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Review Article

Doses Evaluation of Some Body Organs of Pediatric Patients Undergoing Chest X-ray Examination Using Thermoluminescent dosimeter

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Abstract: Pediatric patients are among the most sensitive on ionizing radiation when they should be undergoing an X-Ray screening. The delivered dose to the pediatric patients should be well optimized to minimize the harmful effect of the X-Ray examinations. The objectives of this work are to measure at chest level and corresponding organ doses for each pediatric patient undergoing X-Ray radiation examination. The study was carried out in three hospitals in Madagascar. During these measurements, the patient doses were determined using thermo luminescent dosimeters (TLDs) placed upon to the patient's body. The examination parameters (high voltage, filtration, field size and focus to skin distance examinations) for 114 patients undergoing chest examination with an Antero- Posterior (AP) projection have been collected. Entrance Surface Air Kerma (ESAK) was determined by using calibrated thermoluminescent dosimeters (TLD- 100) through the Secondary Standard Dosimetry Laboratory of Institut National des Sciences et Technique nucleaire- Madagascar. Patients population were categorized into four groups in accordance with their ages ([<1) year] (group 1), for group 2([1-5] years), for group 3([5-10] years) and for group 4([10-15] years).Values of organs doses vary following the age: the received dose increase inversely with the age of the patient. The breast received doses represents the maximum values compared with the other organs. Results of the ESAK have been used to evaluate the radiation dose levels for pediatric patients in Madagascar, to establish local diagnostic reference level and to optimize pediatric patient delivered doses. The patient organ received doses versus the dose at chest level have been determined by using National Radiological Protection Board (NRPB) coefficients through Visual Basic Application (VBA) tool.

Keywords: X-Rays, Entrance Surface Doses, Organ Doses, Radiography

1. Introduction

Madagascar is starting the implementation of the Dose Reference Levels (DRL) for current diagnostic procedures on conventional radiology [1]. For children, who are more vulnerable than adults, each X-Ray radiation exposure must be performed with great vigilance [2]. Radiation doses in the various organs or tissues of the body cannot be measured directly for the patient undergoing such examinations [3]. A calculation approached could be done, using the NRPB coefficients. [3] The aim of this study is to evaluate received doses distribution into the patient.

For that, thermoluminescent dosimeters-100 [4] (TLDs) have been placed upon the chest of the pediatric patient. The dose distributions to the other organ have been evaluated accordingly using the data provided by the NRPB-SR 279 of Chest examinations [3]. A Visual Basic Application (VBA), MS Excel have been Developed using the values provided by NRPB SP279 Monte Carlo data [4, 5]. The Organ Doses results have been arranged in spreadsheets.

2. Materials and Method

2.1. Examination Parameters

The study was performed in three X-Ray units of three hospitals in Madagascar. The batch of pediatric patient studied in this work included male and female children. The acquisition parameters as the voltage, charge, distance focus film, projection type [6] with the morphology (sex, thickness of the trunk, age) have been recorded. Patients were categorized into four groups in accordance with their age: group (>1 year), group (1–5years), group (5–10 years) and group (10-15years).

The examination parameters (high voltage, field size and focus to skin distance examinations) for 114 patients undergoing chest examination were collected.

2.2. Patient Dosimetry Using TLD

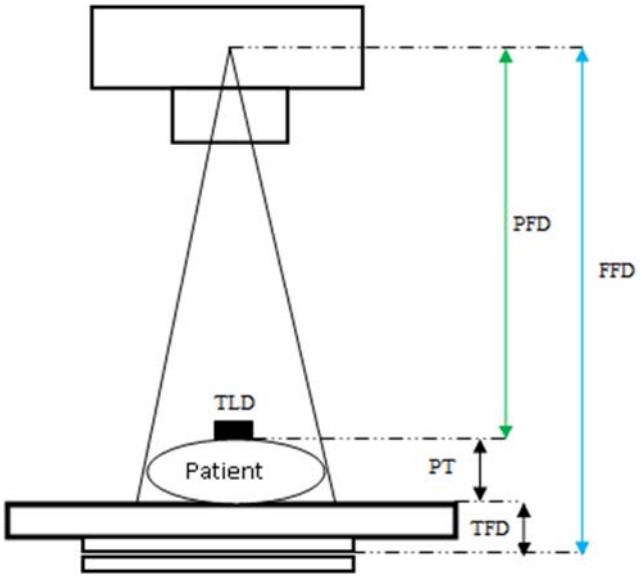

Figure 1. *Patient ESAK measurement using TLD.*

F.F.D: Focal Film Distance
P.T: Patient Thickness
T.F.D: Table Film Distance

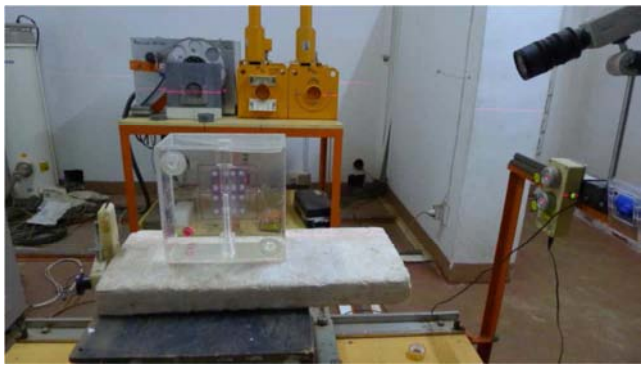

Figure 2. *Irradiation of TLDs at SSDL (INSTN-Madagascar).*

For the measurement of the patient doses, TLDs were placed in contact with the chest of each patient under X-Ray examination, as closer as possible to the examined part of the patient. At the DRP laboratory, TLDs were reading, using an HARSHAW 6600 TLDs Reader [7].

The TLD-100 (LiF: Mg, Ti) dimension used during the study is 3 mm ×3 mm ×1 mm. The acquisition parameters and the informations for each patient have been recorded. After being proceeded at HARSHAW TLDs Reader [8], the TLDs Cards are irradiated in order to know the correction factor of each TLD chipstrate at SSDL.

ESAK has been taken as the measured dose at the target point.

3. Results and Discussion

Among the 114 patients, the ESAK value have been calculated by using the output [9] of the X- Ray machine for the 98 patients (see appendix), and 16 of them have been determined through direct measurements using TLDs.

Table 1. *Entrance surface air kerma (ESAK) (mGy) for Chest examination with AP projection for 3hospitals (using TLDs) [10].*

Parameters (Age, kVpmAs)	ESAK (mGy)
(1 month, 80, 8)	3.77 E-01
(2 months, 80, 5)	1.81 E-01
(6 months, 80, 8)	2.56 E-01
(11 months, 82, 8)	1,78 E-01
(1 year, 80, 8)	4.36 E-01
(1 year, 80, 10)	4.46 E-01
(2 years, 85,10)	2.56 E-01
(2 years, 82, 10)	3.08 E-01
(2 years, 84, 8)	2.49 E-01
(4 years, 85,8)	1.85 E-01
(4 years, 83, 10)	2.69 E-01
(6 years, 86, 8)	2.50 E-01
(8 years,80, 8)	1.48 E-01
(9 years, 85, 10)	3.70 E-01
(11 years, 90, 10)	2.74 E-01

Table 2. *Organ Doses (mGy) for Chest examination with AP projection for 3 hospitals.*

Organes	[<1]year (80 kV, 8 mAs)	([1- 5]) years (80 kV,10 mAs)	([1- 5]) years (90 kV, 8 mAs)	([1- 5]) years (90 kV,10 mAs)	([5-10]) years (90 kV, 10 mAs)
Adrenals	3,27 E-01	3.11 E-02	3.16 E-02	3.25 E-02	4.48 E-02
Brain	1.00 E-04	4.00 E-04	4.00 E-04	4.00 E-04	5.00 E-04
Breasts	2.25 E-01	2.11 E-01	1.86 E-01	1.90 E-01	2.75 E-01
Eye lenses	1.00 E-03	3.00 E-04	4.00 E-04	4.00 E-04	7.00 E-04
Gall bladder	1.36 E-02	3.37 E-02	3.31 E-02	3.40 E-02	7.21 E-02
Stomach	4.07 E-02	7.89 E-02	7.42 E-02	7.63 E-02	1.40 E-01
Small intestine	2.80 E-03	3.50 E-03	3.70 E-03	3.80 E-03	6.30 E-03
Upper large intestine	3.50 E-03	4.50 E-03	4.80 E-03	4.90 E-03	8.80 E-03
Lower large intestine	9.00 E-04	1.00 E-03	1.10 E-03	1.10 E-03	1.60 E-03
Heart dose	1.64 E-01	1.41 E-01	1.32 E-01	1.36 E-01	1.84 E-01
Kidneys	7.40 E-03	1.30 E-02	1.34 E-02	1.37 E-02	2.49 E-02
Liver	5.04 E-02	7.60 E-02	7.17 E-02	1.10 E-01	1.20 E-01
Lungs	1.33 E-01	1.15 E-01	1.07 E-01	1.10 E-03	1.51 E-01
Ovaries	9.00 E-04	1.00 E-03	1.10 E-03	6.55 E-02	2.10 E-03
Pancreas	3.27 E-02	6.51 E-02	6.37 E-02	2.22 E-02	9.29 E-02
Skin	3.64 E-02	2.44 E-02	2.16 E-02	4.10 E-02	3.19 E-02
Spleen	2.70 E-02	4.00 E-02	3.98 E-02	3.33 E-02	6.07 E-02
Testicles	2.00 E-04	0	1.00 E-04	1.00 E-04	0
Thymus	2.23 E-01	1.96 E-01	1.78 E-01	1.84 E-01	2.63 E-01
Thyroid	1.40 E-01	1.83 E-02	1.80 E-02	1.85 E-02	2.29 E-02
Urinary bladder	5.00 E-04	4.00 E-04	5.00 E-04	5.00 E-04	6.00 E-04
Uterus	1.20 E-03	9.00 E-04	9.00 E-04	1.00 E-03	1.60 E-03
Oesophagus	8.02 E-02	5.73 E-02	6.65 E-02	5.81 E-02	7.70 E-02
Residue	3.17 E-02	2.51 E-02	2.35 E-02	2.42 E-02	3.49 E-02
Head region	1.06 E-03	3.10 E-03	3.30 E-03	3.40 E-03	4.80 E-03
Trunk region	6.50 E-02	5.70 E-02	5.30 E-02	5.45 E-02	7.70 E-02
Leg region	0	0	0	0	0
Total bone	9.14 E-02	5.70 E-02	2.25 E-02	5.40 E-02	6.70 E-02

Table 3. *Organ Doses (mGy) for Chest examination with AP projection for hospital.*

Organes	([5-10]) years (80 kV, 8 mAs)	([10- 15]) years (90 kV, 10 mAs)
Adrenals	1.49 E-02	1.90 E-02
Brain	2.00 E-04	4.00 E-04
Breasts	1.08 E-01	1.89 E-01
Eye lenses	2.00 E-04	8.00 E-04
Gall bladder	2.56 E-02	7.90 E-03
Stomach	5.17 E-02	2.96 E-02
Small intestine	2.00 E-03	8.00 E-04
Upper large intestine	2.90 E-03	1.10 E-03
Lower large intestine	5.00 E-04	2.00 E-04
Heart dose	6.70 E-02	1.22 E-01
Kidneys	8.30 E-03	3.80 E-03
Liver	4.38 E-02	3.97 E-02

Organes	([5- 10]) years (90 kV, 8 mAs)	
Lungs	5.52 E-02	9.12 E-02
Ovaries	7.00 E-04	2.00 E-04
Pancreas	3.23 E-02	2.53 E-02
Skin	1.25 E-02	1.86 E-02
Spleen	2.09 E-02	1.60 E-02
Testicles	0	0
Thymus	9.90 E-02	1.84 E-01
Thyroid	7.90 E-03	2.12 E-02
Urinary bladder	2.00 E-04	0
Uterus	5.00 E-04	1.00 E-04
Oesophagus	2.63 E-02	4.66 E-02
Residue	1.28 E-02	1.93 E-02
Head region	1.60 E-03	4.20 E-03
Trunk region	2.84 E-02	3.78 E-02

Organes	([5- 10]) years (90 kV, 8 mAs)	
Leg region	0	0
Total bone	2.50 E-02	3.59 E-02

The results of 114 patient dose calculations are summarized in Tables 2 and 3. These values have been obtained from the three hospitals which one public and two privates. The examination parameters change with the age.

According to the tables 2 and 3,these maximum values obtained in the breasts for children under 1 year was2.25 E-01 mGy, for children between 2and5 years was 2.11 E-01 mGy, for childrenbetween6 and10 years was 1.08 E-01 mGy, for childrenbetween11 and15 years was1.89 E-01mGy.

The dose values decrease with the existing distance between the targeted and the studied organs. It have been established also that, for two organs having the same distance from the target, the exposition level takes into account the fraction of the organ being irradiated.

4. Conclusions

The patient Organ Doses during X-Ray examination have been determined from ESAK measurements and acquisition parameters (High Voltage, mAs, Thickness of the irradiated part of the patient, the Focal Film Distance and the projection AP).

The augmentation of the high voltage engender the augmentation of the X-Ray beam energy, then increase at the same time the exposition of the organ doses of the patient to

the ionizing radiation.

The present work established that the parameters selection in paediatric examination protocols should be optimized in order to reduce patient doses.

Measurements and calculations performed throughout the present work are a good asset to implement a national data base and then, to establish a national Dose Reference Levels.

Acknowledgements

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Appendix I

Table A1. *Entrance Surface Air Kerma (ESAK) (mGy) for Chest examination with AP projection for hospital.*

[kVp/ mAs/thichness (cm)]	Age (years)	ESAK (mGy)
[110 /1.2 /14]	4	0.115
[95 /1.2 /12]	3	0.108
[60 /08 /15]	8	0.193
[60 /25/12]	2	0.126
[90/1.6/11]	2 months	0.107
[83/10 /13]	4	0.094
[82 /10/12]	2	0.103
[80/05/11]	8months	0.169
[100/2.5/14]	5	0.161
[85/1.6/14]	7	0.145
[80/4/13]	4	0.162
[95/2.5/15]	8	0.152
[90 /1.2/11]	1	0.118
[80/08/12]	2	0.14
[60/1.2/13]	5	0.109
[80/10/12]	3	0.2
[95 /1.8/14]	10	0.174
[85/10/12]	4	0.204
[120/1.6/14]	11	0.161
[80/1.2/14]	10	0.164
[70 /02/13]	4	0.211
[100/1.6/12]	3	0.177
[60/1.8/13]	6	0.207
[95/08/12]	2	0.180
[80/1.6/11]	1	0.111
[83/2.5/14]	9	0.165
[70/1.3/12]	2	0.103
[100/2.5/13]	5	0.128
[80/1.6/14]	8	0.190
[90/2.5/12]	2	0.122
[70/03/11]	2.5 months	0.102
[81/02/12]	1	0.092
[85/10 /12]	3	0.110
[83/2.5/12]	2	0.109
[110/2.1/15]	12	0.204
[100 /1.6/15]	13	0.212
[80/04/13]	5	0.153
[70/2.5/13]	4	0.134
[90 /1.6 /14]	8	0.145
[80 /1.6 /12]	3	0.132
[90/1.2/14]	6	0.164
[80/08/12]	2	0.120
[100/1.8/13]	10	0.184
[120/10/15]	15	0.256
[120/1.6/14]	11	0.161
[80/02/13]	9	0.153
[60/1.2/11]	1	0.096
[85/1.6/12]	4	0.135
[85 /1.8/14]	7	0.307
[90/08/13]	6	0.179
[80/02/12]	2	0.124
[83/2.5/14]	9	0.159
[85/1.6/13]	4	0.125
[90/02/15]	8	0.210
[60/1.6 /12]	2	0.121
[80/2.5/12]	4	0.156
[90/03 /13]	6	0.162
[82/1.2/12]	3	0.132
[70/10/13]	5	0.135
[80/02/12]	3	0.230
[120/2.1/14]	14	0.210
[90/1.6/13]	10	0.201
[70/04/13]	4	0.127
[80/2.5/12]	1.2	0.115
[80/1.2 /13]	5	0.135
[85/1.6 /12]	4	0.132
[100/02/14]	9	0.164
[80/06/12]	2	0.119
[90/1.6/15]	10	0.182
[110/1.8/15]	12	0.257
[85/1.6/14]	10	0.156
[83/1.2 /13]	7	0.146
[70 /2.5/12]	3	0.125
[80 /02 /13]	4	0.140
[82 /1.8/14]	6	0.125
[90 /08/13]	5	0.186
[70 /1.2/12]	3	0.125
[80 /1.6 /14]	8	0.135
[70/1.2/13]	4	0.132
[80 /02 /12]	3	0.125
[80 /1.6 /13]	8	0.145
[90/02/13]	6	0.133
[85/1.2/13]	4	0.125
[120/1.8/14]	13	0.209
[80 /1.6/14]	9	0.184
[84/2.5/13]	4	0.146
[70/1.2/12]	1	0.107
[90/1.6/13]	5	0.140
[85/1.2/13]	6	0.147
[110/02/14]	9	0.170
[80/06/14]	7	0.160
[95/2.5/15]	10	0.170
[100/1.8/15]	11	0.210
[83/1.2/14]	8	0.182
[75/1.6/13]	6	0.148
[120/2.5/14]	15	0.215
[60/02/12]	2	0.117
[80/1.8/13]	5	0.138

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