Junctional rhythm quantity and duration during slow pathway radiofrequency ablation in patients with atrioventricular nodal re-entry supraventricular tachycardia

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Aim The occurrence of accelerated junctional rhythm during radiofrequency energy delivery at the region of the slow pathway is a well-recognized marker of successful treatment of atrioventricular nodal re-entry tachycardia (AVNRT). Our aim was to evaluate if the quantity and duration of accelerated junctional rhythm during radiofrequency ablation of the slow pathway is correlated with residual slow pathway conduction.

Methods and results Forty consecutive patients with AVNRT undergoing radiofrequency ablation of slow pathway who developed accelerated junctional rhythm during ablation were included. We compared accelerated junctional rhythm quantity and duration between two groups: group A, without echo beats and group B, with echo beats on post-ablation electrophysiology study. The total amount of accelerated junctional rhythm was significantly greater in group A than in group B [75.0 (63.5–165.0) vs. 36.0 (24.0–65.0), \( P = 0.006 \)], as well as total duration of accelerated junctional rhythm [47.0 (33.5–81.0) s vs. 23.0 (16.0–42.0) s, \( P = 0.006 \)]. The cycle length of accelerated junctional rhythm did not differ between the two groups [510.0 (445.0–545.0) ms vs. 500.0 (450.0–585.0) ms, \( P = 0.5 \)].

Conclusions The amount and duration of accelerated junctional rhythm is correlated with the total abolishment abolition of slow pathway conduction. A higher amount and duration of accelerated junctional rhythm during radiofrequency applications may be an additional marker of successful ablation.

KEYWORDS
- Atrioventricular nodal re-entry tachycardia;
- Ablation;
- Junctional ectopy;
- Echo beats

Introduction

Radiofrequency ablation of the slow pathway is the most effective treatment for patients with atrioventricular nodal re-entry tachycardia (AVNRT).1,2

The final result of this treatment is the lack of supraventricular tachycardia (SVT) inducibility with or without single atrioventricular (AV) nodal echo beats. The occurrence of accelerated junctional rhythm during radiofrequency energy delivery at the region of the slow pathway is a well-recognized marker of successful treatment.3,4

The aim of this study was to evaluate if the quantity and duration of accelerated junctional rhythm during radiofrequency ablation of the slow pathway is correlated with residual slow pathway conduction.

Methods

A consecutive group of 40 patients with AVNRT undergoing radiofrequency ablation of the slow pathway at Rabin Medical Center electrophysiology laboratory who developed accelerated junctional rhythm during ablation were included. The primary endpoint of the ablation procedure—non-inducibility of AVNRT after provocative electrical and pharmacological manoeuvres—was achieved in all patients. There were 27 females and 13 males, with mean age 53.3 ± 16.1 years.

Electrophysiological testing and ablation procedure

Written informed consent was obtained from all patients. Electrophysiological study was performed in the fasting state after all antiarrhythmic agents had been discontinued for at least five half-lives. Standard recording methods, stimulation techniques, and definitions were used.1,2 In all cases, the same radiofrequency generator—Atakr® (Medtronic, Inc., Minneapolis, MN, USA) and same type of ablation catheter—Mariner (Medtronic, Inc.) were used.
Data were recorded and stored on optical disks for further analysis by the Electrophysiology Lab System (Biotronik, Berlin, Germany). Radiofrequency energy was delivered at the assumed slow pathway site along the septal portion of the tricuspid annulus, with atrial to ventricular ECG ratio <0.5, supported by appearance of fractionated atrial and, whenever present, discrete slow pathway potentials.1,2,4

The ablation protocol consisted of radiofrequency delivery pulses of 1 min duration between the distal tip of the ablation catheter and a posterior thorax patch electrode, delivered under closed-loop temperature control at 70°C using a thermostop-controlled system (preset power output 50 Watt).

Accelerated junctional rhythm was identified based on a QRS configuration and duration identical to that of sinus beats and preceded by a His bundle electrogram. Ventrículo-atrial conduction was defined as ventricular electrogram followed by an atrial electrogram. The cumulative number and duration (in seconds) of accelerated junctional rhythm for each case were recorded and correlated with residual slow pathway conduction at post-ablation electrophysiology study.

After radiofrequency ablation the persistence of AVN echo beats during programmed stimulation was considered as a criterion of residual slow pathway conduction.

No attempt was made to induce AVNRT after each radiofrequency delivery.

Electrophysiological testing was usually repeated after two to three radiofrequency energy deliveries where accelerated junctional rhythm was observed. If AVNRT was inducible, radiofrequency current applications were repeated. If AVNRT was not inducible (no more than a single AVN echo beat), no further current deliveries were applied. Programmed stimulation with isoprenaline infusion was repeated to test the non-inducibility of the tachycardia.

We defined two groups of patients based on the evidence of residual slow pathway physiology (induction of AVN re-entrant atrial echo beats) after the ablation procedure, and correlated with the amount and duration of the accelerated junctional rhythm (Table 1).

### Follow-up

The patients were followed in the outpatient clinic at 1, 3, 6, and 12 months after the ablation procedure. Holter monitoring was performed in patients complaining of palpitations.

### Statistical analysis

Data are presented as mean ± SD, median (25th; 75th percentiles) and proportions (percentages). Univariate comparisons between groups were made by Fisher’s exact test for categorical variables, two-tailed unpaired t-test or Mann-Whitney test for continuous variables. Probability value less than 0.05 was considered statistically significant.

### Results

#### Baseline characteristics

Clinical characteristics of the patients are shown in Table 2. Two patients had coronary artery disease and the remainder had no evidence of structural heart disease. All patients had normal systolic left ventricular function according to echo-Doppler examination.

### Results of radiofrequency ablation

The average number of radiofrequency ablations applied to each patient was 3.7 (3.0–5.5). Accelerated junctional rhythm appeared in all patients with cycle lengths between 380–850 ms. Median ablation temperature was 63.4 (52.3–70.0) °C. Median power output was 35.4 (27.2–46.7) Watts.

There was no difference between patients without and with evidence of residual slow pathway conduction in terms of age (50.4 ± 19.5 vs. 55.7 ± 12.8 years, respectively, P = 0.33). There were no gender differences between the two groups (Table 2).

The total amount of accelerated junctional rhythm was significantly greater in group A as well as total duration of accelerated junctional rhythm (Table 1). According to the scatter-plot cumulative amount of accelerated junctional rhythm, more than 175 beats can be considered as a marker of successful abolition of dual AVN conduction (Figure 1), but in our sample only three patients were in this range. The mean total duration of accelerated junctional rhythm was significantly greater in group A than in group B. There was an easily identifiable outlier that precluded the establishment of cut-off value for accelerated junctional rhythm duration. There was no difference in terms of number of ablation attempts and accelerated junctional rhythm cycle length (Table 1).

One patient in group A developed transient AV block and on follow-up there was no evidence of AVN dysfunction.

At follow-up of 1 year, there were two recurrences of AVNRT—both in group B. They were treated successfully with repeat slow pathway ablation with no evidence of residual slow pathway conduction.

### Table 1 Characteristics of the two groups without (group A) and with (group B) residual slow pathway conduction (echo beats)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group A (n = 17)</th>
<th>Group B (n = 23)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of ablation attempts</td>
<td>4.0 (3.0–4.5)</td>
<td>2.0 (2.0–3.0)</td>
<td>0.43</td>
</tr>
<tr>
<td>Number of accelerated junctional rhythm beats</td>
<td>75 (63.5–165.0)</td>
<td>36 (24.0–65.0)</td>
<td>0.006</td>
</tr>
<tr>
<td>Total duration of accelerated junctional ectopy (s)</td>
<td>47.0 (33.5–81.0)</td>
<td>23.0 (16.0–42.0)</td>
<td>0.006</td>
</tr>
<tr>
<td>Cycle length of junctional ectopy (ms)</td>
<td>510.0 (445.0–545.0)</td>
<td>500.0 (450.0–585.0)</td>
<td>0.53</td>
</tr>
</tbody>
</table>

Continuous variables are presented as median (25th–75th percentiles).

### Table 2 Demographic and clinical characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group A (n = 17)</th>
<th>Group B (n = 23)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>50.4 ± 19.5</td>
<td>55.7 ± 12.8</td>
<td>0.30</td>
</tr>
<tr>
<td>Male (%)</td>
<td>42.5</td>
<td>57.5</td>
<td>0.15</td>
</tr>
<tr>
<td>Coronary artery disease (%)</td>
<td>5.9</td>
<td>4.3</td>
<td>0.60</td>
</tr>
<tr>
<td>Symptoms during tachycardia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palpitations</td>
<td>79.3</td>
<td>81.6</td>
<td>0.82</td>
</tr>
<tr>
<td>Pre-syncope/syncope</td>
<td>10.2</td>
<td>13.5</td>
<td>0.84</td>
</tr>
<tr>
<td>Others</td>
<td>10.5</td>
<td>4.9</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Continuous variables are presented as median (25th–75th percentiles).
Discussion

The major finding of our study was that patients without residual slow pathway conduction (no echo beats) after AVNRT ablation had a greater amount and total duration of accelerated junctional rhythm than their counterparts with residual slow pathway conduction. During AVNRT ablation the total amount of accelerated junctional rhythm that exceeds 175 beats can be considered as a marker of successful abolition of dual AVN conduction.

The significance of residual slow pathway conduction in the prediction of AVNRT recurrence is an unresolved issue. Residual slow pathway conduction in the form of a persistent jump in the AV conduction time or atrial echo beats is a common finding after successful radiofrequency ablation of the slow pathway.1,2 In one recent large study, post-ablation jump or echo beats were observed in about 30% of cases and no correlation was observed with elimination of AVNRT.4 In the study of Manolis et al.,5 after successful ablation of slow pathway in patients with AVNRT, residual slow pathway conduction did not correlate with clinical tachycardia recurrences. However, the site of successful slow pathway ablation correlated with arrhythmia recurrences. They showed that AVNRT recurrences are rare (1%) when slow pathway radiofrequency ablation is performed in medial or anterior locations at the tricuspid annulus, rather than in infero-posterior sites.6

In contrast, the presence of residual slow pathway conduction and AVN echo beats after slow pathway ablation generally is believed to be associated with an increased risk of recurrent AVNRT.7,8 Even the absence of residual slow pathway conduction (echo beats) on the immediate post-ablation electrophysiology study does not necessarily ensure complete elimination of AVNRT.

Junctional tachycardia is accepted as a sensitive but non-specific marker of successful ablation.9–11 It appears in 75–92% of all AVNRT ablation attempts.1,12 The precise mechanism of junctional automaticity is not yet established. Several hypotheses13 were proposed: (i) the presence of a heat-sensitive area located above, or very close to, the compact AVN that is considered to induce the accelerated junctional activity;14 (ii) the injury current, which is conducted decrementally through the specialized tissues from the ablation site to the AV junctional area, enhances the diastolic depolarization of the pacemaker cells in the junctional area;15 (iii) the post-ganglionic release of noradrenaline from sympathetic nerve endings in excess of acetylcholine release from vagal nerve endings by the radiofrequency current, which may increase AV junctional automaticity by increasing the rate of diastolic depolarization.16

Junctional tachycardia with a faster rate and ventriculoatrial block was identified as a useful marker of impending AV block during slow and fast pathway ablation.9 In the study of Lipscomb et al.,17 fast junctional tachycardia with cycle lengths less than 350 ms seen during slow pathway modification was a predictor of conduction block, suggesting proximity to the compact node. In our study, accelerated junctional rhythm cycle length ranged from 380–850 ms.

Jentzer et al.3 characterized accelerated junctional rhythm during radiofrequency ablation of the slow pathway in patients with AVNRT. The bursts of accelerated junctional rhythm were significantly longer at effective target sites than at ineffective sites but there was considerable overlap in the number of accelerated junctional rhythm beats occurring during effective and ineffective energy applications, and it was concluded that quantification of the accelerated junctional rhythm is probably useless for predicting successful slow pathway ablation. In another study using multivariate analysis, the ablation site (mid-septal rather than posterior), duration of atrial electrogram (including slow pathway potential when present), and occurrence of accelerated junctional rhythm were independent predictors of success but not the characteristics of accelerated junctional rhythm.18 The univariate analysis revealed a longer duration and more peaks in the atrial electrogram with a lower AV ratio, and a higher incidence and shorter duration of accelerated junctional rhythm.
onset time of accelerated junctional rhythm during the energy delivery at successful than at unsuccessful target sites.\textsuperscript{19}

Wagshal \textit{et al.}\textsuperscript{20} compared different patterns of accelerated junctional rhythm. Higher ablation temperature resulted in the most successful slow pathway ablation and was characterized by the least duration and few accelerated junctional rhythm beats.\textsuperscript{20} Higher temperature lesions simultaneously abolished all slow pathway activity as well as the focus of accelerated slow pathway potential. They concluded that this accelerated junctional rhythm was specific for the slow pathway and was not a non-specific regional effect.

### Conclusion

In conclusion, we presume that induction of a higher amount and longer duration of accelerated junctional rhythm (with cycle length longer than 380 ms) results in more complete abolition of slow pathway conduction. The fact that longer periods of accelerated junctional rhythm correlated with the absence of slow pathway conduction after radiofrequency energy delivery suggests that every beat of this arrhythmia may represent a cumulative effect towards the success of the treatment. A greater amount of junctional rhythm may be indicative of a larger lesion, which results in abolition of AVN duality; however, this is not necessarily required to cure the arrhythmia. The combination of this sign with other accepted markers of successful AVNRT ablation may be used for the assessment of procedural result.

### Limitations

(i) This is a retrospective study and no strict protocol was used regarding the number of radiofrequency applications per treatment. No attempt was made to induce SVT or determine slow pathway conduction after each ablation delivery. Therefore, the influence and significance of radiofrequency deliveries without accelerated junctional rhythm is unknown, as well as the number of radiofrequency application needed to reach successful result.

(ii) The catheter tip location was guided anatomically and electrophysiologically and was not limited strictly to any of the specific regions of the Koch triangle. It is well-recognized that the different regions in this triangle have different electrophysiology properties. Posterior location is associated with the least occurrence of accelerated junctional rhythm during successful AVNRT ablations whereas a mid-septal location of the ablation catheter tip and occurrence of accelerated junctional rhythm were 100% specific for procedural success.\textsuperscript{19}

In further studies, the characterization of accelerated junctional rhythm must be addressed in correlation with successful distinct anatomical locations.

### References


