Increased resting heart rate following radiofrequency catheter ablation for atrial fibrillation

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Abstract Aim Sinus tachycardia has been observed following radiofrequency (RF) catheter ablation for various kinds of supraventricular tachycardia. This study is aimed at determining the occurrence of changes in sinus-rhythm heart rate (HR) after pulmonary vein (PV) isolation in patients with paroxysmal/persistent atrial fibrillation (AF), prospectively.

Methods Patients with a history of AF underwent segmental or circumferential isolation of the PVs. A total of 62 consecutive patients, mean age 55 ± 10, was included. Clinical evaluation was performed before and one, three, six, nine, and 12 months following the procedure.

Results Following PV isolation, the mean HR significantly increased from 58 ± 10 bpm at baseline to 67 ± 12 bpm at one month, 71 ± 13 bpm at three months, 69 ± 12 bpm at six months, 69 ± 13 at nine months, and 70 ± 13 at 12 months follow-up. The ablation success significantly correlated with the increase in HR at one month follow-up. In three patients the mean HR increased >25 bpm resulting in symptoms necessitating therapy with rate-controlling drugs.

Conclusion PV isolation in patients with AF may result in increased HR, which positively correlated with the ablation success. This change does not seem to resolve spontaneously after a follow-up of 12 months. Approximately 5% of patients may develop symptoms due to an increased HR, necessitating treatment with rate-controlling drugs.

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Introduction

PV isolation is an emerging curative therapy for patients with drug-refractory paroxysmal or persistent AF, and after antiarrhythmic medication, it may be considered to be the second choice of treatment. Sinus tachycardia is a well-known complication of RF ablation of various kinds of supraventricular tachycardia [1–7]. Although the precise mechanism of this complication is still uncertain, it has been suggested that autonomic dysfunction, caused by destruction of parasympathetic fibres innervating the sinus node, may be a contributing factor [8]. PV ablation in patients with AF may involve extensive ablation in the left atrium. The aim of this prospective study was to evaluate the effect of segmental and circumferential PV isolation on the resting heart rate (HR) of patients with paroxysmal/persistent AF.

Methods

Patients and study design

The study population consisted of 62 consecutive patients (age 55 ± 10 years; 44 men), presenting with sinus-rhythm (SR), referred for RF ablation of drug-refractory paroxysmal or persistent AF at the Rigshospitalet, Copenhagen University, in the period November 2002–July 2004. The patients were randomised in a 1:1 ratio for circumferential (n = 25, 40%) or segmental (n = 37, 60%) PV isolation. Only patients with ECGs exhibiting SR were included in the results. Patients fulfilling the following criteria were excluded from the ablation procedure: congenital heart disease, younger than 18 years, significant valve disease, left ventricular ejection fraction (EF) < 20%, and New York Heart Association class IV. The patient characteristics and clinical history, including antiarrhythmic medication, are summarized in Table 1. Antiarrhythmic drugs considered in this assessment were any agent in Vaughan Williams classes I–IV (Table 2).

The Local Ethics Committee approved the study, and all patients gave written informed consent before study entry.

The ablation procedure

During segmental PV isolation, the left atrium and PVs were mapped after transseptal catheterization with two catheters: a circular mapping catheter (Lasso, Biosense Webster) and a 5-mm quadripolar saline irrigated mapping/ablation catheter (Celsius thermo-cool, Biosense Webster). The ablation targeted regions of the earliest PV activation until complete elimination of PV-muscle conduction distally to the ablation line. To confirm complete PV isolation following both procedures, remapping was performed in at least four different places in each PV approximately 30 min following the final RF application.
Table 2  Number of patients and antiarrhythmic medication including digoxin used before compared with one, three, six, nine and 12 months following the ablation procedure (count (%))

<table>
<thead>
<tr>
<th>Patients (n)</th>
<th>Before ablation</th>
<th>One month</th>
<th>Three months</th>
<th>Six months</th>
<th>Nine months</th>
<th>12 months</th>
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<td>58</td>
<td>50</td>
<td>40</td>
<td>33</td>
<td>18</td>
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<td>9</td>
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<td>11</td>
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Class I–IV refers to Vaughan Williams classification of antiarrhythmic drugs.

Statistical analysis

The paired Student’s t-test was used to compare changes in HR over time. Statistical significance was established at $P < 0.05$. Means are reported ± SD. All statistics were calculated using the SPSS programme, version 11.5.

Results

Successful PV isolation was achieved in all patients, except two. Forty-five patients (73%) underwent two ablation sessions (circumferential: 72%, and segmental: 73%), all with complete PV isolation. In 34 patients (55%), additional ablation was performed: ablation of non-PV triggers of AF ($n = 26$), isolation of the superior ($n = 26$) and inferior vena cava ($n = 26$), and ablation of an accessory pathway ($n = 26$). The duration of the primary procedure was significantly longer in circumferential compared with segmental PV isolation (166 ± 28 versus 138 ± 32 min, respectively, $P < 0.001$). A similar but less pronounced difference was found at the reablation procedure (115 ± 35 versus 99 ± 30, $P = 0.06$). During a follow-up period of 8.8 ± 3.6 months a total of 27 patients (44%) experienced no recurrent AF. No significant difference was found in patients with paroxysmal compared with persistent AF (49% versus 33%, $P = 0.19$).

Treatment with antiarrhythmic drugs before and during the follow-up period is given in Table 2, classified according to Vaughan Williams classification. Changes in doses of the antiarrhythmic drugs, relative to study entry, are given in Fig. 1. One month following the procedure, a total of 41 of 62 patients (66%) had no change in antiarrhythmic drug preparation, 12 (19%) had an increase, and nine (15%) had a reduction. The rest of the study period, approximately 70% had a reduction in antiarrhythmic medication compared with pre-ablation; the remaining 30% was equally divided between patients with no change and those with an increase in medication.

The mean HR significantly increased from 58 ± 10 bpm at baseline to 67 ± 12 bpm at one month (change: 9 ± 10, $P < 0.001$), 71 ± 13 bpm at three months (change: 13 ± 15, $P < 0.001$), 69 ± 12 bpm at six months (change: 12 ± 14, $P < 0.001$), 69 ± 13 at nine months (change 13 ± 16, $P < 0.001$), and 70 ± 13 at 12 months (change 10 ± 16, $P = 0.016$) after the PV isolation.
Figure 2. Change in antiarrhythmic medication at different follow-up times compared with before ablation. Antiarrhythmic medication: unchanged (black bars), increased (white bars), and reduced (grey bars).

(Fig. 2). In patients \((n = 41)\) with no change in medication at one month follow-up, the HR increased from \(57 \pm 10\) at baseline to \(66 \pm 11\) at one month (change \(9 \pm 9, P < 0.001\)). Among patients \((n = 12)\) with an increased dose of antiarrhythmic medication at one month follow-up, only two patients experienced a reduction in HR, and overall the HR increased from \(59 \pm 8\) to \(65 \pm 13\) (change \(5 \pm 14, P = 0.276\)). Among patients with a reduced dose of antiarrhythmic drugs at one month follow-up, the HR increased from \(59 \pm 8\) to \(71 \pm 14\) (change \(12 \pm 14, P = 0.013\)).

One month after the procedure, a total of 40 of 58 patients (69%) had an increase in HR of \(\leq 5\) bpm (Fig. 3); 19 of these patients (48%) noticed the increased HR at rest. However, three months after the ablation, only three patients (age: 33, 44, and 74 years) all with an HR increase \(> 25\) bpm in the absence of medication, experienced adverse symptoms such as palpitations and dyspnoea during exercise. In these three patients, circumferential

PV isolation was performed in one, and segmental PV isolation in the other two. Before PV isolation only one of the three patients was treated with an antiarrhythmic drug (Sotalol). A 14 day Holter monitoring approximately three months after PV isolation showed a minimum, mean, and maximum HR as follows: patient 1: 80, 99, and 135; patient 2: 77, 99, and 143 (on calcium antagonist); patient 3: 78, 98, and 141. Additional treatment with calcium antagonist and digoxin resulted in a decrease in resting HR with subsequent symptom alleviation.

There was no significant relation between overall increase in HR at baseline compared with one month follow-up according to the method of PV isolation (segmental: \(9 \pm 12\) versus circumferential \(9 \pm 8, P = 0.94\)), number of procedures (one procedure: \(12 \pm 8\) versus two procedures: \(8 \pm 11, P = 0.22\)), or additional ablation (no additional ablation \(8 \pm 9\) versus \(12 \pm 13, P = 0.19\)). However, patients with no recurrent AF experienced a significant increase in HR compared with SR phase recordings from patients with recurrent AF (\(13 \pm 10\) versus \(6 \pm 10, P = 0.011\)).

Two patients experienced transient cerebral ischaemia, one in each ablation group. In both patients the symptoms resolved within a few days. No other major complications, especially no pulmonary vein stenosis, were observed in the acute phase or during follow-up.

Discussion

The main finding of the present study is that PV isolation for AF may result in an increase in resting HR. The mean HR significantly increased from \(58\) bpm at baseline to \(67\) bpm, one month after the ablation procedure (66% of the patients were on the same medication in the same dose). After
discontinuation of antiarrhythmic drugs the mean resting HR increased to approximately 70 bpm throughout the rest of the follow-up period of 12 months.

Increased HR has been observed following ablation of slow pathway of the atrioventricular node and the septal accessory pathway [1–7]. There have been three studies which reported an increase in HR following ablation for AF [9–11]. Hsieh et al. [9] reported an increase in mean and maximal sinus rate of 10–16 bpm one week following focal ablation inside the PVs for treatment of AF, but the HR returned to the baseline level one month after ablation. Khaykin et al. [10] performed segmental PV isolation in 31 patients with AF and sick sinus syndrome. Similar to our study, PV isolation was considered successful after abolition of the PV potentials during SR or atrial pacing. Overall, they reported an increase in mean, minimum, and maximum HR after up to six months follow-up. Again, similar to our study, the minimum HR increased from 40 ± 10 bpm at baseline to 52 ± 8 bpm after PV isolation. Pappone et al. [11] reported a slight increase in HR (5–9 bpm) following circumferential PV ablation for AF, where two additional ablation lines were performed in the posterior left atrium, and one ablation line was placed in the mitral isthmus to prevent postablation LA flutter. In addition, if a vagal reflex was elicited, RF energy was delivered until such reflexes were abolished. The increased HR persisted for only three months, with return to baseline at six months follow-up. However, some differences in the ablation techniques exist between the method of Pappone et al. [11] and the present study, which in part could explain this difference. Pappone et al. performed PV ablation with an end point defined according to the following criteria: (1) low peak-to-peak bipolar potentials (<0.1 mV) inside the lesion and (2) a local activation time delay > 30 ms between contiguous points lying in the same axial plane across the line. We used an end point defined as elimination of electrical conduction into the PV area distal to the ablation line in both circumferential and segmental PV isolation. This may create deeper lesions with a more extensive destruction of the vagal fibres causing a more pronounced and persistent HR increase. This is in accordance with the prevailing theory that an increased HR following ablation for supraventricular tachycardias is caused by autonomic dysfunction due to lesions of the parasympathetic nerve fibres [7], which is known to influence the sinus rate, the atrial refractory period, and atrioventricular conduction [12]. Another possible pathophysiological mechanism may be mediated by the cardiocardiac reflex [13–15]. This reflex, typically seen following myocardial infarction, is caused by an increased sympathetic and decreased vagal activity due to changes in chamber geometry. However, this is more speculative as ablation for AF does not seem to cause significant changes in chamber volume [16].

Another interesting finding in the present study was a significant correlation between the increase in HR at one month follow-up and recurrent AF. This is in accordance with the finding by Pappone et al. [17], again possibly due to deeper, transmural lesions in the atrial myocardium, eventually destroying vagal fibres. This could normalize the imbalance in the autonomic system required to trigger and maintain AF. Finally, a high rate of recurrent AF was found. However, a possible explanation could be that more than one third of our patients were suffering from persistent AF compared with 0–20% in earlier studies) who are known to have a significantly worse outcome compared with patients with paroxysmal AF. In addition, all our patients were offered another ablation in case of only one episode with recurrent AF, even if the episode had short duration or occurred early after the primary ablation session.

In order for a new therapy to be thoroughly evaluated, all possible complications must be clarified in order to arrive at a well-founded treatment policy. In the present study, the prevalence of symptomatic HR increase was 4.8%, consistent with previous reports regarding ablation of supraventricular tachycardias [1,2,4,5,9,18]. Patients considered for ablation of AF should be informed of this complication that eventually may cause symptoms and re-initiation of frequency-limiting drugs.

**Study limitations**

Not all patients had the same dose of antiarrhythmic drugs during the first month after the procedure, which may have had an influence on the results. However, one month following the ablation, only 15% had a reduced dose of antiarrhythmic medication, and among the 10 patients (19%) with an increase in dosage, only two patients experienced a reduction in HR following the ablation procedure(s). Although, the change in mean HR seems to be independent of drug dose, our results from follow-up beyond one month should be taken with reservation due to the change in antiarrhythmic medication. However, continued medication in case of no recurrent AF following ablation cannot be justified. The HR was determined from a 12-lead ECG, and not from a 24-h ECG monitoring. However, we find our method of...
analysis acceptable, as all the results were obtained under the same conditions. The study population is heterogeneous in clinical and procedural characteristics. However, increased HR was a consistent finding across the study population despite these differences. Lastly, only ECGs obtained in an SR phase were evaluated, as the physiological interpretation of the findings would otherwise be unclear.

Conclusions

PV isolation in patients with AF may result in increased HR, which is probably positively correlated with ablation success. This change does not seem to resolve spontaneously during the first six months. Approximately 5% of patients may develop symptoms due to an increased HR, necessitating treatment with frequency-limiting drugs. Patients undergoing PV isolation for AF should be informed of this possible complication.

References