Feasibility, Efficacy, and Safety of Radiofrequency Catheter Ablation for Cardiac Arrhythmias: A Twelve-Year Experience in Thailand

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Background: *Radiofrequency catheter ablation (RFCA) is widely accepted as a curative treatment for many types of cardiac arrhythmias.*
Material and Method: *The authors retrospectively reviewed 1,193 cases (mean age 45, 41% male) performed in the electrophysiology laboratory at Ramathibodi Hospital from 1996 to 2007. Success rate, recurrence rate and complications were analyzed.*
Results: *Ablations of atrioventricular nodal reentrant tachycardia (AVNRT, 428 cases, 35.9%) and atrioventricular reentrant tachycardia (AVRT, 346 cases, 29%) were the most common procedures. The overall success rate and recurrence rate of RFCA were 88.8% and 6.1% respectively. Complications occurred in 50 patients (4.2%) with 1 death (0.08%). RFCA of AVNRT or AVRT rather than other arrhythmias (Odd ratio 11.46, 95% confidence interval 8.14-16.15, $p < 0.001$) and adult rather than pediatric patients (Odd ratio for age 1.007, 95% confidence interval 1.003-1.011, $p < 0.001$) were independent predictors for successful RFCA.*
Conclusion: *RFCA of cardiac arrhythmia in our institution is safe and effective.*

Keywords: *Arrhythmias, Cardiac, Catheter ablation, Tachycardia*

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The search for the better treatment of cardiac arrhythmias has been pursued for almost a century[1,2]. Medications used to be the mainstay especially after the invention of Calcium channel blockers and Amiodarone[3,4]. However, with the inefficacy and mediocre safety profile of medications, together with the much improved techniques of catheter ablations; radiofrequency catheter ablation (RFCA) has now become the first line treatment for many types of cardiac arrhythmias[5,6].

Since the introduction in late 1980s, RFCA was rapidly adopted. The number of cases increased to more than 5 times in early 1990s[7] and continued to rise[8]. The success rate of RFCA ranged from 70-99%, varied by the type of the arrhythmias[8,9]. Since it can be performed percutaneously, the complications from the procedure were reportedly low, with major complication rate of approximately 1%, and mortality rate of less than 1%[7-9].

In Thailand, RFCA has been performed since 1995. Over the years, the number of cases has increased. In the year 2007 alone, there were approximately 800 cases performed countrywide[10]. The present study is to report the results of RFCA performed in our hospital over the past 12 years. The authors hypothesized that the results would be comparable to those reported in Europe and America.

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Material and Method

A total of 1,193 consecutive cases performed in the electrophysiology laboratory of Ramathibodi Hospital between 1996 and 2007 were reviewed. The

procedures were categorized in to 3 types, electrophysiologic study without ablation (EPS), paroxysmal supraventricular tachycardia (PSVT) ablation and non-PSVT ablation. PSVT ablation included RFCA for atrioventricular nodal reentrant tachycardia (AVNRT) and atrioventricular reentrant tachycardia (AVRT). Patients with coronary artery diseases (CAD), impaired left ventricular function (left ventricular ejection fraction < 40%), or any types of congenital heart diseases were considered to have structural heart diseases. Major complications included death, myocardial infarction, stroke, cardiac tamponade, major bleeding and need for permanent pacemaker. The study was approved by Ramathibodi Ethical Committee.

Electrophysiologic study and RFCA

Before the procedure, each patient gave informed consent. All antiarrhythmic agents were discontinued according to the standard protocol. All procedures were performed according to the techniques previously published and widely accepted[11-21]. Briefly, for PSVT ablation, the slow pathway of the atrioventricular (AV) node was the target for RFCA of AVNRT[11]. For AVRT, AV valve rings were carefully mapped. The target site was guided by local electrogram, *i.e.* the earliest atrial or ventricular signal for antegrade and retrograde conduction respectively and etc[12].

For non-PSVT ablation, the chamber of origin was carefully mapped. For atrial flutter, activation mapping was created during tachycardia. Linear ablation was made across the circuit from one non-electrically conducted area of choice to another[13-15]. For atrial tachycardia and premature atrial contraction, activation mapping was created during tachycardia. Focal ablation was made at the earliest site[16]. For atrial fibrillation, ablation techniques included targeting complex fractionated electrograms (CFAEs)[17] and/or pulmonary vein isolation[18]. For ventricular tachycardia (VT) and premature ventricular contraction (PVC), activation and pace mappings were used to target the ablation site[19]. In the case of scar-related VT, substrate mapping was also created. If VT was too unstable to map, ablation was made across the scar[20].

For EPS, the induction protocol included pharmacological induction and/or programmed stimulation. The MUST protocol was used for programmed ventricular stimulation to stratify the risk of sudden cardiac death[21].

All RFCAs were performed using 4 mm, 8 mm, or irrigated-tip catheters at the operators' own discretion. Intravenous Heparin was given in all RFCAs in left atrium or left ventricle with the target activating clotting time (ACT) of 250-300 seconds. Left atrium was entered via transeptal technique[22] or retrograde transaortic approach. Isoproteronol infusion was used to induce or re-induce the tachycardia. Since 1994, electroanatomical mapping has been available. The decision to use was at the operators' judgment. Success of each RFCA except atrial fibrillation was defined as the inability to re-induce the target tachycardia for at least 30 minutes after the last ablation applied. For atrial fibrillation, the presence of sinus rhythm at one month after the procedure was required to define success.

Patients were monitored in the hospital for at least 24 hours and were reevaluated in 2-3 weeks. Subsequent follow-ups were up to the physicians taking care of the patients.

Statistical analysis

SPSS 13.0 was used for analysis. The differences between groups were analyzed using Chi-square for categorical variables and One-Way ANOVA for continuous variables. Predictors of successful RFCA were analyzed using backward stepwise binary logistic regression. The variables entered included age, sex, diabetes mellitus (DM), hypertension (Htn), structural heart diseases, and PSVT ablation. Odd ratios (OR), and 95% confidence intervals (CI) were calculated. P-value of ≤ 0.05 was considered statistically significant.

Results

The majority of the patients was relatively young and had no structural heart diseases (Table 1). Of the total of 1,193 cases, PSVT ablation accounted for 62.6% (n = 747), while non-PSVT ablation and EPS accounted for 26.8% (n = 320) and 10.6% (n = 126) respectively (Fig. 1). For PSVT ablation, there were 428 cases of AVNRT (35.9% of all cases) and 346 cases of AVRT (29% of all cases). For non-PSVT ablation, there were 65 cases of atrial flutter (5.4% of all cases), 59 cases of atrial tachycardia (4.9% of all cases), 24 cases of atrial fibrillation (2% of all cases), 13 cases of premature atrial contraction (1.1% of all cases), 148 cases of ventricular tachycardia (12.4% of all cases) and 78 cases of premature ventricular contraction (6.5% of all cases). Over the span of 12 years, the number of the total procedures increased, with a

marked increase of non-PSVT ablation in 2007. The average procedure time was 144 minutes and the average fluoroscopic time was 33 minutes. Electro-anatomical mapping was used in 192 cases (16.1%); all were for non-PSVT ablation.

Success, recurrence, and complication

RFCA was performed in 1,067 cases. The results are shown in Table 2. The overall success and recurrence rate were 88.8% and 6.1% respectively. There were a total of 50 complications; none occurred in EPS cases. Of all complications, 13 were major complications including one death. The death occurred in a 4 year-old boy with hemodynamically unstable atrial tachycardia. While ablating in the left atrium, he developed an acute myocardial infarction, and sudden cardiac arrest. Other major complications included 7 cardiac tamponades, and 5 needs for permanent pacemaker. For minor complications, there were 22 transient heart blocks, 5 first degree atrioventricular block, 3 pericardial effusions, and 1 minor bleeding. PSVT ablation was likely to be more success (91.9% vs. 81.6%, $p < 0.001$) and less recurred (3.9% vs. 11.3%, $p < 0.001$) than non-PSVT ablation. There were no differences in the incidences of any complications or major complications between PSVT and non-PSVT ablations. By multivariate analysis, older age and PSVT ablation were the predictors of successful RFCA (Table 3).

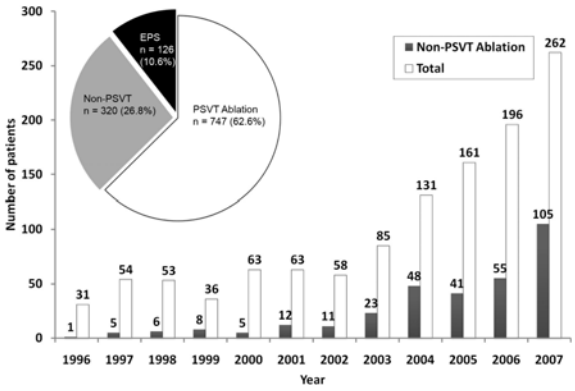

Fig. 1 The number of procedures by types and years (n = 1,193)
EPS = electrophysiologic study without ablation, PSVT = paroxysmal supraventricular tachycardia

Table 1. Baseline characteristics (n = 1,193)

Variables	Value
Age (years) (Mean ± SD, range)	44.8 ± 16 (4-88)
Age < 15 (n, %)	39 (3.3%)
Age > 65 (n, %)	129 (10.8%)
Male (n, %)	486 (40.7%)
Presenting Symptoms	
Palpitation (n, %)	1,018 (85.3%)
Syncope (n, %)	291 (24.4%)
Hypertension (n, %)	73 (6.1%)
Diabetes Mellitus (n, %)	38 (3.2%)
Coronary artery disease (n, %)	33 (2.8%)
Impaired left ventricular function (n, %)	25 (2.1%)
Atrial septal defect (n, %)	11 (0.9%)
Other congenital heart diseases (n, %)	10 (0.8%)

Discussion

The authors reported a large series of more than 1,000 electrophysiologic procedures performed in our institution over 12 years. RFCA performed in our laboratory was safe (< 0.1% mortality rate and < 1.5% major complications) and efficacious (success rate of > 90% for AVNRT and AVRT and > 80% for other ablation). The results are comparable to the prior

Table 2. Results of Radiofrequency Cather ablation (n = 1,067)

Results of the procedure	Overall (n = 1067)	PSVT ablation (n = 747)	Non-PSVT ablation (n = 320)	p-value*
Success	948 (88.8%)	687 (91.9%)	261 (81.6%)	<0.001
Recurrence	65 (6.1%)	29 (3.9%)	36 (11.3%)	<0.001
Any complications	50 (4.7%)	30 (4.0%)	20 (6.3%)	0.11
Major complications	13 (1.2%)	7 (0.9%)	6 (1.9%)	0.20

PSVT = paroxysmal supraventricular tachycardia
* p-value for differences between PSVT and non-PSVT ablation

Table 3. Odd ratios of successful radiofrequency catheter ablation. Variables left in the final model were shown

Variables	Odd ratios	95% confidence interval	p-value
Age	1.007	1.003-1.011	<0.001
PSVT ablation	11.460	8.140-16.15	<0.001

PSVT = paroxysmal supraventricular tachycardia

series in Europe[7] and North America[9]. In Thailand, Raungratanaamporn et al[23] showed a 5-year series of 626 patients who underwent RFCAs. The types of arrhythmias and the results of RFCA were not different from ours, *i.e*. AVNRT and AVRT were the most common procedure, accounted for > 60% with the success rate of > 90% and etc.

All electrophysiologic procedures were categorized into PSVT ablation, non-PSVT ablation and electrophysiologic study without ablation. PSVT ablation, which included RFCAs of AVNRT or AVRT, is more frequently performed. The ablation technique has been established for a longer period of time. On the other hand, non-PSVT ablation, which has only been increasingly performed in the recent years (40% in 2007 vs. 3% in 1996), is more technically challenging; some required ablating in the left atrium and some required the use of electroanatomical mapping. Therefore, not surprisingly, PSVT ablation, rather than non-PSVT ablation, was shown to be one of the two independent predictors of successful RFCAs (OR 11.46, 95% CI 8.14-16.16). Age was another predictor (OR 1.007, 95% CI 1.003-1.011). By calculating from the OR of 1.007, for every increasing year of age, the chance of successful ablation is raised by 0.7%, which implied a higher chance of failure in pediatric rather than adult populations. This could be explained by the difficulties and complexities in ablating pediatric cases. Structural heart diseases, DM, or Hypertension were not related to the success of RFCA.

In Europe and America, RFCA is considered the first line therapy for many types of arrhythmias, including AVNRT, AVRT, idiopathic VT/PVC, typical atrial flutter, and etc. Many prospective studies have clearly shown the benefits of RFCA in reducing cardiovascular morbidity[13,18,20,24] and improving quality of life[25,26]. In addition, RFCA is shown to be cost-effective[27-29], even in a low income country[30]. Therefore, the authors believe that RFCA should be highly considered in Thailand the same way it was in Europe and America.

Conclusion

RFCA of cardiac arrhythmia is safe and effective. It should be considered in Thailand as a first-line therapy for many types of arrhythmias.

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ผลสำเร็จ และผลข้างเคียงของการรักษาภาวะหัวใจเต้นผิดปกติ ด้วยการจี้ด้วยคลื่นไฟฟ้าความถี่สูง จากประสบการณ์ 12 ปีในประเทศไทย

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***ภูมิหลัง**: การจี้ด้วยคลื่นไฟฟ้าความถี่สูงเป็นที่ยอมรับว่าเป็นวิธีรักษาระดับแรกของภาวะหัวใจเต้นผิดปกติหลายชนิด*

***วัสดุและวิธีการ**: คณะผู้นิพนธ์ได้ทำการศึกษาย้อนหลังกลุ่มผู้ป่วย 1,193 ราย ที่เข้ารับการรักษาที่ห้องปฏิบัติการระบบไฟฟ้าหัวใจ โรงพยาบาลรามาธิบดี ระหว่างปี พ.ศ. 2539-2550 เพื่อวิเคราะห์อัตราความสำเร็จ อัตราการเกิดซ้ำ และผลข้างเคียง*

***ผลการศึกษา**: การรักษาที่ทำมากที่สุดคือ การจี้ atrioventricular nodal reentrant tachycardia (AVNRT, 428 ราย, 35.9%) และ atrioventricular reentrant tachycardia (AVRT, 346 ราย, 29%) อัตราความสำเร็จของการจี้คือ 88.8% และอัตราการเกิดซ้ำของการจี้คือ 6.1% ผลข้างเคียงจากการรักษาทั้งหมดเกิดในผู้ป่วย 50 ราย (4.2%) โดยมีเพียง 1 ราย (0.08%) ที่เสียชีวิตปัจจัยที่มีผลโดยตรงต่ออัตราความสำเร็จของการจี้คือ การจี้ AVNRT หรือ AVRT (Odds ratio 11.46, 95% ของความเชื่อมั่น 8.14-16.15, p < 0.001) และอายุของผู้ป่วย (Odds ratio 1.007, 95% ของความเชื่อมั่น 1.003-1.011, p < 0.001) โดยการจี้ในผู้ป่วยอายุน้อยมีโอกาสสำเร็จน้อยกว่า*

***สรุป**: การจี้ด้วยคลื่นไฟฟ้าความถี่สูงที่โรงพยาบาลรามาธิบดีได้ผลดี และปลอดภัย*