Radiofrequency Catheter Ablation in Pediatrics: Experience at Siriraj Hospital

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Abstract

Tachyarrhythmia is one of the life threatening cardiac electrophysiology problems in children. It also affects quality of life of the patients. Radiofrequency catheter ablation (RFCA) has made a significant impact in the treatment of tachyarrhythmia since 1989. The present report is the first and largest report in Thai children. There have been 24 RFCA procedures in 21 children since it was initially performed at Siriraj Hospital from January 1996 to December 1999. The electrophysiology studies and medical records were analyzed retrospectively. Median age and weight at the time of the procedure were 11 (1.1-13) years old and 38.8 (6.8-78.2) kg respectively. The presenting symptoms were palpitation 66.7 per cent, presyncope 16.7 per cent, congestive heart failure and cardiogenic shock 8.3 per cent, syncope 4.2 per cent, and chest pain 4.2 per cent. Median duration of symptom was 3.5 (0.1-8.0) years. The underlying cardiac arrhythmias were Wolff Parkinson White (WPW) syndrome 50 per cent, concealed accessory pathway 16.7 per cent, atrioventricular node re-entry tachycardia (AVNRT) 16.7 per cent, atrial ectopic tachycardia (AET) 12.5 per cent, and WPW with AVNRT 4.2 per cent. The median fluoroscopy time and procedure time were 25 (4-145) minutes and 125 (60-320) minutes respectively. The median tachycardia cycle length was 332.5 (220-460) seconds. The immediate success rate was 21/24 (87.5%) procedures. The procedural complication was 1/24 (4.2%). Two patients (8.3%) had recurrences of tachycardia and were successfully controlled with antiarrhythmic drugs.

Conclusion: RFCA is a safe, effective, and curative procedure with high success rate for pediatric tachyarrhythmias.

Key word : Radiofrequency Catheter Ablation, Tachyarrhythmia, Supraventricular Tachycardia

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Background

Tachyarrhythmia is one of the main problems in cardiac electrophysiology and adversely affects the patient's life style. In symptomatic patients, there are options for treatment i.e., antiarrhythmic medications, or destruction of the abnormal tissue through surgery or transcatheter ablation. In the past, direct current shock ablation was used by transcatheter approach. It resulted in explosive gas formation and was susceptible to adverse barotrauma[1]. RFCA has been proposed to be safer, and less invasive than surgical treatment. It produces tissue injury solely through resistive heating[2]. The appeal of this technique for young patients is readily apparent since it can obviate the need for prolonged exposure to antiarrhythmic drugs and their side effects. The procedure was initially applied in pediatric patients in 1989[3]. There were many subsequent reports of RFCA in the pediatric age group with a good success rate (80-94%) and low complication rate (<4.8%)[4-7]. As a result, RFCA in children is the most attractive way for curative management of tachyarrhythmia. However, type of arrhythmia, location and number of accessory pathways, age of the patient at the time of RFCA, and institutional experience are factors affecting the outcome [5,7,8]. RFCA was first implemented in Thai children at Siriraj Hospital in January 1996. This is the largest report to date o f RFCA in Thai children.

METHOD

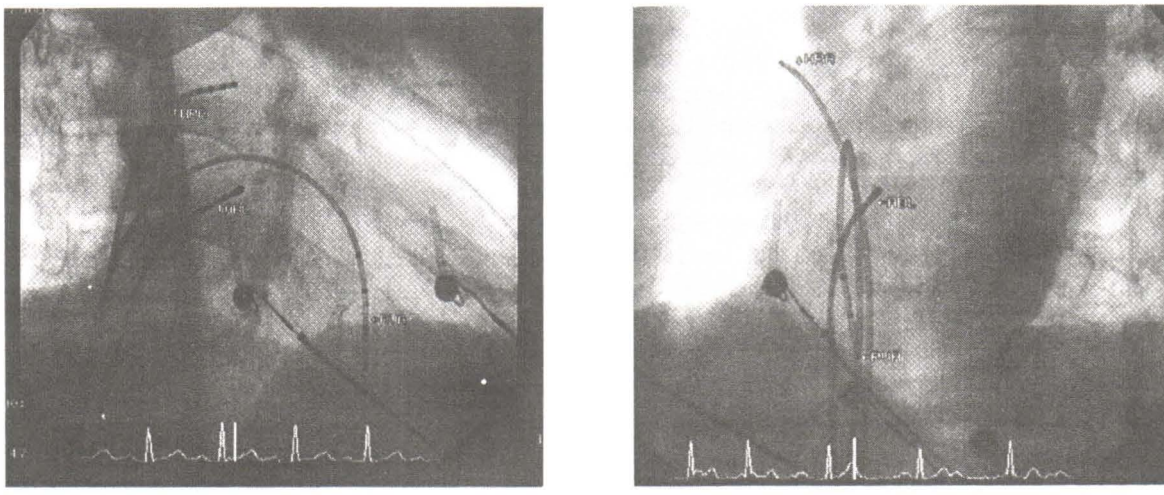
The authors reviewed 24 consecutive procedures in 21 pediatric cases (newborn to 13 years old) who underwent RFCA for tachyarrhythmia at Siriraj Hospital from January 1996 to December 1999. The electrophysiology study, RFCA procedure data and medical records of every patient were analyzed retrospectively. Demographic data, presenting symptoms, duration of symptoms, associated cardiac problems, antiarrhythmic medications, electrophysiologic data, results of RFCA, complications, and recurrence were reviewed.

Electrophysiology study (EPS) and RFCA

The authors modified the indications for RFCA in children recommended by Walsh EP[6] and Van Hare GF[2] as followed: 1. life-threatening symptoms, 2. medically refractory arrhythmias, 3. withdrawal of medical therapy because of adverse drug effects, 4. ventricular dysfunction associated with incessant tachycardia, 5. patient preference (in ≥ 8 years old).

The course of tachyarrhythmia and options of treatment were thoroughly explained and discussed with the parents. The EPS, RFCA procedures, the expected success rate and complications were also described in detail including the post-procedural course. Then, informed consent was taken. Antiarrhythmic drugs were discontinued for five half-lives of the medication prior to the procedure. The patients were admitted to the hospital one day before the study. Upon admission, 12 lead ECG, hematocrit (Hct), CXR (or recent one within the last 6 months) were routinely obtained. Cross matching for pack red cell 20 ml/kg was prepared.

EPS and RFCA were performed in the fasting state under general anesthesia, except for atrial ectopic tachycardia (AET) which needed very light anesthesia in the cardiac catheterization laboratory. Two diagnostic, quadripolar electrodes 5 Fr. or 6 Fr. catheters were passed percutaneously from the femoral vein (usually the right side) and placed at right atrium and right ventricular apex. Then a 6 Fr. or 7 Fr. ablation catheter (Webster or EP tech) was also passed from the femoral vein into the heart. For left-sided accessory pathway (AP), a 5 Fr. or 6 Fr. decapolar electrode catheter was placed in the coronary sinus as a reference. Fig. 1 demonstrates the position of electrode catheters in the RFCA procedure in a patient with AVNRT. The ablation catheter entered from the femoral artery percutaneously and passed retrogradely into the heart. Heparin 100 units/kg at the maximum of 5000 units intravenously was given before the left-sided catheter manipulation. More might be needed in case of prolonged left sided procedure. Surface ECG and intracardiac electrogram were simultaneously recorded and displayed on a multichannel oscilloscopic recorder (Cardiolab, Prucka Engineering). Atrial and ventricular program stimulation were performed to evaluate the properties of accessory pathways, atrioventricular node and to induce tachycardia. If tachycardia could not be induced, isoproterenol 0.01- 0.05 μg/kg/min was administered. Activation sequence was used to map the proper site for applying radiofrequency energy. For WPW syndrome, the earliest ventricular (V) electrogram in pre-excited rhythm with pre-delta > 20 milli second (msec), and/or AP potential were crucial for the success (Fig. 2). The earliest atrial (A) electrogram under ventricular pacing or supraventricular tachycardia (SVT), and/or AP potential were used



1.1 RAO view 1.2 LAO view

Fig. 1. X-Rays of the successful site in a patient with AVNRT. 1.1) Right anterior oblique view (RAO) 1.2) Left anterior oblique view (LAO).

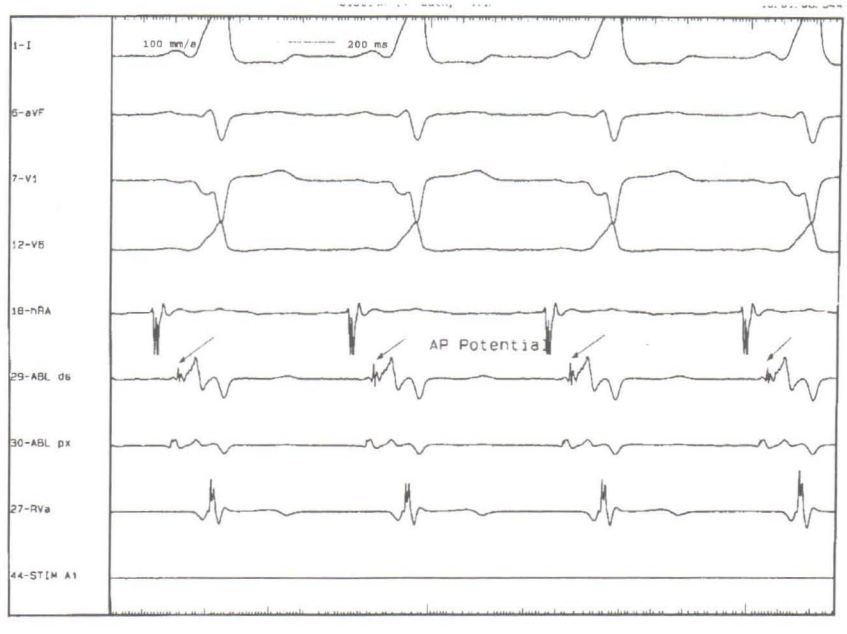


Fig. 2. Electrogram at the successful ablation site in WPW syndrome; arrows point at the AP potential.

for the proper sites of concealed accessory pathway. The earliest A electrogram with pre P wave on surface ECG >20 msec was used as the good spot for RF energy application in AET. The favored approach in slow pathway modification for atrioventricular node re-entry tachycardia (AVNRT) was a combined anatomical/electrical approach i.e., in the triangle of Koch when A electrogram was much smaller than V electrogram. The energy was gradually increased to 20-30 Watts and/or tip catheter

temperature of 50-55°C. If there was no evidence of ECG and/or electrogram change in the accessory pathway and AET or no junctional rhythm for atrioventricular node modification in AVNRT in 15 seconds, the RF energy was terminated. If the ECG showed loss of pre-excitation in WPW syndrome, electrogram revealed lengthening of VA time in concealed AP, P wave morphology on surface ECG changed in AET, and slow junctional rhythm (rate < 150 beat per minute) in AVNRT, RF energy was applied for 60 seconds. Successful RFCA was defined as follows i.e., under program A and V stimulation without/with isoproterenol at 30 minutes after the last RF application, there was inability to induce tachycardia, and no eccentric antegrade and retrograde AV conduction in AP; inability to induce tachycardia in AET; no dual AV node physiology (AH or AV jump more than 50 msec) and no echo beat in AVNRT. Antiarrhythmia medications were discontinued. The patients were hospitalized overnight with ECG monitoring. Complete leads ECG was obtained the next morning. Echocardiogram was also performed prior to discharge from the hospital to look for any damage to heart valves, pericardial effusion, or abnormal clotting at the site of RF application. Every patient was followed-up for at least 3 months and whenever the symptom recurred. The patients who suffered recurrent tachyarrhythmia were rescheduled for ablation.

Statistical analysis

Measured variables are presented as median, minimum and maximum value. Categorical data are shown as count and percentage.

RESULTS

There were 24 procedures in 21 patients who underwent EPS and RFCA at Siriraj Hospital from January 1996 to December 1999. Female: male ratio was 2:1. Median age and weight were 11.0 (1.1-13.0) years old and 38.8 (6.8-78.2) kg respectively. Presenting symptoms were palpitation 66.7 per cent, presyncope 16.7 per cent, congestive heart failure and cardiogenic shock 8.3 per cent, syncope 4.2 per cent and chest pain 4.2 per cent. The most common cause of tachyarrhythmia was WPW 50 per cent as shown in Fig. 3. Sixty six per cent of the patients were on antiarrhythmic drugs i.e., beta blocker 37.5 per cent, calcium channel blocker 17 per cent, amiodarone 8.3 per cent, and sotalol 4.2 per cent. Associated cardiac problems were dilated cardiomyopathy 3 cases (16.7%), atrial septal defect 1 case (4.2%), and Ebstein's anomaly 1 case (4.2%). Dilated cardiomyopathy was believed to be tachycardia induced and completely reversible in 2/3 cases within 5 months post successful RFCA. Electrophysiology and RFCA data are demonstrated in Table 1. Seventeen APs were found and ablated in this study i.e., 53 per cent were on the right side and the rest were on the left. The abnormal foci of AET were at the mouth of the right atrial appendage and the opening of left upper pulmonary vein. The immediate success rate was 87.5 per cent. Three cases who failed at the first RFCA procedure attempt had AET, anteroseptal AP, and right posterior AP. All were successfully treated with subsequent RFCA. Two cases had recurrent SVT that were easily controlled by antiarrhythmic drugs. There was one patient with WPW syndrome whose

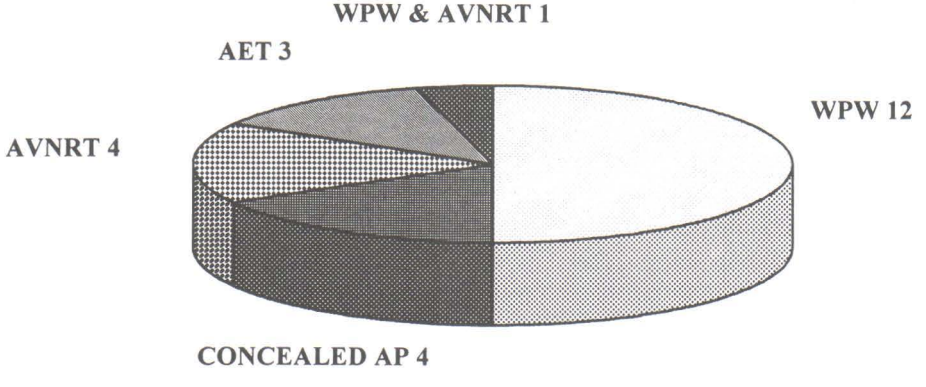


Fig. 3. Diagram shows the diagnosis of tachyarrhythmia.

Table 1. Demonstrated tachycardia data, procedural data, and follow-up data.

	N	Median	Range
Duration of symptoms (yrs)	21	3.5	0.1-8.0
Cycle length of tachycardia(msec)	22	332.5	220-460
Attempts of RFA	24	6.5	1-50
Time return to sinus (second)	19	1.8	0.6-60.0
Fluoroscopy time(mins)	21	25.0	4.0-145.0
Procedure time (mins)	23	125.0	60.0-320.0
Follow-up time (month)	21	6.1	1.2-13.7

AP was at anteroseptum very close to the normal conducting system. She had fully pre-excited sinus rhythm and no antegrade and retrograde conduction through AV node after RFCA. We decided to stop the procedure and did not put her on permanent pacemaker due to reasonably good antegrade conduction through AP and the shortest RR interval during atrial fibrillation (AF) was 270 msec. She has had a good quality of life and no more tachycardia. Exercise test was done the following week which showed one to one AV conduction with fully pre-excitation at 100 per cent predicted maximum heart rate throughout the test. No AF occurred during the test. Every patient was scheduled for follow-up. The median follow-up time is also demonstrated in Table 1.

DISCUSSION

Most of the patients in this study were semi elective except for 3 cases who had depressed left ventricular function and on intravenous inotropic drugs. Low body weight (<15 kg) and institutional experience have been documented as independent risk factors of RFCA[5]. These affect the indication for RFCA in children. However, there are infants who require curative treatment for hemodynamic unstable, uncontrollable incessant tachyarrhythmia especially in AET, permanent form of junctional reciprocating tachycardia (PJRT). Currently in some institutions, approximately 10 per cent of pediatric patients undergoing RFCA are less than 5 years old and 3 per cent are younger than 1 year old[5]. In our study only 1/21 case (4.8%) who presented with cardiogenic shock with uncontrollable incessant tachyarrhythmia and left ventricular dysfunction was 1.1 years old at the time of RFCA. Supraventricular tachycardia caused by orthodromic re-entry tachycardia of accessory pathways has been shown to be the most common cause of SVT in children[9]. Whereas, the incidence of AET was quite constant throughout childhood, the AVNRT gradually rose and peaked at age 6-10 years old[9]. Our study also revealed that the accessory pathway (WPW syndrome and concealed AP) was the cause in the majority of patients. Spontaneous regression of accessory pathway plays an important role in the appropriate age for RFCA in symptomatic patients. There was a report of 93 per cent disappearance of pre-excitation in infancy and 31 per cent reappearance at the age of 8. The majority (78%) of tachycardia persisted in patients who presented after the age of 5[10]. Twenty to fifty per cent of infants with uncommon SVT (AET, PJRT) improved or resolved [11]. Twenty one per cent of our patients had underlying cardiovascular problems i.e., myopathy 12.5 per cent, congenital heart disease (Ebstein's anomaly 1, atrial septal defect 1) 8.3 per cent. This is also the experience of Walsh et al[6]. Ebstein's anomaly, corrected transposition of great arteries, and hypertrophic cardiomyopathy are more likely to have accessory pathways. Shortest RR interval <220 msec during AF in WPW syndrome has been documented to be the more sensitive risk factor for sudden death than clinical history in children < 18 years old[12].

Electrophysiology study and radiofrequency catheter ablation

In this study, right sided AP was found more frequently than the left (53% *vs* 47%) contrary to the report by Park et al[13]. The fluoroscopy time, procedure time and number of RF applications were comparable with other reports in children[5,13]. These durations were affected by types

of tachyarrhythmia, location and number of AP, underlying congenital heart diseases, and institutional experience[5,7,13,14]. RFCA of right free wall and AET needed longer fluoroscopy and procedure time. Walsh EP et al recommended RFCA as the preferred first-line therapy for patients with AET and depressed myocardial function[15]. The mouth of the right atrial appendage and opening of pulmonary veins are the common foci of AET[15, 16]. This was also experienced in this study. There were reports of up to 55 per cent of AET or incessant tachycardia from AP that had ventricular dysfunction before RFCA and all recovered after successful ablation[7,17]. This was also found in this study.

Overall success rate of RFCA in children was 80-98 per cent depending on types of tachyarrhythmia, location and number of AP, underlying heart disease, and institutional experience (5,7,13,14, 18,19). This study had a recurrence rate of 8.3 per cent; one in AET and the other in WPW syndrome (right posterior AP). Recurrence rate of AET was shown to be 10-25 per cent[8,20]. This study revealed 1/3 (33%) of recurrence of AET post RFCA.

Complications

Complications of RFCA in children has been reported to be 1.2-4.8 per cent[5,7]. Consisting of complete AV block, cardiac perforation, cerebrovascular accident, and late death etc. The only complication in this study was accidental AV node ablation. Despite extreme caution, AV node ablation occurred in a patient who had medical failure SVT from anteroseptal accessory pathway in WPW syndrome. This was due to the proximity of AP and AV node. Her shortest RR interval was 270 msec which was reasonable for us to decide not to ablate the AP and put her on close follow-up for heart block.

Follow-up

Even though RFCA is a curative procedure, the recurrence of tachyarrhythmia can happen. It usually occurs within 24-48 hours post procedure. However, this can happen later especially in paroxysmal tachycardia. In this study, we did not have a single case with symptomatic tachycardia later than 90 days.

In summary, RFCA has revolutionized arrhythmia management in pediatrics with good outcomes. The use has also been extended to postoperative congenital heart diseases tachyarrhythmia e.g. incisional atrial re-entrant tachycardia, and postoperative ventricular tachycardia.

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การทำ Radiofreqnency catheter ablation ในผู้ป่วยเด็กโรงพยาบาลศิริราช

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การเต้นเร็วผิดจังหวะของหัวใจ เป็นปัญหาที่สำคัญและอาจถึงแก่ชีวิตได้ในผู้ป่วยเด็ก นอกจากนี้ยังมีผลต่อคุณภาพชีวิตของผู้ป่วยด้วย การรักษาด้วยวิธีจี้โดยใช้คลื่นวิทยุผ่านทางสายสวนหัวใจได้ทำให้เกิดผลการรักษาอย่างดียิ่งในภาวะนี้เริ่มตั้งแต่ปี พ.ศ. 2532 รายงานนี้เป็นรายงานแรกที่มีจำนวนผู้ป่วยมากที่สุดในเด็กไทย โดยศึกษาย้อนหลังทั้งหมด 24 ครั้ง ในผู้ป่วย 21 ราย ในรพ. ศิริราช โดยรวบรวมตั้งแต่ทำครั้งแรกในเดือนมกราคม พ.ศ. 2539 ถึง ธันวาคม 2542

ได้ศึกษาจากรายงานผู้ป่วย และการตรวจทางเดินประจุไฟฟ้าหัวใจในห้องปฏิบัติการ cardiac catheterization พบว่าอายุเฉลี่ยของผู้ป่วยทั้งหมดคือ 11 ปี (1.1–13 ปี) และน้ำหนักเฉลี่ย 38.8 กิโลกรัม (6.8–78.2 กิโลกรัม) อาการแสดงนำมี ใจสั่น 66.7%, ใกล้จะเป็นลม 16.7% ภาวะหัวใจวายและช็อก 8.3%, เป็นลมหมดสติ 4.2% และเจ็บหน้าอก 4.2% ระยะเวลาเฉลี่ยที่ผู้ป่วยมีอาการ 3.5 ปี (0.1–8.0 ปี) สาเหตุของการเต้นเร็วผิดจังหวะของหัวใจ คือ Wolff Parkinson White syndrome (WPW) 50%, concealed accessory pathway 16.7%, atrioventricular node re-entry tachycardia (AVNRT) 12.5% และ WPW ร่วมกับ AVNRT 4.2% ระยะเวลาเฉลี่ยของการทำ fluoroscopy คือ 25 นาที (4–45 นาที) และเวลาทำทั้งหมดเฉลี่ย 125 นาที (60–320 นาที) cycle length เฉลี่ยของการเต้นเร็วผิดจังหวะ คือ 332.5 มิลิวินาที (220–460 มิลลิวินาที) อัตราความสำเร็จระยะสั้นของการทำคือ 21/24ครั้ง (87.5%) มีภาวะแทรกซ้อน 1/24 ครั้ง (4.2%) ผู้ป่วย 2 ราย เกิดการเต้นเร็วผิดจังหวะขึ้นมาใหม่ และสามารถควบคุมได้ง่ายโดยใช้ยา โดยสรุป ถือได้ว่าการรักษาภาวะหัวใจเต้นเร็วผิดจังหวะโดยการจี้ด้วยคลื่นวิทยุในเด็กมีความปลอดภัย และได้ผลดี มีโอกาสหายขาดได้สูง

คำสำคัญ : Radiofrequency Catheter Ablation, Tachyarrhythmia, Supraventricular Tachycardia

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