Risk of development of delayed atrioventricular block after slow pathway modification in patients with atrioventricular nodal reentrant tachycardia and a pre-existing prolonged PR interval

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Aims The objective of this prospective study was to assess risk factors for the development of atrioventricular block following slow pathway modification in patients with atrioventricular nodal reentrant tachycardia and a pre-existing prolonged PR interval.

Methods and Results Of 346 consecutive patients with atrioventricular nodal reentrant tachycardia undergoing slow pathway modification, 18 patients (62 ± 7 years; five females) were found to have a prolonged PR interval prior to ablation. Total elimination of the functional slow pathway was assumed if the antegrade effective refractory period following slow pathway modification was longer than the cycle length of atrioventricular nodal reentrant tachycardia. To detect atrioventricular node conduction disturbances, 24-h Holter recordings were performed 1 day prior to slow pathway modification, and 1 day, 1 week, 1, 3 and 6 months after the procedure. Six patients developed late atrioventricular block. The incidence of delayed atrioventricular block following successful slow pathway modification was higher in patients with, compared to patients without, prolonged PR interval at baseline (6/18 vs 0/328, P<0.001). In the former group, the antegrade effective refractory period was longer in patients with, compared to those without, a delayed atrioventricular block (492 ± 150 ms vs 332 ± 101 ms, P<0.05). The incidence of delayed atrioventricular block was higher in patients with total elimination of the slow pathway compared to patients without (5/7 vs 1/11, P<0.01).

Conclusions Slow pathway modification in patients with atrioventricular nodal reentrant tachycardia and a prolonged PR interval is highly effective. However, there is a significant risk of development of delayed atrioventricular block, particularly when the procedure results in total elimination of the slow pathway.


Key Words: Atrioventricular nodal reentrant tachycardia, radiofrequency catheter ablation, PR interval, atrioventricular block, complications.

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Introduction

Slow pathway modification for cure of atrioventricular nodal reentrant tachycardia (AVNRT) has been reported to be highly effective and safe, with an incidence of atrioventricular block of <1.5% in patients with atrioventricular nodal reentrant tachycardia and a normal PR interval[1–10]. However, in patients with atrioventricular nodal reentrant tachycardia and a pre-existing prolonged PR interval, only sparse data are available concerning the incidence and risk factors of delayed development of atrioventricular block during long-term follow-up after successful slow pathway modification[11–13]. For instance, Sra et al. reported no instances of second- or third-degree atrioventricular block in seven such patients[11]. However, in that study electrophysiological data in the seven patients were not compared with those obtained in patients with atrioventricular nodal reentrant tachycardia without PR prolongation; furthermore, no Holter recordings were done to document asymptomatic higher-degree atrioventricular block. The objective of the prospective study reported here was, therefore, to define prospectively the
characteristics of atrioventricular nodal reentrant tachycardia patients with a pre-existing prolonged PR interval and the incidence of and risk factors for the development of delayed atrioventricular block after successful slow pathway modification using repeated Holter monitoring.

Methods

Patient characteristics

The study population comprised 346 consecutive patients (53 ± 14 years; 221 females) undergoing radiofrequency catheter ablation for atrioventricular nodal reentrant tachycardia. Patients were divided into two groups: group A (18 patients; five women and 13 men, mean age 62 ± 7 years) with a pre-existing prolonged PR interval during sinus rhythm; group B (328 patients) without a prolonged PR interval. In group A, typical atrioventricular nodal reentrant tachycardia was present in 16 patients and atypical atrioventricular nodal reentrant tachycardia in the remaining two. All patients complained of paroxysmal palpitations with an average duration of symptoms of 11 ± 9 years. No patient had previously undergone fast pathway ablation for atrioventricular nodal reentrant tachycardia. Five patients had coronary artery disease, one patient had had prior aortic valve replacement, and one patient had dilative cardiomyopathy.

Electrophysiological study

All patients gave informed written consent for the electrophysiological study, which was performed after antiarrhythmic drugs had been discontinued for at least five half-lives. Three quadrupolar electrode catheters were inserted via the femoral vein and positioned in the high right atrium, the His bundle position and the right ventricle. A fourth 6F quadrupolar electrode catheter was positioned in the coronary sinus via the subclavian vein. Recordings were made utilizing a computerized multichannel system (BARD Labsystem 2.56). The filter range of the recorded electrograms was 30–250 Hz. The pacing stimuli were provided by a digital programmable stimulator (Biotronic UHS 20, Germany) at a pulse duration of 2 ms at twice the diastolic threshold. The atrioventricular nodal effective refractory period (at a cycle length (S1S1) of 600 ms, or 500 ms for cases with a fast baseline sinus rhythm), the atrioventricular block cycle length, the ventriculo-atrial block cycle length, and the retrograde atrioventricular nodal effective refractory period were determined. Dual atrioventricular nodal physiology was defined as a sudden prolongation of the A2H2 interval by >50 ms in response to a 10 ms decrease in the A1A2 interval. Programmed atrial stimulation using the S1S2 extrastimulus technique and atrial burst pacing were performed in order to induce atrioventricular nodal reentrant tachycardia. If atrioventricular nodal reentrant tachycardia could not be induced, isoproterenol was infused at 1–3 µg.min⁻¹, and the stimulation protocol was repeated. Diagnosis of atrioventricular nodal reentrant tachycardia was based on classic criteria[14].

Radiofrequency catheter ablation

The catheter used for ablation was a temperature-guided, quadrupolar 7 French catheter with a 4-mm distal electrode, 2–5–2 mm interelectrode spacing and a deflectable tip (Cordis Webster, U.S.A.). It was introduced percutaneously into the femoral vein, advanced to the right atrium and then positioned across the tricuspid valve. The radiofrequency energy was delivered during sinus rhythm as an unmodulated sinewave at a frequency of 500 kHz (Stockert epshuttle, Cordis Webster, U.S.A.). The radiofrequency current was delivered between the tip electrode and the indifferent path electrode positioned at the mid-posterior chest wall with a power setting of 30 W. According to the stepwise approach proposed by Jazayeri et al.[11], slow pathway modification was started low in the posteroseptal area, moving higher to the midseptal area in unsuccessful cases. The prospectively defined end-point of the procedure was non-inducibility of dual atrioventricular nodal physiology and atrioventricular nodal reentrant tachycardia. If dual atrioventricular nodal physiology persisted or one or more atrioventricular nodal echoes were observed during the control stimulation, at least two additional radiofrequency applications were delivered. Total elimination of the functional slow pathway was assumed if the antegrade atrioventricular nodal effective refractory period following slow pathway modification was longer than the atrioventricular nodal effective refractory period. If total elimination of the slow pathway was not attained after two additional radiofrequency applications, slow pathway modification was assumed.

Follow-up

After the procedure, patients were monitored continuously in the hospital for 24 h and regularly followed in the outpatient clinic. Twenty-four hour Holter recording was performed 1 day prior to slow pathway modification and 1 day, 1 week, 1, 3 and 6 months after the procedure. If palpitations or syncope occurred during the follow-up period, 24-h Holter monitoring was repeated immediately.

Statistical analysis

All data are displayed as the mean ± standard deviation (SD). The variables were compared using Student's
Table 1: Comparison of electrophysiological characteristics of patients with and without a prolonged PR interval before and after ablation

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Prior to ablation</th>
<th>After ablation</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Group A</td>
<td>Group B</td>
</tr>
<tr>
<td>Sinus rhythm–cycle length (ms)</td>
<td>798 ± 136</td>
<td>794 ± 149</td>
</tr>
<tr>
<td>PR (ms)</td>
<td>235 ± 28</td>
<td>154 ± 19</td>
</tr>
<tr>
<td>QRS (ms)</td>
<td>121 ± 24</td>
<td>103 ± 17</td>
</tr>
<tr>
<td>AH (ms)</td>
<td>156 ± 28</td>
<td>83 ± 16</td>
</tr>
<tr>
<td>HV (ms)</td>
<td>52 ± 7.4</td>
<td>45.8 ± 9.1</td>
</tr>
<tr>
<td>Dual AV nodal physiology</td>
<td>10/18</td>
<td>172/328</td>
</tr>
<tr>
<td>Antegrade-AV node effective refractory period (ms)</td>
<td>281 ± 55</td>
<td>255 ± 50</td>
</tr>
<tr>
<td>Antegrade-AV nodal Wenckebach block cycle length (ms)</td>
<td>378 ± 72</td>
<td>320 ± 60</td>
</tr>
<tr>
<td>Retrograde-AV node effective refractory period (ms)</td>
<td>277 ± 50</td>
<td>258 ± 59</td>
</tr>
<tr>
<td>Retrograde-AV nodal Wenckebach block cycle length (ms)</td>
<td>395 ± 66</td>
<td>325 ± 74</td>
</tr>
<tr>
<td>AVNRT cycle length (ms)</td>
<td>433 ± 56</td>
<td>358 ± 57</td>
</tr>
<tr>
<td>Ventriculo-atrial dissociation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ns = not significant.

t-test, chi-squared test or Fisher’s exact test as appropriate. A P value <0.05 was considered significant.

Results

Characteristics of patients with pre-existing PR prolongation

Comparison of clinical and electrophysiological data prior to slow pathway modification for patients with and without a prolonged PR interval are shown in Table 1. Patients with a prolonged PR interval were older (62 ± 7 vs 52 ± 15 years, P<0.0001), had a higher incidence of structural heart disease (8/18 vs 19/328, P<0.001) and of His-Purkinje disease (BBB, 7/18 vs 10/328 patients, P<0.001; duration of QRS, 121 ± 24 vs 103 ± 17 ms, P=0.01; HV interval, 52 ± 7.4 vs 45.8 ± 9.1 ms, P<0.001). They also had a longer antegrade atrioventricular nodal Wenckebach block cycle length (378 ± 72 vs 320 ± 60 ms, P=0.003) and atrioventricular nodal reentrant tachycardia cycle length (433 ± 56 vs 358 ± 57 ms, P<0.0001). After successful slow pathway modification, the antegrade atrioventricular nodal effective refractory period in group A patients was significantly longer than in group B patients (385 ± 139 vs 281 ± 67 ms, P=0.0056). There were no significant differences in success rate (18/18 vs 327/328 patients), in immediate higher degree atrioventricular block (0/18 vs 0/328 patients), or in recurrence rate (0/18 vs 2/328 patients) between either group.

Electrophysiological data and ablation results in patients with and without pre-existing PR prolongation

Successful slow pathway modification was performed in all patients with a prolonged PR interval. In 4/18 group A patients, slow pathway modification with 1–4 radiofrequency applications resulted in abolition of retrograde ventriculo-atrial conduction (two patients with uncommon and two patients with common atrioventricular nodal reentrant tachycardia). The PR interval did not change in any of these four patients. In the remaining 14 patients retrograde ventriculo-atrial conduction was still present after slow pathway modification. In 7/18 patients, the antegrade slow pathways were eliminated following radiofrequency application in the procedure. Detailed electrophysiological data for patients with and without delayed development of atrioventricular block are given in Tables 1 and 2.

The antegrade atrioventricular nodal effective refractory period (385 ± 139 vs 281 ± 55 ms, P<0.01 in group A; 281 ± 67 vs 255 ± 50 ms, P<0.001, in group B) and Wenckebach cycle length (459 ± 121 vs 378 ± 72 ms, P<0.025 in group A; 343 ± 67 vs 320 ± 60 ms, P<0.001 in group B) after ablation were significantly prolonged compared to those before ablation in both groups. The incidence of ventriculo-atrial dissociation after slow pathway modification was higher in group A than in group B.

Predictors of development of high degree atrioventricular block during follow-up

During baseline Holter recordings no episodes of atrioventricular block were detected. At the end of the observation period (12 ± 6 months), there were no instances of delayed atrioventricular block in group B patients. In contrast, intermittent higher degree atrioventricular block was documented in six group A patients; this difference was statistically significant (0/328 vs 6/18 patients, P<0.001). Delayed atrioventricular block occurred in three patients after 1 day, in two after...
1 week, and in one patient after 1 month following slow pathway modification (Figs 1 and 2). In five of the patients it was found during the night or in the early morning hours and was not associated with symptoms. The impairment of atrioventricular conduction persisted during the late follow-up of all patients. Second degree atrioventricular block occurred both during the day and at night in only one patient and was associated with symptoms that resulted in implantation of a DDDR pacemaker.

There were no significant differences concerning age, gender, PR-, AH-, or HV-interval, incidence of bundle branch block, antegrade effective refractory period and Wenckebach cycle length, retrograde atrioventricular nodal effective refractory period and Wenckebach cycle length in group A patients with or without delayed atrioventricular block following slow pathway modification. However, after slow pathway modification the antegrade atrioventricular nodal effective refractory period (492 ± 150 ms vs 332 ± 101 ms, \(P < 0.05\)) was longer and the antegrade atrioventricular nodal Wenckebach cycle length (550 ± 143 ms vs 414 ± 82 ms, \(P = 0.069\)) tended to be longer in patients with, than in patients without, delayed atrioventricular block. The incidence of delayed atrioventricular block was significantly higher in patients with total elimination compared with patients having modification of the slow pathway (5/7 vs 1/11, \(P < 0.01\)). There were no differences in the incidence of delayed atrioventricular block between patients with and without elimination of retrograde ventriculo-atrial conduction (2/4 vs 4/14, \(P = \text{ns}\)).

### Characteristics of patients with a prolonged PR interval

Few data are available about the characteristics of patients with atrioventricular nodal reentrant tachycardia and a prolonged PR interval. Sra et al.\(^{[11]}\) reported seven such patients with a mean age of 31 years; none of these patients had structural heart disease. Although slow pathway modification in these patients is effective, 33% of them may develop delayed atrioventricular block within 1 month. The atrioventricular node effective refractory period was significantly longer after slow pathway modification in patients with delayed atrioventricular block. The incidence of delayed atrioventricular block was higher if slow pathway modification resulted in complete elimination of the functional slow pathway.

### Risk factors of the development of delayed atrioventricular block

Radiofrequency catheter ablation is considered to be the first-line therapy for patients with symptomatic atrioventricular nodal reentrant tachycardia\(^{[15,16]}\) with a very low incidence of complications after slow pathway ablation.
However, procedural success and safety have not been well defined in atrioventricular nodal reentrant tachycardia patients with a prolonged PR interval. Preliminary data indicated that slow pathway modification was effective with a very low incidence of complications; in particular, the incidence of second- and third-degree atrioventricular nodal block after slow pathway modification was likely to be low if a posterior approach was used\(^{[11]}\). Recent data indicated a high incidence of complete atrioventricular nodal block after slow pathway modification\(^{[12]}\). Due to the small size of the patient group in that report\(^{[12]}\), the safety of slow pathway modification in this patient population could not be precisely assessed. No acute complete atrioventricular nodal block occurred in the present work but delayed higher degree atrioventricular block may develop. This risk was particularly relevant when the functional slow pathway was totally eliminated.

In our patients with a normal PR interval, 40 patients showed an antegrade effective refractory period longer than the atrioventricular nodal reentrant tachycardia cycle length following slow pathway modification. However, no delayed atrioventricular block occurred during follow-up in this patient group. One explanation is that the atrioventricular nodal reentrant tachycardia cycle length is shorter in this group and results in a shorter antegrade effective refractory period. It has been previously reported that slow pathway ablation in patients with atrioventricular nodal reentrant tachycardia and a prolonged fast pathway effective refractory period is safe and effective\(^{[17]}\). Therefore, the development of delayed atrioventricular block in group A may be mainly due to the different patient characteristics of older age\(^{[18]}\), a higher incidence of structural heart disease and of His-Purkinje disease.

**Comparison of slow and fast pathway modification**

In accordance with the findings of Sra et al.\(^{[11]}\), the slow pathway can be successfully modified without further
prolongation of the PR interval in patients with atrioventricular nodal reentrant tachycardia and a prolonged PR interval in the posterior or midseptal region. The successful sites were similar to those found in patients with atrioventricular nodal reentrant tachycardia and a normal PR interval. However, the retrograde pathway was eliminated during slow pathway modification in 4/18 patients (22%) with a prolonged PR interval in our series. If we consider only the patients with typical atrioventricular nodal reentrant tachycardia, 2/16 patients (13%) had ablation of the retrograde fast pathway. There was no difference in the incidence of delayed atrioventricular block in these compared to patients without elimination of the retrograde fast or slow pathway. It has been shown that lesions anterosuperior to the site of the larger His bundle deflection, near the apex of the Koch’s triangle, are usually effective in eliminating the fast pathway function. Preliminary reports[19–21] show the effectiveness and safety of fast pathway ablation in patients with atrioventricular nodal reentrant tachycardia and a prolonged PR interval. However, our results suggest that the retrograde fast pathway may be located close to the antegrade slow pathway in some patients.

**Conclusion**

Patients with atrioventricular nodal reentrant tachycardia and a prolonged PR interval are older with a higher incidence of structural heart disease and His-Purkinje disease. These characteristics may contribute to the risk of development of delayed atrioventricular block after slow pathway modification. Slow pathway modification in patients with atrioventricular nodal reentrant tachycardia and a prolonged PR interval is highly effective. However, if slow pathway modification results in complete elimination of the functional slow pathway, high-degree atrioventricular block is more likely to occur. Accordingly, our results do not support the concept of complete slow pathway elimination in those patients. Radiofrequency ablation can still be considered first-line therapy in patients with a long PR interval; however, it is recommended that non-inducibility of atrioventricular nodal reentrant tachycardia rather than total slow pathway elimination should be used as the appropriate end-point in this selected group of patients.

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**References**


