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Original Scientific Paper

SHOULD PATIENT AGE AND BODY MASS BE TAKEN IN CONSIDERATION WHEN ZERO FLUORO ABLATION IS SCHEDULED?

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SUMMARY – Since the introduction of 3D mapping systems, the use of x-rays in electrophysiology procedures has significantly decreased. The goal of this study was to analyze the frequency of x-ray use in pediatric electrophysiology in relation to age or body mass, indication for the procedure, and arrhythmia substrate. This retrospective, cross-sectional study included all pediatric procedures in two centers, Gottsegen Cardiovascular Center, Budapest, Hungary and Sestre milosrdnice University Hospital Center, Zagreb, Croatia. Patient data included weight, age, sex, presence of structural heart disease, indication for the electrophysiology study, arrhythmia substrate, and x-ray use. A total of 914 participants were analyzed, mean age 13.25 years and mean mass 53.20 kg. Of all procedures, 62.04% were performed without and 37.96% with fluoroscopy. There were no statistically significant differences in the frequency of x-ray use when comparing the groups by sex (p=0.181), age (p=0.380) or mass (p=0.120). Left-sided accessory pathways required x-ray use most frequently, whereas unknown substrates and of the known substrates atrioventricular nodal reentry tachycardia required it least frequently (p<0.001). Younger or smaller children were not irradiated more frequently during electrophysiology procedures performed with 3D mapping systems. In conclusion, there is no reason to postpone the procedure based on radiation frequency use.

Key words: *Electrophysiology; Fluoroscopy; 3D mapping; Pediatrics*

Introduction

In electrophysiology, in addition to x-rays for catheter display, 3D mapping systems have been used for many years. These systems use the magnetic field or changes in electrical voltage in the patient's body to display a live image of catheter position. The use of x-rays has decreased significantly after their introduction in electrophysiological procedures in the heart[1-6]. This is especially important in the case of pediatric patients, since children are more sensitive to ionizing radiation and their life expectancy is longer than that of adult patients[7].

In electrophysiology, small children present a greater challenge in carrying out these procedures, from the puncture of blood vessels to the mapping and

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ablation itself, where the possibility of complications is greater due to the proximity of normal anatomical structures. Janson *et al*.[8] have shown that in small children (<30 kg), the success rate in electrophysiology procedures is higher, but the risk of major adverse events is also greater. Since it is known that the use of x-rays is more common in complex procedures[9], it could be expected to be more frequent in small children, since many of the potential complications can be re-assessed with x-rays. Although this question is extremely important and can influence the decision on the right time to perform these procedures, we did not find articles that would compare the frequency of radiation use in pediatric electrophysiology in relation to age or body mass.

The goal of this study was to discuss this issue, and to correlate the frequency of x-ray use with the indication for the procedure and the arrhythmia substrate diagnosed during electrophysiological study.

Patients and Methods

This was a retrospective, cross-sectional study that was carried out in two centers, Gottsegen Cardiovascular Center, Budapest, Hungary (from January 1, 2016 until December 31, 2021) and Sestre milosrdnice University Hospital Center, Zagreb, Croatia (from January 1, 2018 until December 31, 2021). Procedures performed on children under 18 years of age, with all types of arrhythmias were included. Patients with congenital heart defects were excluded since they represent a much smaller group with more frequent troubleshooting and x-ray use.

The 3D mapping systems used were Abbott's Ensite NavX system and Johnson & Johnson Carto system. All procedures were performed in accordance with the 'as low as reasonably achievable' (ALARA) policy[9]. Intracardiac echocardiography (ICE) or transesophageal ultrasound was not used routinely, and left-sided accessory pathways were ablated through open foramen ovale or transseptal approach using fluoroscopy for puncture. Coronary arteries or coronary sinus angiography was not performed routinely but only on the indication of the operator during a procedure.

We collected the following data: weight, age, sex, presence of structural heart disease, indication for the electrophysiology study, arrhythmia substrate determined during the electrophysiology study, and x-ray use. Subjects were classified according to their weight (0->15, 15-<30, 30-<50, 50-<80 and ≥80 kg) and age (0-<7.5, 7.5-<12.5 and 12.5-18 years).

Based on the diagnosis established before the electrophysiological procedure (indication), the results were classified into the following groups: palpitations, recorded supraventricular tachycardia (SVT), asymptomatic preexcitation, Wolff-Parkinson-White (WPW) syndrome, and premature ventricular contractions (PVC)/ventricular tachycardia (VT).

Furthermore, we classified groups according to the arrhythmia substrate diagnosed by electrophysiological study as right-sided accessory pathways (AP), left-sided AP, atrioventricular nodal reentry tachycardia (AVNRT), atrial tachycardia (AT), and ventricular substrate.

The study protocol was approved by the Ethics Committees of Sestre milosrdnice University Hospital Center, Zagreb (registry no. 251-29-11-21-05) and Gottsegen National Cardiovascular Center, Hungarian Pediatric Heart Center, Budapest (Health Science Council, Scientific and Research Ethics Committee, ETT TUKEB, registry no. BMEÜ/3824-3/2022/EKU). Both ethics committees waived the need of informed consent. This was a cross-sectional study so no additional actions were taken on the patients due to the study. An individual patient cannot be identified based on the data presented in this paper.

Statistical analysis

Differences in categorical data were analyzed with χ^2-test while t-test for independent samples was used for the analysis of differences in continuous variables. All p values below 0.05 were considered significant. IBM SPSS statistical software for Windows version 29.0.1 was used in all statistical procedures.

Results

After all inclusion and exclusion criteria were met, there were 914 participants including 509 (55.7%) males and 405 (44.3%) females. Their mean age was 13.25 years (1 month to 18 years), and mean mass was 53.20 (3.7-134) kg. The number of patients in particular groups is shown in Table 1.

In the majority of 914 electrophysiological procedures, 567 (62.04%) could be performed without any x-ray, but during 347 (37.96%) procedures, the use of x-rays was unavoidable. There were no statistically significant differences in the frequency of x-ray use when comparing patient groups according

to sex (p=0.181), age (p=0.380) or mass (p=0.120), as illustrated in Table 2.

If the use of x-ray was not compared according to groups but according to the mean patient age (13.03 years in those when radiation was used *vs*. 13.40 years in those when it was not used, p=0,139) or mass (54.09 kg in those when radiation was used *vs*. 52.65 kg in those when it was not used, p=0.308), there was no significant difference either (Table 3).

There was a significant difference (p<0.001) between arrhythmia substrates in the frequency of x-ray use. The highest percentage of x-ray use was in left-sided accessory pathways (86.2%), and the lowest was in unknown substrates (2.7%) and, of known substrates, in AVNRT (12.2%). These data are shown in Table 4.

Significant difference (p<0.001) was also observed in the indication groups (Table 4). Of all indications, the highest percentage of x-ray use was in WPW (45.0%), and the lowest in palpitations (21.7%).

Table 1. Descriptive statistics of study participants

		n	%
Sex	Male	509	55.7
	Female	405	44.3
Age group (years)	<7.5	80	8.8
	7.5-12.5	248	27.1
	>12.5	586	64.1
Arrhythmia substrate	Unknown	37	4.0
	AVNRT	246	26.9
	Right sided AP	303	33.2
	Left sided AP	232	25.4
	AT	32	3.5
	Ventricular	64	7.0
Indication	SVT	348	38.1
	Preexcitation	210	23.0
	WPW	149	16.3
	Palpitation	138	15.1
	PVC/VT	69	7.5
Weight group (kg)	<15	10	1.1
	15-<30	107	11.7
	30-<50	279	30.5
	50-<80	440	48.1
	≥80	78	8.5

AP = accessory pathways; AT = atrial tachycardia; AVNRT = atrioventricular nodal reentry tachycardia; PVC = premature ventricular contractions; SVT = supraventricular tachycardia; VT = ventricular tachycardia; WPW = Wolff-Parkinson-White syndrome

Table 2. Frequency of x-ray use according to sex, age and body mass

		Use of x-ray				p
		No N=567		Yes N=347		
		n	%	n	%	
Gender	Male	306	60.1	203	39.9	0.181
	Female	261	64.4	144	35.6	
Age group (years)	<7.5	46	57.5	34	42.5	0.380
	7.5-12.5	148	59.7	100	40.3	
	>12.5	373	63.7	213	36.3	
Weight groups	<15 kg	2	20.0	8	80.0	0.120
	15 - <30 kg	66	61.7	41	38.3	
	30 - <50 kg	183	65.6	96	34.4	
	50 - <80 kg	276	62.7	164	37.3	
	>=80 kg	40	51.3	38	48.7	

N = total number of participants

Table 3. Comparison of the mean patient age and weight when x-ray was used and when it was not used

	Radiation	N	Mean	SD	t	df	p
Age (years)	Yes	347	13.03	3.89	-1.48	912.00	0.139
No	567	13.40	3.65				
Weight (kg)	Yes	347	54.09	21.95	1.06	912.00	0.308
No	567	52.65	18.66				

N = total number of participants; SD = standard deviation; df = degrees of freedom

Table 4. Comparison of x-ray use frequency according to arrhythmia substrate and indication for the procedure

		Radiation				p
		No N=567		Yes N=347		
		n	%	n	%	
Arrhythmia substrate	Unknown	36	97.3	1	2.7	<0.001
	AVNRT	216	87.8	30	12.2	
	Right-sided AP	233	76.9	70	23.1	
	Left-sided AP	32	13.8	200	86.2	
	AT	13	40.6	19	59.4	
	Ventricular	37	57.8	27	42.2	
Indication	SVT	200	57.5	148	42.5	<0.001
	Preexcitation	136	64.8	74	35.2	
	WPW	82	55.0	67	45.0	
	Palpitation	108	78.3	30	21.7	
	PVC/VT	41	59.4	28	40.6	

AP = accessory pathways; AT = atrial tachycardia; AVNRT = atrioventricular nodal reentry tachycardia; N = total number of participants; n = number of participants *per* group; PVC = premature ventricular contractions; SVT = supraventricular tachycardia; VT = ventricular tachycardia; WPW = Wolff-Parkinson-White syndrome

Discussion

According to data presented here, there was no difference in the frequency of x-ray use in pediatric electrophysiology regardless of the child's age or body mass. One could expect more frequent use of radiation in smaller children since these procedures are more demanding, but with the use of 3D mapping systems, even smaller children are not more frequently irradiated. Both centers included in this research are dedicated pediatric centers, and pediatric cardiologists perform the procedures that, in our opinion, influence these results.

We cannot draw conclusions on children weighing less than 15 kg because we had only ten such patients in total, and perhaps there was no significant difference just because of such a low number of patients. Since pediatric electrophysiology is already performed only when it is absolutely necessary in this mass group, indications in this mass group would probably not change regardless of the frequency of radiation use.

There was no significant difference in x-ray use between female and male participants, which was expected since these procedures are carried out regardless of sex.

Left-sided AP requires x-rays most of all arrhythmia substrates, which is a consequence of the transseptal approach mostly without ICE. An increased radiation exposure due to transseptal puncture has already been described[10]. In the centers where the retrograde approach or ICE for transseptal puncture is routinely used, radiation exposure will be lower in all age groups[11,12].

In the indication groups, there was no such prominent difference as in substrates, and the percentages were, although statistically significant, less different. They can be used when giving information to parents or caregivers before the procedure when asked about the likelihood of x-ray use in a specific indication.

Compared to other articles, Smith and Clark[2] describe 30 patients (mean age 12.9 years) with supraventricular tachycardia, 80% of whom were

ablated without the use of x-rays, which is more than our data.

Ozyilmaz *et al*.[3] presented ablation of idiopathic ventricular tachycardia in 17 children, of which 6 (35.3%) procedures were 'zero fluoro' compared to our 57.8% in ventricular substrates. We included PVCs in ventricular substrates, so this comparison should be taken with caution. Ablation of ventricular arrhythmia has been shown in pediatric population by Von Bergen *et al*.[13], however, in only 5 cases, of which 3 (60%) were performed without the use of fluoroscopy.

Elciran *et al*.[4] report on atrial tachycardia ablation. In their article, it was used in 25 of 39 (64.1%) pediatric patients who were ablated without the use of x-rays, which is higher than our result for this substrate.

In AP and AVNRT ablation, Miyake *et al*.[5] showed that 2 of 37 (5.4%) patients underwent ablation exclusively with the 3D mapping system, which is quite low. Jiang *et al*.[14] showed ablation of AVNRT in 95 children using the 3D mapping system, although the radiation dose decreased significantly compared to 135 cases performed with x-ray alone, there were no cases performed without fluoroscopy. Riche *et al*.[15] report on a cohort of pediatric patients who underwent an electrophysiological study with x-ray only, showing how diverse the management of the pediatric population nowadays is.

Similar results to ours are reported in the article by Tuzcu[16] on 305 patients, of which 191 (63%) procedures were performed without the use of fluoroscopy. Koca *et al*.[17] showed a less frequent use of radiation in children, with only 18.4% (14 of 76 patients) done with the use of x-ray. Kipp *et al*.[18] also report on very good results with 105 of 138 (76.1%) pediatric and adult electrophysiology procedures performed without the use of x-ray.

Our article is the first to show the independence of the frequency of radiation use on the age or mass of the child. These data should be taken into account when deciding when to stop medical treatment and suggest performing an electrophysiological procedure at the pediatric age.

Conclusion

In conclusion, younger or small children are not irradiated more frequently during electrophysiology procedures in the heart when performed with 3D mapping systems. There is no reason to postpone the procedure based on potential radiation.

It is important to note that most procedures are performed without the use of x-ray. There are large differences among centers in the frequency of x-ray use in different indications for procedures and arrhythmia substrates, so there is great potential to standardize and improve the approach to the pediatric population in electrophysiology.

Our study suffered from some limitations; the number of patients in the <15 kg mass group was only 10, which is quite small, but represents live clinical data. In pediatric electrophysiology, the procedure is postponed to a mass greater than 15 kg if possible, due to the possibility of complications.

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Sažetak

TREBA LI UZETI U OBZIR DOB I TJELESNU MASU BOLESNIKA KAD SE PLANIRA ELEKTROFIZIOLOŠKO ISPITIVANJE?

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Primjena zračenja u elektrofiziološkim ispitivanjima značajno se smanjila od uvođenja 3D sustava mapiranja. S obzirom na to da složeniji postupci češće zahtijevaju uključivanje rendgena moglo bi se očekivati da će u djece zračenje biti češće. Cilj ovog istraživanja bio je analizirati učestalost primjene rendgenskog zračenja u pedijatrijskoj elektrofiziologiji u odnosu na dob, tjelesnu masu, indikaciju za postupak i aritmogeni supstrat. U ovo retrospektivno, presječno istraživanje uključeni su svi elektrofiziološki postupci u djece u dva centra, Gottsegen Cardiovascular Center, Budimpešta, Mađarska i Sveučilišni bolnički centar Sestre milosrdnice, Zagreb, Hrvatska. Obrađeni podaci o bolesnicima uključivali su težinu, dob, spol, prisutnost strukturne bolesti srca, indikaciju za elektrofiziološku studiju, aritmogeni supstrat i uporabu rendgenskih zraka. Analizirano je ukupno 914 bolesnika srednje dobi 13,25 godina i srednje mase 53,20 kg. Od svih zahvata 62,04% učinjeno je bez, a 37,96% s fluoroskopijom. Usporedba skupina prema spolu (p=0,181), dobi (p=0,380) ili masi (p=0,120) nije pokazala statistički značajnih razlika u učestalosti korištenja rendgena. Lijevostrani akcesorni putevi najčešće su zahtijevali primjenu rendgena, a najrjeđe su ga zahtijevali nepoznati supstrati te od poznatih supstrata AVNRT (p<0,001). Mlađa ili manja djeca ne zahtijevaju češće korištenje zračenja tijekom elektrofizioloških postupaka uz 3D mapiranje. Nema razloga za odgodu postupka na temelju učestalosti zračenja.

Ključne riječi: *Elektrofiziologija; Fluoroskopija; 3D mapiranje; Pedijatrija*