

## ESTIMATION OF EFFECTIVE DOSE FROM PEDIATRIC RADIOGRAPHY OF THE CHEST IN MEDELLÍN-COLOMBIA<sup>a</sup>

## ESTIMACIÓN DE LA DOSIS EFECTIVA DE RADIOGRAFÍA PEDIÁTRICA DE TÓRAX EN MEDELLÍN-COLOMBIA

WILLIAM JARAMILLO G.<sup>b</sup>, JAVIER MORALES A.<sup>a\*</sup>, ANSELMO PUERTA O.<sup>a</sup>

Recibido para revisar 01-09-2014, aceptado 23-02-2015, versión final 04-03-2015.

Research Paper

**ABSTRACT:** The International Commission on Radiological Protection (ICRP) asserted that the use of effective dose is actually not recommended for assessing the risks of stochastic effects in retrospective situations for exposures in patients, however this quantity can be of value for comparing the use of similar technologies and procedures in different hospitals and countries as well as the use of different technologies for the same medical examination.

The aim of this study was to estimate the effective dose of pediatric patients undergoing X-ray examinations of the chest at the largest pediatric hospital in Medellín, Colombia. For this purpose entrance surface air kerma (ESAK) was measured for 331 patients in the anteroposterior (AP) and left lateral (L LAT) projections. The age intervals studied were: 0-1 years, 1-5 years and 5-10 years. The effective dose was calculated using the computer program PCXMC 2.0. The results were validated with other works reported in the literature.

**KEYWORDS:** Pediatric dosimetry, radiation protection.

**RESUMEN:** La Comisión Internacional de Protección Radiológica (ICRP) afirmó que actualmente el uso de la dosis efectiva no es recomendado para evaluar el riesgo de efectos estocásticos en situaciones retrospectivas para exposiciones de pacientes, sin embargo esta cantidad puede ser el valor para comparar el uso de tecnologías similares y procedimientos en diferentes hospitales y países, así como el uso de diferentes tecnologías para un mismo tipo de examen.

El objetivo de este estudio fue estimar la dosis efectiva en pacientes pediátricos sometidos a exámenes de rayos X de tórax en el hospital pediátrico más grande de Medellín, Colombia. Para este propósito fue medido el Kerma en aire en la superficie de la entrada (ESAK) para 331 pacientes en las proyecciones anteroposterior (AP) y lateral izquierda (L LAT). Los intervalos de edad estudiados fueron: 0-1 años, 1-5 años y 5-10

<sup>a</sup>Jaramillo, W. & Morales, J. & Puerta, A. (2015). Estimación de la dosis efectiva de radiografía pediátrica de torax en Medellín - Colombia. *Revista de la Facultad de Ciencias*, 4(1), 11–16. DOI: <https://doi.org/10.15446/rev.fac.cienc.v4n1.50759>

<sup>b</sup>Escuela de Física. Universidad Nacional de Colombia Sede Medellín. Calle 59A No 63 - 20 Medellín, Colombia - Núcleo El Volador Medellín

\*[jmorales@unal.edu.co](mailto:jmorales@unal.edu.co)

años. La dosis efectiva se calculó utilizando el programa computacional PCXMC 2.0. Los resultados fueron validados con otros trabajos reportados en la literatura.

**PALABRAS CLAVE:** Dosimetría pediátrica, protección radiológica.

## 1. INTRODUCTION

The use of radiation in medical exposure of patients contributes over 95% of total exposure to artificial radiation and is only exceeded worldwide by natural background radiation as a source of exposure (UNSCEAR, 2000). More people are exposed to ionizing radiation for medical practice than any other human activity, and in many cases, individual doses are highest. Exposure to radiation in medicine involve people undergo diagnostic radiographic, interventional procedures or radiation therapy. Diagnostic radiology examinations lead to higher risks per unit dose of radiation to cancer in infants and children compared with adults. The high risk is explained by the higher life expectancy for children to manifest harmful effects of radiation and the fact that the developing organs and tissues are more radiosensitive (Khong *et al.*, 2013). The International Commission on Radiological Protection (ICRP) asserted that the use of effective dose is actually not recommended for assessing the risks of stochastic effects in retrospective situations for exposures in patients, however this quantity can be of value for comparing the use of similar technologies and procedures in different hospitals and countries as well as the use of different technologies for the same medical examination (ICRP, 2007). This amount is not easy to measure in a routine so it is necessary to resort to the use of conversion factors and computer programs.

PCXMC 2.0 is a computer program based on the Monte Carlo method for calculating organ and effective dose in medical X-ray examinations (Tapiovaara & Siiskonen, 2008). The effective dose is calculated with both new tissue weighting factors of ICRP Publication 103 (2007) and the old tissue weighting factors of ICRP Publication 60 (1991).

## 2. METHODOLOGY

For this study the pediatric service of the San Vicente Fundación Hospital in the city of Medellín-Colombia was chosen because it receives most of the pediatric patients from Antioquia Region. Chest radiographs in the anteroposterior (AP) and left lateral (LAT L) projections are the most common examinations performed in the institution. The X-ray machine employed in this study is a G.E. PROTEUS XR/a, which possesses an X VARIAN RAD 14 X-ray tube with 0.6 and 1.2 mm focal spots and with a total filtration of 2.6 mm of Al. The acquisition of the radiographic images was performed with a system CR 35-X from AGFA. The anti-scatter grid was removed for the equipment. Following international recommendations a quality control check was carried out on X-ray Equipment. The results showed good acceptability in the technical parameters and radiographic image in the equipment. For estimation of entrance surface air kerma (ESAK), data

were collected from the technical parameters used in examinations as the kVp, the mAs, focus-to-surface distance (FSD), field size and the relative position of the patient, as well as data such as sex, and age of the patient. The ESAK for each radiographic study was obtained from the incident air kerma (INAK) multiplied by an appropriate backscatter factor (BSF), equation 1.

$$ESAK = INAK * BSF \quad (1)$$

The INAK (equation 2) was estimated from output measurements (R (d)) at a 1 m from the X-ray tube focal spot in a range of tube voltages and mAs employed in the examinations.

$$INAK = R(d) * \left( \frac{1}{d_{FSD}} \right)^2 * mAs \quad (2)$$

Where  $d_{FSD}$  is the focus-to-surface distance and mAs is the product of tube current (mA) and exposure time (s) used in the pediatric studies. The air kerma measurements and quality control in the X-ray equipment were made with a flat ionization chamber PTW of 30 cm<sup>3</sup> calibrated in the energy range of diagnostic radiology. The backscatter factor values (BSF) used in calculations of ESAK was taken from the literature (Petoussi-Henss *et al.*, 1998); a value of 1.3 was adopted for patients from 1 to 10 years and 1.16 for infants.

To estimate the effective dose from PCXMC 2.0 software was necessary to introduce the geometric parameters of the X-ray beam, the radiographic projection, focus-surface distance and the mathematical model of the simulator used later in the Monte Carlo simulation. For each simulation 1x10<sup>6</sup> photons were generated.

### 3. RESULTS

In this study were evaluated 331 pediatric patients undergoing chest x-ray examinations for AP and L LAT projections.

Table 1: Summarizes the patient data per gender and age interval

Age range (y)	Patient Gender	Patient Number
0-1	F	17
	M	13
1-5	F	102
	M	80
5-10	F	66
	M	53

Tables 2 and 3 present the statistical data for ESAK and E values found in this work as well as radiographic parameters used in the chest examinations for the three age groups in the AP and L LAT projections respectively. This data were compared with previous data published from literature.

Table 2: Comparison of radiographic parameters, ESAK and E for AP projection found in this work with other data

Work	Age groups (y)	Sample size	kVp	mAs	ESAK ( $\mu\text{Gy}$ )	E( $\mu\text{Sv}$ )
			Mean Min-Max	Mean Min-Max	Mean Min-Max	Mean Min-Max
This Work	0-1	30	58,9 (51-95)	1,21 (0,6-4)	53,50 (22,5-237,4)	17 (9-69)
	1-5	182	66.3 (52-102)	1.7 (0.8-8)	72 (18,9-273,5)	17 (5-69)
	5-10	119	71.5 (54-106)	2.4 (0.8-10)	77.8 (18.5-351.6)	18 (5-86)
M. Lacerda et al. (2008)	0-1	5	48	3.2	73	16
	1-5	10	50.3	3.6	87	19
	5-10	8	63.8	4.7	112	16
A. Azevedo et al. (2006)	0-1	22	63	3.1	67	12
	1-5	51	67	3.7	77	12
	5-10	17	68	3.2	79	11
EC(s)	0		60-65		80 <sup>a</sup>	
	5		60-80		100 <sup>a</sup>	

<sup>a</sup>ESAK values are presented in terms of the third quartile

Table 3: Comparison of radiographic parameters, ESAK and E for L LAT projection found in this work with other data

Work	Age groups (y)	Sample size	kVp	mAs	ESAK ( $\mu\text{Gy}$ )	E( $\mu\text{Sv}$ )
			Mean Min-Max	Mean Min-Max	Mean Min-Max	Mean Min-Max
This Work	0-1	30	62.2 (50-95)	1.24 (0.8-4)	66.87 (30-264.5)	12 (5-51)
	1-5	182	70.8 (50-102)	1.9 (0.8-6)	93.8 (21.4-310.6)	14 (2-51)
	5-10	119	77.6 (50-109)	2.9 (0.8-10)	113.3 (23.6-431.8)	15 (2-57)
M. Lacerda et al. (2008)	0-1	15	55.4	3.7	118	22
	1-5	12	56.6	4	126	18
	5-10	6	68.7	5.2	205	19
A. Azevedo et al. (2006)	0-1	11			190	26
	1-5	44			109	13
	5-10	18			113	11
EC(s)	5			200 <sup>a</sup>		

<sup>a</sup>ESAK values are presented in terms of the third quartile

Although radiographic and dosimetric parameters showed a wide variability for each age group evaluated in this study as shown in Tables 2 and 3, the mean values of the entrance surface air kerma found for all age groups are comparable to those of European Guidelines for standards patients of 0 and 5 years (European Commission, 1996). Additionally ESAK values in this study showed a good agreement with the values reported in the work of Azevedo et al. for the age groups of 1-5 and 5-10 years old for both AP and LAT projections (Azevedo *et al.*, 2006). Regarding to the results of effective dose, significant differences were found for the group of patients between 0 and 1 year for the two types of projections. Differences of 45.45% and 53.8% were observed with the works of Lacerda et al. and Azevedo et al. respectively for the LAT projection (Lacerda *et al.*, 2008; Azevedo *et al.*, 2006). Analyzing data from Tables 2 and 3 can be seen a high difference between the values of mAs and ESAK reported in this study with those reported in the studies mentioned above. For example in the work of Azevedo et al. the radiographic examinations in the hospitals for this age group (0-1 years) were performed with the antiscatter grid coupled to X-ray equipment (Azevedo *et al.*, 2006). For this study the radiographic examinations were carried out without use of anti-scatter grid for patients under five years and high values of kV and low values of mAs values were used as recommended internationally (IAEA, 2012). Another of the reasons for these differences can be attributed to the use of different systems of image acquisition. In the works of Azevedo et al. & Lacerda et al. radiographic images in the hospitals were obtained with screen-film systems, whereas in this work the images in the hospital studied were acquired with a Computed Radiography system (Azevedo *et al.*, 2006; Lacerda *et al.*, 2008).

## 4. CONCLUSIONS

Although Effective dose is not recommended to assess the radiological risk in patients undergoing diagnostic examinations, this quantity showed a useful quantity to compare the use of different technologies in X-ray examinations of the chest in pediatric patients.

The use of digital imaging system operated by trained technicians and a careful monitoring of parameters used in the individual pediatric radiology leads to a reduction of the patient dose.

The use of computer programs based on the Monte Carlo method to evaluate the effective dose in patients due to diagnostic x-ray examinations is a modern and efficient tool in hospitals.

## ACKNOWLEDGEMENTS

The authors thank the Dirección de Investigación Medellín (DIME) of the Universidad Nacional de Colombia for the projects financing, and the San Vicente Hospital for their collaboration.

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