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Assessment of the influence of radiofrequency catheter ablation of the slow pathway of the atrioventricular node on cardiac function in patients with atrioventricular nodal reentrant tachycardia: a speckle tracking echocardiography study

Atriyoventriküler nodal reenteran taşikardili hastalarda radyofrekans kateter ablasyonu ile atriyoventriküler düğümün yavaş yolağının yakılmasının kalp fonksiyonları üzerine etkisinin araştırılması: Bir benek takip ekokardiyografi çalışması

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ABSTRACT

Objectives: Typical atrioventricular nodal reentrant tachycardia (AVNRT) can be cured with slow pathway ablation. This study was designed to assess the alterations in atrial and ventricular functioning using speckle tracking echocardiography in consecutive patients with typical AVNRT who underwent slow pathway radiofrequency (RF) ablation.

Study design: Included in this study were 23 consecutive patients with symptomatic drug-resistant typical (slow-fast) AVNRT, all of whom underwent an invasive electrophysiology study and RF ablation. Patients underwent transthoracic echocardiographic evaluation 24 hours before and 24 hours after the ablation procedure.

Results: AVNRT was induced during the electrophysiological study, and RF ablation successfully eliminated tachyarrhythmia in 23 (100%) patients. The atrial-His (A-H) interval was decreased in the post-ablation period compared to the pre-ablation period without the occurrence of immediate conduction disturbances. Peak left atrial longitudinal strain during the reservoir phase was increased in the post-ablation period compared to the pre-ablation period (48.24±16.45 *vs.* 38.07±15.72, p<0.001). The left atrial septal electromechanical coupling time was significantly decreased after the procedure (48.90±12.26 *vs.* 38.92±7.14 ms, p=0.036).

Conclusion: In addition to treatment of arrhythmia, RF catheter ablation of AVNRT may also restore left atrial function as early as 24 hours after the procedure.

ÖZET

Amaç: Tipik atriyoventriküler nodal reenteran taşikardiler (AVNRT) yavaş yolağın ablasyonu ile tedavi edilebilir. Bu çalışmanın amacı benek takip ekokardiyografisi kullanarak tipik AVNRT nedeniyle radyofrekans ablasyonu tedavisi uygulanan hastalarda atriyum ve ventrikül fonksiyonlarının değişiminin değerlendirilmesidir.

Çalışma planı: Semptomlu ilaca direçli tipik AVNRT'si olan ve girişimsel elektrofizyolojik çalışma ve radyofrekans ablasyonu uygulanan 23 ardışık hasta çalışmaya dahil edildi. Hastalara işlemden 24 saat önce işlemden 24 saat sonra transtorasik ekokardiyografi yapıldı.

Bulgular: Bütün hastalarda elektrofizyolojik çalışmada AVNRT uyarıldı. Bütün hastalarda (n=23, %100) radyofrekans abalsyonu ile taşikardi başarılı şekilde tedavi edildi. Ablasyon öncesi döneme göre AH aralığı ablasyon sonrası dönemde anlamlı olarak azaldı ve ileti problemi görülmedi. Tepe sol atriyum düzlemsel gerilimi ablasyon sonrası dönemde ablasyon öncesi döneme göre anlamlı derecede arttı (48.24±16.45 ve 38.07±15.72, p<0.001). Sol atriyum-septum elektromekanik eşleşmesi işlem sonrası anlamlı olarak azaldı (48.90±12.26 vs. 38.92±7.14 ms, p=0.036).

Sonuç: Atriyoventriküler nodal reenteran taşikardilerin radyofrekans kateter ablasyonu, aritminin tedavisi yanında sol atriyum fonksiyonlarını 24 saat kadar kısa bir süre içerisinde iyileştirebilir.

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In the typical atrioventricular nodal reentrant tachycardia (AVNRT), anterograde conduction occurs through the slow pathway, while retrograde conduction occurs through the fast pathway.[1,2] Recurrent tachycardia attacks may lead to systolic dysfunction and arrhythmic cardiomyopathy.[3] This tachycardia can be cured with slow pathway ablation.[1,2] It was shown that catheter-based therapies may restore normal left ventricular function in patients with arrhythmic cardiomyopathies.[4] Although conventional echocardiographic parameters assess only global left ventricular function, the new speckle tracking based echocardiographic techniques, such as strain, strain rate (SR) and torsion measurements, provides a more accurate assessment of the systolic and diastolic function of the heart chambers.[5] To our knowledge, there is insufficient data in the current literature regarding alterations in cardiac function after AVNRT radiofrequency (RF) ablation.

This study was designed to assess the alterations in atrial and ventricular function using speckle tracking echocardiography (STE) in consecutive patients with typical AVNRT who underwent slow pathway RF ablation.

PATIENTS AND METHODS

Patients

Twenty-three consecutive patients with symptomatic drug-resistant typical slow-fast AVNRT who underwent an invasive electrophysiology study and RF ablation from June 2011 to September 2011 were included in the study. Patients with concomitant arrhythmias, bundle blocks, right and left ventricular systolic dysfunction, overt diastolic dysfunction (diastolic dysfunction ≥grade 2), left ventricular hypertrophy, coronary artery disease, diabetes mellitus, chronic renal failure, and moderate to severe valvular heart disease and those using anti-arrhythmic drugs were excluded from the study. All ablation procedures were performed by the same cardiologist and all patients provided written, informed consent. The local ethics committee approved the study protocol. This investigation conforms to the principles outlined in the Declaration of Helsinki. A Vivid 7 Pro GE cardiovascular ultrasound system [3S sector probe (1.5-3.6 MHz), GE] was used for transthoracic echocardiographic evaluation 24 hours before and 24 hours after the ablation procedure. Tricuspid, septal and lateral atrial electromechanical coupling time, global torsion and basal and apical rotation measurements were obtained with echocardiographic evaluation.[6] The analysis for left atrium deformation was performed using an apical four-chamber view. Peak positive longitudinal strain corresponding to left atrium reservoir phase was measured. Right ventricular deformation was assessed using an apical four-chamber view. The analysis for left ventricle deformation was performed with apical four-chamber, apical two-chamber and apical long-axis views. Using speckle tracking derived from both the right ventricle and left ventricle, global longitudinal peak systolic strains were measured. Automatic frame-by-frame tracking of these markers during the heart cycle (two-dimensional STE methods) yielded measures of strain and sinus rhythm (SR) at any point of the myocardium. To calculate ventricular and atrial strain and SR, the endocardium is first traced manually. The epicardial surface is calculated automatically, and after manually reducing the region of interest to the atrial and ventricular thickness, the software automatically divides the atrial and ventricular walls. Echocardiographic analysis of strain, SR and tissue velocity imaging were performed offline with EchoPAC dimension 2010 software by two experienced cardiologists.

Abbreviations:

AVNRT	*Atrioventricular nodal re-entrant tachycardia*
IQR	*Interquartile range*
RF	*Radiofrequency*
SR	*Strain rate*
STE	*Speckle tracking echocardiography*

Electrophysiological study and ablation procedure

Electrophysiology study and RF ablation were performed according to the previously described procedure.[7] All anti-arrhythmic agents had been discontinued for more than three days. No patient had received amiodarone. Conventional quadripolar (Jos 6F) and multi-polar (Marinr CS-7Fr) (for coronary sinus and His) catheter were introduced into the right atrium across the tricuspid valve to record a right-sided His bundle electrogram, the coronary sinus, and right ventricle. Bipolar electrograms were filtered at 30-500 Hz, amplified at gains of 20-80 mm/mV, and displayed and acquired on a physiological recorder (Cardiotek EP Tracer System, Holland), together with surface electrocardiograms. Two stimulation protocols were performed: 1) programmed stimulation of the coronary sinus with an eight basic stimuli train and a subsequent single, and afterwards double extra stimuli with gradually (20-ms step) shortened coupling interval, and 2) an incremental pacing protocol. Typical slow-fast AVNRT was diagnosed according to standard criteria.[8] AV nodal conduction jumps were diagnosed using the criteria of an increase of at least 50 msn in the atrial-His (A-H) interval for a 10 msn decrease in the atrial coupling interval. Demonstration of a conduction jump indicated persistent conduction over the slow pathway. The ablation catheter (RF Marinr MC-7Fr) is withdrawn inferiorly from the His bundle region along the atrial edge of the tricuspid annulus. Positioning of the catheter at the slow pathway region can be performed in either the left anterior oblique or right anterior oblique view. RF energy was delivered at an energy of 30-50 W and temperature up to 50-60°C, for 60 s. Basal and atropine-induced stimulation protocols were repeated after ablation RF in order to stimulate AVNRT and to confirm elimination of tachyarrhythmia. Following successful ablation, patients were discharged from the hospital within 24 hours on aspirin and no anti-arrhythmic drugs.

Statistical analysis

Statistics were obtained using the Statistical Package for the Social Sciences (SPSS Inc, Chicago, IL, USA) version 17.0. All the values were expressed as mean ± standard deviation. Wilcoxon signed ranks test was used to examine pre-ablation and post-ablation differences. P<0.05 was considered significant.

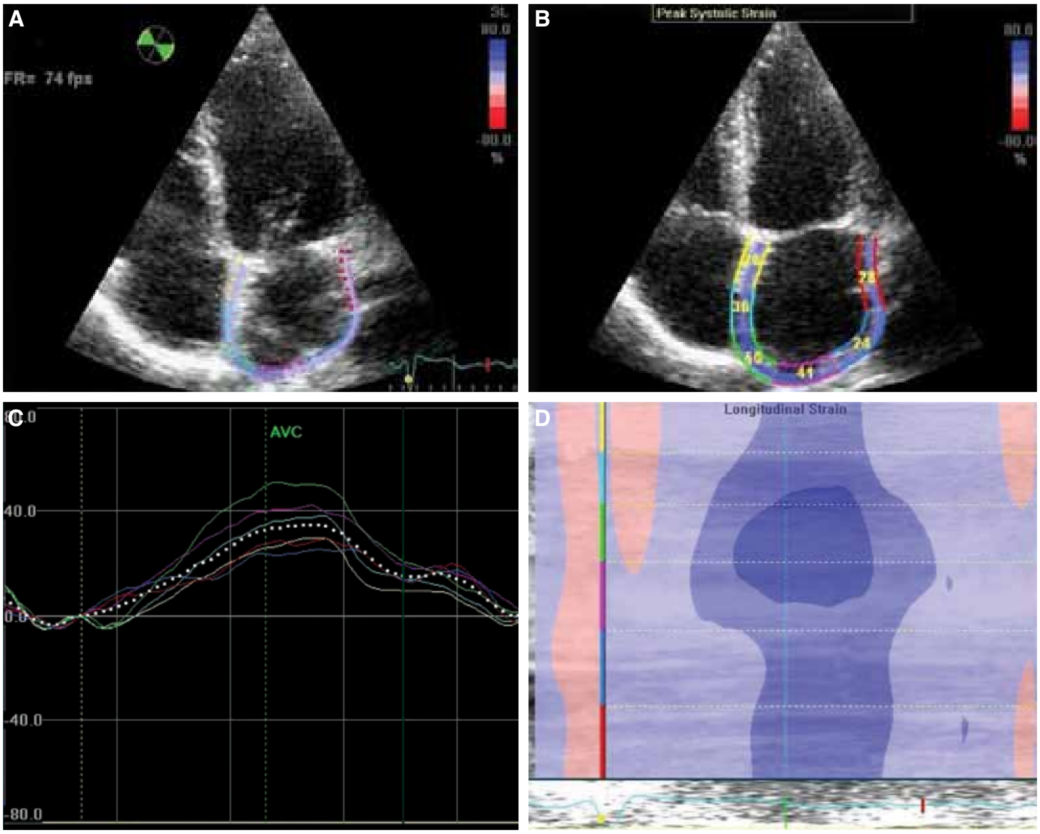

Figure 1. Preoperative measurement of 2D longitudinal atrial strain with speckle tracking. Quad view. **(A)** Once the atrial endocardial border is traced, atrial thickness is traced automatically; **(B)** Strain value of the reservoir in the six atrial walls; **(C)** Longitudinal strain curves of the six atrial segments. The dotted line represents average atrial longitudinal strain. During the period in which the atrium acts as a reservoir (includes isovolumic contraction, ejection and isovolumic relaxation phases), the atrial strain increases, reaching a peak at the end of filling from pulmonary vein flow. During the conduit atrial phase, atrial strain decreases, with a plateau during diastasis and a negative peak at the end of atrial contraction; **(D)** Curved anatomical M-mode: the light blue color indicates that atrial roof strain is lower than that of the rest of the walls, colored in blue. AVC: Aortic valve closure.

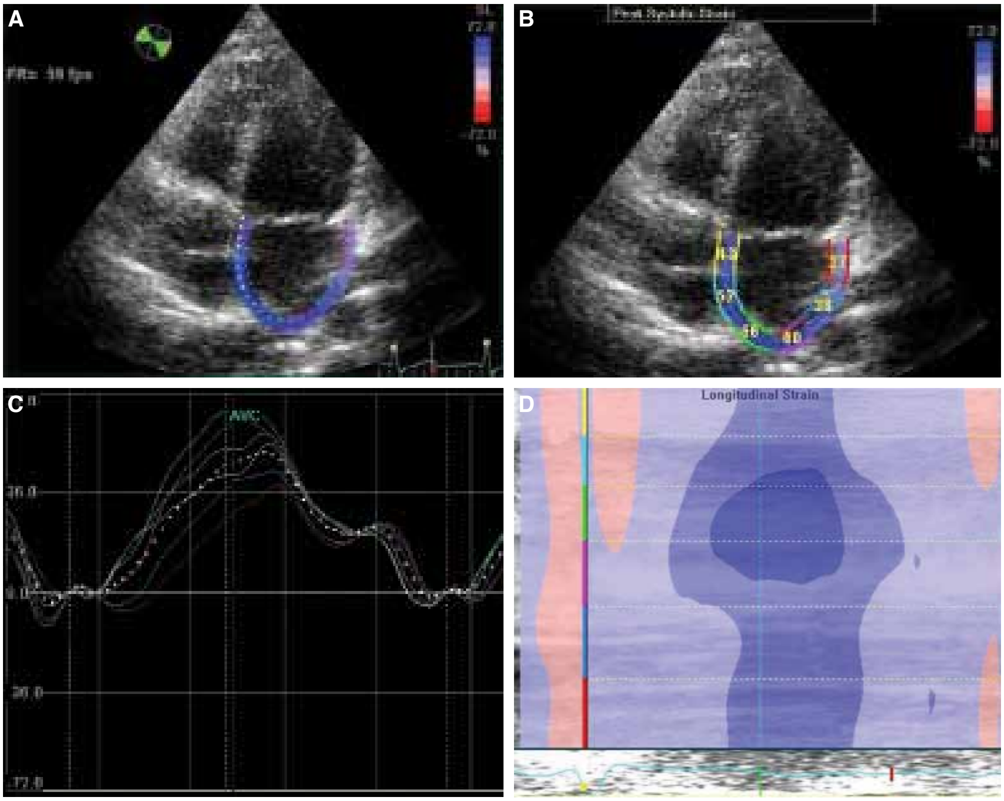

Figure 2. (A-D) Postoperative measurement of 2D longitudinal atrial strain with speckle tracking. Quad view shows improvement in left atrial peak systolic strain during the reservoir phase, after RF ablation.

RESULTS

Twenty-three consecutive patients [age: 37.4±9.43 years, body mass index: 25.22±5.49 kg/m², systolic blood pressure: 124.57±8.79 mmHg, diastolic blood pressure: 74.70±6.12 mmHg, heart rate before ablation 74.00±4.97 beat/min] with slow-fast AVNRT (8 men, 34.8%) were ablated. All patients had at least a one attack of palpitation per month. The median duration of palpitation was 9 years (interquartile range

Table 1. The echocardiographic characteristics of patients before and after the procedure

Variable	Basal (Mean±SD)	Post procedural (Mean±SD)	*p*
AH interval (ms)	66.96±8.20	59.52±7.92	**<0.001**
Left ventricle apical four chamber peak systolic strain (%)	–18.90±9.22	–20.57±2.58	0.976
Left ventricle apical two chamber peak systolic strain (%)	–20.12±3.03	–20.22±4.17	0.951
Apical long axis peak systolic strain (%)	–19.31±3.35	–19.39±1.80	0.821
Left ventricle global peak systolic strain (%)	19.67±3.24	–20.07±2.79	0.287
Right ventricle global peak systolic strain (%)	–24.29±5.33	–25.43±3.46	0.180
Peak left atrial longitudinal strain during reservoir phase (%)	38.07±15.72	48.24±16.45	**<0.001**
Tricuspid atrial electromechanical coupling time	48.90±14.26	50.04±11.36	0.855
Septal atrial electromechanical coupling time	43.53±8.34	38.92±7.14	0.036
Lateral atrial electromechanical coupling time	48.09±14.56	52.69±12.87	0.059

[IQR]: 6 years), and the patients had a median 8 (IQR: 5) attacks longer than 1 minute/per year. All patients had normal left ventricular function (ejection fraction >50%), without evidence of underlying structural heart disease. The mean left ventricular ejection fraction was 63.22±4.22. In all patients, AVNRT was induced during the electrophysiology study. RF ablation successfully eliminated tachyarrhythmia in 23 (100%) patients. The A-H interval was decreased in the post-ablation period compared with the pre-ablation period (59.52±7.92 *vs.* 66.96±8.20 ms, p<0.001), and immediate conduction disturbances did not occur. Procedure and fluoroscopy times were 59.39±12.83 and 12.09±3.52 min, respectively. In the transthoracic echocardiography, peak left atrial longitudinal strain during the reservoir phase was increased in the post-ablation period compared with the pre-ablation period (48.24±16.45 *vs.* 38.07±15.72, p<0.001) (Figures 1, 2) (Table 1). Global longitudinal peak systolic strain of the left ventricle, right ventricle and left atrium are shown in Table 1. The left atrial septal electromechanical coupling time was significantly decreased after the procedure (48.90±12.26 *vs.* 38.92±7.14 ms, p=0.036).

DISCUSSION

We found that the left atrial function, including peak left atrial strain, during the reservoir phase was significantly increased and left atrial septal electromechanical coupling time was significantly decreased as early as 24 hours after the RF ablation of AVNRT.

Radiofrequency ablation is an established method of treatment of AVNRT.[1,2] Recurrent AVNRT attacks may lead to systolic dysfunction and arrhythmic cardiomyopathy.[3] Catheter-based therapies may restore normal left ventricular function in such circumstances.[4] Atrial stunning is well established in patients with atrial fibrillation, and after restoration of sinus rhythm, it recovers gradually.[9] Tachycardia attacks lead to an increase in atrial pressure. Left atrial systolic function and strain improve after RF ablation in addition to a decrease in left atrial volume in patients with atrial fibrillation and flutter.[10,11] Recurrent AVNRT attacks increase atrial pressure, causing elevated atrial wall distension, leading to a negative remodeling and systolic impairment. Thus, the elimination of AVNRT may improve left atrium systolic function. Lelakowski et al.[12] reported that in patients with AVNRT, RF ablation improves left ventricular systolic and diastolic function. Elimination of AVNRT resulted in reduction of left and right atrial size, and exercise capacity improved significantly after RF ablation of AVNRT.[12] Duszanska et al.[13] studied the alteration of left ventricle systolic and diastolic function in 25 patients with AVNRT after RF ablation, and reported that successful RF ablation of the slow atrioventricular conduction pathway in patients with AVNRT resulted in improvement in LV systolic and diastolic function six months after the procedure. Similarly, we found that atrial function improved after RF ablation, but we assessed cardiac function by STE-based measurements and in the short-term. The assessment of atrial function with 2D speckle tracking strain and SR permits evaluation of the three components of atrial function (pump, passive conduit and reservoir function) in both atria.

This is an important study that investigated the effect of RF catheter ablation of the AVNRT on various components of right ventricle, left ventricle and left atrium systolic deformation. Although an improvement in LV longitudinal and circumferential strains was reported in former studies, we did not find any difference in this study, which may be attributable to the short follow-up period.[10,11] Moreover, patients with decreased left ventricular systolic function and overt diastolic dysfunction were excluded from the study. Interestingly, RF energy may deteriorate both ventricular and atrial functioning, but ventricular function did not deteriorate after the procedure besides a significant increase in atrial SR. As the measurements were recorded 24 hours before and after the procedure, it may be expected that ventricular function may also further improve after the procedure, which necessitates long-term follow-up.

Injury of the parasympathetic fibers and receptors by RF energy may influence the left atrial function. It is known that sinus rate increases after RF ablation. Jimpo et al.[13] reported that the high frequency component of heart rate variability analysis, indicating parasympathetic activity, was significantly decreased immediately after RF ablation in the AVNRT. These alterations in heart rate variability analysis returned to the control level after one week or more. Similarly, Soejima et al.[14] reported that sinus rate was increased and parasympathetic activity was decreased after RF ablation of the AVNRT. The ratio of low-frequency to high-frequency power reflecting sympathovagal balance was increased in patients with AVNRT. Increases in sinus rate were correlated with decreases in high-frequency power and percent of adjacent cycles more than 50 ms apart indicating that the increase in heart rate was due to parasympathetic nervous withdrawal.[14] The parasympathetic withdrawal and relative increase in sympathetic tone may augment left atrial function in the short term.

This study has several limitations. First, the sample size is relatively small. The echocardiography alterations were evaluated in the short term. Various factors may affect short-term results, including induction of tachycardia, programmed electrical stimulation and the administration of sympathomimetic drugs. Therefore, further large-scaled studies are required for the assessment of long-term effects on cardiac mechanics.

In conclusion, in addition to treatment of arrhythmia, RF catheter ablation of the AVNRT may also restore left atrial function as early as 24 hours after the procedure.

Conflict-of-interest issues regarding the authorship or article: None declared

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Key words: Ablation; electrocardiography; tachycardia, atrioventricular nodal reentry; speckle tracking; strain.

Anahtar sözcükler: Ablasyon; elektrokardiyografi; taşikardi, atriyoventriküler nodal reenteran; benek takip; gerilim.