SURVEY FOR DETERMINATION OF DIAGNOSTIC REFERENCE LEVELS FOR COMMON RADIOGRAPHY EXAMINATIONS OF PAEDIATRIC PATIENTS IN LITHUANIA

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Abstract

European Commission Directive (97/43 EURATOM) on Medical Exposure requires the member states to promote the establishment and use of diagnostic reference levels (DRLs) for diagnostic examinations in radiology. Following the requirements of this Directive, Lithuania has established DRLs for adult patients. In recent years, the Radiation Protection Centre has mainly paid attention to protecting children from the hazards of ionizing radiation and has performed determinations of children's DRLs for common X ray radiography examinations. Measurements of kerma area product (KAP) [Gy·cm^2] using KAP meters and radiation output [mGy] using semiconductor detector MPD for calculations of entrance surface doses (ESD) were carried out. The data were analyzed and the third quartiles of dose values for common radiography X ray examinations were determined for newborns, 1, 5, 10 and 15 years old. The dependence between ESD, KAP and patient age has been studied in five Lithuanian hospitals that perform the most procedures for paediatric patients. The survey results will assist to determine DRLs and optimize paediatric patient doses in Lithuania.

1. INTRODUCTION

The International Commission on Radiological Protection (ICRP) notes that ionizing radiation is especially harmful for young people and newborns, therefore it is necessary to take into account the different population age groups and assessing of population exposure Exposure to ionizing radiation for paediatric patients requires special attention because of their longer life expectancy: the risks of late manifestations of detrimental radiation effects are greater than for adults [1]. For children under the age of 10 years, it is assumed that the probability of cancer is two to three times higher than for the whole population [2]. For this reason, it is very important to observe the main radiation safety principles of justification and optimization. Diagnostic reference levels (DRLs) are one of the main ways for optimization in diagnostic radiology. The concept of DRLs is defined by the European Commission Directive (97/43 EURATOM) on Medical Exposure. This Directive requires the member states to promote the establishment and use of DRLs for diagnostic examinations in radiology and nuclear medicine [3]. Following this Directive, Lithuania has – as many European Union countries – established DRLs for adults. In recent years, the Radiation Protection Centre has mainly paid attention to protecting children from the hazards of ionizing radiation and has performed determinations of children's DRLs for common X ray radiography examinations.

2. METHODS

In 2009, the specialists of the Radiation Protection Centre in Lithuania began a survey about children's doses from common X ray radiography examinations. Third quartiles of dose values were determined for newborns, 1, 5, 10 and 15 years old. Because of wide variation in children size they children were divided into the above-mentioned age groups according to international experience and recommendations. For survey the kerma area product (KAP) (Gy·cm^2), voltage (kVp), current (mA), time (s), patient thickness (cm), high (cm), weight (kg), and etc. were recorded. KAP meters and a Barracuda Cabinet meter with semiconductor detector MPD were used to measure the KAP values and kerma in air for radiation output, respectively. The calibrated Barracuda Cabinet meter has been used for checking the accuracy of KAP meters [4]. The dependence of radiation output curves on high

voltage and beam quality were built for further calculation of entrance surface doses (ESD). The ESD was calculated according to the following equation (1) of Ref. [4]:

$$\ldots ESD = Y(d) P_{it} \frac{d}{(d - t_p)^2} BSF \quad (1)$$

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where:

Y(d) – X ray tube output measured at a distance *d*, (mGy/mAs),
P_{it} – tube loading during the exposure of the patient, (mAs),
t_p – the patient thickness, (cm),
BSF – backscatter factor. The value of BSF of 1.32 was applied in this work.

Questionnaires with instructions were sent to each hospital for collection of information about patient and parameters of radiography X ray examinations. The filled questionnaires were sent back to the Radiation Protection Centre. During the years of 2009-2011 the specialists evaluated the above-mentioned parameters from five hospitals that perform the most examinations for paediatric patients, and collected about 2600 KAP values. DRLs for chest PA/AP, skull AP/PA/LAT and abdomen AP were determined. Collected data from other radiography X ray examinations were also collected, but the numbers were insufficient for statistical analysis.

3. RESULTS

For measured KAP and calculated ESD values, third quartiles of performed X ray radiography examinations were defined and compared with DRLs established in other countries. Data presented for newborns, 1, 5, 10, 15 years old paediatric patients. DRLs for chest PA/AP, skull AP/PA/LAT, abdomen AP radiography examinations were evaluated. Variations in exposure doses between hospitals for the same age groups was noticed, and it indicates that different X ray machine parameters for the same X ray procedure of these hospitals were selected.

4. DISCUSSION

In Tables 1 and 2 preliminary data is presented for newborns, 1, 5, 10, 15 years old paediatric patients. Preliminary DRLs for paediatric patients were determined by the 3rd-quartile method. The presented data shows dependency of age and doses. The exposure doses for chest PA/AP, skull PA/AP, skull LAT and abdomen AP examinations are increasing smoothly with the children's age, except for skull PA/AP and skull LAT for 15 year old children group and abdomen AP for 10 years old patients. These exceptions can be caused by data insufficiency for above mentioned procedures. Also a large variation in average doses between hospitals for the same age groups was noticed, and this indicates that different X ray machine parameters for the same X ray procedure of these hospitals were selected. For example, one of the hospitals used quantities of low kilovolts and high milliamperes and it caused big differences between health institutions. Radiation Protection Centre specialists will perform an analysis for reasons of these variations and later will prepare the document with Lithuanian DRLs for children.

TABLE I. QUARTILES, MINIMUM AND MAXIMUM KAP VALUES

X ray examination	Age (y)	No. of patients	1st quartile ($Gy \cdot cm^2$)	2nd quartile, ($Gy \cdot cm^2$)	3rd quartile, ($Gy \cdot cm^2$)	Minimum, ($Gy \cdot cm^2$)	Maximum, ($Gy \cdot cm^2$)
Chest PA/AP	0	169	0.02	0.02	0.03	0.009	0.033
	1	155	0.01	0.03	0.04	0.009	0.045
	5	66	0.02	0.04	0.05	0.013	0.053
	10	20	0.04	0.05	0.05	0.025	0.146
	15	20	0.04	0.07	0.09	0.041	0.085

X ray examination	Age (y)	No. of patients	1st quartile ($Gy \cdot cm^2$)	2nd quartile, ($Gy \cdot cm^2$)	3rd quartile, ($Gy \cdot cm^2$)	Minimum, ($Gy \cdot cm^2$)	Maximum, ($Gy \cdot cm^2$)
Skull PA/AP	0	39	0.06	0.08	0.21	0.066	0.259
	1	39	0.09	0.14	0.22	0.065	0.419
	5	41	0.14	0.19	0.31	0.126	0.594
	10	28	0.20	0.24	0.33	0.202	0.576
	15	20	0.20	0.32	0.39	0.232	0.693
Skull LAT	0	35	0.06	0.08	0.15	0.060	0.186
	1	31	0.09	0.14	0.18	0.058	0.142
	5	18	0.11	0.17	0.34	0.095	0.379
	10	15	0.17	0.21	0.31	0.164	0.309
	15	5	0.22	0.26	0.29	0.235	0.300
Abdomen AP	0	72	0.07	0.11	0.15	0.040	0.190
	1	27	0.09	0.12	0.23	0.107	0.310
	5	10	0.13	0.15	0.24	0.140	0.280
	10	8	0.50	0.61	0.95	0.196	0.581
	15	5	0.32	0.43	0.45	0.322	0.950

TABLE II. QUARTILES, MINIMUM AND MAXIMUM ESD VALUES

X-ray examination	Age (y)	No. of patients	1st quartile ($Gy \cdot cm^2$)	2nd quartile, ($Gy \cdot cm^2$)	3rd quartile, ($Gy \cdot cm^2$)	Minimum, ($Gy \cdot cm^2$)	Maximum, ($Gy \cdot cm^2$)
Chest PA/AP	0	169	0.027	0.034	0.042	0.022	0.053
	1	155	0.034	0.042	0.046	0.028	0.055
	5	66	0.049	0.055	0.056	0.035	0.062
	10	20	0.045	0.061	0.062	0.042	0.147
	15	20	0.051	0.061	0.064	0.047	0.079
Skull PA/AP	0	39	0.253	0.408	0.537	0.094	0.621
	1	39	0.326	0.423	0.548	0.104	0.854
	5	41	0.558	0.646	1.031	0.137	2.424
	10	28	0.598	0.760	1.230	0.404	1.555
	15	20	0.635	0.680	1.181	0.481	1.693
Skull LAT	0	35	0.163	0.253	0.292	0.073	0.253
	1	31	0.135	0.197	0.259	0.073	0.320
	5	18	0.261	0.414	0.520	0.108	0.625
	10	15	0.372	0.433	0.556	0.310	0.677
	15	5	0.446	0.446	0.446	0.446	0.498
Abdomen AP	0	72	0.047	0.053	0.087	0.047	0.122
	1	27	0.108	0.157	0.263	0.059	0.368
	5	10	0.202	0.318	0.435	0.086	0.551
	10	8	0.307	0.307	0.307	0.196	0.543
	15	5	0.615	0.615	0.615	0.195	0.943

Preliminary measured third quartiles (ESD and KAP) of paediatric patient doses of radiography X ray examinations were compared with established DRLS in Austria, Germany, and NRPB-Report 318 [5, 6, 7]. Measured third quartiles of ESD were quite similar and KAP values were slightly higher in comparison to above-mentioned countries (Table 3). The KAP values were slightly higher because incorrect collimation had been chosen for X ray field on patient. Besides, the Lithuanian newborns group's age was from 0 till 12 months and weight was from 3 kg till 12 kg, while for example in German DRLs the weight of newborns is defined as 3 kg and in Austria it is 3.5 kg [5]. Therefore the doses of Lithuanian newborn group are higher than in other countries.

TABLE III. COMPARISON OF LITHUANIA PRELIMINARY DRLs WITH PUBLISHED DRLs

X ray examination	Age (y)	Lithuania KAP 3rd quartile, (Gy·cm^2)	Germany DRLs, KAP (Gy·cm^2)	Austria DRLs, KAP, (Gy·cm^2)	Lithuania ESD 3rd quartile, (mGy)	Austria DRLs, ESD, (mGy)	NRPB R318, ESD, (mGy)
Chest PA/AP	0	0.03	0.008	0.017	0.042	0.055	0.05
	1	0.04	0.02	0.023	0.046	0.069	0.05
	5	0.05	0.03	0.026	0.056	0.082	0.07
	10	0.05	0.04	0.037	0.062	0.108	0.12
	15	0.09	–	0.073	0.064	0.112	–
Skull PA/AP	0	0.21	–	0.10	0.537	0.379	–
	1	0.22	0.30	0.19	0.548	0.690	0.8
	5	0.31	0.40	0.31	1.031	0.880	1.1
	10	0.33	–	0.37	1.230	0.998	1.1
	15	0.39	–	–	1.181	1.123	1.1
Skull LAT	0	0.15	–	0.077	0.292	0.294	–
	1	0.18	0.30	0.23	0.259	0.700	0.5
	5	0.34	0.30	0.20	0.520	0.506	0.8
	10	0.31	–	0.25	0.556	0.557	0.8
	15	0.29	–	0.33	0.446	0.676	0.8
Abdomen AP	0	0.15	–	–	0.087	0.100	–
	1	0.23	0.25	0.035	0.263	0.172	0.4
	5	0.24	0.50	0.11	0.435	0.511	0.5
	10	0.95	0.60	0.36	0.307	0.966	0.8
	15	0.45	–	–	0.615	–	1.2

5. CONCLUSIONS

This survey represents the first steps for establishing DRLs in paediatric radiography examinations in Lithuania. Additional data collection and evaluation is intended for rigorous survey during the year 2012. During further investigation of the situation in radiography examinations, it is intended to establish DRLs for more procedures. In 2012 it is planned to confirm DRLs for common radiography examinations for children in Lithuania. After establishing DRLs it is essential for all hospitals not to exceed them, and the main function of the regulator is supervising and controlling of this process.

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