: LV apical four chamber peak systolic strain; A2C-S: LV apical two chamber peak systolic strain; LAX-S: apical long axis peak systolic strain; LV-G-S: left ventricle global peak systolic strain; RV-G-S: right ventricle global peak systolic strain; LA-S-r: peak left atrial longitudinal strain during reservoir phase; TPA: tricuspid atrial electromechanical coupling time; SPA: septal atrial electromechanical coupling time; LPA: lateral atrial electromechanical coupling time; E: peak transmural filling velocity during early diastole; A: peak transmural filling velocity during late diastole; DT: deceleration time of E wave; LAVI: left atrial volume index; LVEF: left ventricle ejection fraction.

4. Discussion
We found that RFA of AVNRT has long-term restorative effects on cardiac functions, as demonstrated via speckle tracking echocardiography.

RFA is the first-line therapy of AVNRT [1–3]. Recurrent AVNRT attacks may cause ventricular dilatation and arrhythmic cardiomyopathy [10,11]. Myocyte loss,
elongation, myofibril misalignment, and breakdown of extracellular matrix architecture were demonstrated on the cellular level [10–13]. Atrial fibrillation causes atrial stunning, which ameliorates progressively after restoration of normal sinus rhythm [14]. Tachycardia attacks raised atrial pressure, resulting in fibrosis of the atrium. Compared to atrioventricular reentrant tachycardia and atrial tachycardia, atrial pressure increase is much more prominent in AVNRT [15]. It has been shown that left atrial functions improved after RFA, along with left atrial volume reduction in atrial fibrillation/flutter patients [10–12]. Recurrent AVNRT attacks increase atrial pressure, leading to elevated atrial wall stress, which causes negative remodeling and systolic impairment [15]. Therefore, termination of AVNRT may restore atrial and ventricular functions. Reduction of the left atrium diameter was shown after RFA of AVNRT and AVRT [16,17]. Similarly, we found that left atrial volume was decreased after RF catheter ablation. We have recently shown that RFA of AVNRT restored left atrial functions shortly after the procedure [7]. However, long-term outcomes of AVNRT RFA on cardiac mechanics are lacking in the literature. To our knowledge, this is the first study evaluating the long-term alterations of cardiac functions after RF ablation of AVNRT. We found that peak left atrial longitudinal strain, as well as interatrial and intraatrial electromechanical coupling times, were significantly improved after RFA.

Lelakowski et al. showed that RFA improves left ventricular systolic and diastolic functions in patients with AVNRT [17]. Jimbo et al. reported that termination of AVNRT with RFA led to reduction of atrial dimensions and significantly improved exercise capacity [17]. The increase of exercise capacity was probably due to improved diastolic and systolic functions. Duszanska et al. studied the variation of left ventricle systolic and diastolic
functions by conventional echocardiographic parameters after AVNRT RFA. They found that successful RFA of AVNRT ameliorated left ventricle systolic and diastolic functions 6 months after the operation [18]. Similarly, we found that cardiac functions were ameliorated after RFA; however, we examined the cardiac function with speckle tracking echocardiography, a more accurate method. Additionally, our study examined the long-term effects of RFA. The evaluation of atrial functions with speckle tracking echocardiography allows assessment of entire elements of atrial functions (pump, passive conduit, and reservoir). Additionally, assessment of left ventricle functions by speckle tracking echocardiography allows detection of even subtle changes. Fishberger et al. reported that an improvement was observed in left ventricular myocardial mechanics after the RFA of ectopic atrial and permanent junctional reciprocating tachycardia. However, they did not study patients with AVNRT[19]. We found that left atrial functions and left ventricular functions significantly improved after successful RFA, as assessed by speckle tracking echocardiography.

The perinodal area is an important locus of parasympathetic innervation of the heart. This area is rich in vagal fibers. Previous studies have demonstrated that heart rate increased after RFA [20]. This increase was associated with parasympathetic withdrawal. Similarly, this partial parasympathetic withdrawal may increase both sympathetic tone and inotrophy.

There are some limitations of this study. First, this study is relatively small in scale. MRI is a useful tool for detection of fibrosis, which is an important component of arrhythmic cardiomyopathy. Unfortunately, we did not perform an MRI study to detect fibrosis. Second, we included only patients with typical slow–fast AVNRT; however, atypical AVNRT and the left variant have the same mechanisms as typical AVNRT. Similar improvement in cardiac functions is expected to be present in atypical and left variant AVNRT cases.

In conclusion, RFA of AVNRT not only provides relief of palpitations but also improves cardiac functions.

Acknowledgment/disclaimers/conflict of interest

There is no conflict of interest. There is no relationship with the industry to be declared. This study did not get any grant support.

Informed consent

This study conforms to the principles of the Helsinki Declaration. All patients gave informed consent. This study was approved by the Clinical Studies Ethical Committee of Kahramanmaraş Sütçü İmam University with a protocol number of 19 (28.02.2018).

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