Cryoablation versus radiofrequency ablation for treatment of atrioventricular nodal reentrant tachycardia: Cryoablation with 6-mm-tip catheters is still less effective than radiofrequency ablation

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BACKGROUND The treatment of choice for atrioventricular nodal reentrant tachycardia (AVNRT) is catheter ablation of the atrioventricular nodal slow pathway.

OBJECTIVE The purpose of this study was to ascertain whether cryoablation (Cryo) with 6-mm-tip catheters is as effective as radiofrequency ablation (RF).

METHODS Patients who had catheter ablation for AVNRT between 2005 and 2008 were identified. The main outcome measure was overall success without the use of an alternative energy source and no recurrence.

RESULTS Two hundred eighty-eight procedures in 272 patients were identified; 184 were female (68%), and the mean age was 53 ± 14 (17–88) years. There were 123 Cryo and 149 RF procedures. Cryo had a lower overall success rate (83% vs. 93%; P = .02). Mean procedure times were similar in both groups (90 minutes; P = .5). Fluoroscopy time was longer with Cryo: 16 (7–48) versus 14 (5–50) minutes (P = .04). Only one case of atrioventricular block was observed in the RF group (0.7%). Cryo was more expensive than RF (£3141 vs. £2153).

CONCLUSION Even when delivering multiple lesions with 6-mm-tip catheters, Cryo is less effective than RF. RF is recommended as a first-line treatment, although the only major complication occurred in the RF group.

KEYWORDS Radiofrequency ablation; Cryoablation; Atrioventricular nodal reentrant tachycardia (AVNRT); Recurrence; Complications

ABBREVIATIONS **AV** = atrioventricular; **AVN** = atrioventricular nodal; **AVNRT** = atrioventricular nodal reentry tachycardia; **Cryo** = cryoablation; **RF** = radiofrequency ablation

(Heart Rhythm 2010;7:340–343)

Introduction

Radiofrequency ablation (RF) of the atrioventricular nodal slow pathway is the accepted treatment for atrioventricular nodal reentrant tachycardia (AVNRT), with success rates greater than 90%.[1,2] The major risk is atrioventricular nodal (AVN) block requiring permanent pacemaker implantation, which occurs in 0.8%–1% of cases.[3,4] Cryoablation (Cryo) is associated with similar acute success rates and may be associated with a lower risk of AV block.[5–7]

We previously compared the efficacy of RF and Cryo in treating AVNRT in patients presenting to our center,[8] finding a higher procedural failure rate (15.4% vs. 2.8%; $P<.01$) and higher recurrence rate (19.7% vs. 5.6%; $P<.01$) associated with 4-mm-tip Cryo catheters. In view of the suboptimal results of Cryo, a practice of using exclusively 6-mm-tip catheters and empirically delivering at least three lesions lasting 4 minutes each was adopted. This study was performed to investigate whether such changes make Cryo as effective as RF in the treatment of AVNRT.

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Methods

Patients

All patients who underwent ablation of the AVN slow pathway at St. Bartholomew's Hospital as treatment of AVNRT during a 3-year period between 2005 and 2008 were identified from the prospectively collected catheter laboratory database. Patients were excluded if they had undergone an ablation before the study period. All patients gave informed consent before undergoing ablation, and antiarrhythmics were stopped 5 days before the procedure.

Electrophysiology procedure

Typical AVNRT was diagnosed on the basis of an electrophysiology study in which there was evidence of dual AVN physiology and induction of tachycardia with a VA time of less than 70 ms, earliest atrial activation at the His catheter, and failure to advance atrial activation by His synchronous ventricular paced beats. If tachycardia could not be induced, isoprenaline boluses of 1–3 μg were administered. The

1547-5271/$ -see front matter doi:10.1016/j.hrthm.2009.11.029

senior operator in charge of the case decided whether to use Cryo or RF on the basis of his or her personal preference.

Acute procedural success was defined as the inability to induce AVNRT and the presence of no more than a single atrial echo beat during programmed atrial stimulation at least 15 minutes after the final ablation lesion. If tachycardia could be induced or more than one atrial echo beat was present, further ablation was performed or an alternative ablation energy was used.

RF ablation

A 4-mm catheter (Celsius, Biosense Webster, Diamond Bar, CA) was positioned on the usual anatomical location of the AVN slow pathway with ablation delivered on the typical slow pathway electrogram.[12] RF power was limited to between 35 and 50 W, with a temperature of 60°C. Where slow junctional beats were noted, ablation was continued for 60 seconds. Ablation was stopped if AV or VA block was seen.

Cryo

A 6-mm Cryo catheter (Freezor Extra 3, CryoCath, Kirkland, Canada) was positioned on the AVN slow pathway as described above. The catheter temperature was lowered to −30°C (cryomapping) for 10–20 seconds to ensure no prolongation of AH conduction time or AVN block, then to −75°C for 4 minutes (Cryo). The catheter was moved to at least two further positions, and at least three lesions were delivered in total.

Follow-up

All antiarrhythmic medications were stopped postprocedure, and all patients were seen in the outpatient clinic at 3 months or earlier if they had symptoms suggesting a recurrence. Where an electrocardiogram or symptoms suggestive of a recurrence were found, a repeat procedure was offered.

Study endpoints

The main outcome measure was the overall success rate of the procedure defined as acute procedural success using a single-energy modality and freedom from recurrence. Primary failure was defined as a lack of acute procedural success or the need to change to the alternative energy modality during the case. Recurrence was defined as electrocardiogram documentation of AVNRT or inducible AVNRT on repeat electrophysiological testing performed for recurrent symptoms. Secondary outcomes were procedure times, fluoroscopy times, and complications. Procedure data were collected prospectively from the electrophysiology laboratory database and consultant reports. Follow-up data were obtained from clinic letters or, where this was incomplete, by contacting patients by telephone.

Cost analysis

An indication of cost was calculated according to service line reporting. This considers the detailed cost of the procedure to the individual hospital including that of medical staff within the electrophysiology laboratory (doctors and nurses) and equipment used, ward costs including staff time and bed costs, pharmacy, overheads (lighting and heating), all high-cost consumables including ablation catheters, and nonmedical staff (for example, managers, porters, and cleaners). The average cost of successfully treating a patient with AVNRT in the Cryo and RF groups was calculated by considering the cost of a case in each group, together with the cost of a second catheter where one was used, the cost of a redo case, and the cost incurred by any major complications (e.g., pacemaker implantation for heart block).

Statistical analysis

Normally distributed nominal data are expressed as mean ± standard deviation, and a Student's *t*-test was used to evaluate statistical significance. Nonnormally distributed data are expressed as median (range), and a Mann-Whitney test was used to ascertain statistical significance. Categorical data were compared using Fisher's exact test. All statistical testing was conducted with a two-tailed significance level of .05. Statistical analysis was performed using commercially available software (GraphPad Prism version 4.00 for Macintosh, GraphPad software, San Diego, California; www.graphpad.com).

Results

Patients and procedures

A total of 272 patients were identified in the study period. The majority of patients were female (n = 184, 68%), and the mean age was 53 ± 14 (range 17–88) years. There were 123 and 149 first-time Cryo (Cryo group) and RF (RF group) procedures, respectively (Table 1). There were no differences in patient characteristics between the two groups.

Primary outcome measures

The initial acute procedural success was 93% (114/123) with Cryo and 95% (142/149) with RF ($P = .8$). There was a greater recurrence of AVNRT with Cryo (12/114, 10% vs. 4/142, 3%; $P = .02$) when compared with RF. The overall success rate was lower in the Cryo group (102/123, 83%) than in the RF group (138/149, 93%; $P = .02$).

The primary failure rate was not different between the two groups (Cryo 7% vs. RF 5%; $P = .4$). However, the

Table 1 Summary of primary and secondary outcomes by catheter

	Cryo	RF	*P*
No.	123	149	
Female:male	84:39	100:49	.9
Age	55 ± 15	54 ± 14	.6
Prevalence of structural heart disease, %	3	3	1
Follow-up in months	3 (1–19)	2 (1–19)	.5
Overall success, %	83	93	.02
Second catheter use, %	6	1	.04
AVNRT recurrence, %	11	3	.02
Permanent AVN damage, n	0	1	1.0
Procedure time, minutes	90 (50–210)	90 (45–220)	.6
Fluoroscopy time, minutes	16 (7–48)	14 (5–50)	.08

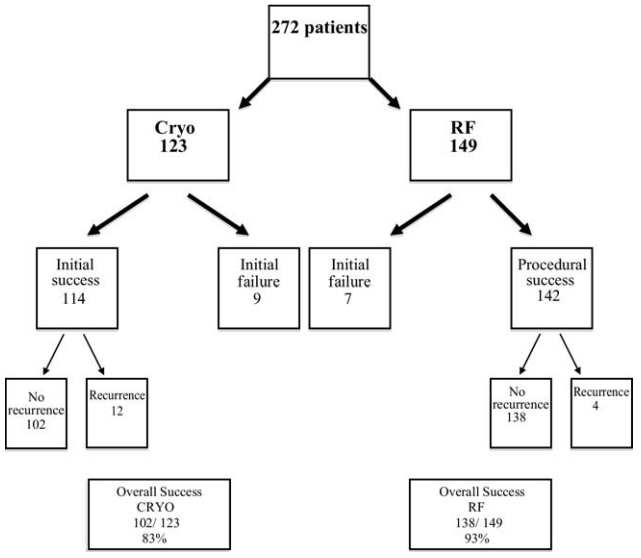

Figure 1 Outline of the primary outcome measures of patients undergoing Cryo and RF. See text for details of patients who had initial failure.

alternative energy modality was used more with Cryo (6% vs. 1%; $P = .04$). The outcomes for all patients are summarized in Figure 1 and in Table 1, which also includes secondary outcome measures.

Cryo

In nine (7%) cases, there was a primary failure of Cryo. In seven of these cases, an RF catheter was used, and the procedure was successful. Of the remaining two, one had a redo procedure, after which symptoms resolved, and the second remained asymptomatic from AVNRT but returned for an atrial tachycardia ablation.

At a median follow-up of 3 (1–19) months, 12 of the 114 patients who had initial success with Cryo (11%) had a redo procedure, nine using RF and three using Cryo again. Cryo was used for one of these cases as the target for ablation was close to the AV node, but no reason was given for the remaining two cases.

RF

In seven (5%) cases, there was a primary failure of RF. A Cryo catheter was used in only two patients; in one, the target for ablation was close to the AV node, and, hence, Cryo was deemed safer. No reason was documented for the second patient. Both of these procedures were then successful. Of the remaining five patients with a primary failure treated with RF, three went on to have successful redo procedures. The procedure was abandoned in one case as the target was approaching the AV node; a recurrence was suspected but not documented, and the patient declined a further electrophysiology study. One patient had persistent slow pathway conduction and returned for a redo electrophysiology study, but no tachycardia was induced.

At a median follow-up 2 (1–19) months, four of the 142 patients who had initial success with RF had a redo procedure (3%). Two of the redos were treated with Cryo because one patient had had transient AV block with RF during the index case, and the target for ablation in the second patient was close to the AV node.

Complications

There was only one major complication: one patient from the RF group developed complete AV block that required a permanent pacemaker (0.7% of all RF cases). A further nine had minor complications: one (0.8%) in the Cryo group, seven (5%) in the RF group, and one treated with RF then Cryo (11%; $P = .08$). These are outlined in Table 2.

Redo procedures

All patients who had a redo procedure suffered no primary failure, recurrence, or complications at a median follow-up of 6 (2–9) months. For redo procedures, the median procedure time was 118 (60–180) minutes, and the median fluoroscopy time was 13 (5–64) minutes. This compares with a median procedure time of 90 (45–220) minutes for index cases and a median fluoroscopy time of 15 (5–50) minutes. There was no statistically significant difference in median procedure and fluoroscopy times between index and redo cases ($P = .1$ and .9, respectively).

Costs

The cost of a single Cryo case is greater than that of an RF case, £3141 versus £2153, predominantly owing to the increased cost of the Cryo catheter. As a gross indicator, the average cost of successfully treating AVNRT in patients in the Cryo group was significantly greater than in the RF group (£3428 vs. £2236; $P<.0001$).

Discussion

Main findings

The main finding of this study is that RF is associated with greater overall success when compared with Cryo for the treatment of AVNRT, despite modification of the ablative technique to increase both lesion size and number. There was only one episode of complete heart block in all 272 procedures (0.3%), which occurred with RF and is consistent with previous published data.[3,4] This is valuable in counseling patients before catheter ablation, who can then decide whether to accept a lower success rate of 83% with Cryo or a higher risk of 0.7% permanent pacing with RF.

Theoretical advantages of Cryo

Cryo uses liquid nitrous oxide infused into the closed catheter tip to cause freezing at the desired position and is able

Table 2 Minor complications by catheter

Complication	Cryo (n)	RF (n)
Haematoma	0	3
Transient second-degree AV block	1	0
Vasovagal episode	0	1
Pericarditis	0	1
Deep vein thrombosis	1 (after RF)	1
Femoral artery puncture	0	1
Ventricular fibrillation	0	1

to produce potentially reversible lesions at higher temperatures (cryomapping) before the production of a permanent lesion (Cryo).[11,13] At the location of the AVN slow pathway, cryomapping is first performed to a temperature of −30°C before Cryo at −75°C. The frozen tissue at the catheter tip then thaws, resulting in cell death. Cryoadherence produced by ice at the tip of the catheter firmly bonds it to endocardium, preventing catheter movement during ablation.[7] AV block seen at the time of cryomapping is transient,[14] and there are no published cases of permanent AVN damage with Cryo where a patient has required permanent pacing. Theoretically, these observations make Cryo a safer option when the target of ablation is close to the AV node such as in AVNRT. Cryo may be particularly valuable in younger patients in whom the triangle of Koch is smaller and permanent pacing carries inherent long-term follow-up, generator and lead changes, and complications. It is also, therefore, useful in those with abnormal AV node anatomy, where the risk of AV block may be higher.

Current evidence supporting Cryo

Single-center registries have shown Cryo to have a higher acute failure and recurrence rate than RF.[9,10] There are two prospective randomized controlled trials comparing Cryo and RF for AVNRT.[5,6] Kimman et al[5] demonstrated high acute procedural success (93% Cryo and 91% RF) without any complications but a high recurrence rate in each group (10% in the Cryo group vs. 9% for RF). The number of Cryos with a 4-mm-tip catheter applied was significantly lower than the number of RF lesions (two vs. seven; $P<.005$). Zrenner et al[6] showed an acute procedural success of 97% for Cryo and 98% for RF without any complications. In the Cryo group, there were more recurrences at a median follow-up of 246 days (8% vs. 1%; $P = .03$), which is a longer follow-up period than in our study.

In contrast, we used 6-mm Cryo catheters and cryomapped to −30°C for 10–20 seconds and cryoablated at −75°C for 4 minutes. Our RF catheters were also 4-mm tip, and RF delivery was at 60°C for 60 seconds where junctional rhythm was seen, with a power of 35–50 W.

Cryo is not as effective as RF

This study has shown that, despite optimizing our Cryo practice, there is a lower success rate than with RF. It does show, however, a reduced recurrence rate compared with our previous study[8] (11% vs. 20%) during a similar follow-up period. This is an important observation as there are situations in which Cryo may be preferred; for example, in the younger population, the risk of permanent pacing may be unacceptable and the greater risk of recurrence associated with Cryo may be preferable.

Cryo has a significantly higher up-front cost than RF, even when the cost of a major complication with RF is accounted for. In addition, the need for a second catheter and the high recurrence rate with Cryo, compared with RF, contributes to the overall increased cost in this group. However, the cost of permanent pacing with RF does not include the lifetime cost of health care for, for example, further procedures.

Limitations of study

This was a nonrandomized, retrospective, observational study with the choice of RF or Cryo ablation made by the senior operator. Although selection bias cannot be excluded, this is a large study including all patients without exception, and therefore it accurately reflects usual clinical practice.

Conclusion

Cryo with a 6-mm-tip catheter is less effective for routine ablation of AVNRT than RF owing to a higher recurrence rate.

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