

Electrophysiological Studies and Radiofrequency Ablations in Children and Adolescents with Arrhythmia

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Abstract

Background: Radiofrequency ablation is the standard non-pharmacological treatment for arrhythmias in pediatric patients. However, arrhythmias and their associated causes have particular features in this population.

Objective: To analyze the epidemiological characteristics and findings of electrophysiological diagnostic studies and radiofrequency ablations in pediatric patients referred to the Electrophysiology Unit at Instituto de Cardiologia do Rio Grande do Sul, in order to characterize the particularities of this population.

Methods: Cross-sectional study with 330 electrophysiological procedures performed in patients aged less than 20 years between June 1997 and August 2013.

Results: In total, 330 procedures (9.6% of the overall procedures) were performed in patients aged less than 20 years (14.33 ± 3.25 years, age range 3 months to 19 years), 201 of which were males (60.9%). A total of 108 (32.7%) electrophysiological diagnostic studies were performed and of these, 48.1% showed abnormal findings. Overall, 219 radiofrequency ablations were performed (66.3%) with a success rate of 84.8%. The presence of an accessory pathway was the most prevalent finding, occurring in 158 cases (72.1%), followed by atrioventricular nodal reentrant tachycardia (16.8%), typical atrial flutter (3.1%) and extrasystoles originating from the right ventricular outflow tract (2.7%). Three patients developed complications during ablation (1.4%). Among congenital heart diseases, which occurred in 51 (15.4%) patients, atrial sept defect was the most frequent (27.4%), followed by ventricular sept defect (25.4%) and Ebstein's anomaly (17.6%).

Conclusion: Electrophysiological study and radiofrequency ablation are effective tools for diagnosis and treatment of arrhythmias in the pediatric population. (Arq Bras Cardiol. 2015; 104(1):53-57)

Keywords: Arrhythmias, Cardiac; Catheter Ablation; Child; Adolescent; Electrophysiologic Techniques, Cardiac.

Introduction

The diagnosis and treatment of arrhythmias in children is challenging, since the knowledge for arrhythmias in pediatric patients is borrowed from data retrieved from the adult population. However, the causes of arrhythmias in these groups are considerably different. In adults, arrhythmias are usually associated with episodes of ischemia, whereas in children, arrhythmias are closely associated with changes in the development of the cardiac conduction system¹. Supraventricular tachycardia emerges as the most common tachyarrhythmia in pediatric patients, responding for nearly 95% of the arrhythmias in this population².

For many years, antiarrhythmic drugs were the only available treatment for arrhythmias. In 1987, radiofrequency (RF) catheter ablation was introduced for treatment of adult patients, and since 1989 has been performed as a treatment modality for tachyarrhythmias in pediatric patients. RF ablation was a major scientific breakthrough in the treatment of tachyarrhythmias and is currently considered the non-pharmacological treatment of choice in children and adolescents³. The success rate associated with RF ablation is high and the rate of severe complications is low⁴.

In order to characterize the particularities of the pediatric population, the aims of this study were to analyze the epidemiological characteristics and findings of electrophysiological study (EPS) and RF ablation in children and adolescents at our institution.

Methods

We analyzed the characteristics of the patients aged less than 20 years who underwent EPS and/or RF ablation at the Electrophysiology and Holter Unit of Instituto de Cardiologia do Rio Grande do Sul between 1997 and 2013, as well as the results of 330 procedures performed in these

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patients. According to the World Health Organization (WHO) classification, we considered as part of the infant population those patients aged less than 9 years and of the adolescent population, those with ages between 10 and 19 years⁵.

Patients were referred for the procedures after presenting refractoriness or adverse effects associated with drug therapy, or clinical worsening caused by the arrhythmia. Before the procedures, all patients filled up an Informed Consent Form (ICF). For underage patients, the parents authorized the procedures and signed the ICF.

All procedures were performed under general anesthesia with midazolam, propofol, fentanyl and sevoflurane. All antiarrhythmic drugs were suspended five half-lives before the procedure. One to three multipolar electrode catheters (deflectable or not, 5 to 7 French) were introduced through the right and/or left femoral veins. For procedures requiring ablation, an ablation catheter was also used. In patients with an accessory pathway, a catheter was inserted into the right femoral artery and advanced into the aorta to map the mitral ring. All patients underwent prior EPS when ablation was indicated. During EPS, records of intracavitary electrogram were taken and supraventricular and ventricular stimulation was performed. When arrhythmia was not induced, intravenous isoproterenol was injected. Fluoroscopy was performed in all cases to position the catheters within the cardiac cavities. The RF energy output, length of application and temperature were individually titrated by the electrophysiologist responsible for the procedure. If ablation of a left accessory path or in the systemic circulation (left heart chambers) were to be performed, aspirin 200 mg daily was prescribed for three months. This precaution aimed at preventing a thrombogenic state that may be triggered during catheter ablation, increasing the risk of severe thromboembolic events in the left circulation⁶⁻⁸. Follow up was conducted by the Electrophysiology and Holter Unit, Pediatric Cardiology Unit and by assistant physicians.

All female patients in childbearing age (10-50 years) were screened with a pregnancy test (serum beta-hCG) the day before the procedure. A 14-year-old patient had the procedure suspended after a positive beta-hCG test diagnosed an unidentified pregnancy at an early stage.

Statistical analysis

This was a descriptive study in which the categorical variables were represented as absolute numbers and percentages. Continuous variables were represented as mean \pm standard deviation. Sample size was calculated with the software WinPepi, with a 95% confidence interval, expected proportion of 0.50 (50%), margin error of \pm 5.5 percentile points, yielding a minimal sample of 318 patients. The software SPSS was used for database organization and statistical calculations.

Results

Of 3406 electrophysiological procedures performed between June 1997 and August 2013 at the Electrophysiology and Holter Unit of *Instituto de Cardiologia do Rio Grande*

do Sul, 330 (9.6%) were performed in patients younger than 20 years. The lowest and highest ages of these patients were, respectively, 3 months and 19 years, with an average of 14.33 ± 3.25 years. In total, 60.9% were males (Table 1).

Overall, 108 diagnostic EPS were performed, corresponding to 32.7% of the procedures performed in the overall pediatric population. Findings were abnormal in 48.1% of these and included atrial tachycardia (19.2%), followed by atrial fibrillation (17.3%), ventricular preexcitation syndrome (15.3%), right bundle branch block (7.6%) and polymorphic ventricular tachycardia (7.6%) (Table 2). Four patients underwent more than one diagnostic procedure during follow up. Access to the heart after femoral catheterization was limited due to venous abnormalities in three cases.

In total, 184 patients underwent 219 RF ablations (66.3% of the total amount of performed procedures). The median number of procedures was 1 (lowest 1 - highest 5). The presence of an accessory pathway was the most prevalent finding, occurring in 158 cases (72.1%), followed by atrioventricular nodal reentrant tachycardia (AVNRT, 16.8%), typical atrial flutter (3.1%) and extrasystoles originating from the right ventricular outflow tract (2.7%). Ablation was successfully performed in 84.8% of the patients (Table 3).

Three patients (1.4%) developed complications during the procedure, including total atrioventricular block in two patients and pseudoaneurysm of the right femoral artery which was treated conservatively in one patient. Electrical cardioversion was required due to induction of atrial fibrillation in three patients, polymorphic ventricular tachycardia in two patients and monomorphic ventricular tachycardia in one patient. The cause of transient hemodynamic instability was not identified in six cases.

A total of 31 procedures were performed in patients below the age of 9 years and in 296 patients aged 10 to 19 years, corresponding, respectively, to the infant and adolescent populations. In patients aged 0-9 years, ablation was performed in 19 cases and was successful in 17 (89.4%). Ablation of an accessory pathway emerged as the main finding, occurring in 16 cases (84.2%), followed by AVNRT in two cases (10.5%). In patients aged 10-19 years, 200 ablations were performed, with immediate success obtained in 157 (75.5%). As in the group of patients aged 0-9 years, ablation of an accessory pathway also emerged as the most prevalent finding in this group with 142 cases (71.0%), followed by AVNRT (17.5%) and typical atrial flutter (1.5%). Of 12 EPS performed in patients in the 0-9 years age group, eight (66.6%) showed abnormal findings, in particular, atrial fibrillation and ventricular preexcitation

Table 1 – Epidemiological characteristics of the cohort

	Total
Total number of procedures (1997-2013)	3406
Number of patients aged 0-19 years	330 (9.6%)
Age (years)	14.33 \pm 3.25
Number of male patients	201 (60.9%)

Table 2 – Electrophysiological studies performed in the cohort

	Performed procedures	Percentage
Total	108	32.7%
Abnormal findings	52	48.1%
Atrial tachycardia	10	19.2%
Atrial fibrillation	9	17.3%
WPW	8	15.3%
RBBB	4	7.6%
VT	4	7.6%

WPW: Wolff-Parkinson-White; RBBB: right bundle branch block; VT: ventricular tachycardia.

Table 3 – Radiofrequency ablation outcomes according to the type of heart disease

Type of ablation	Success n (%)	Total n (%)
Accessory pathway	106 (83.5%)	127 (100%)
AVNRT	33 (91.7%)	36 (100%)
VT originating from the RV outflow tract	4 (66.7%)	6 (100%)
Typical atrial flutter	4 (80.0%)	5 (100%)
Fascicular VT	2 (66.7%)	3 (100%)
Focal VT	3 (100%)	3 (100%)
Coumel (PJRT)	2 (100%)	2 (100%)
Atrial tachycardia	1 (100%)	1 (100%)
Atypical atrial flutter	1 (100%)	1 (100%)
Total	156 (84.8%)	184 (100%)

AVNRT: atrioventricular nodal reentrant tachycardia; VT: ventricular tachycardia; RV: right ventricle; PJRT: persistent junctional reciprocating tachycardia.

syndrome. In the group of patients aged 10-19 years, a total of 96 EPS were performed resulting in 44 abnormal findings, mainly atrial tachycardia (9.4%), atrial fibrillation (7.3%) and Wolff-Parkinson-White syndrome (6.3%) (Table 4). These findings demonstrate a predominance of cases in individuals above the age of 10 years and a subtle difference in the types of arrhythmias present in both populations.

Among patients undergoing the procedures, 51 presented structural congenital heart disease (17.5%). Of these, 24 (47.0%) had complex congenital heart disease. There were 25 types of congenital structural heart disease. Of these, atrial sept defect (ASD) was the most frequent, occurring in 14 cases (27.4%). Others included ventricular sept defect (VSD, 25.4%), Ebstein's anomaly (17.6%), pulmonary stenosis (17.6%) and patent ductus arteriosus (PDA, 15.6%) (Table 5). Among the pathologies occurring in patients with complex heart disease were VSD (45.8%), ASD (41.6%), pulmonary stenosis (37.5%), PDA (29.1%) and tricuspid valve atresia (20.8%).

Table 4 – Performed procedures according to age range

	0-9 years n (%)	10-19 years n (%)
Total procedures	31 (100%)	296 (100%)
RF ablation	19 (59.3%)	200 (67%)
Accessory pathway	16 (84.2%)	142 (71.0%)
AVNRT	2 (10.5%)	35 (17.5%)
Typical atrial flutter	0	3 (1.5%)
EPS	12 (38.7%)	96 (32.4%)
Atrial fibrillation	2 (16.6%)	7 (7.29%)
WPW	2 (16.6%)	6 (6.25%)
Atrial tachycardia	0	9 (9.37%)

RF: radiofrequency; EPS: electrophysiological study; AVNRT: atrioventricular nodal reentrant tachycardia; WPW: Wolff-Parkinson-White.

Table 5 – Diagnoses associated with structural congenital heart disease

	Cases	Percentage
Total	51	17.5%
Complex heart disease	24	47.0%
ASD	14	27.4%
VSD	13	25.4%
Ebstein's anomaly	9	17.6%
Pulmonary stenosis	9	17.6%
PDA	8	15.6%

ASD: atrial sept defect; VSD: ventricular sept defect; PDA: patent ductus arteriosus.

Mean intra-atrial (P-A), atria-to-His (A-H) and His-to-ventricle (H-V) conduction intervals were, respectively, 20.8 ± 8.8 msec, 82.4 ± 25.5 msec and 30.6 ± 21.0 msec. Mean Wenckebach point was 386.4 ± 81.2 msec.

Discussion

Intracardiac EPS is an invasive procedure that uses electrode catheters under fluoroscopic control to study the process of cardiac depolarization. This evaluation is conducted during sinus rhythm or induced arrhythmias with programmed stimulation and/or with several cardioactive drugs⁹. Catheter ablation using RF energy has revolutionized the treatment of cardiac arrhythmias and improved the quality of life of the patients at a lower cost than long-term treatment with medications¹⁰.

Even though a significant share of EPS and RF ablation is performed in pediatric patients, physicians are often unfamiliar with specific managements at this age group. This is mainly due to lack of studies in the literature about the epidemiological and electrophysiological characteristics of this population, particularly in our area. Such procedures have risks and increased rates of complications in the

pediatric population due to particularities such as limitation of vascular access, reduced cardiac dimensions and potential anatomical variations due to congenital heart disease³.

In children, RF ablation is the first-line therapy for supraventricular tachycardias (SVT), the most common type of arrhythmia in pediatric patients and approximately 95% of the tachyarrhythmias in this population^{11,12}. The main indications for RF ablation in children are atrioventricular tachycardia involving accessory conduction pathways, followed by AVNRT and atrial tachycardia¹¹. In our study, tachycardia involving accessory pathways was the main indication for RF ablation, followed by AVNRT. Since it is uncommon in children, ventricular tachycardia is rarely an indication for RF ablation¹¹.

Van Hare et al¹³ reported a success rate of 95.7% with RF ablation in SVT secondary to accessory pathways and AVNRT in pediatric patients, whereas Tanel et al¹⁴ reported 90% of success with RF ablation in arrhythmias in the pediatric population. In our cohort, successful outcomes were observed in 91.7% of the ablations for AVNRT and 83.5% for accessory pathways. The reasons for a lower success rate with accessory pathways in our population may be due to the fact that transeptal puncture was not performed in these cases, as well as to a higher prevalence of complex congenital heart disease in our cohort (12% of the overall ablations), which was obtained from a referral center for congenital heart disease.

There were three procedural complications in our study, which affected 1.4% of the patients undergoing RF ablation. Complication rates in the literature vary from 1.2% to 8.7%^{8,13-15}. The findings of the current study suggest that RF ablation and EPS are safe procedures in the pediatric population and are associated with low probability of complications. Indication of different mapping techniques not involving radiation, such as magnetic resonance¹⁶ and electroanatomic mapping¹⁷, as well as use of different ablation techniques such as cryoablation¹⁸ must be individualized for each patient and his/her characteristics to minimize the risks associated with the procedures.

The development of arrhythmias in the infant population is closely related to the presence of congenital heart diseases. They affect approximately 1% of the newborns, contributing significantly with childhood mortality and morbidity¹⁹. The changes in cardiac architecture associated with the cardiopathy itself or with the corrective surgery, may in certain cases result in changes in the cardiac conduction system, leading to an increased tendency of these individuals to develop arrhythmias²⁰. Some types of congenital heart disease, such as Ebstein's anomaly, transposition of the great arteries and tricuspid valve atresia, are associated with a high incidence of accessory conduction pathways²¹.

In our institution, serum beta-hCG test was performed on all female patients of childbearing age, which according to the World Health Organization encompasses the ages between 10 and 50 years. The exposure of women of childbearing age to ionizing radiation during RF ablation imposes a substantial risk of teratogenicity due to the susceptibility of the fetus during the entire prenatal period²². Based on that, screening was conducted to identify potentially unidentified pregnancies at the time of the procedure.

Limitations

This is a cross-sectional study in which the epidemiological characteristics of the patients and the findings of electrophysiological procedures were retrieved from patients' charts. Therefore, it describes only the immediate results of the interventions and does not include long-term outcomes.

Conclusions

The current study shows that in our institution, a significant share of the pediatric population referred for invasive testing of arrhythmias presented congenital heart disease. The outcomes of RF ablation and EPS showed acceptable success rates, similar to those in the literature. The complications rate in our cohort was low as shown in other studies.

Author contributions

Conception and design of the research, Analysis and interpretation of the data and Writing of the manuscript: Simão MF, Rios MN, Leiria TLL, Kruse ML, Lima GG; Acquisition of data: Simão MF, Rios MN, Leiria TLL, Kruse ML, Pires LM, Lima GG; Statistical analysis: Simão MF, Rios MN, Leiria TLL, Lima GG; Critical revision of the manuscript for intellectual content: Simão MF, Rios MN, Leiria TLL, Kruse ML, Pires LM, Sant'Anna RT, Lima GG.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

This study is not associated with any thesis or dissertation work.

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