Journal of the American College of Cardiology
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Published by Elsevier Inc.

Vol. 45, No. 4, 2005
ISSN 0735-1097/05/$30.00
doi:10.1016/j.jacc.2004.10.051

Cryo-Ablation for Septal Tachycardia Substrates in Pediatric Patients

Mid-Term Results

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OBJECTIVES The aim of this study was to evaluate the efficacy and safety of catheter-based cryo-therapy for septal tachycardia substrates in pediatric patients.

BACKGROUND Cryo-therapy may be particularly useful for ablation of septal tachycardias, including atrioventricular nodal re-entry tachycardia (AVNRT), atrioventricular reciprocating tachycardia (AVRT), and ventricular tachycardia (VT) originating high in the conduction system.

METHODS Thirty-one pediatric patients (median = 13.7 years, range 5.3 to 19.6 years) with septal tachycardia substrates underwent cryo-ablation (CA). Twenty-two had AVNRT, 8 AVRT, and 1 VT. Applications were considered cryo-maps (CMs) if the temperature set-point was −35°C or the application time was <120 s. Other lesions were considered CAs.

RESULTS A total of 242 CMs (4 per patient, range 0 to 40 CMs) and 89 CAs (2 per patient, range 1 to 8 CMs) were performed, for a total cryo-therapy time of 689 s/patient (range 158 to 3,300 s). Procedural success with cryo-therapy was achieved in 27 of 31 patients (87.1%), including two procedures with a His potential at the CA location and three performed in tachycardia. The success rate for AVNRT was higher than for AVRT (95.5% vs. 62.5%, $p < 0.05$). For AVRT, a sustained effect on accessory pathway conduction occurred −3.3 ± 4.9 s after reaching −25°C, whereas for those sites at which the effect was transient, the effect took 24.8 ± 25.5 s ($p = 0.07$). Transient atrioventricular (AV) block occurred during eight cryo-applications (1 CA, 7 CMs) with immediate return of normal AV conduction upon cessation of application. There were no other complications.

CONCLUSIONS Cryo-therapy was used to effectively and safely ablate septal tachycardias in this group of 31 pediatric patients. Cryo-therapy may be more effective for AVNRT than septal AVRT. (J Am Coll Cardiol 2005;45:581–8) © 2005 by the American College of Cardiology Foundation

Catheter-based cryo-therapy has been introduced recently for ablation of a variety of cardiac arrhythmias (1–8), but only limited reports exist in children (9). Cryo-therapy has several potential advantages over radiofrequency ablation (RFA), which include: 1) reversible cryo-mapping before the production of a permanent lesion (1,10,11); 2) adherence of the catheter tip to the endocardium upon freezing (2); 3) a well-defined edge of the cryo-lesion (10); 4) minimal effects on adjacent coronary arteries (1); and 5) a lower incidence of thrombus (12). The first four of these are particularly relevant to small children because of the close proximity of a variety of critical cardiac structures to the ablation target and the reported potential for radiofrequency lesion growth in immature myocardium (13). In fact, the most common major complication during RFA in pediatric patients is atrioventricular (AV) block (14–16). Acute coronary artery injury has also been reported in a variety of locations in children (17,18), including during slow pathway modification (17).

This report addresses the efficacy and safety of catheter-based cryo-therapy in pediatric patients for ablation of septal tachycardias, including atrioventricular nodal re-entry tachycardia (AVNRT), atrioventricular reciprocating tachycardia (AVRT) caused by a septal accessory pathway, and ventricular tachycardia (VT) originating high in the conduction system.

METHODS

The pediatric ablation registry at the Medical University of South Carolina was searched for all patients who had undergone catheter-based cryo-ablation (CA) for tachycardias with septal substrates during the period from May 2003 until July 2004. Only patients with structurally normal hearts under 20 years of age were included in the analysis.

Electrophysiologic study. Informed written consent was obtained before each procedure. All anti-arrhythmic drugs were discontinued for at least five half-lives. Under either general anesthesia or conscious sedation, all patients underwent an electrophysiologic study using standard pacing and mapping techniques to determine the mechanism of the tachycardia and the location of the ablation target. Patients were administered an initial heparin bolus of 100 IU/kg up to 5,000 IU. Activated clotting times were checked every 30 min, and additional heparin boluses were given to keep the activated clotting time >200 s (right) or >250 s (left). Isoproterenol was administered when the tachycardia was not inducible at baseline.

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Manuscript received August 30, 2004; revised manuscript received October 12, 2004, accepted October 26, 2004.

JACC Vol. 45, No. 4, 2005
February 15, 2005:581–8

Abbreviations and Acronyms

AV = atrioventricular
AVNRT = atrioventricular nodal re-entry tachycardia
AVRT = atrioventricular reciprocating tachycardia
CA = cryo-ablation
CM = cryo-map
RAS = right anteroseptal
RFA = radiofrequency ablation
VT = ventricular tachycardia

Cryo-therapy. Once a target had been established, cryo-mapping and CA were undertaken using a microprocessor-based electromechanical refrigeration console controlling a 7-F, 4-mm or 6-mm tipped ablation catheter (CryoConsole, Freezor, Freezor Xtra, CryoCath Technologies Inc., Montreal, Canada). For AVNRT, both anatomical and electrogram criteria were used to choose initial application sites (19). For AVRT, sites for cryo-applications were determined on the basis of previously reported standard mapping criteria (20). For the patient with VT, the site of earliest ventricular activation was used as an ablation target. Cryo-therapy was performed in sinus rhythm, with atrial or ventricular pacing, or in slow junctional rhythm. However, in contrast to RFA, cryo-therapy was also used both during active tachycardia (AVNRT or AVRT) and in the presence of isoproterenol, because junctional acceleration is not generally present during cryo-therapy, and because catheter adherence during cryo-therapy allows for catheter stability during tachycardia or isoproterenol infusion. Cryo-therapy was initiated with either a preset minimal temperature of −35°C for up to 1 min, or a preset temperature of −70°C for up to 8 min. For the purposes of this study, a "cryo-map" (CM) was defined as any application with a set-point of −35°C or a colder application of <120 s duration. A CA was defined as an application with a set-point of −70°C that was ≥120 s. Each CM or CA was considered a separate cryo-application. The number of "cryo-sites" was defined as the number of anatomically separate locations where either a CM or CA was delivered. If an application at a single site was initiated as a CM but then extended to a CA, it was counted as two cryo-applications, but one cryo-site. "Application time" was defined as the time of each CA or CM. "Cryo-therapy time" was defined as the time from <−25°C until the termination of cryo-therapy at each cryo-site.

The decision to proceed from CM to CA was made using one or more of the following criteria: 1) AVNRT termination in the slow pathway; 2) modification or elimination of the slow pathway during atrial extra-stimulus testing; 3) accessory pathway block during sinus rhythm, ventricular pacing, or AVRT; and 4) for this VT case, a site of early ventricular activation not associated with AV block. For any CM or CA, the application was immediately discontinued for any degree of AV block.

Cryo-site success. Each cryo-site was classified by the outcome at that location, as success, transient success, failure, or post-success (additional application). A cryo-site was considered successful if it resulted in elimination of the slow pathway, the accessory pathway, or the disappearance of VT. A cryo-site was considered a transient success if there was recurrence of the arrhythmia or its substrate within 30 min of cryo-therapy termination. A cryo-site was considered a failure if it had no effect on the substrate. A cryo-site was considered post-success if it was performed very near the location of a previously successful cryo-site.

Procedural success. Procedural success was defined using RFA standards, including a minimum of 30 min of post-ablation testing. No inducible tachycardia was mandatory for any substrate. For AVNRT, a procedure was deemed successful if there was elimination of the slow pathway or not more than a single echo beat. For AVRT, loss of accessory pathway conduction was also required. If isoproterenol was required for the assessment of slow pathway or accessory pathway conduction or for the induction of tachycardia before ablation, the use of isoproterenol was required during post-ablation testing to deem the procedure a success. If cryo-therapy was considered a failure, a switch was generally made to RFA; however, there was no preset protocol for making this determination. The investigators tended to switch more readily when the results of the cryo-therapy indicated that the pathway location was one where there was a lower risk of AV block.

Statistical analysis. Values are shown as median and range unless otherwise specified. Comparisons were made with the two-tailed unpaired Student *t* test or by Fisher exact test, whenever appropriate. A p value ≤0.05 was considered statistically significant.

RESULTS

Patients. Thirty-three pediatric patients with septal tachycardia substrates underwent catheter-based cryo-therapy. Two patients with AVNRT and congenital heart disease were excluded because of variation in AV node anatomy. Thus, 31 patients (19 male; age 13.7 years, range 5.3 to 19.6 years; weight 51.4 kg, range 19.7 to 130.2 kg) are included in this study (Table 1). Twenty-two patients had AVNRT, 8 AVRT, and 1 VT. Among patients with AVRT, accessory pathway locations were as follows: five right anteroseptal (RAS), one right mid-septal, and two right posteroseptal.

The RFA had been performed previously in four patients. Two of these patients had recurred after a previous RFA attempt (1 AVNRT, 1 AVRT), and one had undergone successful RFA of permanent junctional reciprocating tachycardia but subsequently developed AVNRT. The one with VT had failed RFA twice at another institution. Another two patients (1 AVNRT, 1 AVRT with RAS pathway) had undergone an electrophysiologic study at another institution, but did not undergo RFA because of unstable fast pathway conduction or a perceived high risk for AV block.