Fast pathway ablation in patients with common atrioventricular nodal reentrant tachycardia and prolonged PR interval during sinus rhythm

C. Reithmann, E. Hoffmann, A. Grünwald, P. Nimmermann, T. Remp, U. Dorwarth and G. Steinbeck

Medizinische Klinik I, Klinikum Großhadern, Universität München, Germany

Aims This study aimed to clarify the safety and efficacy of selective fast pathway ablation in patients with atrioventricular nodal reentrant tachycardia and a prolonged PR interval during sinus rhythm. Such patients have been reported to have an increased incidence of complete atrioventricular block.

Methods and Results In this study, the earliest retrograde atrial activation during atioventricular nodal reentrant tachycardia and right ventricular stimulation was localized. Fast pathway ablation was then performed in five patients with the common form of atrioventricular nodal reentrant tachycardia and a prolonged PR interval. Three of the five patients had almost incessant atrioventricular nodal reentrant tachycardia. Radiofrequency catheter ablation induced a complete ventriculo-atrial block during right ventricular stimulation in four patients and a marked prolongation of ventriculo-atrial conduction during right ventricular stimulation in one. Non-inducibility of common atrioventricular nodal reentrant tachycardia with and without isoproterenol was achieved in all five patients. The PR interval increased from $254 \pm 53$ ms to $276 \pm 48$ ms and the atrio-His interval from $172 \pm 46$ ms to $192 \pm 45$ ms. Second- or third-degree atrioventricular block did not occur during the ablation procedure. During the follow-up of $19 \pm 20$ months none of the patients developed symptoms suggestive of atrioventricular nodal reentrant tachycardia or evidence of second- or third-degree atrioventricular block.

Conclusion These data suggest that atrioventricular node (retrograde) fast pathway ablation can apparently be safely performed in patients with common atrioventricular nodal reentrant tachycardia and a prolonged PR interval during sinus rhythm.

(Eur Heart J 1998; 19: 929–935)

Key Words: Atrioventricular nodal reentrant tachycardia, atrioventricular block, catheter ablation.

See page 828 for the Editorial comment on this article

Introduction

Atrioventricular nodal reentrant tachycardia, in its typical form, consists of antegrade conduction via a slow pathway and retrograde conduction via a fast pathway. Catheter-directed radiofrequency ablation is considered to be the treatment of choice for patients with the drug-refractory condition\(^1\)\(^-\)\(^5\). Although both the fast and the slow pathway can be selectively ablated to control atrioventricular nodal reentrant tachycardia, slow pathway ablation has been shown to be the best at preventing the risk of second- or third-degree atrioventricular block\(^6\)\(^-\)\(^9\).

Radiofrequency catheter ablation has not been well defined in patients with atrioventricular nodal reentrant tachycardia and a prolonged PR interval during sinus rhythm. In a small group of seven young patients with common or uncommon atrioventricular nodal reentrant tachycardia and a prolonged PR interval (mean age 31 \pm 15 years), Sra \textit{et al.}\(^10\) accomplished slow pathway ablation without the occurrence of second- or third-degree atrioventricular block. In contrast, Ridgen \textit{et al.} demonstrated a high incidence of complete atrioventricular block (two out of seven patients) in elderly patients (mean age 70 \pm 8 years) with atrioventricular nodal reentrant tachycardia and a prolonged PR interval\(^11\). Recently, a case of fast pathway ablation was reported to be successfully performed without second- or third-degree atrioventricular block in a 73-year-old patient with common atrioventricular nodal reentrant tachycardia and a prolonged PR interval.
The following report describes the electrophysiological effects of fast pathway ablation in five patients with the common form of atrioventricular nodal reentrant tachycardia and a prolonged PR interval.

**Methods**

**Patients**

Among 220 consecutive patients undergoing radiofrequency catheter ablation for atrioventricular nodal reentrant tachycardia, five patients had a prolonged PR interval during sinus rhythm (mean 254 ± 53 ms, range 210 to 330 ms) (Table 1). The PR interval was constantly prolonged after the withdrawal of antiarrhythmic medication in all patients. Five patients were female with a mean age of 54 ± 17 years (range 32 to 77). They had had recurrent episodes of paroxysmal tachycardias for 13 ± 10 years and had received 3 ± 1 ineffective antiarrhythmic drugs. Three of these patients (patients 1, 2 and 4) had previously undergone fast pathway ablation for common atrioventricular nodal reentrant tachycardia at our or another institution. Symptoms had recurred 6 ± 3 weeks after the previous ablation. Three of the patients (patients 3, 4 and 5) were admitted to our institution with almost incessant atrioventricular nodal reentrant tachycardia. None of the five patients had structural heart disease.

**Electrophysiological study**

Written informed consent was obtained from all patients. All antiarrhythmic medication had been discontinued before the procedure for at least five half lives. Four multipolar electrode catheters were inserted percutaneously into the left and right femoral veins and were positioned in the high right atrium, His bundle region, in the coronary sinus and in the right ventricular apex.

Standard electrophysiological intervals were measured before and after radiofrequency ablation. The atrioventricular node effective refractory period and atrioventricular nodal Wenckebach cycle length could not be acquired in patients 3, 4 and 5. This was due to almost persistent tachycardias which initiated spontaneously after a short period of sinus rhythm or during basic atrial stimulation. The earliest right atrial activation during atrioventricular nodal reentrant tachycardia or right ventricular stimulation was recorded. To do this the His bundle electrode catheter was withdrawn from His bundle and positioned cranio-caudally and anteroposteriorly in order to map Koch's triangle. Surface electrocardiographic leads I, II, V1 and V3, intracardiac electrocardiograms and time lines were displayed simultaneously on a multichannel oscilloscope and were recorded on optical disks by the electrophysiological laboratory system (BioLab PRUCKA, U.S.A.). The electrophysiological study protocol consisted of decremental atrial and ventricular pacing and extra-stimulation of up to two premature atrial extra-stimuli or one premature ventricular extra-stimulus. In cases where atrioventricular nodal reentrant tachycardia could not be induced at baseline, tachycardia induction was attempted during isoproterenol infusion (1 to 4 μg . min⁻¹). At the end of the ablation procedure, inducibility of atrioventricular nodal reentrant tachycardia was tested in all cases with and without isoproterenol infusion.

Dual pathway physiology was defined by a sudden prolongation of the H1/H2 interval > 40 ms (with or without initiation of atrioventricular nodal reentrant tachycardia) in response to a 10 ms decrease in the A1/A2 interval.

**Catheter ablation**

A 4 mm-tipped standard ablation catheter (Cordis Webster) was used as the ablation catheter. Radiofrequency current was delivered between the distal

---

**Table 1 Electrophysiological data in patients with atrioventricular nodal reentrant tachycardia and first degree atrioventricular block undergoing fast pathway ablation**

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (years)</th>
<th>Before ablation</th>
<th>After ablation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PR (ms)</td>
<td>AH (ms)</td>
<td>ERP AV (ms)</td>
</tr>
<tr>
<td>1</td>
<td>32</td>
<td>220</td>
<td>130</td>
</tr>
<tr>
<td>2</td>
<td>46</td>
<td>210</td>
<td>170</td>
</tr>
<tr>
<td>3</td>
<td>77</td>
<td>290</td>
<td>190</td>
</tr>
<tr>
<td>4</td>
<td>60</td>
<td>330</td>
<td>240</td>
</tr>
<tr>
<td>5</td>
<td>53</td>
<td>220</td>
<td>130</td>
</tr>
</tbody>
</table>

PR=PR interval of surface electrocardiogram; AH=Atrio-His conduction interval; 1:1 AV=shortest atrial pacing cycle length at which atrioventricular conduction maintained a 1:1 relation; ERP AV=effective refractory period of atrioventricular conduction; ERP VA=effective refractory period of ventriculo-atrial conduction; AVNRT CL=cycle length of atrioventricular nodal reentrant tachycardia; HA AVNRT=His-atrial conduction interval during atrioventricular nodal reentrant tachycardia; VA block=complete ventriculo-atrial block during right ventricular stimulation; nd=not determined.

---

electrode of the ablation catheter and an external adhesive patch electrode. A 500 kHz radiofrequency ablation unit (Stockert, Cordis) was used for ablation. The current was initially applied at a power output of 5–10 W and, if no junctional ectopy or prolongation of the AH interval was seen, the power output was increased by 5 W every 10 to 15 s to a maximum output of 20–40 W. Delivery of impulse was guided by impedance control and was immediately stopped if an impedance rise was imminent or if the catheter was displaced. All patients underwent an electrophysiological evaluation 30 min after the successful ablation procedure. They received intravenous heparin for 24 h after the procedure.

**Results**

**Patient characteristics**

In all patients, sustained atrioventricular nodal reentrant tachycardia of the common type (cycle length 412 ± 101 ms) was induced by atrial premature stimulation with one extra-stimulus or initiated spontaneously. Patients 3, 4 and 5 had almost incessant atrioventricular nodal reentrant tachycardia before the ablation. Dual pathway physiology could not be demonstrated in any patient. In sinus rhythm, all patients had prolonged PR intervals (254 ± 53 ms) and prolonged atrio-His (AH) intervals (172 ± 46 ms). All patients had intact ventriculo-atrial conduction during right ventricular pacing before radiofrequency ablation. The His-atrial (HA) interval during atrioventricular nodal reentrant tachycardia was 79 ± 34 ms (range 40 to 130 ms).

**Fast pathway ablation**

The exact site of retrograde fast pathway conduction within Koch’s triangle was localized by mapping the earliest retrograde atrial activation during common atrioventricular nodal reentrant tachycardia and right ventricular stimulation. Similar positions were found in all five patients. In four patients, the earliest retrograde atrial activation, with respect to a reference signal (atrial retrograde activation in proximal coronary sinus), was found in an anterior position with a large His bundle potential. During sinus rhythm, the catheter was withdrawn while maintaining clockwise torque until the amplitude of the atrial electrocardiogram exceeded that of the ventricular electrocardiogram and the His bundle potential was minimal (Fig. 1). In one patient (patient 3) the earliest retrograde atrial activation was found in a midseptal position. In this position, no His bundle potential was seen.

To avoid catheter contact with the His bundle, radiofrequency current application was performed during sinus rhythm under constant fluoroscopic control. Termination of radiofrequency current application was guided by (1) development of visible prolongation of the AH interval, (2) development of an accelerated junctional rhythm or (3) a maximum duration of energy delivery of 80 s. Elimination of fast retrograde ventriculo-atrial conduction during right ventricular pacing was required as the end point of the ablation procedure (Fig. 1). A mean of 5.8 ± 3.7 radiofrequency ablations (mean ± SD, range 30 ± 6 W, range 20–40, for 15–80 s) was performed.

Immediately after the ablation procedure, retrograde ventriculo-atrial conduction was eliminated in all patients. However, it resumed during right ventricular pacing with a cycle length of 600 ms after 30 min in one patient (patient 2) under isoprenaline infusion (2 µg·min⁻¹) with a marked prolongation (80 ms) of the ventriculo-atrial interval (Fig. 2). Complete ventriculo-atrial block with or without isoprenaline persisted after 30 min in the remaining four patients.

The common type of atrioventricular nodal reentrant tachycardia, either as a sustained tachycardia or as a single echo beat, was absent after fast pathway ablation in all five patients. Under isoproterenol infusion (2 µg·min⁻¹) an uncommon type of atrioventricular nodal reentrant tachycardia (slow-slow conduction) was inducible in patient 2.

After radiofrequency ablation, the PR interval was significantly prolonged from 254 ± 53 ms to 276 ± 48 ms and the AH interval from 172 ± 46 ms to 192 ± 45 ms (P<0.05). The atrioventricular node effective refractory period and atrioventricular node Wenckebach cycle length could only be determined in two of the patients before catheter ablation (Table 1).

**Follow up**

The common type of atrioventricular nodal reentrant tachycardia could not be induced in any patient during electrophysiological evaluation performed 30 to 60 min after the ablation. One patient (patient 3) developed atrial tachycardia one day after the ablation. During a follow-up to 19 ± 20 months (range 7 to 53 months) no patient had recurrence of symptoms suggestive of atrioventricular nodal reentrant tachycardia or evidence of second- or third-degree atrioventricular block.

**Discussion**

Radiofrequency catheter ablation has evolved as the therapeutic method of choice in patients with drug-refractory atrioventricular nodal reentrant tachycardia [8-5]. The frequency of the occurrence of patients with prolonged PR intervals during sinus rhythm among those with common atrioventricular nodal reentrant tachycardia is low and apparently amounts to about 2-3% [10,11]. At present, there are only limited data on the safety of slow pathway ablation in patients with atrioventricular nodal reentrant
Incessant common atrioventricular nodal reentrant tachycardia with a prolonged PR interval. Electrograms were recorded at electrophysiological study. (a) Incessant common atrioventricular nodal reentrant tachycardia with a cycle length of 430 ms (left). In sinus rhythm, the AH interval was prolonged (240 ms) before catheter ablation. The ablation catheter was withdrawn from the His bundle position while maintaining clockwise torque until the amplitude of the atrial electrogram exceeded that of the ventricular electrogram and the His bundle potential was minimal (ABL) (right). (b) After (retrograde) fast pathway ablation, the AH interval was unchanged or only minimally increased (left). During right ventricular stimulation there was a complete ventriculo-atrial block showing successful fast pathway ablation (right). During the 19 months of follow-up the patient developed no symptoms suggestive of a supraventricular tachycardia. Surface leads I, II, V1, and V3 are shown simultaneously with intracardiac recordings from the high right atrium (HRA), His bundle (HBE), coronary sinus (CS), right ventricular apex (RV) and the position where the fast pathway ablation could be successfully performed (ABL).

Figure 1 Fast pathway ablation for common atrioventricular nodal reentrant tachycardia in a patient (patient 4) with a prolonged PR interval. To our knowledge, only one case report\cite{12} has been published concerning the effect of fast pathway ablation for common atrioventricular nodal reentrant tachycardia with pre-existing first-degree atrioventricular block. In this study, among five patients with atrioventricular nodal reentrant tachycardia and prolonged PR intervals three patients had previously undergone fast pathway ablation. Goldberger et al. had recently reported a series of six patients who had various forms...
Figure 2  Fast pathway ablation for common atrioventricular nodal reentrant tachycardia in a patient (patient 2) with a prolonged PR interval. Electrograms were recorded at electrophysiological study: (a) Induction of common atrioventricular nodal reentrant tachycardia by premature atrial stimulation (A1–A1: 600 ms, A1–A2: 420 ms). At sinus rhythm, the AH interval before ablation was 170 ms (not shown). (b) Right ventricular stimulation with a short ventriculo-atrial interval before ablation (left). After fast pathway ablation there was a 1:1 ventriculo-atrial conduction with a prolonged ventriculo-atrial interval (under 2 μg . min⁻¹ isoproterenol) (right). Without isoproterenol, there was a complete ventriculo-atrial block (not shown). The AH interval was prolonged after ablation from 170 ms to 210 ms (not shown). During the follow-up of 7 months the patient developed no symptoms suggestive of a supraventricular tachycardia. Surface leads I, II, V₁ and V₃ are simultaneously shown with intracardiac recordings from the high right atrium (HRA), His bundle (HBE), coronary sinus (CS) and the right ventricular apex (RV).
of uncommon atrioventricular nodal reentrant tachycardia following prior fast pathway ablation. The retrograde limb of the atypical atrioventricular nodal reentrant tachycardia had been shown in all six patients to be posterior slow pathway. A further anterior approach was reported to result in complete atrioventricular block in one of the six patients. Among the seven patients with atrioventricular nodal reentrant tachycardia and a prolonged PR interval reported by Sra et al., two patients had previously undergone fast pathway ablation and presented with uncommon atrioventricular nodal reentrant tachycardia. The authors suggested that the occurrence of uncommon atrioventricular nodal reentrant tachycardia after prior fast pathway ablation indicates that the retrograde limb of the common atrioventricular nodal reentrant tachycardia (retrograde fast pathway) was effectively abolished. Sra et al. proposed that the posterior approach may be the first-choice treatment for the ablation of uncommon atrioventricular nodal reentrant tachycardia after previous fast pathway ablation.

The data reported here indicated that all five patients with atrioventricular nodal reentrant tachycardia and first-degree atrioventricular block had a common atrioventricular nodal reentrant tachycardia, with the AH interval being longer than the HA interval and with the earliest retrograde atrial activation being found in the anterior septum. The occurrence of common atrioventricular nodal reentrant tachycardia with a prolonged PR interval after prior fast pathway ablation suggests unidirectional antegrade prolonged conduction or complete antegrade fast pathway block, despite rapid retrograde conduction along the fast pathway. This may also be the cause of the prolonged PR interval in the two other patients with common atrioventricular nodal reentrant tachycardia and prolonged PR intervals without prior fast pathway ablation.

It has previously been suggested that the location of the antegrade fast atrioventricular nodal pathway may not be identical with that of the retrograde counterpart in some patients. This may explain why in some patients it is possible to ablate retrograde fast pathway conduction without affecting fast antegrade conduction.

The prolongation of the PR interval in patients with common atrioventricular nodal reentrant tachycardia indicates that the antegrade fast pathway in these patients may be damaged or even non-existent. As a complete antegrade atrioventricular nodal fast pathway block cannot be excluded in patients with common atrioventricular nodal reentrant tachycardia and first-degree atrioventricular nodal block without dual atrioventricular nodal physiology, it seems reasonable to prefer (retrograde) fast pathway ablation in these patients. In the five patients described in this study, fast pathway ablation could be safely performed eliminating atrioventricular nodal reentrant tachycardia. Complete ventriculo-atrial dissociation during right ventricular stimulation was accomplished in four of the five patients. In one patient (patient 2) slow retrograde atrioventricular nodal conduction and the inducibility of a slow-slow tachycardia under isoproterenol infusion was demonstrated after the ablation procedure. However, during the follow-up of 7 months the patient was free of symptoms suggestive of supraventricular tachycardia.

It appears that in elderly patients the risk of complete atrioventricular block is markedly increased after slow pathway ablation in patients with common atrioventricular nodal reentrant tachycardia and a prolonged PR interval. On the basis of the limited data presented in this study, no firm guidelines can be proposed. However, fast pathway ablation can apparently be safely performed in patients with a prolonged PR interval in sinus rhythm and without dual atrioventricular nodal physiology. As also outlined by Varotto et al., it seems to be important to exactly map Koch’s triangle before fast pathway ablation in order to localize the earliest atrial activation during atrioventricular nodal reentrant tachycardia. Selective ablation of the retrograde limb of common atrioventricular nodal reentrant tachycardia (retrograde fast pathway) may thus decrease the risk of complete atrioventricular block in patients with common atrioventricular nodal reentrant tachycardia and a prolonged PR interval.

References


