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Research Article

Comparison of X-ray Doses for Child and Adult Patients Undergoing ASD Procedure

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ABSTRACT

Objectives: Transcatheter atrial septal defect (ASD) closure is a well-established practice and has become the method of choice, being safe and effective even in small children. Despite the fact that the radiation exposure during percutaneous closure of ASD is comparatively low and the deterministic effects are rather impossible, the potential stochastic effects (especially on young organisms) enforce a constant dose reduction.

Material and Methods: The study compares the radiation exposure during ASD percutaneous closure procedures performed in one tertiary centre in both children and adults with use of two angiographs: Artis Zee made by Siemens and Allura Clarity made by Philips. The procedures were performed in a routine fashion by a single well-experienced team. X-ray doses were evaluated experimentally using thermoluminescent (TL) dosimeters made by Ladis Laboratory (Krakow, Poland). Patients during exposure were imitating by the physical antropomorphic phantoms (CIRS, USA) representing adult man and 5-year old child, respectively.

Results: As the results of measurements the doses absorbed in the volumes corresponding to particular organs and body parts have been evaluated. Obtaining that, the effective doses (as a measure of future health effects probability) were also computed according ICRP recommendations. The results were statistically analyzed using non-parametric Wilcoxon' test sum of rank.

Conclusion: While the whole collection of organ doses from both angiographs do not differ significantly as well for children as for adult patients, doses absorbed by certain organs differed visibly from one angiograph to the other: namely, exposure by the Artis Zee in comparison to Allura caused higher absorbed doses in organs located deeply in the trunk. Although ASD procedure belongs to low-dose ones among interventional cardiology procedures, the doses to the lungs and the thoracic spine for small children (ab. 5-years old) are higher than these for adult patients.

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Introduction

Interventional cardiology (IC) procedures constitute the majority of all interventional radiology procedures. Thus, the evaluation of radiation risk for patients undergoing these interventions is crucial and make subject of analysis and recommendations published by the world authorities for radiation protection (International Agency of Atomic

Energy (IAEA), International Commission for Radiation Protection (ICRP)). In consequence of diagnostic tools' development, atrial septal defect (ASD) accounts for even 25% of all congenital heart diseases (CHD) with prevalence of up to 2.5 per 1000 live births. Due to its relatively minor symptoms, ASD diagnosis is frequently delayed until adulthood. Transcatheter ASD closure is a well-established practice and has become the method of choice, being safe and effective even in small

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children. Generally, up to 80% of patients are suitable for this approach [1-4]. Despite the fact that the radiation exposure during percutaneous closure of ASD is comparatively low and the deterministic effects are rather impossible, the potential stochastic effects (especially on young organisms) enforce a constant dose reduction.

Methods

The study compares the radiation exposure during ASD percutaneous closure procedures performed in one tertiary centre in both children and adults with use of two angiographs: Artis Zee made by Siemens and Allura Clarity made by Philips. The procedures were performed in a routine fashion by a single well-experienced team. X-ray doses were evaluated experimentally using thermoluminescent (TL) dosimeters made by Ladis Laboratory (Krakow, Poland). Patients during exposure were imitating by the physical anthropomorphic phantoms (CIRS, USA) representing adult man and 5-year-old child, respectively.

The "standardized" working schedule for ASD procedure was elaborated on the basis of direct careful observation of real patients' treatment, for adults and children separately. The scheme of projections together with time of them duration (i.e. chronometry) and the current-voltage parameters were recorded. The procedures without any specific clinical complications were taken into consideration. Moreover, patients who underwent them were adults of standard body size and children aged from 4 to 7 years. As the results of measurements, the doses absorbed in the volumes corresponding to particular organs and body parts have been evaluated. Obtaining that, the effective doses (as a measure of future health effects probability) were also computed according ICRP recommendations [5].

Results

Doses in ASD procedure were measured at exposure parameters exactly the same for both angiographs. The only difference was frequency of X-ray pulses: 10 frames/s for Artis Zee and 15 frames/s for Allura Clarity. (These values were routinely applied.) Exposure parameters for child patients were the following:

- i. radiography: 2 times at ab.70 kV (mAs - set automatically), LAO- 22° and SID=100 cm,
- ii. fluoroscopy: LAO- 27° : 100s, RAO-27° : 90s, PA: 70s.

Displayed on monitors Entrance Air Kerma value in reference point was as follows:

8.8 mGy for Artis Zee (at 10 frames/s) and 7.3 mGy for Allura Clarity at 15 frames/s).

Exposure parameters for adult patients were the following:

- i. radiography: 2 razy 81 kV, LAO-22° (mAs - set automatically), SID=100 cm,
- ii. fluoroscopy: LAO- 27° : 150s, RAO-27° : 140s, PA: 100s.

Displayed on monitors Entrance Air Kerma value in reference point was as follows:

94.4 mGy for Artis Zee (at 10 frames/s) and 21.4 mGy for Allura Clarity (at 15 frames/s).

Results of measurements performed according the above schedule are given in (Table 1).

Table 1: Comparison of doses for child and adult patients undergoing ASD procedure under control on the same angiograph.

	Artis Zee		Allura Clarity	
	Children	Adults	Children	Adults
Effective dose [mSv]	0.82±0.24	1.09±0.40	0.55±0.19	0.44±0.23
Absorbed organ doses [mGy]				
Thyroid	1.73±0.15	1.61±0.73	0.48±0.03	0.67±0.33
Lungs	3.32±2.08	3.01±1.28	2.56±1.24	1.13±0.96
Heart	2.65±0.98	7.27±1.93	2.00±0.37	1.94±0.86
Liver	0.23±0.15	0.57±0.35	0.17±0.14	0.17±0.10
Stomach	0.27±<0.01	0.82±0.52	0.20±<0.01	0.23±0.10
Kidneys	0.19±0.02	0.40±0.13	0.15±0.03	0.13±0.04
Ribs	1.14±0.66	2.18±1.20	0.69±0.11	0.83±0.61
TH spine	5.99±0.43	8.21±0.98	3.37±0.22	2.17±1.97
L-S spine	0.23±0.02	0.18±0.15	0.16±0.03	0.05±0.03
Red Bone Marrow (as a whole)	1.49±0.35	3.19±1.28	0.82±0.10	1.35±0.41

The results were statistically analysed using non-parametric Wilcoxon' test sum of rank (in wider version Mann-Whitney-Wilcoxon). The statistical probe was completed from set of organ doses obtained during exposure performed the given angiograph. The compared probes were independent and had the same number of elements. Value of test statistic (W) was calculated as sum of ranks and critical value at assumed significance level was checked in the appropriate statistical tables [6].

Discussion and Conclusion

The dose values collected in (Table 1) indicate what follows:

- i. The whole collection of organ doses from both angiographs do not differ significantly as well for children as for adult patients, even at significance level $\alpha=0.10$;
- ii. Despite, doses absorbed by certain organs differed visibly from one angiograph to the other: namely, exposure by the Artis Zee in comparison to Allura caused higher absorbed doses in organs located deeply in the trunk.

For children it concerns Th spine and total RBM. (Dose to the thyroid was also higher at Artis Zee because of a radiation intensively scattered on the bones.) For adults it concerns Th spine and total RBM, but the doses absorbed in the heart and the lungs are also higher in comparison to the corresponding values for Allura angiograph. In consequence, as well for children as for adults' effective dose for Artis Zee is also higher than for Allura. It should be underlined that the above divergences appear despite the same "patient", identical exposure conditions and the procedures performed by physicians with a comparable professional experience.

The above conclusions result from different way of acting AEC systems of both angiographs: Artis Zee system is more dynamic i.e. dose increases quickly with thickness of object, whereas Allura Clarity system acts softly i.e. objects of different sizes are weakly differentiated (especially at low-dose options). However, a quality of image for Allura Clarity stays diagnostically satisfying even at low doses.

Summarising, it should be underlined that ASD procedure belongs to low-dose ones among IC procedures. Despite, the doses to the lungs and Th spine for small children (ab. 5-years old) are higher than these for adult patients. Whereas it should be remembered that young organisms have 2-3 times higher susceptibility on induction health effects of irradiation. Hence, every effort for reduction of doses for children is very valuable.

Author Contributions

- i. Krzysztof Sasak: Collecting material, Research methodology.

- ii. Izabela Milcewicz-Mika, Ewelina Pyszka: Research methodology, Interpretation of results.
- iii. Michał Gałeczka, Roland Fiszer: Collecting materials, References.
- iv. Maria Anna Staniszevska: Research concept, Statistical analysis, Interpretation of results.

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