Open Journal of Radiology, 2015, 5, 125-130
Published Online September 2015 in SciRes. http://www.scirp.org/journal/ojrad
http://dx.doi.org/10.4236/ojrad.2015.53019

Evaluation of Entrance Skin Radiation Exposure Dose for Pediatrics Examined by Digital Radiography at Asser Central Hospital-KSA

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Received 27 May 2015; accepted 19 July 2015; published 23 July 2015

Abstract

Assessment of entrance skin doses for patients in Digital radiography examinations should be made as a means for the optimization of the radiation protection of the patients. We measured the entrance skin dose (ESD) received by 50 pediatrics undergoing 12 types of diagnostic X-ray examination at Radiology Department of Asser Central Hospital-KSA. The entrance skin dose ESD was determined via measurements parameters: focus to skin distance (FSD), tube current (mAs) and tube voltage (kV) in arithmetical equation. The mean ± SD for ESDs were found to be 0.16 ± 0.03, 0.21 ± 0.01, 0.63 ± 0.26, 0.55 ± 0.09, 0.15 ± 0.05, 0.27 ± 0.06, 0.41 ± 0.19, 0.46 ± 0.18, 0.46 ± 0.12, 0.20 ± 0.02, 0.39 ± 0.01, 0.29 ± 0.03, for PA chest, foot, AP pelvis, PA skull, PA hand, AP arm, ankle, AP shoulder, abdomen, forearm, AP femur, AP elbow consequently. Our study is considered as an attempt to evaluate the ESDs received by digital radiographic x-ray machine for children aged between 2 - 15 years old, taking in our considerations number of other variables. The mean ESD values obtained are found to be within the standard reference. The data obtained may add to the available information in national records for general use. It may provide guidance on where efforts on dose reduction will need to be directed to fulfill the requirements of the optimization process and serve as a reference for future researches.

Keywords

Entrance Skin Dose, Pediatrics, Digital Radiography

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How to cite this paper: Eljak, S.N.A., Ayad, C.E. and Abdalla, E.A. (2015) Evaluation of Entrance Skin Radiation Exposure Dose for Pediatrics Examined by Digital Radiography at Asser Central Hospital-KSA. *Open Journal of Radiology*, **5**, 125-130.
http://dx.doi.org/10.4236/ojrad.2015.53019

1. Introduction

In radiology field dose assessment should be made to enhance the optimization of the radiation protection of the patients and to deliver minimum dose to the examinations. Dose measurements are necessary for the fulfillment of the international guidelines and regulations [1].

It is known that children diagnostic radiological examinations have higher risk when compared to the ones carried out for adults. Young individuals have longer life expectancy and their developing tissues are more radiosensitive. The relative risk of harmful effect after radiation exposure during the first 10 years of life is 3 to 4 times if compared to an exposure for 30 or 40 years old [2]. Children have a risk of developing a radiation-induced cancer, because of their greater cell proliferation rate and long life span expectancy [3].

Entrance surface Dose (ESD) is a measure of the radiation dose absorbed by the skin where the X-ray beam enters the patient [1], it have been used to report patient doses, and this has been studied for pediatric patients all over the world [4]. In Saudi Arabia few studies have been carried out in patient radiation concerns, especially with regards to children, moreover work was concerned with calculation of the ESD for pediatric patients undergoing X-ray examinations in a pediatric hospital took place in Taif hospital [5].

Our aim in this study was to measure the entrance skin dose (ESD) for pediatrics undergoing diagnostic X-ray examinations in four hospitals (Asser Central Hospital-Saudi Arabia). To the best of our knowledge, no study was done in the open literature regarding that issues.

2. Materials and Methods

2.1. Selection and Description of Participants

This prospective study was performed in the period of August 2013 to September 2014. Patients were examined at the radiology department of Asser Central Hospital-Saudi Arabia. Prior to patients examined, a formal approval was obtained from the Ethics and Scientific Committee of this medical center. Informed consents were obtained from patients.

2.2. Digital Radiography Machine

(AXIOM Aristos FX/FX Plus system—Siemens). Manufactured for GE Health care, Milwaukee, wi By Siemens, S.N: 4927, Model: ALOIC II, Manufactured: February/2013, Location: Kemnath/Germany, Type: 5234954, Filtration: 2.0 mm Al/70 KV, Localizer Lights: 24 v, 150 W.

2.3. Parameters and Measuring ESD

Different radiological examinations including: Foot, AP Pelvis, Skull PA, PA Hand, AP Arm, Ankle, AP Shoulder, Forearm, AP Femur, AP Elbow, were included, these examinations were obtained using fine focus and FFD of 100 cm. Chest PA and Abdomen were obtained by using broad focus and FFD 180 - 100 cm respectively. Patient information including age, gender, weight, BMI, height was considered. The type radiological examination and applied projection as well as the exposure details such as tube voltage (KV), tube current (MAS), organ thickness, focal to skin distance (FSD) were evaluated. Data were collected on patient doses during the period from 2013-2014. The ESD was calculated according to the following equation which was applied by (Tung and Tasi; 1999) [6].

$$\mathrm{ESD} = \mathrm{c}\left(\frac{\mathrm{KVp}}{\mathrm{FSD}}\right)^{2}\left(\frac{\mathrm{mAs}}{\mathrm{mm.Al}}\right) \tag{1}$$

where:

ESD stands for Entrance skin dose, c = constant = 0.2775, Kvp = Applied Tube potential, mAs = Tube current multiplied by exposure time, FSD = Focus to skin distance, Al = Aluminum Filtration.

2.4. Statistical Analyses

Data were presented as mean ± SD in a form of comparison tables. Statistical analysis was performed using the standard Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA) version 16. ANOVA and person correlation, Independent t-test were used. Correlation is significant at the $p < 0.05$.

3. Results and Discussions

The mean and ±SD values of all the pediatrics examined in the study were presented in (**Table 1**). Study population comprised 50 pediatric patients (26 males and 24 females). Pediatric ages ranged from 2 to 15 years; with a mean age of (7.19 ± 3.10) years, weight ranged from 21 to 51 Kg; with a mean value of (22.31 ± 7.86) years, mean height of (117.4 ± 17.36) years, height ranged from 86 to 140 cm; the smallest BMI of the population was 13.2 and the largest value was 26.4.

The mean and ±SD of the Digital Radiography X-ray machine parameters were presented in (**Table 2**). The maximum Kv was found to be 74, mAs of 10, organ thickness 16 cm, Focus to Skin Distance (FSD) of 168.5 and the measured ESD was of 0.92.

Mean and standard deviation for ESDs in mGy for the radiological examinations were compared with other authors, and were presented in (**Table 3**), The maximum ESD was found in the AP pelvis (0.63 ± 0.26) and the minimum dose was found in PA hand (0.15 ± 0.05). It was found that the dose level received by the digital radiography machine in our hospital were lower than other studies levels [7], [8] with significant difference at $p < 0.000$ in respected to different type of X-ray examinations. The justification may be due to the fact that the digital X-ray machine was manufactured with high engineering technology and gave low doses because of the cathode cup is optimized for use in a line-focus, planar anode tube and has a slot in which the emitter is situated. **Table 3** showed that the ESD (mGy) for the PA chest was close to that reported by the (NRPB, 2000) [8] mGy, but lower than the value of European Commission [7] by 0.14 mGy. The ESD (mGy) for the AP pelvis was lower than the value that reported by European Commission [7] by 3.7 mGy may be due to the patients thickness under study. The ESD (mGy) for abdomen half than value recorded by the European Commission [7] and close to that values reported by National Radiological Protection Board [8] and (IAEA, 1996) [9].

Similar examinations carried out in Sudan at four hospitals, eight X-ray units, their hospital mean ESDs estimated range from 0.17 to 0.27 mGy for chest AP, 1.04 - 2.26 mGy for Skull AP/PA [10].

The radiological technique including AP, Dorsi planter, lateral and oblique projections have no impact on the ESDs measures it ranged between 0.15 - 0.33 mGy Dorsi planters and oblique have less ESD than other projections (**Table 4**).

The maximum pediatric age class was found at ages between 6 - 9 years, they constituting 23 pediatric patients. The maximum ESD received was for pediatric of ages of 10 and more; however there is no significant relation between age classes and ESD (**Table 5**).

Table 1. Pediatrics demographic data.

	Age/years	Weight/Kg	BMI	Height/cm
Mean	7.19	22.31	15.76	117.44
Median	7.25	23.00	15.20	124.00
Std. Deviation	±3.10	±7.86	±2.17	±17.36
Minimum	2.0	12.00	13.20	86.00
Maximum	15.0	51.00	26.40	140.00

Table 2. Mean and standard deviation of the digital radiography X-ray machine.

	Tube Voltage (Kv)	Tube Current (mAs)	Organ Thickness	Focus to Skin Distance (FSD)	Entrance Skin Dose (ESD)
Mean	63.76	5.32	7.01	103.59	0.33
Median	65.00	5.50	5.00	96.00	0.29
Std. Deviation	±5.98	±1.94	±4.19	±24.69	±0.18
Minimum	48.00	2.00	2.00	85.00	0.11
Maximum	74.00	10.00	16.00	168.50	0.92

Table 3. Mean and standard deviation for ESDs in mGy for the radiological examinations were compared with other authors.

	Entrance Skin Dose (ESD)					Other Authors	
	N	Mean	Minimum	Maximum	*p*-Value	EC, 1996 mGy [7]	NRPB, 2000 mGy [8]
Chest PA	7	0.16 ± 0.03	0.11	0.20		0.3	0.2
Foot	2	0.21 ± 0.01	0.21	0.21		-	-
AP Pelvis	3	0.63 ± 0.26	0.41	0.92		10	4
Skull PA	6	0.55 ± 0.09	0.42	0.69		5	3
PA Hand	6	0.15 ± 0.05	0.12	0.25		-	-
AP Arm	5	0.27 ± 0.06	0.17	0.32		-	-
Ankle	2	0.41 ± 0.19	0.27	0.55	0.000	-	-
AP Shoulder	3	0.46 ± 0.18	0.29	0.64		-	-
Abdomen	6	0.46 ± 0.12	0.29	0.62		10	-
Forearm	4	0.20 ± 0.02	0.19	0.22		-	-
AP Femur	2	0.39 ± 0.01	0.39	0.41		-	-
AP Elbow	4	0.29 ± 0.03	0.28	0.34		-	-
Total	50	0.33 ± 0.18	0.11	0.92			-

Table 4. Mean and standard deviation for ESDs in mGy according to the radiological technique.

	Entrance Skin Dose (ESD)					*p*-Value
	N	Mean	Std. Deviation	Minimum	Maximum	
AP	30	0.37	±0.20	0.113	0.919	0.105
Dorsi Planter	4	0.15	±0.04	0.120	0.214	
Lateral	15	0.33	±0.13	0.136	0.547	
Oblique	1	0.16	±0.0	0.163	0.163	
Total	50	0.33	±0.18	0.113	0.919	

Table 5. Mean and standard deviation for ESDs in mGy according to the pediatrics ages.

	Entrance Skin Dose (ESD)					*p*-Value
Age/Years	N	Mean	Std. Deviation	Minimum	Maximum	
2 - 5 y	16	0.29	±0.17	0.120	0.693	0.344
6 - 9 y	23	0.34	±0.17	0.113	0.630	
≥10 y	11	0.39	±0.23	0.157	0.919	
Total	50	0.33	±0.18	0.113	0.919	

Gender and body characteristics including weight, height, BMI, had no impact on the ESDs, however the organ thickness had a significant relation with ESD at $p < 0.000$ (**Table 6** and **Table 7**). Correlations between Entrance Skin Dose (ESD) and exposure parameters showed significant relation (**Table 8**). Many authors stated that the absorbed dose in skin is directly proportional to tube current; the length of exposure, and the square of peak kilovoltage [11]. Our justification was that the digital imaging X-ray machine may allow for use of a lower tube current or a shorter exposure, thus reducing the dose to the patient as mentioned previously [11] and where the image quality controlled automatically because the using of automatic exposure control as well as the presence of aluminum filter of 2.0 mm.

Table 6. Mean and standard deviation for ESDs in mGy according to gender.

Entrance Skin Dose (ESD)						*p*-Value
Gender	**N**	**Mean**	**Std. Deviation**	**Minimum**	**Maximum**	
Male	26	0.32	±0.19	0.122	0.693	0.549
Female	24	0.35	±0.18	0.113	0.919	
Total	50	0.33	±0.18	0.113	0.919	

Table 7. Correlation between the Entrance Skin Dose (ESD) and the pediatrics body characteristics.

Correlations between the Entrance Skin Dose (ESD) and the Pediatrics Body Characteristics		
Weight/Kg	Pearson Correlation	0.064
	Sig. (2-tailed)	0.657
	N	50
BMI	Pearson Correlation	−0.175
	Sig. (2-tailed)	0.224
	N	50
Height	Pearson Correlation	0.189
	Sig. (2-tailed)	0.189
	N	50
Organ Thickness	Pearson Correlation	0.364**
	Sig. (2-tailed)	0.009
	N	50

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

Table 8. Correlation between the Entrance Skin Dose (ESD) and exposure parameters

Correlations between Entrance Skin Dose (ESD) and Exposure Parameters		
Tube Voltage (KV)	Pearson Correlation	0.351*
	Sig. (2-tailed)	0.013
Tube Current (MAs)	Pearson Correlation	0.709**
	Sig. (2-tailed)	0.000
Focus to Skin Distance (FSD)	Pearson Correlation	−0.491**
	Sig. (2-tailed)	0.000
Total Number	N	50

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

However, the risk from radiation exposure of the patients must be balanced versus the diagnostic benefit. Many departments do not use recommended radiographic parameters for children using digital radiography, furthermore, wide variations in the applications of the radiographic techniques, equipment performance at different hospitals over the world.

4. Conclusion

Our study in Saudi Arabia at Asser Central Hospital-KSA is considered as an attempt to evaluate the ESDs re-

ceived by digital radiographic X-ray machine for children aged between 2 - 15 years old, taking in our considerations number of other variables. For all the examinations studied in the hospital, the mean ESD values obtained are found to be within the standard reference values of doses. The data obtained may add to the available information in national records for general use. It will provide guidance on where efforts on dose reduction will need to be directed to fulfill the requirements of the optimization process and serve as a reference for future researches and in pediatrics of ages less than two years old.

Acknowledgements

Thanks for Asser Central Hospital-KSA, and Sudan University of Science and Technology, College of Medical Radiological Science, Khartoum, Sudan.

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