Safety and efficacy of cryoablation of atrial tachycardia with high risk of ablation-related injuries

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Aims The purpose of this study was to evaluate the safety and efficacy of cryoablation as an alternative to radio frequency (RF) ablation in high-risk-located atrial tachycardia (AT).

Methods and results Between 2004 and 2007, 164 patients underwent catheter ablation due to AT at our institution. Twenty-six of these patients (22 women and 4 men), median age 58 years (range 14–76), were considered having high-risk-located AT and were treated by cryoablation. Seven patients had failed prior RF ablation due to high risk of complications. The AT foci distribution was: close to the AV node (n = 14), vicinity of the sinus node (n = 7), and crista terminalis adjacent to the phrenic nerve (n = 5). Cryomapping, using a 6 mm tip catheter, at -30 °C was performed before ablation with a goal temperature of -80 °C for 240 s. Acute success rate was achieved in 25/26 patients (96%). During a follow-up of 493 ± 258 days, three patients had recurrences. Two of these underwent a second successful cryoablation procedure. Long-term success rate was 92%. Phrenic nerve palsy occurred in two patients with complete recovery after 1 day and 5 months, respectively.

Conclusion Cryoablation of high-risk-located AT foci is a safe and effective alternative to RF therapy.

Keywords Cryomapping • Cryoablation • Atrial tachycardia • High-risk location • Complication

Introduction

Radio frequency (RF) ablation has a high success rate with few complications in patients with focal atrial tachycardia (AT).1–5 However, RF ablation of arrhythmia substrates originating from the vicinity of the atrioventricular (AV) node, sinus node (SN), and phrenic nerves poses specific challenges to electrophysiologists, including the risk for AV block, SN dysfunction, and phrenic nerve palsy.6,7 Cryoablation of supraventricular arrhythmias is an alternative to RF therapy.8,9 Cryothermal energy has the advantage of reversible cryothermal mapping, decreased thrombus risk, increased catheter stability, and decreased risk of injury to vascular structures.10–15

This study evaluates the safety and efficacy of cryoablation in high-risk-located AT foci.

Methods

Patients

The study population consisted of all patients undergoing a first transvenous catheter ablation procedure for high-risk-located AT using cryothermal energy between May 2004 and July 2007. During this period, 164 patients underwent transvenous catheter ablation of AT at our institution. Twenty-six of these patients were considered having high-risk-located AT and constituted the study population (Table 1).

High-risk location AT was defined as follows.

Atrial tachycardia near the atrioventricular node

Atrial tachycardia originating near the AV node or the His bundle is characterized by the presence of His-bundle potential in the local
Electrogram or by fluoroscopic proximity of the ablation site to the His-bundle, excluding AV nodal re-entrant tachycardia (AVNRT) and AV re-entrant tachycardia (n = 14). For detailed electrophysiological (EP) characteristics, see Table 2.

**Atrial tachycardia near sinus node**

Atrial tachycardia originating from the SN complex is located at the superior aspect of the crista terminalis with identical or almost identical P wave and intracardiac activation sequence during tachycardia and sinus rhythm (n = 7) (Figure 1).

**Atrial tachycardia near phrenic nerve**

Atrial tachycardia originating along the lateral right atrium and high output (10 mA) pacing resulted in phrenic nerve stimulation (n = 5).

Seven subjects (27%) had undergone a previous EP study without RF ablation attempt due to an estimated high risk of injuries to vital structures.

### Electrophysiological study and ablation procedure

Anti-arrhythmic medication was discontinued five half-lives before the study. All procedures were performed under light sedation, in the fasting state. A 12-lead surface ECG during AT was obtained and analysed. The P-wave morphology was assessed to predict the site of origin.16

A conventional diagnostic EP study was performed, and the diagnosis of AT was confirmed. Isoproteronol infusion was used when the tachycardia was not inducible at baseline. An 8 Fr 6 mm cryocatheter Freezor Extra (CryoCath Technologies, Montreal, Quebec, Canada) was advanced to the area of interest. The arrhythmia substrate was mapped by combining electrogram analysis and anatomical location.

A non-contact mapping system (Ensite, St Jude Medical, St Paul, MN, USA) was used for mapping and ablation of AT near the SN (Figure 1).

In cases with AT foci along the lateral right atrium, fluoroscopy was performed every 10–15 s during cryoablation to observe the respiratory motion of the right hemidiaphragm and the ablation was stopped if impairment was seen.

At potential target sites, cryomapping at –30°C for a maximum of 20 s was performed. If AT became non-inducible or tachycardia terminated, cryoablation with a goal temperature of –80°C for 4 min was performed. The AV nodal conduction and sinus cycle length were continuously monitored during cryomapping and cryoablation.

Procedural success was defined as non-inducibility 30 min after the last cryoapplications.

The ablation procedures were part of the clinical treatment to which the patients gave their informed consent. The study was approved by the Institutional Ethics Committee.

### Follow-up

Clinical follow-up was based on outpatient visits, medical record review, or telephone contact. In addition, a symptom questionnaire was sent to all patients in September 2007. Patients were queried about recurrence of arrhythmia symptoms and, if so, they were asked to describe these symptoms. If recurrent arrhythmia was

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**Table 1 Patient characteristics**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Number (%)</th>
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</thead>
<tbody>
<tr>
<td>Total</td>
<td>26</td>
</tr>
<tr>
<td>Women</td>
<td>22 (85%)</td>
</tr>
<tr>
<td>Men</td>
<td>4 (15%)</td>
</tr>
<tr>
<td>Age (years); median (range)</td>
<td>58 (14–76)</td>
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<tr>
<td>No underlying heart disease</td>
<td>21 (81%)</td>
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<tr>
<td>Hypertension</td>
<td>2</td>
</tr>
<tr>
<td>VOC</td>
<td>1</td>
</tr>
<tr>
<td>Fallots anomaly</td>
<td>1</td>
</tr>
<tr>
<td>HOCMP</td>
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</tr>
</tbody>
</table>

HOCMP, hypertrophic obstructive cardiomyopathy; VOC, vitium organicum cordis.

**Table 2 Electrophysiological characteristics of patients with atrial tachycardia near the atrioventricular node**

<table>
<thead>
<tr>
<th>Patient number</th>
<th>Site of AT origin</th>
<th>His-bundle potential in ablation catheter</th>
<th>Dual AVN pathway physiology</th>
<th>Slow pathway ablation</th>
<th>VA block at baseline</th>
<th>Variable VA interval during tachycardia</th>
</tr>
</thead>
<tbody>
<tr>
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<td>N</td>
<td>Y</td>
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<tr>
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<tr>
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<tr>
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<td>9</td>
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<tr>
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<td>N</td>
<td>Y</td>
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<tr>
<td>11</td>
<td>MS</td>
<td>N</td>
<td>N</td>
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</tr>
<tr>
<td>12</td>
<td>MS</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
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<tr>
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<td>N</td>
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<td>NA</td>
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<tr>
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<td>N</td>
<td>Y</td>
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</tr>
</tbody>
</table>

AS, anteroseptal; MS, midseptal; CSo, roof of the coronary sinus ostium.

Y, yes; N, no; NA, not available.
suspected, the patient was subjected to further investigation. Holter monitoring, event recording, or a new EP study was used depending on the presented symptoms and the clinician’s preference. Recurrence was defined as ECG-documented tachycardia or return of clinical symptoms identical to those prior to cryoablation.

**Statistical analysis**

Data are given as median and range or mean ± SD as appropriate.

**Results**

Acute procedural success was achieved in 25 of 26 patients (96%). In one patient with a parahissian AT location, multiple cryomapping (n = 20) were not able to identify the arrhythmia substrate and therefore cryoablation was not performed. Due to the high-risk location of AT and moderate symptom, no new ablation attempt was made.

Patients were followed up for a mean of 493 ± 258 days. Three patients (12%) had late recurrences. Two of these underwent a second successful cryoablation. The remaining patient experienced improvement after cryoablation; due to previous phrenic nerve palsy, no new intervention was performed. No further recurrences were seen during 383 ± 53 days in the two patients who had a redo procedure, giving a total success rate of 92%. Total procedure and fluoroscopy time were 197 ± 47 and 26 ± 18 min, respectively. The total number of cryomapping and cryoablation was 6.8 ± 5.8 and 3.6 ± 2.7, respectively, per patient. Detailed procedural and cryoablation characteristics are shown in Table 3.

No patient showed prolongation of the AH (atrial-to-His) interval during cryomapping. One patient had transient AH prolongation during cryoablation. No impairment of SN function was observed.

**Symptom questionnaire**

All patients responded to the questionnaire. Four patients did not consider the procedure successful. Of these, one patient had unchanged symptoms, but no AT could be documented on Holter and event recorder. The remaining three patients experienced some improvement. One had an ECG-documented index arrhythmia but due to previous phrenic nerve palsy, no new ablation attempt was made. The second patient who was successfully re-ablated described a sensation of tachycardia start without the development of clinical arrhythmia. In the third patient, diagnostic evaluation with Holter did not show any arrhythmia.

An additional five patients were still on anti-arrhythmic medication: beta-blockers (n = 4) and sotalol (n = 1). In these cases, symptomatic palpitations experienced during Holter monitoring were related to atrial or ventricular premature beats.

**Complications**

In a total of 28 procedures, two patients developed phrenic nerve palsy during cryoablation of ATs along the lateral right atrium.

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![Figure 1](Non-contact mapping in atrial tachycardia (AT) near the sinus node. (A) and (B) Sequence of early endocardial breakthrough during sinus rhythm at baseline, in an isopotential map. (C) An early breakout during AT, in a new created isopotential map, indicating the origin of the AT in the vicinity of the sinus node. SVC, superior vena cava; IVC, inferior vena cava; SN, sinus node; bo, breakout.)
In one case, the palsy completely recovered within 1 day, whereas it fully recovered after 5 months in the second case.

Discussion

This study shows that cryothermic ablation of ectopic foci in high-risk locations has a high acute and long-term success rate without any permanent complications.

Several studies have shown that RF ablation is an effective treatment of AT with primary success rates ranging from 80 to 100%, with late recurrence rates up to 20% and complication rates up to 12%.1–7 Although complications with RF ablation are relatively low, there are certain complications specific to ablating of high-risk-located AT, including permanent AV block, damage to the phrenic nerve, and SN dysfunction.1–7 Acute or late superior vena cava (SVC) syndrome has also been described as a potential complication in SN modifications related to multiple RF applications at the SVC–right atrial junction.7

Importantly, the fear of these complications may have biased the published data regarding complication risks and treatment failure with RF ablation. In many reports, success rates of RF therapy in AT are calculated for the patients who actually underwent ablation, whereas it is not specified how often RF therapy was abandoned due to an estimated high risk of complications. In fact, a substantial part (27%) of the patients in this study had previously been subject to an EP study, in which RF therapy was avoided for these reasons. However, these patients subsequently underwent successful cryoablation without any permanent complications, suggesting that cryoenergy may enable curative treatment for almost all patients with high-risk AT.

Even though cryothermal therapy has emerged as an alternative to RF ablation in the treatment of AVNRT9,12 and perinodal accessory pathways (APs),10,11 very few data have been published regarding the use of cryoablation for the treatment of AT. Data are limited to a small number of patients or case reports.17,18 The high acute success rate in the present study is similar to that of RF ablation.1–7 We had a high long-term success rate (92%), with no permanent damage to the conduction system. A reasonable explanation for the high success rate and low complication rate is the feasibility of reversible cryomapping and the catheter stability due to cryoadhesion enabling cryoapplications at the most effective positions.

In this study, cryomapping resulted in the elimination of the substrate in 25 of 26 patients. In one patient with a parahissian AT location, multiple cryomapping did not identify the AT location and therefore cryoablation was not performed. In a series of patients with perinodal APs, Atienza et al.11 found that the only complication (right bundle branch block) and most recurrences had occurred in patients in whom cryoablation was performed without prior cryomapping. This was due to the fact that the mechanical AP block precluded cryomapping evaluation, and therefore cryoablation was performed at the mechanically induced AP block. We have used an approach of systematic cryomapping and ablating only at positions when cryomapping suggested a safe and effective location.

Phrenic nerve palsy was seen in two patients despite fluoroscopic control. One patient recovered after 1 day and the other after 5 months. It is important to maintain careful monitoring for phrenic nerve palsy during the procedure and check for full recovery of the respiratory motion of the right hemidiaphragm. However, phrenic nerve palsy caused by cryoablation seems to recover more quickly and completely than palsy caused by RF therapy.19–21

The safety and effectiveness profile in this study supports the conclusion that cryoablation enables effective treatment in high-risk-located AT that otherwise might remain untreated.

Limitations

Our study is limited by its observational and non-controlled design and the limited sample size. However, to the best of our knowledge, this is the largest series using cryoablation in high-risk AT so far, and randomization between different ablation approaches would not be possible in a substantial part of our patients who were deemed ineligible for RF energy.

In non-symptomatic patients, EP studies were not routinely performed during the follow-up period. Therefore, the recurrence rate might have been underestimated, although the clinical
importance of this is probably minimal as the patients were clinically arrhythmia-free.

**Conclusion**

This study shows a high success rate and low complication risk of cryomapping, followed by cryoablation of focal AT in high-risk areas. The study suggests that cryoablation in this setting is a safe and effective alternative to RF therapy.

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**Conflict of interest:** M.J.-U. and P.I. have received consultancy fees from CryoCath Technologies, Inc. F.B. is a member of the speakers bureau for Medtronic and is carrying out research sponsored by Medtronic.

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**References**