Radiofrequency catheter ablation in children and adolescents with preexcitation syndrome

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Abstract

Background: Atrioventricular reentrant tachycardia (AVRT) is the most common tachycardia, accounting for 70% of regular narrow-QRS arrhythmias in children. Because of the potential disadvantages of a life-long drug therapy and relatively favourable results from radiofrequency catheter ablation (RFCA) therapy in adults, the indications for ablation therapy in children with preexcitation syndrome (PS) need to be considered.

Aim: To assess efficacy and safety of RFCA in children and adolescents with PS.

Methods: The study population consisted of 302 consecutive, symptomatic, drug-refractory patients with PS undergoing RFCA. Two age groups were selected: 52 patients younger than 19 years (24 females, age 15.38±2.53 years); and 250 adults (115 females, age 38.67±13.1 years). In all study patients electrophysiological study and radiofrequency catheter ablation were performed. Comparative analysis between groups was performed with respect to procedure duration, fluoroscopy exposure time, location of accessory pathways (AP), success rate, recurrences and complications.

Results: No significant differences between the groups were noted with respect to procedure duration and exposure time. Success and recurrence rates did not differ between the two-age groups. The mean procedure time for children was 124.12±43.48 min (range 45-285) and for adults – 126.3±61.49 min (range 25-330) (NS). The mean fluoroscopy time for children was 27.95±16.86 min (range 4-75) and for adults – 31.27±25.51 min (range 1-131) (NS). The initial RF ablation procedure was successful in 48 (92.31%) children and in 233 (93.2%) adults (NS). Recurrence rate was 12.5% (6 patients) in children vs. 8.58% (20 patients) in adults (NS). In one child (1.92%) and in two adult patients (0.8%) serious complication occurred (NS). Electrophysiological study revealed significantly more frequent presence of the right free wall and right antero-septal AP in children than in adults (21.15 vs. 7.6%, and 17.31 vs. 5.2%, respectively, $p < 0.01$). In adults more frequent left antero-lateral AP was detected: 32.4 vs. 7.69%, $p < 0.01$.

Conclusions: Radiofrequency catheter ablation is a safe and efficient procedure in paediatric patients with preexcitation syndrome. Effectiveness, safety, recurrence rate and RFCA procedural aspects, including total procedure time and fluoroscopy time, are comparable in paediatric patients with PS and in adults.

Key words: radiofrequency catheter ablation, preexcitation syndrome, children and adolescent

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Introduction

Radio-frequency catheter ablation (RFCA) was introduced into clinical practice in 1987 as a new non-pharmacological and effective tool for the treatment of various cardiac arrhythmias. This method proved very effective and safe in adult patients with the preexcitation syndrome [1]. During recent decades, the use of RFCA has expanded rapidly, both with respect to the spectrum of treated arrhythmias and the age of treated patients. Children and adolescents have been

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treated with RFCA more and more frequently. In this age-group, every year approximately 30 000 new arrhythmias are diagnosed worldwide, of which 70% are due to the presence of accessory pathways (AP). Pharmacological therapy is effective in no more than 60-70% of patients [2, 3]. Therefore, a question arises as to how to treat these young patients, when to offer an invasive therapy such as RFCA, and whether RFCA in this age group is as effective and safe as in the adult population.

Thus, the aim of the present study was to compare the safety and efficacy of RFCA in children and adolescents versus adult patients with the preexcitation syndrome as well as to identify factors associated with the efficacy and recurrences of arrhythmias after RFCA.

Methods

Patients

The study group consisted of 302 consecutive, symptomatic patients with the preexcitation syndrome in whom pharmacological therapy failed, and who underwent the RFCA procedure in our centre between January 2001 and June 2005. Two subgroups of patients were formed: group I consisted of 52 patients aged ≤18 years, whereas the remaining 250 adult patients served as a control group (group II). All patients underwent diagnostic electrophysiological study (EP) and RFCA after written informed consent was obtained from their parents (group I) or from the patients (control adult population).

Electrophysiological study and RFCA

All antiarrhythmic agents were stopped before the procedure for at least five half-life times, and in the case of amiodarone – at least two months before RFCA. Two to four diagnostic catheters were introduced for a diagnostic EP: four-pole 5 or 6 F electrodes for bipolar signal recordings were placed in the high right atrium (HRA), His bundle area (HBE) and the right ventricle (RV), whereas four or eight-pole catheter for both unipolar and bipolar signal recordings was introduced into the coronary sinus (CS). The diagnostic EP study was followed by RFCA, which was performed using standard settings.

Localisation of the atrial insertion of AP was performed using unipolar and bipolar signal from the CS electrode obtained during RV pacing or during atrio-ventricular orthodromic tachycardia (AVRT). In patients with left-sided pathways, a transseptal puncture was used in order to enter the left atrium, according to the previously published method [4].

The location of AP was evaluated using the Josephson criteria. Accordingly, the right free wall (RFW), right antero-septal (RAS), right mid-septal (RMS), right postero-septal (RPS), left postero-septal (LPS), left postero-lateral (LPL), left antero-lateral (LAL) and AP confined to the CS were identified [5, 6]. This scheme was used to compare the location of AP between the two analysed groups. For statistical analysis, due to the low number of patients, the AP in children and adolescents were grouped as follows: RFW, septal (RAS, RMS, RPS, LPS and CS) and LFW (LPL and LAL).

In the case of presence of more than one AP, patients were classified in all AP locations. For example, a patient with LPS and LPL is present in both LPS and LPL groups. This resulted in a greater number of analysed AP than the number of patients.

Follow-up

In all patients standard ECG was recorded after RFCA and at discharge. Follow-up evaluation with ECG recording was performed one and three months after RFCA. Afterwards, the patients remained under ambulatory control in the outpatient clinic.

Recurrence of preexcitation syndrome was defined as a recurrence of overt preexcitation in a standard ECG in those who had overt WPW syndrome before RFCA or documented recurrence of AVRT. In patients with multiple pathways, a recurrence of conduction over any of AP was defined as the RFCA failure.

Statistical analysis

Results are presented as mean ± SD or numbers and percentages. In both groups, demographic, EP, RFCA and follow-up data were analysed. Continuous parameters were compared using unpaired Student's t-test, whereas categorical variables were compared using χ^2 test with Yates correction. When more than two groups were compared, differences between continuous variables were analysed using a univariate analysis of variance. In order to identify factors associated with RFCA efficacy and the risk of recurrence, a logistic regression analysis was performed. The recurrences were also analysed using Kaplan-Meier curves.

Results

Demographic and clinical characteristics of the two analysed groups are presented in Table I. In group I no patient had any concomitant disorder and the mean weight of patients was 55±11 kg (range 28-77). Out of the 250 patients from group II, 10 (4%) patients had coronary artery disease, 4 (1.6%) had remote

Table I. Comparison of clinical and demographic characteristics

Parameter	Young	Adults	p
Number of patients	52	250	NS
Female gender	24 (46%)	115 (46%)	NS
Age [years]	15.4±2.5 (7-18)	38.7±13.1 (19-72)	<0.05
Overt preexcitation	40 (77%)	180 (72,0%)	NS
LVEDD [mm]	45.7±5.05 (39-54)	48.8±6.2 (35-67)	NS
LVESD [mm]	29.2±4.6 (23-38)	30.6±5.1 (22-44)	NS
EF [%]	64.9±4.42 (60-72)	55.6±6.5 (35-75)	NS

Abbreviations: LVEDD – left ventricular end-diastolic diameter, LVESD – left ventricular end-systolic diameter; EF – ejection fraction

Table II. Comparison of the location of accessory pathways

Location	Young	Adults	P
Right free wall	11 (21%)	19 (8%)	<0.01
Right antero-septal	9 (17%)	13 (5%)	<0.01
Right mid-septal	3 (6%)	28 (11%)	NS
Right postero-septal	8 (15%)	28 (11%)	NS
Coronary sinus	2 (4%)	26 (10%)	NS
Left postero-septal	4 (8%)	20 (8%)	NS
Left postero-lateral	13 (25%)	54 (22%)	NS
Left antero-lateral	4 (8%)	81 (32%)	<0.01
Multiple AP	2 (4%)	20 (8%)	NS

Table III. Comparison of procedural details

Parameter	Young	Adults	p
Number of patients	52	250	
Procedure duration [min]	124±43 (45-285)	126±61 (25-330)	NS
Fluoroscopy time [min]	28±17 (4-75)	31±26 (1-131)	NS
Efficacy	48 (92%)	233 (93%)	NS
Complications	1 (1.9%)	2 (0.8%)	NS

myocardial infarction, 30 (12%) had hypertension, and one (0.4%) had diabetes.

Location of AP. In group I, RFW and RAS locations were the most frequent, whereas in group II the LAL AP were the most prevalent. The distribution of other AP locations and the presence of multiple AP were similar in both groups (Table II).

RFCA procedures. Duration of RFCA, fluoroscopy time, efficacy and complication rate were similar in both groups. A single RFCA session was effective in 48 (92.3%) patients from group I and 233 (93.2%) patients from group II (NS) (Table III). All patients in whom the first RFCA procedure was ineffective underwent a second procedure.

Complication rate was similar in both groups. Out of the patients from group I, one (1.9%) patient, following internal jugular vein puncture, developed pneumothorax with a small amount of fluid in the pleural cavity without the need for drainage. In group II, two (0.8%) patients developed complications – one had right femoral vein thrombophlebitis and another one had cardiac tamponade caused by an inadvertent puncture of the right atrial free wall during an attempted interatrial septum puncture.

Relationship between AP location and RFCA efficacy in group I. Location of AP did not significantly affect the mean duration of RFCA procedures. The univariate analysis of variance revealed a significantly

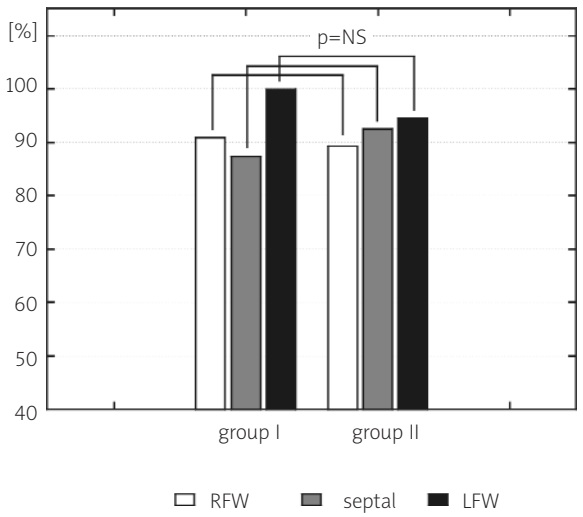

Figure 1. Relationship between accessory pathway location and efficacy of RFCA in the two studied groups

Abbreviations: RFW – right free wall, LFW – left free wall

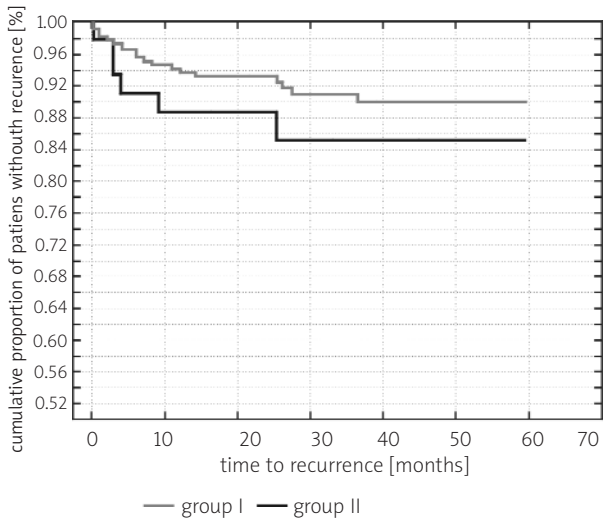

Figure 2. Kaplan-Meier curves showing the proportion of patients with recurrences in both age-groups (only patients in whom RFCA procedures were initially successful were taken into account) – HR 1,66 (95% CI 1,19-2,13); p=NS

shorter fluoroscopy time during RFCA of LL AP compared with septal pathways (Table IV). Univariate regression analysis did not disclose any significant effects of age, gender or AP location on RFCA efficacy. Successful ablation was achieved in 10 (90.9%) RFW AP, 21 (87.5%) septal AP, and 17 (100%) LL pathways (Figure 1).

Factors associated with recurrences. The mean duration of follow-up in group I was 27.2±19.3 months (range 0-59.5 months); in group II it was 30.8±17.6 months (range 0.13-59.7 months) (NS). During this period, no significant differences in the recurrence rate between the studied groups were found (Figure 2). In group I, the mean time to the recurrence was 6.4 months (range 0-25, median 3 months), in group II, 11.4 months (range 0-36, median 6 months).

Of the patients from group I, 6 (12.5%) had a recurrence – 4 (8.3%) had symptomatic episodes of AVRT whereas in 2 (4.2%) preexcitation was again recorded in standard ECG. A redo-procedure was performed only in those with recurrences of palpitations, whereas the remaining two were followed in the outpatient clinic.

In group II, recurrences were noted in 20 (8.6%) patients – 17 (7.3%) subjects suffered from palpitations whereas in 3 (1.3%) patients asymptomatic preexcitation in standard ECG was again present. A second RFCA procedure was performed in 16 patients with a recurrence of palpitations (one patient did not consent to undergo repeated procedure).

In group I, no significant relationship between age, gender, AP location and the risk of recurrence was noted. However, when analysing the whole studied population, the presence of RFW AP was associated with a four-fold increase in the risk of long-term ablation failure (OR/unit 4.05, 95% CI 1.54-10.7, p <0.01), and the presence of RPS AP with over three-fold risk increase (OR/unit 3.47, 95% CI 1.24-9.7, p <0.05) compared with other AP locations (Table V).

Long-term efficacy. In group I, a single RFCA session was effective in 48 (92.3%) patients. The procedure was repeated in 4 (7.7%) patients in whom the first ablation failed, and in another 4 (7.7%) patients who experienced recurrences of palpitations or preexcitation. The second procedure was effective in 7 (87.5%) patients – 3 with a failure of first RFCA and all 4 with recurrences.

Table IV. Procedural details in relation to accessory pathway location in the young

Location	Right free wall n=11	Septal n=24	Left free wall n=17
Procedure duration [min]	135±54 (90-285)	126±42 (60-210)	106±33 (45-150)
Fluoroscopy time [min]	25±15 (9-58)	33±18.9 (10-75)	20±11* (4-46)

**p <0.05 vs. septal*

In group II, the first session of RFCA was effective in 233 (93.2%) patients. Redo-procedures were performed in 33 patients – 17 (6.8%) subjects with ineffective first ablation and 16 (6.4%) patients with symptoms and/or preexcitation recurrence. The second procedure was successful in 26 (78.89%) patients – 10 with ineffective first ablation and 16 with recurrences.

In total, the long-term efficacy of RFCA was 49 (94.2%) patients in group I and 242 (96.8%) patients in group II (NS).

Table V. Location of accessory pathway and the risk of recurrences

Location	OR/unit (95% CI)	p
Right free wall	4.05 (1.54-10.69)	<0.01
Right antero-septal	–	NS
Right mid-septal	–	NS
Right postero-septal	3.47 (1.24-9.69)	<0.05
Left postero-septal	–	NS
Coronary sinus	–	NS
Left antero-lateral	–	NS
Left postero-lateral	–	NS

Discussion

The high efficacy and low risk of complications of RFCA, documented in adults, enabled its use in children and adolescents. In patients with the preexcitation syndrome, RFCA has become a routine method of treatment. The present study showed that procedure duration, fluoroscopy time, efficacy and safety were similar in adults and in younger patients.

Our results are in line with previously published data. Park et al. found no differences in RFCA safety, efficacy or duration between patients aged below 13 years, those aged 13-19 years, and older patients [7]. Kugler et al. in the *Pediatric Radiofrequency Catheter Ablation Registry of the Pediatric Electrophysiology Society* (1994) reported duration of fluoroscopy time ranging from 59.4 to 79.6 min, depending on the location of AP, in patients undergoing RFCA due to AVRT. In 1997, the mean duration of fluoroscopy during RFCA of supraventricular tachycardias was 47.6 min, and in 2002, 40.1 min [8-10].

In our group of young patients fluoroscopy duration was much shorter; however, we did include in the analysis patients with cardiac defects. We also found that fluoroscopy time was significantly longer in patients with septal AP compared with LL AP. These findings are consistent with the data of Kugler et al., who demonstrated longer fluoroscopy time in patients with antero-septal, postero-septal and RFW AP locations [9, 10]. Also, Park et al. found increased X-ray exposure in patients with RFW AP (78±30 min) compared with other AP locations of which RFCA of septal AP was associated with longer fluoroscopy time than that of LL AP (58±49 vs. 37±23 min, respectively) [7]. The longer fluoroscopy time during RFCA of septal AP, especially antero-septal AP, is probably due to the care taken during RFCA because of the proximity of the normal conduction system to the AP and the risk of inadvertent ablation of AV node and His-Purkinje system.

In our study, no significant differences in the RFCA efficacy between groups I and II was found. Also, in group I, the efficacy of RFCA was similar in various AP locations, ranging from 100% in LL AP to 90.9% in RFW AP and 87.5% in septal AP. Van Here et al. also found the highest efficacy of RFCA in children with LL AP compared with other AP locations (98 vs. 88-90%); the lowest RFCA effectiveness was found in patients with congenital heart defects [11, 12]. Differences in the RFCA efficacy in various AP locations may be explained by differences in the structure of the mitral and tricuspid annuli. The circumference of the tricuspid valve is greater than that of the mitral valve. In addition, an AP can be located only in part of the mitral annulus, omitting the triangle between the mitral and aortic valves. Furthermore, atrial or ventricular insertions of the right-sided AP are not always single, and may be multiple [13].

We also failed to detect any significant differences in the complication rate between the two groups. It may be speculated that the risk may be higher in children due to the smaller heart size, lower body weight, difficulties with vascular access and the need for general anaesthesia. The long-term risk associated with X-ray exposure and effects of RF applications on the growing heart as well as coronary vessels has not yet been evaluated [14, 15]. According to the published data, the complication rate of RFCA procedures in children and adolescents reaches 4% and is comparable to that in the adult population [16]. In paediatric patients, body mass <15 kg and the presence of structural heart disease have been regarded as risk factors [9, 11, 16]. Goldberg et al. documented a positive correlation between the size of the triangle of Koch and the body mass and area, which confirms an increased risk of AV node injury during RF current application in the antero-septal region in smaller children [17]. Accessory pathways of this location are quite frequent in children, and the use of programmed atrial stimulation as well as long vascular sheaths is helpful during RFCA procedures [18].

In our study, RFW and AS AP were more frequent, and LAL AP less prevalent in children and adolescents than in adults. This may be due to the earlier occurrence of tachyarrhythmias associated with right-sided rather than left-sided AP. These findings are consistent with those presented by Fan et al., who found RFW AP in 14% of patients aged <30 years compared with 2% in subjects aged >50 years [19]. Tada et al. in a population of 910 patients with the preexcitation syndrome found that tachycardias associated with right-sided AP occurred at younger age than tachycardias due to the presence of left-sided AP (21±12 vs. 23±15 years) [20]. The most frequent trigger initiating AVRT is an atrial premature beat, arising in the proximity of the atrial insertion of AP. Because the right atrium is more prone to generating premature beats than the left atrium, AVRT using right-sided AP may occur earlier in life than AVRT using left-sided AP [19].

There were no significant differences in the recurrence rate between the two analysed groups. In patients from group I no relationship between age, gender, AP location and the risk of recurrence was found. In the whole studied population the risk factors for a recurrence were the RFW and RPS locations of AP. These patients had a four-fold higher risk than others. Also Van Hare et al. found a significantly higher risk of recurrences for the right septal AP (24.6%) and RFW AP (15.8%) compared with LL AP (9.3%) [12]. Calkins et al. found four independent predictors of recurrences – septal, postero-septal and RFW location of AP as well as the presence of multiple AP [21].

In conclusion, we found RFCA in patients with the preexcitation syndrome equally effective and safe in children and adolescents as in adults, which suggests that indications for RFCA may be similar and age-independent. The RFW and RPS locations of AP are associated with the highest risk of recurrences.

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Zastosowanie ablacji prądem o częstotliwości radiowej w leczeniu dzieci i młodzieży z zespołem preekscytacji

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Streszczenie

Wstęp: Nawrotny częstoskurcz przedsionkowo-komorowy w przebiegu zespołu preekscytacji (PS) to główna przyczyna tachyarytmii u dzieci i młodzieży. Słuszne więc jest postawienie pytania, kiedy podjąć decyzję o leczeniu inwazyjnym i czy ablacja prądem o częstotliwości radiowej (RFCA) jest w tej grupie wiekowej równie bezpieczna i skuteczna jak u dorosłych.

Cel: Ocena skuteczności wczesnej i odległej oraz bezpieczeństwa leczenia dzieci i młodzieży z PS za pomocą RFCA.

Metodyka: Badaną populację stanowiło 302 kolejnych, objawowych chorych z PS, leczonych za pomocą RFCA. Wyodrębniono dwie grupy: I – 52 chorych w wieku do 18 lat, II (kontrolną) – 250 chorych dorosłych w wieku średnio 38,6±13,1 lat. Analizie poddano dane demograficzne, wyniki i przebieg RFCA – czas zabiegu, czas ekspozycji radiologicznej, lokalizację dróg dodatkowych (AP), obecność mnogich AP, skuteczność RFCA wczesną i odległą, wystąpienie poważnych powikłań oraz nawrotów. Zastosowano podział lokalizacji AP na szlaki prawostronne boczne (RFW), prawostronne przegrodowe przednie (RAS), prawostronne przegrodowe pośrednie (RMS), prawostronne przegrodowe tylne (RPS), lewostronne przegrodowe tylne (LPS), lewostronne tylno-boczne (LPL), lewostronne przednio-boczne (LAL) oraz zależne od zatoki wieńcowej (CS). Do celów analizy statystycznej wewnątrz grupy I przyjęto podział AP na prawostronne boczne (RFW), przegrodowe – SEPTAL (RAS, RMS, RPS, LPS oraz CS), lewostronne – LFW (LPL i LAL).

Wyniki: W grupie I istotnie częściej stwierdzono lokalizację AP RFW – u 11 (21,1%) chorych oraz RAS – u 9 (17,3%) chorych; w grupie II RFW AP stwierdzono u 19 (7,6%) chorych, RAS – u 13 (5,2%), p <0,01. W grupie II częściej występowała lokalizacja LAL – 81 chorych (32,4%), w grupie I – u 4 (7,6%), p <0,01. Rozkład pozostałych AP był podobny w obu grupach. Zabiegi RFCA w obu grupach miały podobny przebieg. W grupie I czas zabiegu wyniósł 124,1±43,5 min, w grupie II – 126,3±61,5 min (NS). Czas ekspozycji radiologicznej: w grupie I 27,9±16,7 min, w grupie II 31,2±25,5 min. Skutecznie leczono w pierwszej sesji w grupie I 48 (92,3%) chorych, w grupie II – 233 (93,2%). Nie stwierdzono znamiennych różnic między średnimi czasami zabiegów szlaków RFW, przegrodowych i lewostronnych bocznych. Stwierdzono natomiast istotnie krótszy czas fluoroskopii w RFCA wiązek lewostronnych bocznych w porównaniu z przegrodowymi. W jednoczynnikowej regresji logistycznej nie stwierdzono wpływu wieku, płci oraz lokalizacji AP na skuteczność RFCA. W grupie szlaków prawostronnych bocznych skuteczność wyniosła 90,9% (10 chorych), przegrodowych – 87,5% (21 chorych), lewostronnych bocznych – 100% (17 chorych). W grupie I u 1 (1,9%) chorej stwierdzono odmę opłucnową. W grupie II powikłania wystąpiły u 2 (0,8%) chorych. Średni czas obserwacji w grupie I wynosił 27,2 mies., a w grupie II – 30,8 mies. (NS). W analizie Kaplana-Meiera nie stwierdzono istotnych różnic w proporcjach nawrotów pomiędzy grupami. W grupie I średni czas do nawrotu wynosił 6,4 mies., a w grupie II – średnio 11,4 mies. W grupie I nawrót stwierdzono u 6 chorych (12,5%), w grupie II u 20 (8,6%). W jednoczynnikowej regresji logistycznej nie stwierdzono istotnego wpływu wieku, płci i lokalizacji AP na ryzyko nawrotu w grupie I. W łącznej analizie w obu grupach wiekowych stwierdzono natomiast istotny wpływ lokalizacji AP na prawdopodobieństwo wystąpienia nawrotu. Dla chorych z RFW AP ryzyko nawrotu było ok. 4-krotnie wyższe, a dla RPS AP ponad 3-krotnie wyższe niż dla pozostałych lokalizacji AP. W grupie I ponowny zabieg RFCA wykonano u 4 chorych (7,69%) leczonych w pierwszej sesji nieskutecznie oraz u 4 (7,7%) chorych z nawrotem. W drugiej sesji skutecznie leczono 7 (87,5%) chorych. W grupie II powtórny zabieg przeprowadzono u 33 chorych – 17 (6,8%) nieskutecznych i 16 (6,4%) z nawrotem. W drugiej sesji skutecznie leczono 26 (78,8%) chorych. Całkowita odległa skuteczność RFCA wyniosła w grupie I 94,2% (49 chorych), a w grupie II 96,8% (242 chorych), (NS).

Wnioski: Skuteczność wczesna i odległa oraz bezpieczeństwo RFCA u dzieci i młodzieży są porównywalne z wynikami osiągniętymi u dorosłych, co sugeruje możliwość zastosowania w obu grupach wiekowych tych samych wskazań do RFCA. Prawostronna boczna i prawostronna przegrodowa tylna lokalizacja AP istotnie zwiększa ryzyko wystąpienia nawrotu.

Słowa kluczowe: ablacja prądem o częstotliwości radiowej (RFCA), zespół preekscytacji, dzieci i młodzież

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