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ARTYKUŁ ORYGINALNY / *ORIGINAL ARTICLE*

Initial experience of catheter ablation for cardiac arrhythmias in children and adolescents at a newly built ablation centre

Radosław Pietrzak[1], Piotr Lodziński[2], Tomasz Książczyk[1], Paweł Balsam[2], Monika Gawałko[2], Grzegorz Opolski[2], Bożena Werner[1]

[1]Department of Paediatric Cardiology and General Paediatrics, 2nd Faculty of Medicine, Medical University of Warsaw, Warsaw, Poland

[2]1st Chair and Department of Cardiology, 1st Faculty of Medicine, Medical University of Warsaw, Warsaw, Poland

Abstract

Background: Catheter ablation (CA) therapy is the first-choice treatment in adults with heart rhythm disturbances. Arrhythmias in adults are mainly conditioned by coronary artery disease. Aetiology of arrhythmias in children is mostly associated with inherited heart disorders. According to the current guidelines, CA is widely used in children, indicating the need to make it more achievable in the paediatric population.

Aim: To assess the efficacy and safety of CA in children with different types of arrhythmias on the initial learning curve at a newly built Ablation Centre in the Independent Paediatric Hospital of the Medical University of Warsaw, Poland.

Methods: The study population comprised 32 children with supraventricular tachycardias, asymptomatic pre-excitation syndrome, or ventricular ectopic beats undergoing CA. The mean age of the study population was 14.1 ± 2.4 years. In all patients, electrophysiological study (EPS) and CA were performed. Analysis with respect to procedure duration, fluoroscopy exposure duration, location of accessory pathways (AP), success rate, recurrences, and complications was performed.

Results: The mean procedure duration was 105.4 ± 41.4 min (range 40–175 min). The mean fluoroscopy duration was 8:34 ± 5:01 min (range 1:28–21:01). The mean exposure to ionising radiation was 4.7 ± 3.2 mcG/kg. EPS revealed significantly more frequent presence of AP in the left side (57.1%). The radiofrequency ablation procedure was successful in 26 of 32 (81.3%) children, and cryoablation was successful in two of four patients. In two (6.3%) children minor complications occurred.

Conclusions: Catheter ablation may be effectively performed without major complications in the initial phase of the learning curve if a reasonable approach with a gradual increase of the procedural complexity is taken.

Key words: catheter ablation, electrophysiological study, supraventricular tachycardia, pre-excitation syndrome, children

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INTRODUCTION

Catheter ablation (CA) has become a standard procedure in the treatment of cardiac arrhythmias in adults in whom heart rhythm disturbances are very common. The main aetiology for cardiac arrhythmias in adults is myocardial damage due to coronary disease. In children, arrhythmia is rather inherited and closely associated with changes in the development of the cardiac conduction system [1], and supraventricular tachycardia (SVT) is responsible for 95% of cases [2]. Despite this fact, data about the heart rhythm disturbances in children are often extrapolated from the adult population. In recent years, technological progress has allowed the introduction of CA therapy to a broad population of paediatric patients [3, 4]. On the other hand, the accessibility of CA for children is still limited in Poland, with a long waiting list. Consequently, there is an increasing need to make CA more achievable in the paediatric population.

The aim of the study was to assess the efficacy and safety of CA in children with different types of arrhythmias at the initial stage of the learning curve in a newly developed Abla-

Address for correspondence:
Prof. Bożena Werner, Department of Paediatric Cardiology and General Paediatrics, 2nd Faculty of Medicine, Medical University of Warsaw, ul. Żwirki i Wigury 61, 02–091 Warszawa, Poland, e-mail: bozena.werner@wum.edu.pl

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tion Centre in the Independent Paediatric Hospital of the Medical University of Warsaw, Poland.

METHODS

The team

Directly after the creation of the paediatric team, the theoretical and practical training began. It started with series of lectures dedicated to each and every staff member. Then, constant practical training in the electrophysiology (EP) lab was performed to achieve sufficient experience before the first procedure was made. Also, a series of meetings was prepared with the hospital administration staff so that they could become familiar with new tools and technical issues.

Finally, the EP team consisted of two physicians experienced in adult CA therapy and two physicians experienced in the treatment of arrhythmias in the paediatric population. The nurses and technicians took part in the procedure under supervision of nurses who were experts in patient care during electrophysiological study (EPS) and CA therapy.

Patients

The study group comprised 32 paediatric patients; mean age 14.1 ± 2.4 (7–17) years. The mean body weight was 58.4 ± 12.1 (25–78) kg. Patients were referred to EPS and CA between 23 July 2016 and 16 February 2017 with the following documented: SVT (atrioventricular re-entry tachycardia [AVRT] or atrioventricular nodal re-entry tachycardia [AVNRT], junctional ectopic tachycardia [JET], focal atrial tachycardia [FAT], and asymptomatic pre-excitation syndrome or ventricular ectopic beats [VES]) [5]. Diagnoses of arrhythmias were based on 12-lead standard electrocardiogram (ECG) and/or 24-h Holter monitoring. In all children, morphologically normal heart was confirmed in echocardiography. Written, informed consent was obtained prior to the procedure from the parents and from patients above 15 years of age. Initially, CA therapies were performed in patients with body weight above 50 kg, and then the procedures were performed in patients of declining size and weight.

Electrophysiological study and CA protocol

All patients underwent EPS and CA under general anaesthesia, except two patients who received conscious sedation. All antiarrhythmic agents were withdrawn at least three half-lives prior to the procedure. Vascular access was gained via femoral veins. Only in one case the procedure was upgraded to femoral arterial puncture due to limited access to accessory pathways (AP) via trans-septal puncture. In order to reduce the fluoroscopy time and facilitate catheter guidance, a non-fluoroscopic catheter navigation system (Carto 3, Johnson and Johnson, USA) was used. Two or three diagnostic catheters were introduced for a diagnostic EPS and were usually placed in the high right atrium (HRA), right ventricle (RV), and coronary sinus (CS). CA followed the diagnostic EPS for supraventricular arrhythmia. Programmed atrial and ventricular stimulation was performed to induce SVT and prove the presence of dual atrioventricular (AV) node physiology, as described in the literature [6, 7]. Programmed atrial stimulation was also performed to measure the effective refractory period of the AP, which was the longest A1–A2 interval without pre-excitation. In patients with left-sided pathways, a trans-septal puncture was used in order to enter the left atrium.

Twenty-eight children underwent radiofrequency catheter ablation (RFCA) and four underwent cryoablation. RFCA was performed in a temperature-controlled mode with a generator setting of 30 W at a target temperature of maximum 55°C for non-cooled catheter and 30 W for Thermocool catheters. For cryoablation, a standard 7 F quadripolar cryoenergy ablation catheter with 4-mm tip was used. In cryomapping, targeted tissue was cooled down to a temperature of –30°C for a maximum of 60 s [8]. In the absence of the electrophysiological effect or impairment of AV nodal conduction, cryomapping was stopped immediately, allowing recovery of the tissue, and cryomapping was repeated at a different site. If cryomapping was successful, cryoablation was started immediately at the same location, with a target temperature of –75°C for at least 2 × 6 min. However, cryoablation was stopped if, in the staff members' opinion, conducting the procedure contributed unnecessary risk of major complications.

Follow-up

In all patients, standard ECG, 24-h Holter monitoring, and echocardiography were performed 24–48 h after CA, to assess immediate results. Afterwards the patients remained under control in the outpatient clinic with routine check-up after one and three months. Follow-up evaluation with ECG recording was performed three months after CA in all patients.

Statistical analysis

Results are presented as mean ± standard deviation and percentage. Demographic variables, EP, CA procedure, and complications were analysed.

Bioethics committee

The study was registered with the local Bioethics Committee with the number AhBE/42/17.

RESULTS

Clinical characteristics

After EPS, arrhythmias diagnosed in the study population included: AVRT (n = 11, 34.4%), AVNRT (n = 6, 18.8%), JET (n = 1, 3.1%), FAT (n = 1, 3.15%), asymptomatic pre-excitation syndrome (n = 10, 31.2%), and VES (n = 3, 9.3%). Among the patients presenting with AVRT, six had manifest pre-excitation and five had concealed APs. Among the patients presenting with AVNRT, one patient was diagnosed with atypical fast-slow AVNRT.

Table 1. Procedural details

No.	Transseptal puncture	CA duration [h:min]	Fluoroscopy duration [min:s]	Fluoroscopic exposure [mGY/kg]	Number of applications	Time of application	Catheter ablation*
1	0	01:25	–	0.5	39	07:12	1
2	1	01:30	07:09	3.68	12	03:49	1
3	0	00:55	04:54	2.41	6	01:11	1
4	1	02:35	10:20	6.1	12	06:31	2
5	1	02:00	06:07	3.2	3	01:25	1
6	1	02:55	15:16	11.29	9	03:33	1
7	1	01:10	09:55	5.04	2	01:48	1
8	1	02:00	08:40	5.14	22	11:29	1
9	1	02:45	21:01		1	01:02	1
10	0	02:10	04:31	2.93	9	08:03	2
11	0	02:45	00:26	0.18	5	08:11	2
12	0	02:20	06:27	1.74	3	01:10	1
13	0	02:30	06:33	5	14	05:21	1
14	0	02:30	05:33	2.3	8	02:12	1
15	0	01:55	08:18	6.32	10	03:59	1
16	0	02:50	10:11	4.84	2	01:43	4
17	0	02:10	03:51	5.32	2	12:00	3
18	0	01:10	09:22	2.54	1	06:00	3
19	0	00:40	02:11	0.73	5	02:02	1
20	1	01:00	13:40	8.73	1	01:22	1
21	0	02:14	06:35	3.62	16	05:54	1
22	0	01:20	10:21	4.82	24	02:43	1
23	1	00:50	20:59	8.24	1	01:03	1
24	1	01:10	05:06	3.13	16	04:51	1
25	0	01:10	08:45	7.56	3	00:33	1
26	1	02:45	15:23	8.5	15	03:05	5
27	0	01:00	01:28	0.5	4	06:55	5
28	1	01:30	12:13	5.87	2	03:00	1
29	1	01:40	10:20		7	14:01	3
30	0	01:17	12:42	12.81	1	00:28	3
31	0	00:45	05:57	3.46	1	00:48	2
32	0	00:52	01:18	0.39	4	02:03	2

CA — catheter ablation; *RF 4 mm (1), RF ThCool (2), cryoablation (3), RF Marinr (4), RF (5)

Catheter ablation procedures

The whole ablation procedure lasted on average 105.4 ± ± 41.4 (range 40–175) min. The mean number of applications needed for success of ablation was 8.1 ± 8.3. The time of application ranged from 0:28 to 14:01 min. Fluoroscopy time was 8:34 ± 5:01 (range 1:28–21:01) min and took longer if the AP was left sided (Table 1). The mean exposure to ionising radiation was 4.7 ± 3.2 mcG/kg and was higher if the AP was left sided.

The 28 patients (eight with AVRT, six with AVNRT, 10 with asymptomatic AP, one with FAT, and three with VES) had radiofrequency (RF) ablation. The total immediate success rate of RF ablation procedure was 85.7% (24 of 28 children). The success rate of RF ablation for AVRT, AVNRT, and asymptomatic AP was 92%. In patients with AVNRT we achieved 100% immediate success rate. The total success rate in patients treated with RF ablation due to AVRT and asymptomatic AP was 16 of 18 (89%). RF ablation was successful in two out of

Table 2. Location of accessory pathways (AP) and documented arrhythmia before and after electrophysiological study (EPS)

No.	Diagnosis before EPS	Diagnosis after EPS	Localisation of AP pathway
1	AVNRT	AVNRT	NA
2	WPW + SVT	WPW + AVRT	LL
3	AVNRT	AVNRT	NA
4	WPW + SVT	WPW + AVRT	LL
5	WPW	WPW	RPS
6	WPW	WPW – antAVRT	LPS
7	WPW	WPW	LL/LA
8	WPW + SVT	WPW + AVRT	LA
9	WPW	WPW	LL
10	VEBs 50%	VEBs – RVFW	NA
11	VEBs 35% + VT	VEBs	NA
12	SVT	conAP + AVRT	RPS
13	WPW + SVT	WPW + AVRT	RL
14	SVT	AVNRT fast-slow	NA
15	AVNRT + VT	AVNRT	NA
16	SVT	conAP + AVRT	LL
17	WPW + SVT	WPW + AVRT	PH (RAS)
18	JET	JET	NA
19	AVNRT	AVNRT	NA
20	SVT	conAP + AVRT	LPL
21	WPW	WPW	RA
22	SVT	AVNRT	NA
23	WPW	WPW + AVRT	LPS
24	WPW	WPW	LPS
25	SVT	conAP + AVRT	PH (RAS)
26	FAT	FAT	NA
27	VEBS + VT	VEBs +VT	NA
28	WPW	WPW	LPS
29	WPW + SVT	WPW + AVRT	LPL
30	SVT	conAP + AVRT	–
31	WPW	WPW + AVRT	RPS
32	WPW	WPW	RPS

Arrhythmias: SVT — supraventricular tachycardia; AVNRT — atrioventricular nodal re-entrant tachycardia; AVRT — atrioventricular reciprocating tachycardia; JET — junctional ectopic tachycardia; FAT — focal atrial tachycardia; VEBs — ventricular ectopic beats; WPW — Wolff-Parkinson-White; conAP — concealed accessory pathways; VT — ventricular tachycardia; RVFW — right ventricular free wall; ant — anterior
Localisation of AP: RL — right lateral; RA — right anterior; RAS — right anteroseptal; PH — para-Hisian; RPS — right posteroseptal; LPL — left posterolateral; LPS — left posteroseptal; LL — left lateral; LA — left anterior: NA — not aplicable

three patients with VES. The cryoablation was done in four patients (three with AVRT and one with JET). It was successful in two of three patients with AVRT. In the cases of JET and unsuccessful AVRT, the cryoablation therapy after initial application was stopped due to a high risk of complete AV block in the opinion of all staff members.

Localisation of AP

Left lateral (LL) was the most frequent localisation of AP (n = 5; 23.8%), there were four cases of right posteroseptal AP (n = 4, 9.1%), and four left posteroseptal AP (n = 4, 9.1%), and the rest of the APs were as follows: right lateral (n = 1, 3.1%), right anterior (n = 1, 3.1%), right anteroseptal (n = 2, 6.2%), left posterolateral (n = 2, 6.2%), left anterolateral (n = 1, 3.1%), and left anterior (n = 1, 3.1%) (Table 2).

Follow-up

All patients were evaluated in an outpatient clinic three months after the procedure. The ablation was effective in all patients treated due to AVNRT and in 15 of 18 (83%) patients treated with RF ablation due to AVRT and asymptomatic AP. Among patients treated with RF ablation due to AP, in three patients standard ECG showed a pre-excitation pattern. In two patients RF ablation therapy was initially unsuccessful, and in another patient the initial result was assessed as good. Those patients had, respectively, right anterior AP, right posteroseptal AP, and right anteroseptal AP. Cryoablation was successful in one of two patients with AVRT, in whom the procedure duration was sufficient. CA was finally successful in one of three patients with VES because in one patient a recurrence of VES was observed after initial success.

Complications

Trivial, procedure-related complications were present in two (6.3%) patients. The first was a 17-year-old patient who developed first-degree AV block, which withdrew after three months, and the second was a seven-year-old girl who had a small pseudoaneurysm of the femoral artery, which resolved without treatment within one month.

DISCUSSION

Catheter ablation has changed the approach to the treatment of cardiac arrhythmias and improved the quality of life of patients at a lower cost than long-term pharmacological treatment [9]. Even though a significant share of EPS and RF ablation is performed in children and adolescents, physicians are often unfamiliar with specific managements in this group of patients.

The main indication for catheter ablation in our paediatric group was SVT, diagnosed in 46.8% of patients. The most common mechanism of SVT was AP-mediated AVRT (34.4%). This is in agreement with Sanatani et al. [10], who concluded that AVRT is the most common mechanism of SVT in infants and children and accounts for as many as 90% of cases of SVT in infants. Moreover, in another study it was found that AVNRT is almost completely absent in infants, and the frequency gradually increases in patients older than one year [11].

Left-sided APs represented the majority of the total number of the AP group (12 of 21 patients, 57.1%), which was in agreement with Wellens et al. [12], who found that more than 50% of APs are located at the left free wall, 20–30% at the posterior septum, 10–20% at the right free wall, and 5–10% at the anterior septum.

In our study, the total immediate success rate of RF catheter ablation for SVT and AP was 92.0%. In paediatric patients, the most recent multicentre data reported successful ablation during the acute phase in approximately 95% of cases [13]. The smaller data show an immediate success rate of about 92% for AVRT and 97% for AVNRT [14, 15]. On the other hand, the earliest Electrophysiology Catheter Ablation Registry, for the period 1991–1995, indicated a relatively low immediate success rate of 90.4% [6]. Our results are in concordance with earlier published data. It shows that satisfactory effectiveness is possible on the learning curve if the team strictly follows the current guidelines, as is the rule in our site.

The mean fluoroscopy time was 8 min 34 s and was not longer than the fluoroscopy time presented in other centres in comparable groups of patients, despite our limited experience [16, 17]. Moreover, our doses of ionising radiation were also relatively low. There are two explanations for these findings. First, since the setup of the site we have become aware of potentially harmful consequences of ionising radiation and follow the rules to minimise radiation exposure. Second, we use a non-fluoroscopic catheter navigation system, which allows us to minimise the use of fluoroscopy.

We reported a 6.3% rate of procedure-related complications. However, these complications were trivial and transient. Severe complications were not observed in the study population. No patients needed pacemaker implantation or cardiosurgical treatment. Previous reports demonstrated that complete AV block was limited to patients with AVNRT and those undergoing ablation of septal pathways, both right and left sided [18, 19]. CA therapy also has an increased rate of complications if it is made in small children, due to particularities such as limitation of vascular access, reduced cardiac dimensions, and potential anatomical variations due to congenital heart disease [20]. On the other hand, in paediatric patients with body weight above 15 kg, the risk of severe complications does not exceed the risk seen in adults, in whom the rate is 1–3% [5]. In fact, pseudoaneurysm occurred in the smallest of our patients (weight 25 kg). It shows that an approach with a gradual decrease in body weight is necessary in new centres, to avoid complications. Taking into account the fact that the treatment is performed in small, developing hearts, where the scar after ablation may cause narrowing of the coronary sinus, coronary artery injury, or even the growth of the lesion after the procedure [21–23], safety should be the priority in the paediatric population treated in the EPS laboratory due to arrhythmias.

There were no deaths in our study although we know from previous reports that death is a possible complication of RF ablation procedures in children, with a total incidence ranging from 0.097% to 0.12% of deaths in patients with structurally normal hearts during ablation [13, 16].

The three-month success rate of CA therapy for SVT and AP in our study was 88%. These data are comparable with current data about the recurrence rate. According to the current epidemiological trials, recurrence at 12 months was related to the substrate type and was highest for right-sided APs (especially for right septal: 24.6%) [24]. That localisation was diagnosed in two of our patients with arrhythmia substrate recurrence.

CONCLUSIONS

Catheter ablation may be effectively performed without major complications in the initial phase of the learning curve if a reasonable approach with a gradual increase of the procedural complexity is taken.

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