Radiofrequency Ablation of Atrioventricular Nodal Reentry Tachycardia: A 14 Year Experience with 901 Patients at the Tel Aviv Sourasky Medical Center

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Abstract

Background: Atrioventricular nodal reentry tachycardia is the most frequent cause of regular, paroxysmal supraventricular tachycardia. Radiofrequency ablation of the slow pathway has been recommended as first-line therapy for curing AVNRT.

Objectives: To report a 14 year experience of RFA of the slow pathway in patients with AVNRT treated in our laboratory.

Methods: A total of 901 consecutive patients (aged 9–92, mean 50.8 ± 18.2 years) underwent RFA of the slow pathway. All patients had sustained AVNRT induced with or without intravenous administration of isoproterenol. A standard electrophysiologic method with three diagnostic and one ablation catheter was used in 317 patients (35.2%); in the remaining 584 patients (64.8%), only two electrode catheters (one diagnostic, one ablation) were used ("two-catheter approach").

Results: Catheter ablation of the slow pathway abolished AVNRT induction in 877 patients (97.3%). In 14 patients (1.6%) the procedure was discontinued while in 10 (1.1%) the procedure failed. In 864 patients (95.9%) there were no complications. Transient or permanent AV block occurred during the procedure in 31 patients (3.4%), of whom 8 (0.9%) eventually required pacemaker insertion (n=7) or upgrade of a previously implanted VVI pacemaker (n=1) during the month following the procedure. The number of catheters used did not significantly affect the rate of results or complications of the ablation procedure. The success and complication rates remained stable over the years, although a significant trend for increased age and associated heart disease was observed during the study period.

Conclusions: The results of this single-center large study, which included patients with a wide age range, showed results similar to those of previous studies. The use of a "two-catheter approach" (one diagnostic and one ablation) was as effective and safe as a multi-catheter approach.

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AVNRT = atrioventricular nodal reentry tachycardia
RFA = radiofrequency ablation

Atrioventricular nodal reentry tachycardia is the most frequent cause of regular, paroxysmal supraventricular tachycardia. The mechanism of AVNRT is classically attributed to dual AV nodal pathways physiology, including one with relatively fast conduction but long antegrade refractoriness (fast pathway) and another with slower conduction but shorter antegrade refractoriness (slow pathway) [1]. However, this concept likely results from functional properties of anisotropic tissue within the triangle of Koch rather than anatomically distinct pathways [1]. The slow pathway is located along the postero-medial tricuspid annulus close to the coronary sinus ostium. Since its introduction in the early 1990s [2-6], RFA of the slow pathway has become first-line therapy for AVNRT. Slow pathway ablation is guided by a combination of fluoroscopic landmarks, electrogram morphology, and the induction of junctional rhythm during the application of RF energy. Although the success rate of slow pathway ablation is as high as 97%, it may be complicated by severe AV nodal conduction disturbances that require permanent pacemaker implantation in 0.9–2% of patients [2-15].

We report here the clinical features, electrophysiologic characteristics, results of RFA, and long-term outcome in all patients who underwent RFA of AVNRT in our laboratory. The evolution of procedural methods and the complications observed during the study period are emphasized.

Patients and Methods

Patients

The study group comprised 901 consecutive patients who underwent RFA of AVNRT during a 14 year period (January 1992 to December 2005). The patients were divided into four equal groups according to the time of the RFA procedure. During the baseline electrophysiologic study, all patients had sustained AVNRT induced before or after intravenous administration of isoproterenol. One of the investigators (B.B.) participated in all but six of the ablation procedures.

Electrophysiologic study

After the patients gave informed consent, the electrophysiologic study was performed using standard techniques [16]. In the early years a multi-catheter approach was used, including the placement of three diagnostic electrode catheters in the coronary sinus, the right ventricular apex and the His bundle area, as well as an ablation catheter. Later, a "two-catheter approach" using a single diagnostic electrode catheter (placed in the high right atrium) and an ablation catheter was employed. A multi-catheter approach was also used for ablation of AVNRT when the mechanism of PSVT was unclear or after ablation of another arrhythmia. The ablation catheter was usually a Mansfield/Cordis/Webster catheter (temperature-guided or not) and less commonly a temperature-guided catheter (EP Technologies, Boston Scientific, MA, USA).

The baseline electrophysiologic study included atrial stimulation (rapid atrial pacing and/or delivery of one to three extrastimuli) as well as ventricular stimulation if AVNRT was not induced with atrial stimulation. If sustained AVNRT (lasting ≥ 30 sec) was not induced with this protocol, isoproterenol (1 µg/min) was administered at incremental dosage until the basic sinus rhythm increased by ≥ 20%, and the stimulation protocol was repeated.

Definitions

Dual AV node physiology was defined as a ≥ 50 msec increment in atrium-to-His (AH) or PR interval following a 10 msec decrement in coupling interval during single atrial extrastimulation or a ≥ 50 msec increment in AH or PR interval in consecutive beats after a 10 msec decrement in pacing cycle length during incremental atrial pacing [15].

Ablation procedure

RFA of the slow AV nodal pathway was performed according to a standard combined electrophysiologic-anatomic approach [17]. Briefly, the catheter tip of the ablation catheter was positioned at the His bundle area and progressively withdrawn along the tricuspid annulus, starting at the most posterior site (near the coronary sinus ostium) and progressing to the more anterior locus (closer to the His bundle recording site). RF energy was delivered with a temperature setting of 55–60°C using an initial 26 Watts power that was gradually increased up to 60 Watts if necessary. If an accelerated junctional rhythm was recognized within 30 seconds, the energy delivery was continued for a total of 1 minute. Administration of RF energy was discontinued upon occurrence of AV block, very rapid junctional rhythm, retrograde block during junctional rhythm, impedance rise, catheter displacement or severe chest pains.

Ablation of the slow pathway was diagnosed when, after RF application, dual AV node physiology could no longer be demonstrated and neither AV nodal echoes nor AVNRT could be induced with and without isoproterenol infusion.

Modification of the slow pathway was defined as the persistence of dual AV node physiology and inducible 1-3 AV nodal echo beats but no inducible AVNRT with and without isoproterenol infusion.

Catheter-induced mechanical trauma to slow and/or fast pathway was observed in 121(13.4%) of the study patients. A separate report dealing with this observation will be published elsewhere.

PSVT = paroxysmal supraventricular tachycardia

Follow-up

The patients were followed at the outpatient clinic every 6 months during the first year after the procedure. Thereafter they were instructed to contact the laboratory in case of recurrent PSVT or rapid palpitations similar to the spontaneous episodes.

Statistics

All continuous variables were presented as mean ± standard deviation and all categorical variables were presented as number of patients and percentages. For all continuous variables the comparisons between the four study groups were done using one-way analysis of variance (ANOVA) and for categorical variables using Cramer's V under chi-square analysis. For all statistical analyses a P value < 0.05 was considered statistically significant. The SPSS statistical package was used to perform all statistical analyses (SPSS Inc., Chicago, IL, USA).

Results

Patient characteristics [Table 1]

The patient population comprised 554 females (61.5 %) and 347 males (38.5%), ranging in age from 9 to 92 years (mean 50.8 ± 18.2). Thirty-seven patients (4.1%) were ≤ 18 years old and 85 (9.4%) were ≥ 75. Group 1 was the youngest and group 4 the oldest (P < 0.0005 for trend). Underlying heart disease was present in 75 patients (8.3%) including coronary artery disease (6.7%), valvular heart disease (1.0%), cardiomyopathy (0.2%), and miscellaneous diseases (0.4%).

Electrophysiologic characteristics

During electrophysiologic study, 140 patients were found to have an associated arrhythmia which was also subjected to RFA: 91 patients (10.1%) had atrial tachyarrhythmias, 25 (2.8 %) had an accessory pathway, 20 (2.4%) had idiopathic right or left outflow tract ventricular arrhythmias, 3 (0.4%) had post-myocardial infarction ventricular tachycardia, and one patient had idiopathic left ventricular tachycardia ("Belhassen type").

The mechanism of tachycardia during electrophysiologic study was slow/fast ("typical") AVNRT in 833 patients (92.5%), fast/slow ("atypical") AVNRT in 23 (2.6%), slow/intermediate AVNRT in 17 (1.9%) and slow/fast and fast/slow AVNRT in 7 (0.8%), while it involved various slow pathways in 21 patients (2.3%). There were no significant differences between the study groups in terms of associated arrhythmia or AVNRT mechanism.

Catheter ablation results

RFA was acutely successful in 877 patients (97.3%); slow pathway ablation was achieved in 452 patients (51.5%) and slow pathway

Table 1. Patient characteristics and results of the ablation procedure

Study patients' (n=901)	Group 1 (n=225)	Group 2 (n=225)	Group 3 (n=226)	Group 4 (n=225)	*P*
Patients' characteristics					
Female prevalence, 61.5%	64.4%	60.4%	62.4%	58.7%	0.622
Mean age (yrs), 50.8 ± 18.2	43.7 ±1 5.3	50.2 ± 16.9	53.1 ± 18.9	56.5 ± 18.9	<0.0005
Patients aged ≤ 18 years, 4.1%	5.8%	4.4%	4.0%	2.2%	0.296
Patients aged ≥ 75 years, 9.4%	0.4%	5.3%	12.8%	19.1%	<0.0005
Organic heart disease, 8.3%	3.6%	7.1%	9.3%	13.3%	0.002
Acute procedure results					
Success, 877 (97.3%)	220 (97.8%)	218 (96.9%)	220 (97.3%)	219 (97.3%)	0.952
Failure, 10 (1.1%)	3 (1.3%)	3 (1.3%)	2 (0.9%)	2 (0.9%)	0.938
Discontinued, 14 (1.6%)	2 (0.9%)	4 (1.8%)	4 (1.8%)	4 (1.8%)	0.833
No of successful RF pulses 5.0 ± 5.9	4.6 ± 4.7	5.2 ± 6.4	5.7 ± 6.5	4.5 ± 5.8	0.087
Successful P1-P2 locations 807 (92.1%)	190 (86.4%)	199 (91.7%)	207 (94.1%)	211 (96.3%)	0.001
No. of catheters used					
2 catheters, 584 (64.8%)	26 (11.6%)	184 (81.8%)	189 (83.6%)	185 (82.2%)	<0.0005
> 2 catheters, 317 (35.2%)	199 (88.4%)	41 (18.2%)	37 (16.4%)	40 (17.8%)	
Procedure-related complications					
None, 864 (95.9%)	216 (96.0%)	216 (96.0%)	220 (97.3%)	212 (94.2%)	0.1
≥ II degree AV block, 31 (3.4%)	5 (2.2%)	9 (4.0%)	5 (2.2%)	12 (5.3%)	NS
Requiring permanent pacemaker, 8 (0.9%)	2 (0.9%)	3 (1.3%)	2 (0.9%)	1 (0.4%)	NS
Miscellaneous (n=6, 0.7%)	4 (1.8%)	0	1 (0.4%)	1 (0.4%)	NS

modification in 411 (46.9%) while in the remaining 14 patients (1.6%) various combinations of pathways were ablated. In 14 patients (1.6%) the procedure was discontinued before AVNRT elimination due to either of the following: a) the patient's desire or the physician's fear of inducing AV block; b) catheter-induced mechanical trauma to fast and/or slow AV nodal pathway. In 10 patients (1.1%) the procedure failed following multiple attempts. No significant difference between the study groups was found with regard to procedural success [Table 1].

The great majority (92.1%) of slow pathways were ablated at posterior sites (P1-P2) close to the coronary sinus ostium [4]. The mean number of RF applications given to achieve successful ablation was 5.0 ± 5.9. No significant difference between the study groups was found in terms of the number of successful ablation pulses.

A "two-catheter approach" was used in 584 patients (64.8%) while a multi-catheter approach was used in the remaining 317 (35.2%). A "two-catheter approach" was more frequently performed in the last three patient groups as compared to the first group ($P < 0.0005$ for trend) [Table 1]. However, there were no significant differences in terms of procedure success rate or complications (mainly AV block) between the "two-catheter" and the multi-catheter groups.

Procedural complications

No complications were observed in 864 patients (95.9%). In 31 patients (3.4%) transient or permanent second- or third-degree AV block occurred during the procedure. Eight of these 31 patients (26%), representing 0.9% of all study patients, required pacemaker implantation (n=7) or upgrade of a previously implanted VVI pacemaker (n=1) during the month following ablation. These 8 patients, six females and two males, ranged in age from 34 to 86 years (mean 60.5 ± 17.1). During temporary pacemaker insertion the youngest of these patients (a 34 year old woman) also developed hemomediastinum that slowly resolved without additional intervention. There were no significant differences between the study groups in terms of occurrence rate of AV block [Table 1]. A significant pericardial effusion occurred in two patients (0.2%). In one of these patients, tamponade requiring pericardiocentesis developed and was attributed to the introduction of a diagnostic catheter in the right ventricle. In another patient with ischemic heart disease, myocardial ischemia was observed during the procedure.

Significant late complications occurred in 6 patients (0.7%): deep femoral vein thrombosis (n=2), pulmonary embolism (n=1), pneumothorax after pacemaker implantation (n=1), severe dermatitis (n=1) and a large groin hematoma (n=1). Excluding transient AV blocks, no significant complications were observed in patients under age 34 whereas significant complications occurred in 1.6% of patients aged ≥ 34 years old ($P = 0.09$).

PSVT recurrences during follow-up

Recurrent PSVT was documented during follow-up in 25 patients (2.8%), including 22 who had an initial successful ablation procedure; in 2 the procedure failed and in one the procedure had to be discontinued. Of these 25 patients, 17 underwent a repeat successful RFA of the slow pathway (15 in our laboratory) with no arrhythmia recurrence, and 2 patients underwent intentional RFA of the AV node with pacemaker implantation; repeat RFA failed in 1 patient and was discontinued in another. Of the four remaining patients, three opted for medical therapy while one patient is scheduled for repeat RFA in our laboratory.

Discussion

Main findings

The present study confirms the safety and efficacy of RFA of AVNRT. We found a high acute success rate (97.3%), a low recurrence rate (2.8%), and a relatively low incidence of complications (4.1%) and need for permanent cardiac pacing (0.9%). Finally, no significant complications were observed in the group of patients under 34 years old.

Comparison with previous reports

During the last decade several studies reporting the results of RFA of AVNRT have been published. The success, the frequency of arrhythmia recurrence, and incidence of major complications reported in the present study are similar to results from these prior reports including multi-center studies [2-15]. To the best of our knowledge, our study is the largest single-center study ever reported. Interestingly, our results showed that the learning curve rates were rapidly achieved with a very high success rate obtained in the first study quartile (96%), which remained stable over the years.

Two-catheters vs. multi-catheter technique

In most laboratories, RFA of AVNRT is performed after introduction of multiple diagnostic catheters in the high right atrium/coronary sinus, His bundle area, and right ventricular apex, along with an ablation catheter. This multi-catheter approach affords optimal documentation of dual AV node physiology, easy pacing from multiple sites and enables safe emergency pacing in case of occurrence of complete AV block. In addition, the continuous documentation during RF application of the His bundle activity as compared to the position of the ablation catheter is expected to increase the safety of the procedure. In the present study, a "two-catheter" approach (a diagnostic catheter in the right atrium and the ablation catheter) was performed in about two-thirds of our patients. No significant differences in terms of procedure success rate and complications were found using this two-catheter approach as compared to the multi-catheter approach. This two-catheter approach has the advantages of reducing procedure time and cost, patient discomfort and probably exposure to X-ray.

Comparison between the different study groups

A significant progressive increase in the age of patients and associated cardiac disease was found over time in the various study groups. However, this did not result in an increased rate of procedure failure or complications over time, unlike results reported by others [12]. On the contrary, the results observed in our last group of patients were the best, as reflected by the lower incidence of iatrogenic AV block requiring pacemaker implantation (0.4%).

RFA as first-line therapy

RFA improves health-related quality of life to a greater extent than do medications [18,19] and was the least expensive therapy as compared to drug therapy options among patients who have monthly episodes of PSVT. AVNRT is readily amenable to definitive therapy by catheter-based RF energy delivery at the slow pathway area. Results from the present and other series [2-15] have shown this strategy to be both safe and effective, supporting ablation therapy as first-line therapy for the majority of patients, especially young patients.

Study limitations

The patients were followed every 6 months during the first year following the procedure, and were instructed to contact the laboratory only in case of recurrent PSVT or rapid palpitations similar to the spontaneous episodes. Therefore, one cannot exclude a recurrent arrhythmia rate higher than what we observed. In addition, we did not take into account the occurrence of extrasystolic palpitations, which are commonly observed during follow-up, since these have been shown to be poor predictors of PSVT recurrence [20].

Conclusions

The results of this single-center large-size study in patients with a wide age range confirm the extraordinary efficacy and relative safety of RFA of AVNRT, especially in young patients in whom it should be offered as first-line therapy. In addition, we found that the use of a "two-catheter" approach (one diagnostic and one ablation) was as effective and safe as a multi-catheter approach.

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