Evaluation of cardiac functions after catheter ablation of atrioventricular nodal re-entrant tachycardia

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Informed consent
This study confirms the principles of Helsinki declaration. All patients gave informed consent. This study is approved by Clinical Studies Ethical Committee of Kahramanmaraş Sütçü İmam University with a protocol number of 19 at 28.02.2018.
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Abstract

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

Materials and methods: This cross sectional study included 55 consecutive patients with symptomatic drug resistant AVNRT who had an invasive electrophysiology study and RFA. Speckle tracking based echocardiographic assessment was performed before and a 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 four chamber PSS -20.8% (-24.7 - -16.0) vs. -22.8% (-26.6 - -17.0), p<0.001), LV apical two chamber PSS -21.5% (-26.8 - -10.1) vs. -22.0% (-27.8 - -13.7), p<0.001), LV global PSS -20.4% (-26.4 - -14.4) vs. -23.0% (-27.1 - -2.3), p<0.001), RV global PSS -26.0% (-30.0 - -18.0) vs. -26.5% (-32.1 - -19.7), p<0.001), 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.

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

Keywords: Speckle tracking, AVNRT, tachycardia, strain, ablation.
1. Introduction

Radiofrequency catheter ablation (RFA) is the effective and accepted treatment strategy in supraventricular tachyarrhythmias [1-3]. Recurrent supraventricular tachycardia may cause systolic dysfunction and dilated cardiomyopathy [4]. RFA could improve ventricular functions in patients with arrhythmic cardiomyopathies [5]. The speckle tracking echocardiography techniques, including strain, strain rate (SR) and torsion measurements, provide assessment of more precise systolic and diastolic function of the heart than conventional parameters [6]. Previously we have shown that RFA of atrioventricular nodal re-entrant tachycardia (AVNRT) improved left atrial functions early after the procedure [7]. However, to our knowledge the long term alterations of cardiac functions after the AVNRT RFA is 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.

2. Methods:

2.1 Patients:

This is a cross sectional study including 55 successive patients who underwent an invasive electrophysiology study and RFA due to symptomatic drug-resistant typical slow-fast AVNRT, between April 2018 and August 2018. Patients with atrioventricular block, atrial tachycardia, atrioventricular reentrant tachycardia, paroxysmal atrial fibrillation, bundle branch block, chronic renal failure (estimated glomerular filtration rate <60ml/min/1.73m²), hypertension, a history of coronary artery disease, left ventricular hypertrophy, heart failure with reduced ejection fraction, diabetes mellitus, and moderate to severe valvular heart disease were excluded from the study. The study protocol was approved by our university ethics committee.
This study confirms 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 echocardiographic examination. Echocardiography assessment was performed 24 hours before and one year after the RFA operation. Atrial electromechanical coupling times, left ventricular peak systolic strain (LVPSS), right ventricle peak systolic strain (RVPSS) measurements were evaluated [8]. The images were acquired at a frame rate of 70-100 frame/sec. Modified biplane Simpson’s method was used for the evaluation left ventricular ejection fraction.

Apical four chamber view was selected for the evaluation of left atrial deformation and peak positive longitudinal strain at reservoir phase was determined. Right and left ventricular global longitudinal peak systolic strains were measured. EchoPAC dimension 2010 software was used to analyze echocardiographic data by two experienced cardiologists. The measurement of left atrial and right ventricular speckle tracking imaging were shown in Figure 1a and 1b, consecutively.

2.2 Electrophysiological study and ablation procedure

Conventional electrophysiology study and RFA were performed to all patients [9]. Antiarrhythmic drugs were stopped for more than 7 days prior to RFA and discontinued thereafter. Conventional quadripolar catheter (Medtronic 6F), decapolar coronary sinus catheter (Abbott Inquiry CS-5Fr), his catheter (Webster His catheter), and ablation catheter (7F Marinr multicurve steerable catheter, Medtronic) were introduced. Micropace electrophysiology recorder and stimulator was used for (Micrapace Sure touch 4.0, CA, USA) programmed stimulation techniques. Typical slow-fast AVNRT was diagnosed and ablated according to standard criteria [9]. After the
administration 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 were evaluated with Shapiro Wilk test.
Continuous variables were expressed as mean ± standard deviation or median
(minimum – maximum), whichever is appropriate. To analyze dependent variables
Wilcoxon signed ranks test was used. Bland-Altman and intra-class observer agreement
tests were used for the evaluation of inter and intra-observer agreement. A two-tailed
p<0.05 was considered statistically significant. SPSS 21.0 was used for statistical
analysis (SPSS Inc, Chicago, IL, USA).

3. Results

Programed electrical stimulation induced AVNRT in all patients. RFA was
successfully eliminated AVNRT in all patients and recurrence was not observed. Thirty-
tree patients were using beta blockers and twenty-two 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 were presented in
Table 1. The duration of palpitations was 10 (2-20) year and the scale of AVNRT
occurrence was 2 (1-3). Apical four chamber LVPSS -20.8% (-24.7 - -16.0) vs. -22.8%
(-26.6 - -17.0), p<0.001), apical two chamber LVPSS -21.5% (-26.8 - -10.1) vs. -22.0%
(-27.8 - -13.7), p<0.001), apical long axis LVPSS -19.2% (-21.9 - -15.6) vs. -21.7% (-
26.9 - -18.0), p<0.001), global LVPSS -20.4% (-26.4 - -14.4) vs. -23.0% (-27.1 - -2.3),
p<0.001), global RVPSS -26.0% (-30.0 - -18.0) vs. -26.5% (-32.1 - -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.

Intra- and inter-observer variability were evaluated from echocardiographic data of 12 patients. To analyze inter-observer variability, the second operator who was unaware of the previous measurements and analyzed the data 2 weeks later. Two weeks after, the first operator repeated analysis to evaluate intra-observer variability, too. The intra- and inter-observer correlation of coefficient for assessment of A4C-S, A2CS, LVG-S, RV-G-S, and LA-S-r were not significantly different. Bland-Altman graphic of apical four chamber peak systolic strain measurement, left ventricle global peak systolic strain measurement, right ventricle global peak systolic strain measurement and left atrial peak systolic strain measurement were demonstrated in Figure 2a, 2b, 2c and 2d successively.

4. Discussion

We found that, RFA of AVNRT has restorative effects on cardiac functions in long term, 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 break down of extracellular matrix architecture was demonstrated on the cellular level [10-13]. Atrial fibrillation causes atrial stunning and after restoration of normal sinus rhythm it ameliorates progressively [14]. Tachycardia attacks raise 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 was 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 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 the long term outcomes of AVNRT RFA on cardiac mechanics is 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 lead 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 later the operation [18]. Similarly we found that cardiac functions ameliorated after RFA however we examined the cardiac function with a more accurate method, speckle tracking echocardiography. Additionally our study examined the long term effects of RFA. The evaluation of atrial functions with speckle tracking echocardiography allows assessment of whole pieces 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 besides left atrial functions, left ventricular functions, assessed by speckle tracking echocardiography, significantly improved after successful RFA.

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

There are some limitations of this study. Firstly this study is relatively small scaled. Fibrosis is an important component of arrhythmic cardiomyopathy. MRI is a useful tool for detection of fibrosis. Unfortunately we did not performed MRI study to detect fibrosis. Secondly, we included only patients with typical slow-fast AVNRT however, atypical AVNRT and left variant bears also the same mechanisms with 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.

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Figure Legends:

Figure 1: A. Measurement of left atrial strain imaging. B. Measurement of right ventricular free wall strain imaging.
Figure 2: A. Bland-Altman graphic of apical four chamber peak systolic strain measurement B. Bland-Altman graphic of left ventricle global peak systolic strain measurement C. Bland-Altman graphic of right ventricle global peak systolic strain measurement D. Bland-Altman graphic of left atrial peak systolic strain measurement.
Table 1: The characteristics of the patients.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, year</td>
<td>35.67 ± 6.95</td>
</tr>
<tr>
<td>Male, n(%)</td>
<td>17(30.9%5)</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>26.48 ± 2.54</td>
</tr>
<tr>
<td>Scale of AVNRT occurrence</td>
<td>2 (1-3)</td>
</tr>
<tr>
<td>Palpitation duration, year</td>
<td>10 (2-20)</td>
</tr>
<tr>
<td>Systolic blood pressure, mmHg</td>
<td>123.49±8.89</td>
</tr>
<tr>
<td>Diastolic blood pressure, mmHg</td>
<td>75.00±6.20</td>
</tr>
<tr>
<td>Procedure time, min</td>
<td>48 (7-80)</td>
</tr>
<tr>
<td>Fluoroscopy time, min</td>
<td>10 (1-21)</td>
</tr>
</tbody>
</table>
Table 2: Echocardiographic outcomes of patients before and 1 year after the procedure.

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

Abbreviations: 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; 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 transmitral filling velocity during early diastole; A, peak transmitral filling velocity
during late diastole; **DT**, Deceleration time of E wave; **LAVI**, Left atrial volume index;

**LVEF**, Left ventricle ejection fraction.