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Cryoablation versus radiofrequency ablation for the treatment of atrioventricular nodal reentrant tachycardia: results of a prospective randomized study

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Abstract
Purpose Radiofrequency ablation (RF) of atrioventricular reentrant tachycardia (AVNRT) is an effective method for treating this arrhythmia. However, inadverted AV block requiring implantation of permanent pacemaker is a worrisome side effect. Although permanent AV block seems to be rare nowadays, patients are by no means spared from this severe complication. Catheter cryoablation is emerging as an alternative technology with an excellent safety profile, but limited data exist regarding its efficacy.
Methods We conducted a randomized study among patients with AVNRT remitted to our center for EP study and ablation between January 2008 and June 2010. After giving a written consent, patients were randomized to conventional RF or cryoablation, unless specific preference of patient was stated. Primary outcomes were acute success, SVT recurrence, and complications, including AV block.
Results One hundred nineteen patients were included (60 cryoablation and 59 conventional RF). There were no differences in demographic and clinical baseline data between groups. Acute procedural success was achieved in 59 patients (98 %) in cryoablation group and 59 (100 %) in RF. One patient in RF group underwent complete AV block and pacemaker implantation. Over a mean follow-up period of 256.6 days, there was a significant difference in AVNRT recurrence between cryoablation and RF patients (15 versus 3.4 %, $p=0.03$).
Conclusion Catheter cryoablation of AVNRT is a clinically effective alternative to RF ablation, with excellent acute success rate. Despite a slightly higher rate of recurrence during long-term follow-up, these results suggest that cryoablation may be considered as first-line approach, especially in younger people, where the risk of permanent pacing because of inadvertent AV block may be relevant.

Keywords Atrioventricular reentrant tachycardia · Radiofrequency · Cryoablation · Outcomes · Complete AV block

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1 Introduction

Radiofrequency catheter ablation (RFCA) has been considered the method of choice for treatment of atrioventricular nodal reentrant tachycardia (AVNRT) because of its high short-term and long-term success rates [1, 2]. However RFCA carries a small risk for atrioventricular nodal (AVN) block, requiring pacemaker implantation in 0.8–1 % of patients [3, 4]. This complication translates into lifetime impairment in health status and quality of life, particularly where a young patient is concerned.

In the last decade, cryoablation has evolved as an alternative technique to conventional RFCA [5]. Some studies have been published comparing these two approaches, showing a similar immediate ablation success but a higher recurrence rate in long-term follow-up [6, 7]. However, other authors do not consistently confirm these results and the potential benefit in AVN block prevention remains unclear [8, 9]. The aim of this prospective randomized study was to compare the efficacy and safety of cryoablation versus RFCA for treatment of AVNRT.

2 Methods

2.1 Study population

All consecutive patients with recurrent narrow QRS complex tachycardia and AVNRT confirmed by electrophysiological study were included. All patients signed an informed consent and were randomly assigned to either radiofrequency (RF) ablation or cryoablation of the slow pathway according to a computer-generated randomization scheme. Exclusion criteria were: patient age less than 18 or over 80 years, pregnancy, previous AVNRT ablation procedures, and complex congenital heart disease.

2.2 Procedure

Electrophysiological study was performed using standardized atrial and ventricular stimulation protocol. AVNRT was diagnosed if there was evidence of dual AV nodal physiology and inducible tachycardia with typical electrophysiological features of slow–fast AVNRT. If tachycardia could not be induced, isoprenaline was given and the electrophysiological study was repeated.

RF ablation was performed with a 4-mm catheter (Celsius, Biosense Webster, Diamond Bar, CA) positioned on the anatomical location of the AVN slow pathway with ablation delivered on the typical slow pathway electrogram. At eligible sites, RF energy (maximum, 60 s; 60 °C, 30–50 W) was delivered. Successful ablation site was determined by the occurrence of junctional beats during application. If no junctional beats occurred, ablation was stopped after 20 to 30 s, and the catheter was moved more midseptally.

Cryoablation was performed with a 6-mm catheter (Freezor Max, CryoCath, Montreal, Canada). Cryoablation was started on the anatomical location of the AVN slow pathway AV amplitude ratio from 1:4 to 1:2. After a 30-s period of cryomapping (performed to a temperature of −30 °C), cryoablation was initiated if no AVN block appeared. During the first minute of cryoablation, the same stimulation maneuver that induced AVNRT was performed. If AVNRT was not inducible, a 6-min ablation was applied. The ablation target temperature was −80 °C. If AVNRT was still inducible, application was stopped and the catheter was moved superiorly.

In both groups, inducibilty of AVNRT was tested after each application. If AVNRT was inducible, a new application was performed. If AVNRT was noninducible, the stimulation maneuver was repeated after a 30-min waiting period. Successful ablation was defined as noninducibility of AVNRT and no more than a single atrial echo beat during atrial stimulation with or without sympathomimetic drugs.

2.3 Follow-up

All patients were followed up in the outpatient clinic at least 6 months after discharge or earlier if they had symptoms suggesting a recurrence. All antiarrythmic drugs were stopped before discharge. The procedure was repeated if a recurrence of AVNRT was documented or in the presence of strongly suggestive symptoms of tachycardia.

2.4 Statistical analysis

SPSS 15.0 (SPSS Inc. Chicago, IL, USA) was used for statistical analysis. A p value <0.05 was accepted as statistically significant. Continuous data are presented as mean± SD or median (range). Comparisons between groups were completed with Student's t test or the Mann–Whitney U test to assess statistical significance. Categorical variables were assessed with the Fisher's exact test or X^2 test. For recurrence analysis, the log-rank test and Kaplan–Meier survival analysis were performed.

3 Results

A total of 119 patients were included in the study—60 were randomized to cryoablation and 59 to RF ablation. Table 1 shows patients' baseline characteristics.

3.1 Acute procedure results

Acute procedural success with noninducibility of AVNRT was achieved in 59 patients in the cryoablation group (98 %) and 59 in the RF ablation group (100 %). Other secondary procedural characteristics are summarized in Table 2. Total procedure duration was comparable in both groups, but fluoroscopy time was significantly longer in the RF ablation group. The number of energy applications was significantly lower in the cryoablation group than the RF group.

One patient in the RF group underwent complete permanent AV block and pacemaker implantation. No permanent AV block was observed in cryoablation group. Transient AV block occurred in three patients in the RF ablation group and

Table 1 Patients' baseline characteristics

	Cryoablation	RF ablation	p
Patients, n	60	59	
Age (years)	47.7±13	49.8±15	0.8
Male (%)	60 %	52.8 %	0.6
Structural heart disease	5 %	6.7 %	0.2

Table 2 Procedural data

	Cryoablation	RF ablation	*p*
Procedure time (min)	61.74±18.94	56.77±17.73	0.142
Fluoroscopy time (min)	9.52±3.69	15.46±5.07	0.0001
Number of energy applications	3.28±1.43	3.98±1.82	0.02

in four patients in the cryoablation group. No other complications occurred during procedure in both groups.

3.2 Follow-up

All patients in both groups underwent at least 6 months follow-up. During a mean follow-up of 252±44 days, nine patients (15 %) had documented arrhythmia recurrence in cryoablation group and three (3.4 %) in RF ablation group (p=0.027, log-rank test, see Fig. 1). No further complications occurred during the follow-up period.

All patients with recurrences of arrhythmia in both groups were treated with RF ablation. No complications were observed in the second procedure. During a mean follow-up of 189±36 days, none of them had a second documented arrhythmia recurrence.

4 Discussion

The main finding of our study is that cryoablation is as effective as RF ablation in terms of acute success rate for the treatment of AVNRT, although it is associated with a significantly higher arrhythmia recurrence in follow-up. In terms of safety, both are associated with a low incidence of adverse events, but the only case of permanent AV block occurred in RF group.

A wide variation in acute success rate has been reported using cryoablation for AVNRT. Initial single center series using cryoablation showed acute failure rates of about 15 % [10, 11]. In more recent studies, acute success rate was higher and comparable with RF ablation [6, 12]. These differences may be explained by the use of wider cryoablation catheter tip (6 mm instead of 4 mm) and longer duration of applications. In our experience, using a 6-mm catheter and 6-min applications, the acute success rate of cryoablation is very high and comparable with success rate using RF ablation.

In our study, procedural times were similar in both RF and cryoablation groups. Several series did not find a significant difference in procedure duration between both techniques [8, 11, 12]. On the other hand, other groups have described a significantly longer procedure duration using cryoablation [6, 7]. There may be several reasons for this former result: longer duration of single application, device failures of the cryoablation console during procedure, learning curve effect, or repetitive search of cryomapping sites before cryoablation was performed. In the present study, the learning curve effect was minimized by the fact that it was performed after a relatively long period of time in which most of the AVNRT ablations in our laboratory were performed using cryoenergy. We also minimized the cryomapping time and therefore total procedure time was reduced. Finally, this reduction in procedure time may be also explained in our series by the reduction in the number of energy applications.

Both fluoroscopy time and number of energy applications were lower in the cryoablation group. The majority of

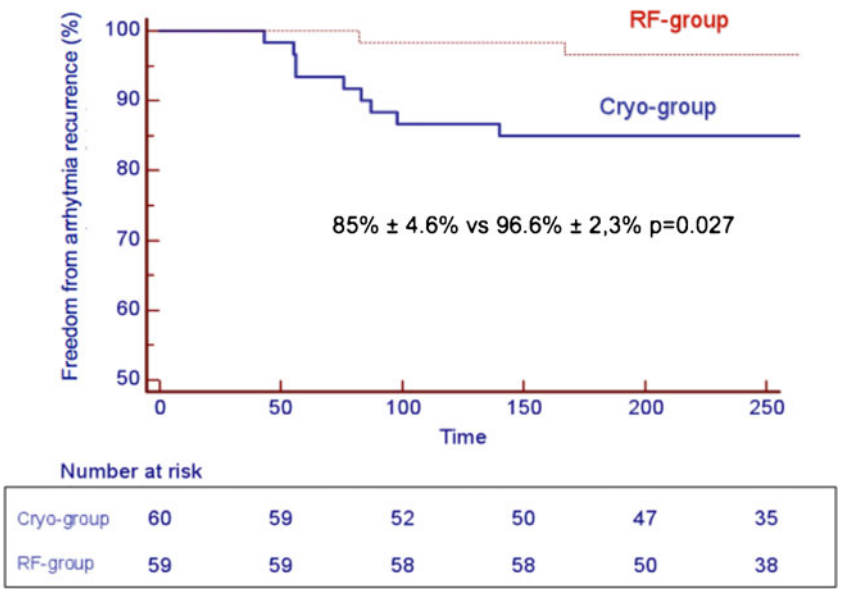

Fig. 1 Kaplan-Meier estimates of arrhytmia recurrence

previous series report no difference in fluoroscopy time between both techniques [6–8, 11, 12]. Our results may probably be explained by the fact that due to adherence of the cryocatheter to the atrial tissue, fluoroscopy can be stopped intermittently during application and thus total fluoroscopy time reduces. Finally, the use of longer application times allows for the reduction of energy applications and fluoroscopy time.

Arrhythmia recurrence was significantly higher in cryoablation group versus RF ablation group. Large retrospective unrandomized series published in the last years showed overall recurrence rate similar [9] or even somewhat lower than previously reported with RF ablation [13]. Comparing the two techniques, some authors published no significant differences in long-term recurrence [8, 14], although several other groups described a significantly higher recurrence risk with cryoablation compared with RF [6, 7, 12]. This fact could be related to different nature and smaller lesion size created by cryoablation as compared with RF [15]. Late progression with fibrosis and vascular damage are commonly present in RF lesions. On the other hand, cryoablation causes more preserved tissue structure lesions leading to better tissue regeneration and less late progression. This might explain why the long-term recurrence rates with cryoablation were higher than those with RF, despite similar results were obtained in terms of acute procedural success.

Complete AV block is the most important complication in RF ablation. No significant differences have been found in overall incidence of ablation-induced AV block in any of the studies comparing cryoablation and RF ablation. Our study confirms this result. However, the only case of permanent AV block occurs in RF ablation group. The overall incidence of ablation-induced AV block using RF energy is very low in experienced centers, so an enormous sample size would be necessary to demonstrate the potential advantage of cryoablation in preventing complete AV block. Anyway, to our knowledge, no permanent AV block has been reported using cryoenergy for ablation of AVNRT. This possible advantage of cryoablation, even if modest, could be relevant in specific circumstances as unusual cardiac anatomies or in young patients where cryoablation could be used as first approach.

5 Conclusions

This study confirms that cryoablation is as effective as the RF ablation, in terms of acute success rate, in patients with AVNRT. In spite of the fact that long-term success rate is somewhat lower than success rate with RF, owing to a higher recurrence rate, this may be offset because of the decreased risk of complete AV conduction block. Although permanent AV block is uncommon nowadays in experienced centers, patients are by no means free from this complication. This risk of permanent pacing may be relevant in selected population, especially in the younger patients. In our opinion, in these patients, an initial approach with cryoablation becomes an excellent alternative.

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Editorial Commentary

Dr. Expósito and colleagues' manuscript provides additional information on the relative utility of cryoablation versus standard radiofrequency ablation for the treatment of AVNRT. Specifically, this study found that cryoablation was not associated with a risk of heart block, but had a higher rate of arrhythmia recurrence. These data help to better define the role of cryoablation for the treatment of AVNRT, providing important information for clinicians.