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ORIGINAL ARTICLE
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Clinical and Electrophysiological Characteristics of Typical Atrioventricular Nodal Reentrant Tachycardia in the Elderly

– Changing of Slow Pathway Location With Aging –

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Background: The aim of this study was to retrospectively evaluate the clinical and electrophysiological characteristics of elderly patients with typical atrioventricular nodal reentrant tachycardia (AVNRT), and to assess the acute safety and efficacy of slow-pathway radiofrequency (RF) ablation in this specific group of patients.

Methods and Results: The present study retrospectively included a total of 1,290 patients receiving successful slow-pathway RF ablation for typical slow-fast AVNRT. Patients were divided into 2 groups: group I included 1,148 patients aged <65 years and group II included 142 patients aged >65 years. The required total procedure duration and total fluoroscopy exposure time were significantly higher in group II vs. group I (P=0.005 and P=0.0001, respectively). The number of RF pulses needed for a successful procedural end-point was significantly higher in group II than in group I (4.4 vs. 7.2, P=0.005). While the ratio of the anterior location near to the His-bundle region was significantly higher in group II, the ratio of posterior and midseptal locations were significantly higher in group I (P=0.0001). The overall procedure success rates were similar. There was no significant difference between the 2 groups in respect of the complications rates.

Conclusions: This experience demonstrates that RF catheter ablation, targeting the slow pathway, could be considered as first-line therapy for typical AVNRT patients older than 65 years as well as younger patients, as it is very safe and effective in the acute period of treatment. (*Circ J* 2015; **79:** 1031–1036)

Key Words: Ablation; Aging; Arrhythmia; Atrioventricular node

Atrioventricular nodal reentrant tachycardia (AVNRT) is the most common form of paroxysmal regular supraventricular tachycardia in adults.[1,2] It is related to the presence of dual anterograde atrioventricular (AV) node pathways with disparate electrophysiological (EP) properties.[3] Although AVNRT is classically described in young patients, it can be detected at any age.[4] Over 50% of patients become symptomatic before the age of 30 years; however, this arrhythmia is very uncommon in the elderly.[5,6] In general, elderly patients (>60 years) represent only 12–22% of those with AVNRT.[7,8]

Slow AV nodal pathway ablation has become the first-line therapy in patients with AVNRT at the present time,[9,10] and radiofrequency (RF) catheter ablation results in high acute success with a low complication rate.[11–13] However, catheter ablation is offered less frequently to elderly patients with AVNRT in daily clinical practice, due to the higher prevalance of cardiovascular comorbidities in the elderly population, which often represents an increased risk for complete AV block or vascular complications.[14]

In the literature, the efficacy and safety of RF catheter ablation have been documented primarily in young patients, and data in the elderly are limited. The aim of this study was to retrospectively evaluate the clinical and EP characteristics of elderly patients with typical AVNRT, and to assess the safety and efficacy of slow-pathway RF ablation for acute and short-term treatment of this specific group of patients.

Methods

Patient Population

This study retrospectively included 1,290 patients who under-

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Table 1. Comparison of Basic Clinical Characteristics Between the 2 Groups

	Group I <65 years of age (n=1,148)	Group II >65 years of age (n=142)	P value
Age (years)	36.7±13.9	71.5±6	0.0001
Male, n (%)	577 (50.3)	74 (52.5)	NS
Frequency of symptoms (attacks/month)	2.1±1.5	2.3±1.6	NS
Duration of tachyarrhythmia symptoms (years)	11.5±9.1	13.6±4.4	NS
History of atrial fibrillation, n (%)	46 (4)	8 (5.6)	NS
History of atrial flutter, n (%)	33 (2.9)	5 (3.5)	NS
Coronary artery disease, n (%)	115 (10)	36 (26)	0.0001
Cardiomyopathy, n (%)	13 (1.1)	3 (2.1)	0.001
Hypertension, n (%)	58 (5)	29 (20)	0.0001
Diabetes mellitus, n (%)	80 (7)	23 (16)	0.0001
Mean number of failed antiarrhythmic drugs	0.8	1.4	0.005

NS, non significant.

Table 2. Baseline Electrophysiologic Characteristics of the 2 Groups

	Group I <65 years of age (n=1,148)	Group II >65 years of age (n=142)	P value
BCL (ms)	737±117	775±84	0.01
ERP of RA (ms)	182±21	186±22	NS
AV node WCL (ms)	308±36	329±46	NS
AV node antegrade ERP (ms)	289±56	280±52	NS
AH interval (ms)	83±16.9	92±21	0.0001
AH interval >140 ms, n (%)	18 (1.6)	3 (2)	NS
HV interval (ms)	44±7	48±8	NS
Multiple AH jumps, n (%)	168 (14)	18 (12)	NS
VA interval during tachycardia (ms)	67±21	68±24	NS
TCL (ms)	334±48	368±63	0.0001
Atrial vulnerability, n (%)	167 (14)	30 (21)	NS

AH, atrium-his; AV, atrioventricular; BCL, basal cycle length; ERP, effective refractory period; HV, his-ventricle; NS, non significant; RA, right atrium; TCL, tachycardia cycle length; VA, ventricle-atrium; WCL, Wenckebach cycle length.

went successful slow-pathway RF ablation for typical slow-fast AVNRT from January 2005 to December 2013. Patient data were collected from 2 separate electrophysiology centers with high patient volumes and experience with ablation procedures. Our results refer to acute period data collected during the EPS procedures until discharge and to short-term data obtained 1 month after discharge. Patients with a form of arrhythmia other than typical AVNRT, obviating the EP study protocol, and those with pre-existing bundle branch block, AV block, or a prolonged PR interval were excluded to yield a homogeneous study population. All patients had symptomatic AVNRT episodes documented by 12-lead surface electrocardiography (ECG) before the ablation procedure. The patients were divided into 2 groups according to age: group I included 1,148 patients <65 years (mean, 36.7±13.9 years) and group II included 142 patients >65 years (mean, 71.5±6 years).

EP Study

All patients signed written informed consent for this clinically indicated procedure. This study protocol was approved by the Ethics Committees of all participating institutions. All antiarrhythmic drugs were discontinued for at least 5 half-lives. The procedure was performed in the fasting state, under local anesthesia without premedication. Three standard 6Fr quadripolar catheters were inserted percutaneously through the femoral vein under local anesthesia and positioned in the high right atrium, the right ventricular apex, and the His bundle region. Additionally, a steerable decapolar electrode catheter was placed in the coronary sinus to record electrical activity around the posterior septum and coronary sinus. The diagnostic EP study was performed by using standard techniques, as described previously,[15,16] with a multichannel digital recorder, and included; (1) assessments of the conduction properties of the atrium, AV node and ventricle; (2) initiation of supraventricular tachycardia using stimulus techniques; and (3) determination of the mechanism of the tachycardia. In accordance with the standard protocol, high right atrial (A1 A1) incremental pacing generally started at 700 ms and decreased in 10-ms steps until the AV node Wenckebach cycle length was reached. Single atrial extra-stimulus (A1 A2) testing with 3 different drive-cycle lengths was performed to induce tachycardia. A jump of the AH interval was defined as the difference between any consecutive AH intervals equal to, or more than, 50 ms during programmed or incremental atrial pacing. Atrial vulnerability was defined as inducibility of AF during an EP study sustained at >30 s.[17] The analysis was performed at a paper

Table 3. Comparison of Electrophysiologic Characteristics After Successful Radiofrequency Catheter Ablation Between the 2 Groups

	Group I <65 years of age (n=1,148)	Group II >65 years of age (n=142)	P value
AV node WCL (ms)	318±31	319±30	NS
AV node antegrade ERP (ms)	309±38	310±34	NS
ERP of RA (ms)	174±27	180±29	NS
Atrial vulnerability, n (%)	60 (5)	11 (7)	NS
Residual dual pathway, n (%)	174 (15)	29 (20)	NS
Successful ablation site			
Anteroseptal, n (%)	60 (5)	40 (28)	0.0001
Midseptal, n (%)	913 (80)	88 (62)	0.0001
Posteroseptal, n (%)	175 (15)	14 (10)	0.0001

Abbreviations as in Table 2.

Table 4. Comparison of the Ablation Procedure-Related Data Between the 2 Groups

	Group I <65 years of age (n=1,148)	Group II >65 years of age (n=142)	P value
Total procedure duration (min)	105±45	125±48	0.005
Total fluoroscopy time (min)	8±4.5	13±2.4	0.0001
Number of radiofrequency impulses	4.4±5.6	7.2±6.2	0.005
Procedure success rate (%)	1,141 (99.4)	140 (99)	NS
Overall complication, n (%)	8 (0.6)	2 (1)	NS
PR prolongation, n (%)	15 (1.3)	3 (2)	NS
Need for pacemaker implantation, n (%)	4 (0.3)	1 (0.7)	NS

NS, non significant.

speed of 100–200 mm/s, with filter settings of 0.5–500 Hz for the surface ECG and for the intracardiac recordings. The AVNRT diagnosis was confirmed based on standard criterias[15,16] as the following: (1) anterograde and rarely retrograde dual AV node pathways with or without echo beats; (2) induction of tachycardia dependent on a critical delay in the atrial-His (A-H) interval (jump); (3) the earliest retrograde atrial activation during tachycardia in the His bundle region; and (4) exclusion of an accessory pathway or atrial tachycardia using conventional pacing and mapping techniques.[18]

Mapping and Ablation

Mapping and RF catheter ablation were performed using a 7Fr quadripolar temperature-controlled electrode catheter with a 4-mm tip and a deflectable curve (Marinr MC; Medtronic Co, Minneapolis, MN, USA). The area in the right atrial septum next to the septal leaflet of the tricuspid valve, which extends from the ostium of the coronary sinus to the His bundle region, was divided into 3 regions. The location nearest the coronary sinus ostium was accepted as posterior (P), the area near His bundle region as anterior (A) and the region between these two locations as medial (M). The slow pathway was targeted for catheter ablation in all patients. The mapping and ablation catheter tip was positioned initially in posterior area to determine the possible anatomical site of the slow pathway. Then, medial and anterior areas were targeted if necessary. The presumed ablation site was considered optimal if bipolar electrograms obtained from the distal electrodes showed an atrial/ventricular electrogram amplitude ratio of 0.1–0.5, with a putative slow-pathway potential.[15,16] RF pulses of 60–90 s were applied at optimal sites, with a maximum temperature of 70°C and maximum power of 45–50 W (Atakr II; Medtronic). Power, impedance and temperature were measured and stored during each application of RF energy. In all cases, junctional ectopic beats during ablation were considered a marker of therapeutic effectiveness. The delivery of RF energy was stopped immediately with a sudden rise in impedance, movement of the catheter, or a retrograde ventriculoatrial block. The EP end-point for ablation success was defined as non-inducibility of AVNRT with or without infusion of atropine, with a maximum of 1 AV nodal echobeat, regardless of the persistence of dual AV nodal physiology during programmed atrial stimulation. The patients were categorized as anterior, medial and posterior according to the region where the slow pathway potentials were obtained and successful ablation was consecutively performed.

The patients were monitored for 3–6 h, and 12-lead ECG (Prucka Engineering Inc, Sugar Land, TX, USA) was taken from all patients immediately after the ablation procedure, before discharge, and 1 month after discharge. Most patients were discharged from the hospital on the day of the ablation procedure performance.

Statistical Analysis

While continuous variables were expressed as mean±SD, categorical variables were expressed as percentages. The differences in categorical and continuous variables between the 2 groups were assessed using the chi-squared test and

unpaired t-test, respectively. A P-value <0.05 was regarded as statistically significant. The SPSS ver. 17.0 (SPSS Inc, Chicago, IL, USA) software was used for all analyses.

Results

Clinical Characteristics

The study population was divided into 2 groups. Group I consisted of 1,148 patients (mean age, 36.7±13.9 years; 50.3% male) and group II included 142 patients (mean age, 71.5±6 years; 52.5% males). There was no difference between the 2 groups with respect of tachycardia-associated symptom frequency or duration. Besides, no differences were observed between the 2 groups in terms of sex distribution and prevalence of atrial fibrillation or atrial flutter. As expected, elderly patients had more structural heart disease; the ratios of coronary artery disease and cardiomyopathy in group II were significantly higher than those in group I (P=0.0001 and P=0.001, respectively). The ratios of patients with hypertension and diabetes mellitus in group II were also significantly higher than those in group I (P=0.0001). Additionally, the mean number of failed antiarrhythmic drugs taken previously by patients was also significantly higher in group II than in group I (P=0.005). The baseline clinical characteristics of the 2 groups are summarized in Table 1.

EP Observations

The EP characteristics of the patients before the RF ablation procedure are presented in Table 2. Baseline AH intervals were significantly longer in patients in group II (P=0.0001), but no difference was observed between the groups in terms of HV interval or the number of patients with an AH interval longer than 140 ms. The right atrium effective refractory period, AV node Wenckebach cycle length, and AV node antegrade effective refractory period values were not different between the 2 groups before and after the RF ablation procedure. The VA interval values during tachycardia were not different between the 2 groups. However, both basal and tachycardia cycle length durations were significantly higher in group II than those in group I (P=0.01 and P=0.0001, respectively). Additionally, no significant difference was observed between the 2 groups for multiple A-H jump prior to ablation; it disappeared completely in the entire study population after successful ablation.

Ablation Procedure-Related Findings

Although the ratio of atrial vulnerability existence before ablation tended to be higher in group II compared to group I, this was not statistically significant (P=0.07), and atrial vulnerability ratios were significantly regressed in both study groups after successful ablation (14% to 5% in group I, and 21% to 7% in group II). In the entire study group, 95% of patients returned spontaneously to normal sinus rhythm within 15 min, and direct-current cardioversion was required for the remaining patients. As for successful ablation sites, while the ratio of the anterior location near to the His bundle region was significantly higher in group II than in group I, the ratios of posterior and midseptal locations were significantly higher in group I than those in group II (P=0.0001).

The total procedural and total fluoroscopy exposure times were significantly higher in group II than those in group I (P=0.005 and P=0.0001, respectively). The number of RF pulses needed for a successful procedural end-point was significantly higher in group II than in group I (4.4 vs. 7.2, P=0.005). The overall procedural success rate was 99.4% in group I and 99% in group II. No significant difference was observed between the groups in terms of the number of patients with a prolonged PR interval or those patients who required a pacemaker after ablation. In addition, complication rates, including all peri- and post-procedural complications, were similar between the 2 groups. Comparisons of the EP characteristics and procedural data after successful RF catheter ablation are shown in Tables 3,4.

Discussion

In this study that compared elderly and younger patients' clinical and EP data, we observed that: (1) elderly patients more often had structural heart disease, hypertension and diabetes mellitus; and (2) although the electrophysiologic features were quite different in some aspects in elderly patients, such as the successful ablation site and some ablation procedural-related data, no differences were observed in the successful RF ablation rate or overall complication rate compared to those in younger patients.

In both cardiology and electrophysiology literature, AVNRT is well-characterized. It is particularly common in middle-aged and elderly females, but can be detected at any age.[4,9] The safety and efficacy of RF catheter ablation of the slow pathway has been very successful in typical AVNRT cases.[19,20] The main risk of this procedure is the high-degree AV block requiring permanent pacing, a complication that occurs in less than 1% of patients and is believed to be more common in elderly patients in some studies.[21,22] However, some conflicting data regarding this complication can be found in the literature. Some studies investigating the success and complication rates for RF ablation in elderly patients >65 years show that the incidences of AV block and implantation of a pacemaker are not different compared to those in younger controls.[23–26] The frequency of a high-degree AV block requiring permanent pacing was also not different between our groups, and our experience demonstrates that the acute and short-term success rates of RF catheter ablation are as good in elderly patients with typical AVNRT compared to those in younger patients.

The ratio of effective ablation performed in an anterior location near to the His bundle region was significantly higher in elderly patients than that in younger patients, and this ablation site might be a clue for probable high-degree AV block occurrence in the future. However, this is an acute and short-term study without long-term follow up. Immediate or early (post procedure up to discharge and at the end of 1 month) AV block required permanent pacemaker implantation and was only observed in 1 patient from the elderly group; this was not statistically significant compared to those in younger controls. Additionally, our patient data in this study were collected from 2 separate centers that have high patient volumes and also are very experienced in terms of ablation procedures. Therefore, we are also of the opinion that the ablation procedures performed by experienced electrophysiologists with more time consuming for carefully mapping of the slow-pathway region in these older patients might be effective for this low and similar complication rates observed between the 2 groups in short-term. This is the first study in the literature comparing successful ablation sites in the AV node between younger and elderly patients.

Age-related degenerative changes evolving at the AV node[27,28] can be related to AVNRT development in elderly patients.[29] It was indicated in the literature that TCL tends to be higher in elderly patients with AVNRT.[24,25,29,30] Additionally, the AH interval and effective refractory periods of antegrade slow

pathway, retrograde slow pathway and fast pathway were shown to increase with age in this group of patients.[30] We found here that there were longer AH intervals and cycle length durations during tachycardia in elderly patients. In contrast, TCL was longer in elderly patients in the present study but the VA interval did not differ during tachycardia, so this might suggest that there was a prolonged antegrade slow pathway conduction time during AVNRT and that it was mainly responsible for the higher TCL in these patients.

In addition, it was also shown in a recent study performed by using 3D mapping with a NavX guided system, that a downward deviation of the His bundle to the midseptum was observed especially in older patients, and slow pathway recording sites were always distributed from the lowest HBE recording site to the middle or bottom of Koch's triangle, and the shape of the SP recording region could be triangular or an oval shape.[31] Therefore, we thought that this higher ratio of the anteriorly located successful site of the slow pathway in elderly patients might be due to age-related changes evolving AV node irrespective of TCL value. All of these changes in the AV node might have been due to degenerative changes associated with the higher incidence of structural heart disease in elderly patients.

Additionally, procedure duration and fluoroscopy time were found to be significantly higher in the elderly patient group. In our experience, we thought that these findings were because of: (1) a more difficult placement of diagnostic and mapping catheters due to a higher incidence of structural heart diseases in these patients; (2) a more time consuming for carefully mapping of the slow-pathway region in elderly patients who are thought to be more susceptible to a high-degree AV block occurence during RF delivery; and (3) a requirement for more RF pulses to reach a successful RF ablation end-point, which is due to the higher degree of fibrosis involving Koch's Triangle in elderly patients.

In general, there is a tendency to withhold ablation therapy in elderly patients because of possible higher complication rates and also because it was considered to be less effective. This way of thinking might explain the fact that elderly patients are exposed to more antiarrhythmic drugs, as seen in our study group. However, it is known that antiarrhythmic drug therapy is often complicated, particularly in elderly patients, due to structural heart disease and other contraindications. Besides, patients who are likely to be unresponsive to commonly prescribed antiarrhythmic drugs have a relatively slow AVNRT and tend to be older.[32] Moreover, AVNRT might cause more severe symptoms in the elderly. A strategy of RF catheter ablation can be used more frequently in elderly patients with AVNRT as a definitive treatment of choice, based on the data from previous studies.[23–26] Therefore, we think that our results would further support the effectiveness and reliability of this procedure.

In conclusion, despite a higher prevalence of structural heart disease, the results of our study suggest that RF catheter ablation targeting the slow pathway could be considered first-line therapy for typical AVNRT patients older than 65 years, as well as for younger patients, as it is safe and effective for acute and short-term periods of the treatment.

Study Limitations

This was a retrospectively designed study without long-term follow up results; however, the EP study and RF ablation protocols have been prospectively standardized. First, we collected data from 2 separate hospitals, one of which is a military hospital. Long-term follow up in military subjects is difficult because they originate from different parts of the country and are present for a limited time. Second, the lower number of patients in group II compared with group I could be due to the lower prevalence of these types of arrhythmia in elderly patients, and the normal demographic pattern of consecutive patients referred to these electrophysiology institutions. Nevertheless, our results might have been different if a greater number of elderly patients had been evaluated. Third, measurement or determination of the anatomical size of the His bundle, by using a conventional fluoroscopic technique, might prolong the procedure duration without helping the operator to achieve ablation success.[31,33] As we have been using a conventional fluorocopic technique for the treatment of these types of arrhythmias in our routine practice, we could not measure the exact anatomical size of the slow pathway in these patients.

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