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Pediatric Radiofrequency Catheter Ablation
—— Sedation Methods and Success, Complication and Recurrence Rates ——

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Background There remains to be issues regarding radiofrequency catheter ablation (RFCA) in pediatric patients that are different to those involving adults. This study was performed to determine the efficacy and safety of RFCA in pediatric patients.

Methods and Results During the period from 1992 to 2003, 2,734 patients underwent RFCA and 131 pediatric patients who were ≤15 years old (70 males, mean age 12.0±3.1 years) were analyzed, retrospectively. The number of accessory pathways (APs) mediating atrioventricular re-entrant tachycardia was 93 (71.4%) and atrioventricular nodal re-entrant tachycardia (AVNRT) was 27 (20.5%). The most common indications for the RFCA were the 'patient's choice' in 94 (71.2%) and 'medically refractory tachycardia' in 29 (22.0%). The age-related indication of the 'patient's choice' was 80.4% (82 of 102) for those >10 years old and 40.0% (12 of 30) for those ≤10 years old (p=0.01). RFCA was performed without sedation in 87.3% (89 of 102) of the subjects >10 years old as compared to 20.0% (6 of 30) of those ≤10 years old (p=0.01). The success rate was 92.8% (90 of 97 APs) for the ablation of APs, and 96.3% (26 of 27) for that of AVNRT. The overall complication rate was 3.8% (5 of 131). During a mean follow-up duration of 13.1±2.5 months, the freedom of recurrence was 87.8% (79 of 90) for the arrhythmia associated with APs and 92.3% (24 of 26) for AVNRT.

Conclusion RFCA in pediatric patients had a good success rate with acceptable recurrence and complication rates when compared to adult patient results. Therefore, RFCA could be considered as the first line of therapy for arrhythmias with concealed and manifested APs and AVNRT in pediatric patients. (*Circ J* 2006; **70:** 278–284)

Key Words: Arrhythmias; Pediatric patients; Radiofrequency catheter ablation

Since 1989, when radiofrequency (RF) ablation was first used in pediatric patients with supraventricular tachycardia (SVT),[1–3] transcatheter treatment of arrhythmias has emerged as a frontline treatment at pediatric centers in many countries.[4–6] The success rate has been improving steadily and the complication rates have been declining with increased user experience.[5,7] Because drug treatment has a limited success rate[8] and involves additional morbidity while requiring rigid compliance, RF catheter ablation (RFCA) is becoming the first line of therapy for the treatment of many tachyarrhythmias in most pediatric patients. However, there are still different issues to deal with in pediatric patients than there are in adult patients. In particular, sedation is needed in most pediatric patients. Complications and the long-term effects of RFCA may differ from adults also. This study was performed to determine the efficacy and safety of pediatric RFCA in a single tertiary electrophysiologic (EP) laboratory for adults and children in Korea.

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Methods

Patient Population

From 1 January 1992 to 30 January 2003, 3,180 RFCA procedures were performed in 2,734 patients in the electrophysiology laboratory at Yonsei Cardiovascular Center, Korea, and the EP study (EPS) and RFCA data from all patients involved were stored in a database. EPS was performed in 142 patients who were ≤15 years old, and this included 2 patients with double arrhythmias (one with Wolff–Parkinson–White (WPW) syndrome and ventricular tachycardia (VT), and one with atrioventricular (AV) nodal re-entrant tachycardia (AVNRT) and atrial tachycardia (AT)). Patients were included in the present study if they were ≤15 years of age at the time of the RFCA (they were analyzed retrospectively). RFCA was not performed in 12 patients with arrhythmias, 6 with non-inducible VTs, 3 with VTs treated medically, 1 with VT treated surgically, 1 with an unreliably induced AVNRT, and 1 with AV re-entrant tachycardia (AVRT) with a concealed bypass tract (CBT) treated medically. The study population consisted of 131 patients (70 male, 61 female) who were ≤15 years old and who had undergone RFCA.

Study Design

The patients were assigned into subgroups representing the mechanisms of the arrhythmias. To account for the potential confounding influence of the patient age on the outcome, the patients were assigned to 3 age subgroups

Table 1 Baseline Characteristics, Type of Tachyarrhythmias and Indications for RFCA

Type	Patient, n (%)	Age (years)	Weight (kg)	Height (cm)	Congenital heart disease	Indications of RFCA, n (%)			
						Life threatening symptoms	Medically refractory	Tachycardia induced cardiomyopathy	Patient's choice
WPW syndrome	47 (35.6)	11.3±3.9 (0.6–15)	45.5±18.8 (8.5–95)	146.5±28.8 (45–179)	VSD 1, ASD 2	1 (2.1)	10 (21.3)	5 (10.6)	31 (66.0)
AVRT with CBT	46 (34.8)	11.8±3.0 (2–15)	46.4±16.8 (11–100)	149.4±18.4 (92–178)	0	1 (2.2)	11 (23.9)	0	34 (73.9)
AVNRT	27 (20.5)	13.1±1.8 (9–15)	50.9±11.6 (32–75)	158.0±13.2 (133–189)	CoA, PDA 1, ASD 1	0	5 (18.5)	0	22 (81.5)
Ventricular tachycardia	6 (4.5)	14.0±1.3 (12–15)	59.5±24.3 (41–97)	161.2±13.1 (140–179)	Corrected TOF 1	1 (16.7)	0	1 (16.6)	4 (66.7)
Atrial tachycardia	6 (4.5)	12.2±1.5 (11–14)	41.5±6.1 (36–48)	149.0±11.0 (141–163)	VSD patch repair 1, Corrected TOF 1	0	3 (50.0)	0	3 (50.0)
Total	132* (100)	12.0±3.1 (0.6–15)	47.6±17.0 (8.5–100)	150.9±21.8 (45–189)	8	3 (2.3)	29 (22.0)	6 (4.5)	94 (71.2)

RFCA, radiofrequency catheter ablation; WPW syndrome, Wolff–Parkinson–White syndrome; VSD, ventricular septal defect; ASD, atrial septal defect; AVRT, atrioventricular re-entrant tachycardia; CBT, concealed bypass tract; AVNRT, atrioventricular nodal re-entrant tachycardia; CoA, coarctation of the aorta; PDA, patent ductus arteriosus; TOF, tetralogy of Fallot.
**The number of arrhythmias was 132 in 131 patients including 1 patient with AVNRT and atrial tachycardia.*

based on their age: (1) ≤5 years; (2) 6–10 years; and (3) >10 years. To assess the effect of the sedation methods, the patients were also assigned to 4 subgroups based on the sedation method used: (1) without sedation; (2) conscious sedation; (3) deep sedation; and (4) general anesthesia.

Indications for Ablation

Of the following indications for ablation[4] only 1 was accepted for each procedure: (1) life-threatening symptoms–tachyarrhythmias associated with syncope, near syncope, seizures, or resuscitation from cardiac arrest; (2) medically refractory tachycardia–tachyarrhythmias not effectively controlled by one or more antiarrhythmic medications; (3) tachycardia-induced cardiomyopathy–ventricular dysfunction associated with incessant tachycardia; and (4) the patient's choice–an indication accepted only when none of the above indications applied. Although the patient's choice (or the family's choice for young patients) was a practical consideration in virtually all procedures, it was regarded as an indication only when it was the sole reason for the ablation.

Definitions of Sedation

To determine the type of sedation to be used, definitions and guidelines for the 3 stages of sedation developed by the American Academy of Pediatrics (AAP) and American Society of Anesthesiologists was used[9] The AAP definitions are: (1) conscious sedation–a medically controlled state of depressed consciousness that allows protective reflexes to be maintained; retains the patient's ability to maintain a patent airway; and permits an appropriate response by the patient to physical or verbal commands; (2) deep sedation–a medically controlled state of depressed consciousness or unconsciousness from which the patient is not easily aroused. It may be accompanied by a loss of protective reflexes. This includes the ability to maintain a patent airway independently or allows the patient to respond purposely to physical stimuli or verbal commands; and (3) general anesthesia–a medically controlled state of unconsciousness accompanied by a loss of protective reflexes, including the ability to maintain a patent airway independently or allows the patient to respond purposely to physical stimuli or verbal commands.

Study Definitions

The definition of the tachyarrhythmias used in the present study have been defined elsewhere[4,5,10] Briefly, the tachycardias with accessory pathways (APs) were subgrouped into WPW syndrome when the AVRT utilized manifest APs for the retrograde conduction pathway, and AVRT with CBT when the APs had exclusively retrograde conduction. The permanent form of junctional reciprocating tachycardia was defined when patients had slowly conducting retrograde APs and were included in AVRT[11] To minimize the variation in the interpretation of the AP location descriptions, arbitrary borders were shown on the data recording form in a diagram representing the left anterior oblique view of the tricuspid-valve annulus and mitral-valve annulus[9] For AVNRT, the fast AV nodal pathway was defined as the anterior or superior AV nodal pathway functioning as the retrograde limb, whereas the slow AV nodal pathway was the posterior or inferior AV nodal pathway functioning as the anterograde limb.

The procedure time was defined as a time from the beginning of EPS to the end of RFCA. Total anesthesia time was defined as the time from anesthesia induction to tracheal extubation or recovery from anesthesia. The success/failure was determined at the conclusion of the procedure. Ablation was considered successful if the conduction through the pathway (eg, pre-excitation) was abolished, or the tachyarrhythmia (eg, AVNRT) could no longer be induced. Complications were included in this report if they met 1 or more of the following criteria: the problem required emergency or ongoing treatment or follow up, or residual effects interfered with normal function.

Follow-up Analysis

Each patient was evaluated after 1 week, 1, 3, 6, and 12 months after the ablation. For each patient and for each pathway or type of tachycardia, only the documentation of the pre-excitation, tachycardia, or both was considered to represent a recurrence. Palpitations were not considered to represent recurrences if they were not associated with documented tachyarrhythmias or if they were associated with a tachyarrhythmia different from that identified before the ablation.

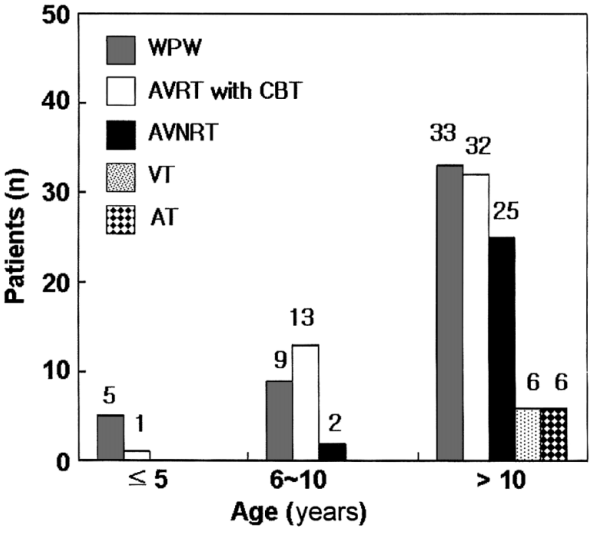

Fig 1. Frequency of the arrhythmias according to 3 age subgroups: ≤5 years (n=6), 6–10 years (n=24), and >10 years (n=102). Arrhythmias with accessory pathways were the most common in all age groups (100% for patients aged ≤5 years, 91.7% for those aged 6–10 years, and 63.7% for those aged >10 years). However, the proportion of AVNRT increased with older age without significance (0% for patients aged ≤5 years, 8.3% for those aged 6–10 years, and 24.5% for those aged >10 years; p=0.08). See Table 1 for abbreviations and definitions.

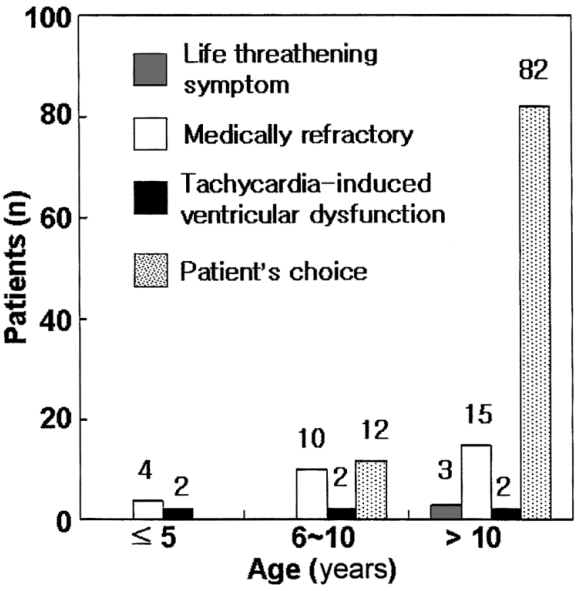

Fig 2. Comparison of the 4 indications for ablation according to the 3 age subgroups: ≤5 years (n=6), 6–10 years (n=24), and >10 years (n=102). Patient's choice (71.2%, 94 of 132) was the most common indication in all patient groups. There was a significant difference (p=0.01) between the age groups for the indication of a 'patients choice' with 80.4 % (82 of 102) for patients aged >10 years as compared to 40.0% (12 of 30) for patients aged ≤10 years (p=0.01).

Statistical Analysis

The mechanisms of the arrhythmias, indications for the RFCA, sedation, and success and recurrence rates were compared among the age and sedation subgroups. Comparisons were made by using the chi-square analysis and the unpaired Student's t-test. Differences with a p-value of <0.05 were considered to be statistically significant.

Results

Basic Characteristics

The number of arrhythmias was 132 in 131 patients, including 1 patient who had AVNRT and AT, simultaneously. The age range was 6 months to 15 years (mean 12.0±3.1 years, median 12.3 years), weight range 8.5 to 100 kg (mean 47.6±17.0 kg, median 48.0 kg), and height range 45 to 189 cm (mean 150.9±21.8 cm, median 156 cm). The arrhythmias observed were WPW syndrome in 47 (35.6%), AVRT with CBT in 46 (34.8%), AVNRT in 27 (20.5%), VT in 6 (4.5%), and AT in 6 (4.5%; Table 1).

The frequency of the arrhythmias was also presented according to the age subgroups. Arrhythmias associated with APs were the most common in all age subgroups (100% for patients aged ≤5 years, 91.7% for patients aged 6–10 years, and 63.7% for patients aged >10 years). However, the proportion of AVNRT increased with older age without significance (0% for patients aged ≤5 years, 8.3% for patients aged 6–10 years, and 24.5% for patients aged >10 years; p=0.08; Fig 1).

According to the analysis of the indications for ablation and EPS, the 'patient's choice' was listed in 71.2% of the ablations, 'medically refractory tachycardia' in 22.0%,

Table 2 Sedation, Success and Recurrence Rate of RFCA According to the Tachyarrhythmias

Type	*Patient, n (%)*	*No sedation, n (%)*	*Sedation, n (%)*			*Procedure time (min)*	*Success, N (%)*	*Free of recurrence, N (%)*
			Conscious sedation	*Deep sedation*	*General anesthesia*			
WPW syndrome	*47 (35.6)*	*29 (61.7)*	*3 (6.4)*	*12 (25.5)*	*3 (6.4)*	*80.4±42.7 (40–170)*	*43 (91.5)*	*38 (88.4)*
AVRT with CBT	*46 (34.8)*	*32 (69.6)*	*5 (10.9)*	*9 (19.6)*	*0*	*76.8±34.7 (40–195)*	*43 (93.5)*	*38 (88.4)*
AVNRT	*27 (20.5)*	*22 (81.5)*	*2 (7.4)*	*3 (11.1)*	*0*	*73.7±24.2 (50–150)*	*26 (96.3)*	*24 (92.3)*
Ventricular tachycardia	*6 (4.5)*	*6 (100)*	*0*	*0*	*0*	*123.3±26.6 (90–160)*	*5 (83.3)*	*5 (100)*
Atrial tachycardia	*6 (4.5)*	*6 (100)*	*0*	*0*	*0*	*131.0±48.8 (85–200)*	*5 (83.3)*	*5 (100)*
Total	*132* (100)*	*95 (72.0)*	*10 (7.6)*	*24 (18.2)*	*3 (2.3)*	*81.7±38.4 (40–200)*	*122 (92.4)*	*110 (90.2)*

See Table 1 for abbreviations.
**The number of arrhythmias was 132 in 131 patients including 1 patient with AVNRT and atrial tachycardia.*

'tachycardia-induced ventricular dysfunction' in 4.5% and 'life threatening arrhythmia' in 2.3% (Table 1). When the indication of the RF ablation and EPS was analyzed according to the age subgroups, the difference between the age groups was significant for the indication of the 'patient's choice' with 80.4% (82 of 102) for those patients aged >10 years old as compared to 40.0% (12 of 30) for those aged ≤10 years old (p=0.01; Fig 2).

RFCA Procedures

Three patients (2.3%) needed general anesthesia (aged 6 months, 9 months, and 4 years old). Deep sedation and conscious sedation were needed in 24 (18.6%) and 10 (7.6%) patients, respectively. The remaining 95 (72.0%) patients had undergone RFCA without sedation (Table 2). When the methods of sedation were compared in the 3 age subgroups, the procedures were performed without sedation in 87.3% (89 of 102) for those patients aged >10 years old as compared to 20.0% (6 of 30) for those aged ≤10 years old (p=0.01; Fig 3).

The procedure time was 81.7±38.4 min in total patients. For each age subgroup, the procedure times were as follows: 111.7±55.0 min for those aged ≤5 years old, 98.8±52.1 min for those aged 6–10 years old, and 75.9±31.4 min for those patients aged >10 years old. The procedure time for those aged >10 years old was significantly shorter than that for those patients aged ≤10 years old (101.3±51.9 min; p=0.01). The procedure times according to the sedation methods for the arrhythmias associated with APs and AVNRT were as follows: 118.3±56.2 min for general anesthesia, 88.0±50.8 min for deep sedation, 81.0±22.1 min for conscious sedation, and 72.7±30.1 min for patients not requiring sedation. The procedure time for patients requiring sedation (88.7±45.1 min) was significantly longer than that for patients not requiring sedation (p=0.02; Table 3). The procedure time for patients who had anesthesia (91.5±51.2 min) was also significantly longer than that for patients who did not have anesthesia (73.6±29.3 min; p=0.02).

RFCA Outcomes

At the conclusion of the procedure, 90 out of 97 APs (92.8%) were successfully ablated. The success varied with the AP site locations, with the highest success of 100% (44 of 44) for left free wall APs to 85.7% (24 of 28) for septal APs, and 88.0% (22 of 25) for right free wall APs. The RFCA success rate for left free wall APs was higher than that for septal (p=0.02) and right free wall APs (p=0.04; Table 4). Among 7 patients who experience a failed RFCA initially, a repeated RFCA was performed in 2 patients. One with a right lateral AP underwent a repeat RFCA 2 years later, and the other with a left posteroseptal AP did so 11 years later. Four patients were treated medically. One patient with a right anteroseptal AP had a complication involving a catheter entanglement in the chordae of the right ventricle, and was treated using open heart surgery. Ablation of the slow AV nodal pathway was successfully performed in 26 of 27 AVNRT (96.3%) cases. One AVNRT case with a failed RFCA initially was successfully treated by a repeat RFCA 3 days later. The RFCA success rate for VT and AT was 83.3 % (5 of 6) and 83.3% (5 of 6), respectively (Table 1).

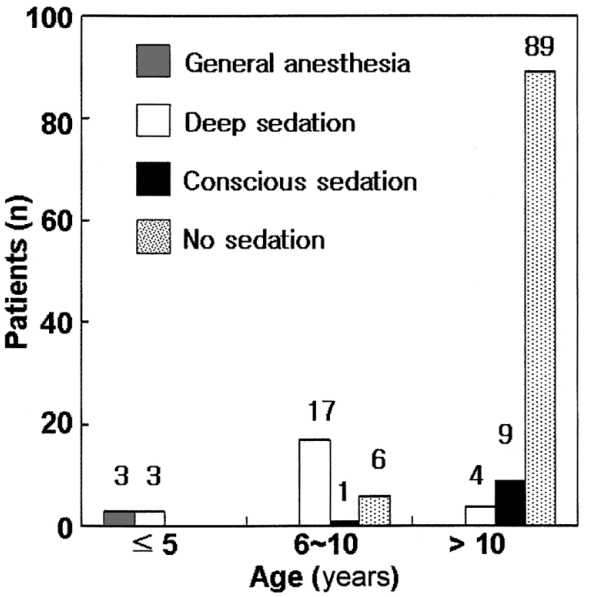

Fig 3. Comparison of the 4 sedation methods used for ablation according to the 3 age subgroups: ≤5 years (n=6), 6–10 years (n=24), and >10 years (n=102). There was a significant difference for the use of the 'no sedation' method between the age groups with 87.3% (89 of 102) for patients aged >10 years as compared with 20.0% (6 of 30) for patients aged ≤10 years (p=0.01).

Table 3 Procedure Time and Total Anesthesia Time According to the Sedation Method and Arrhythmia Type in Patients With Accessory Pathway and AVNRT

Type of arrhythmias	*Patient n*	*Time (min)*					*p value†*
			Sedation				
		No sedation (n=83)	*Conscious sedation (n=10)*	*Deep sedation (n=24)*	*General anesthesia (n=3)*	*Total (n=37)*	
WPW syndrome	*47*	*70.9±27.1*	*96.7±14.4*	*90.0±66.0 (105.4±68.6)*	*118.3±56.2 (156.7±48.0)*	*95.8±57.7*	*0.09*
AVRT with CBT	*46*	*74.3±36.0*	*68.0±18.9*	*91.7±35.1 (115.6±33.0)*	*–*	*83.2±31.7*	*0.15*
AVNRT	*27*	*72.7±25.1*	*90.0±28.3*	*70.0±17.3 (81.7±22.5)*	*–*	*78.0±21.7*	*0.78*
Total	*120*	*72.7±30.1*	*81.0±22.1*	*88.0±50.8 (106.3±52.8)*	*118.3±56.2 (156.7±48.0)*	*88.7±45.1*	*0.02*

See Table 1 for abbreviations.
**Numbers in parenthesis represent total anesthesia time.*
†The comparison of the procedure time between sedation and no sedation.

Table 4 Success and Recurrence Rates According to the Site of the Accessory Pathway in WPW Syndrome and Atrioventricular Re-Entrant Tachycardia With a Concealed Bypass Tract (AVRT With CBT)

Site of accessory pathway	WPW syndrome n (%)	AVRT with CBT n (%)	Total n (%)	Success n (%)†	Freedom of recurrence, n (%)‡
Left free wall pathway	22 (43.1)	22 (47.8)	44 (45.4)	44 (100)	40 (90.9)
Left anterior	4 (7.8)	2 (4.3)	6 (6.2)	6 (100)	6 (100)
Left lateral	17 (33.3)	17 (37.0)	34 (35.1)	34 (100)	31 (91.2)
Left posterior	1 (2.0)	3 (6.5)	4 (4.1)	4 (100)	3 (75.0)
Septal pathway	14 (27.5)	14 (30.4)	28 (28.9)	24 (85.7)	20 (83.3)
Parahisian	3 (5.9)	2 (4.3)	5 (5.2)	4 (80.0)	4 (100)
Right midseptal	1 (2.0)	0 (0)	1 (1.0)	1 (100)	1 (100)
Right anteroseptal	6 (11.8)	4 (8.7)	10 (10.3)	8 (80.0)	5 (62.5)
Posteroseptal	4 (7.8)	8 (17.4)	12 (12.4)	11 (91.7)	10 (90.9)
Right free wall pathway	15 (29.4)	10 (21.7)	25 (25.8)	22 (88.0)	19 (86.4)
Right anterior	0 (0)	1 (2.2)	1 (1.0)	1 (100)	1 (100)
Right lateral	12 (23.5)	6 (13.0)	18 (18.6)	15 (83.3)	12 (80.0)
Right posterior	3 (5.9)	3 (6.5)	6 (6.2)	6 (100)	6 (100)
Total	51 (100)*	46 (100)	97 (100)	90 (92.8)	79 (87.8)

See Table 1 for abbreviations.
**Four patients had dual accessory pathways (APs) (one with a left lateral and left posterior AP, one with a left lateral and right anteroseptal AP, one with a left lateral and right lateral AP, and one with a left anterior and right lateral AP).*
†The RFCA success rate for left free wall APs was higher than that for septal (p=0.02) and right free wall APs (p=0.04). Among 7 patients with an initial RFCA failure, redo RFCA was repeatedly performed in 2 patients. One with a right lateral AP underwent a repeated RFCA 2 years later, and the other with a left posteroseptal AP, 11 years later. Four patients were treated medically. One patient with a right anteroseptal AP had a complication of a catheter entanglement with the chordae of the right ventricle, and was treated with open heart surgery.
‡All 11 recurred APs were successfully ablated with a redo RFCA. In particular, 1 patient with a left posterior AP had a recurrence after a redo RFCA and was treated successfully with a third RFCA.

Table 5 Complications of Radiofrequency Ablation

Patient	Weight (kg)	Height (cm)	Substrate	Heart disease	Sedation method	Complications	Treatment
F/14	41	149	Right lateral AP	No	No	Hemothorax	Closed thoracotomy
F/12	49	160	AVNRT	No	No	Hemothorax	Thoracentesis
M/15	60	162	Right anteroseptal AP	No	No	Pneumothorax	High O_2 therapy
M/15	69	176	Right posteroseptal AP	No	Conscious sedation	Pneumothorax	High O_2 therapy
M/12*	29	140	Right anteroseptal AP	VSD	No	Catheter entanglement	Chordae repair, VSD repair

F, female; AP, accessory pathway; M, male. Other abbreviations see in Table1.
**In this 12-year-old male, the entanglement of the ablation catheter in the chordae of the right ventricle was caused by a multiply reused catheter.*
This patient required open heart surgery to remove the entangled catheter, which had cracks at the distal part.

The mean time for the follow up was 13.1±2.5 months. For the arrhythmias associated with APs, the freedom from recurrence was in 79 out of 90 APs (87.8%; Table 4). All 11 recurred APs were successfully ablated with a repeated RFCA. In particular, 1 patient with a left posterior AP had a recurrence after a repeat RFCA and was treated successfully with a third RFCA. Freedom from recurrence was assessed further by comparing the AP locations. The freedom of recurrence for left free wall, septal, and right free wall pathways were 90.9% (40 of 44 APs), 83.3% (20 of 24 APs), and 86.4% (19 of 22 APs), respectively. Two of 26 patients (7.7%) with AVNRT had the AVNRT recur during the follow-up period, and were treated successfully with a repeat RFCA. In the patients with AT and VT, no recurrence was observed. The success and recurrence rates did not differ according to the sedation method (data not shown).

Complications

The ablation-related complication rate was 3.8% (5 of 131). The complications were: pneumothorax (n=2, 1.6%), hemothorax (n=2, 1.6%), and entanglement of the ablation catheter (n=1, 0.8%; Table 5). The entanglement of the ablation catheter in the chordae of the right ventricle was caused by a reused catheter utilized in a 12-year-old male with a manifest right anteroseptal AP. This patient required open heart surgery to remove the entangled catheter, which had cracks at the distal end. The incidence of complications did not differ according to the sedation method.

Discussion

Because RFCA has been a curative modality for the treatment of a variety of cardiac tachyarrhythmias in adult patients, RFCA in pediatric patients has emerged as a promising modality for the treatment of SVT. However,

there have been special concerns about the use of RFCA in pediatric patients. An increased risk with RFCA in children has been associated with the cardiac anatomy, arrhythmia substrate, patient size, and general anesthesia in growing children as compared to adults.[4,5,12]

Indications for RFCA

In our laboratory, we preferred to perform RFCA in patients aged >10 years old because of the technical difficulties and procedural complications related to the patient's size and general anesthesia, unless the tachyarrhythmia was life threatening. Therefore, the RFCA indications in the present study showed a higher proportion (71.2%) of the 'patient's choice' as compared to the previous data by Campbell et al,[10] which reported 54% indication for the 'patient's choice' in 6,578 pediatric patients (with normal cardiac anatomy). The indication of the 'patient's choice' was 0% in patients aged ≤5 years old and 80.4% in the patients aged >10 years old. We performed RFCA in the patients aged ≤ 5 years only when the patient had a medically refractory, life-threatening arrhythmia, adverse anti-arrhythmic drug effect or tachycardia-induced cardiomyopathy.

Sedation and Catheterization Procedure

In many pediatric laboratories, EPS/RFCA procedures are performed with the patient under general anesthesia. Alternatively, patients may receive continuous intravenous sedation with agents such as ketamine, propofol, midazolam, and/or fentanyl with careful monitoring by a trained nurse or anesthetist. In the present study, more than 70% of the pediatric patients underwent RFCA without sedation. In particular, 87.3% of the RFCA procedures were possible without sedating patients who were aged >10 years old. In our experience, the assurance, good rapport and shorter procedure time allowed us to perform the procedures without sedation in the patients aged >10 years old. The RFCA without sedation significantly decreased the procedure time. General anesthesia and deep sedation were usually required in patients aged ≤10 years old. The procedure time for those patients aged ≤10 years old was significantly longer than that for those aged >10 years old. These results might reflect the difficulty of the procedure in younger children.

RFCA Outcomes

Regarding the RFCA success rate for APs, our success rate (92.8%, 90 out of 97 APs) was comparable to the previous results from the Pediatric RFCA Registry by the Pediatric Electrophysiology Society (92.2%, 4,462 of 4,838 APs).[10,13,14] In general, the acute success rate for left free wall APs was higher than that for right free wall APs, because of catheter stability issues and tissue heating.[10] This study also showed similar results.

In the present study, the RFCA success rate for slow AV nodal pathways was 96.3% without any AV block. This result was comparable to the 97.7% determined by the Pediatric RFCA Registry.[10] Because of the low number of patients, the RFCA success rate for VT and AT was not appropriate for evaluation in the present study.

The present study revealed an 87.8 and 92.3% freedom from recurrence for APs and AVNRT, respectively. This result was better than the data found by the Pediatric RFCA Catheter Ablation Registry presented in 1997 by Kugler et al (77% for APs and 71% for AVNRT).[5] The lower recurrence rate found in the study may reflect the learning curve involved with the ablation procedures. We started EPS/RFCA in 1986 and we had already performed EPS/RFCA in 442 adult cases by the end of 1991.

Complications

The Pediatric RFCA Registry revealed a significant decrease in the complication rate between the first (4.4%) and last (2.6%) 2-year intervals for major complications among the first 4,651 pediatric RFCA procedures.[15] The low complication rate (3.8%) in the present study may also have been influenced by the fact that we started our pediatric program at the end of the learning curve for adult RFCA in our EP laboratory. Particularly, AV block after RFCA is a serious problem in children especially for septal APs and AVNRT.[10] Schaffer et al[16] reported that an increased risk of inadvertent AV block was associated with a decreased operator experience, and anterior, mid, or right posterior septal AP sites. There was no AV block in our patients with septal APs. The RFCA of the slow AV nodal pathway, which included two 9-year-olds, also did not result in any AV block during or after the RFCA.

Study Limitations

Because this study was performed retrospectively, the frequency of arrhythmias could be influenced by the patient selection. As we did not record the radiation time in some patients, we could not show this data. Considering that the overall procedure time was not necessarily prolonged, we believe that the radiation time also was not too long.

The RFCA of AT and VT was performed in selected cases because of technical difficulties. Three dimensional electroanatomical mapping has been particularly useful in localizing AT by the scar of a prior atriotomy or VT.[17] However, 3-dimensional mapping was not available at the beginning of the present study.

Conclusions

In the present study, we can conclude that: (i) the RFCA in pediatric patients had a good success rate with acceptable recurrence and complication rates; (ii) with the delay of the RFCA until the patient was aged >10 years old, the RFCA could be performed without sedation in a large number of pediatric patients with a shorter procedure time; and (iii) the RFCA could be considered as the first line of therapy for arrhythmias with APs and AVNRT.

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