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Measurements of Entrance Skin Dose in Egyptian Pediatric During Diagnostic X-Rays using Thermo Luminescence Dosimeter (TLD -100)

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Radiation protection in pediatric radiology deserves special attention due to the fact that children are more sensitive to radiation than the adults. This study is concerned with the measurements of pediatric entrance surface dose (ESD) using thermo-luminance dosimeter (TLD, LIF100) for patients ranging from age intervals: 0.1-5 years, 5-10 years and 10-16 years, respectively. A central public pediatric hospital and 120 Egyptian patients were included in this investigation. By careful selection of the patients, three types of simple radiography were selected, as follows: (50 to the chest, 35 to the abdomen and 35 to the skull). Pediatric chest examinations are the most frequent radiological examinations. Comparisons were performed between these doses and the diagnostic reference levels (DRLs).

The results showed that mean patient skin doses measured with TLD for the patients ranging from 10-16 years old were 0.20 mGy 14%, 1.10 mGy 23% and 1.00 mGy 40% for chest, abdomen and skull examination, respectively. The mean ESD values were found to be within the range of ESD reference values, except those for the chest examination.

Introduction

The medical use of the ionizing radiation represents the major cause of human exposure to artificial ionizing radiation sources [1, 2]. The development of new techniques and equipment can contribute to an early and accurate diagnosis. However, the dissemination of the application of ionizing radiation in medicine results in the increasing of the human exposure to ionizing radiation. Thus, the medical routine optimization is essential to guarantee the benefits of this technology and to reduce the associated risks. In this way, quality control programs are indispensable.

Entrance skin dose measurement is an important tool in quality control programs: the more optimized the technical procedure, the lower the dose levels [3-5]. The entrance skin dose (ESD) can be influenced by several factors, such as exposure parameters (voltage, exposure time and focus-film distance), field size and x-ray beam limitation [6]. To establish entrance skin dose levels, both direct (ionization chambers or solid state dosimeters) or indirect measurements can be utilized. Most of entrance skin dose measurements are performed using Thermo Luminescent Dosimeters (TLD), this type of dosimeters presents some advantageous characteristics such as linearity of response in a wide dose interval, high sensitivity and easy handling.

A commonly utilized Thermo Luminescent (TL) material to measure the entrance skin dose in conventional radiology is the lithium fluoride (LiF: Mg, Ti) because its effective atomic number is very close to the one of human tissue [7].

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Materials and Methods

In this work, - the TL material used was LiF: Mg, Ti, produced by Bicron-Harshaw, USA. The LiF: Mg, Ti (TLD-100) - card contains two TLD-100 - chips mounted Teflon sheet on aluminum substrates. The TLD system was calibrated to determine the reader calibration factor that is used in evaluating the ESD.

A Harshaw 6000 – plus - readout system was utilized for TL measurements. The TLD cards were treated for 5s at a preheat temperature of 150 ^{o}C with a heating rate of 15 ^{o}C/s, up to a maximum temperature of 300 ^{o}C within a reading time of 13.3s. The TLD chips were labeled with identification numbers and then fixed in the central position of the beam.

The TLDs were irradiated with radiodiagnostic standard beams (see Table 1) [8] using gamma rays beams with different energies, namely ^{137}Cs of 0. 66 MeV and ^{60}Co of 1.25 MeV effective energy. The main dosimetric characteristics of the tested materials (reproducibility, linearity of TL response as a function of the absorbed dose, and energy dependence of TL materials) were determined.

Table (1): X ray radiation standard qualities utilized in this work [8]

Radiation Quality	^{1nd} HVL $^{(a)}$ (mmAl)	^{2nd} HVL $^{(a)}$ (mmAl)	Effective Energy (keV)	Air Kerma Rate (mGy/min)
RQR2	1.43	1.84	25.0	10.82
RQR3	1.79	2.34	27.2	19.40
RQR4	2.08	2.75	28.8	29.40
RQR5	2.32	3.39	30.0	39.86
RQR6	2.60	3.96	31.4	51.30
RQR7	2.87	4.55	32.7	64.07
RQR8	3.17	5.11	34.1	76.81
RQR9	3.74	6.25	36.6	104.86
RQR10	4.59	7.82	40.2	152.26

$^{(a)}$The half value layer (HVL) corresponds to the thickness of material that reduces the initial intensity of the radiation beam to half

Table (2): Listing of Reference Levels[9] **(pediatric radiographs values are ESD in µGy)**

Pediatric Radiographs [values are ESD in uGy, except for MCU exam]	(Pediatric) NRPB 2000					(Pediatric) EC 1996b,1999a	(General) NRPB 1999
	0-yr	1-yr	5-yr	10-yr	15-yr		
AP & PA Chest		50	70	120		100 (5-yr old)	100 (5-yr old)
LAT Chest						200 (5-yr old)	200 (5-yr old)
AP Chest Newborns	50					80 (newborn)	80 (newborn)
PA or AP Skull		800	1100	1100	1100	1500 (5-yr old)	1500 (5-yr old)
LAT Skull		500	800	800	800	1000 (5-yr old)	1000 (5-yr old)
AP Pelvis (infants)						200 (infant)	200 (infant)
AP Pelvis (older children)		500	600	700	2000	900 (5-yr old)	900 (5-yr old)
AP or PA Abdomen (with vertical beam)		400	500	800	1200	1000 (5-yr old)	1000 (5-yr old)
MCU exam (**Note: DAP in mGy cm2**)	600	900	1200	2400			
[NOTE: quality criteria, but not reference levels also given for the following pediatric radiographs in EC (1996b)]							
PA or AP Full Spine	Micturating Cystourethrography					AP or PA Urinary Tract	
PA or AP Segmental Spine	AP or PA Urinary Tract					(after contrast)	
LAT Segmental Spine	(without or before contrast)						

Results and Discussion

Reproducibility

The response reproducibility of the TL materials (TLD-100) was evaluated after five identical cycles of irradiation, reading and thermal treatment. The samples were exposed to the ^{137}Cs gamma radiation standard source, at 1 m, with 5 mGy (absorbed dose). The TL response spread of each sample was less 4.5% for the TLD-100 chips.

Calibration curves

The TL responses as a function of absorbed dose in air were obtained using all three radiation sources already cited: ^{137}Cs and ^{60}Co gamma sources and x-ray units at the standard radiation qualities listed in Table (1). Because of the low air kerma rate, the samples were irradiated in the ^{60}Co source in an absorbed dose interval of 0.5-10 mGy. In all other cases, the TL materials were irradiated in the absorbed dose interval from 1 to 50 mGy. Up to these doses, no saturation of TL response was observed, as shown in Figure (1).

The TL materials exhibited a linear relationship between the TL response and the absorbed dose, as expressed by the correlation coefficients obtained for the applied linear fit. These results showed the feasibility of both materials for the dosimetry of patient in common x-ray examinations.

The TL response as a function of the radiation beam energy was obtained by irradiating the samples with the x-ray qualities listed in Table 1 and the ^{137}Cs standard source, considering the same geometrical conditions, with an absorbed dose in air of 50 mGy. The results are shown in Figure (2).

The maximum ratio between the TL response obtained for each tested X-ray quality and the TL response obtained for the ^{137}Cs energy was equal to 1.4 for the TLD-100 samples. These values indicate that even though these materials can be utilized for ESD measurements, correction factors should be used to avoid overestimation of the measured doses.

The mean entrance surface dose for the most common x-ray examinations of different pediatric age groups are summarized in Tables (2 to 5).

Experimental TLD Results

The experimental results for ESD obtained using TLD -100 dosimeters are shown in Tables (3 to 6), for the considered age ranges. Furthermore, the comparison of the obtained results with the reference levels is also presented see Table (7).

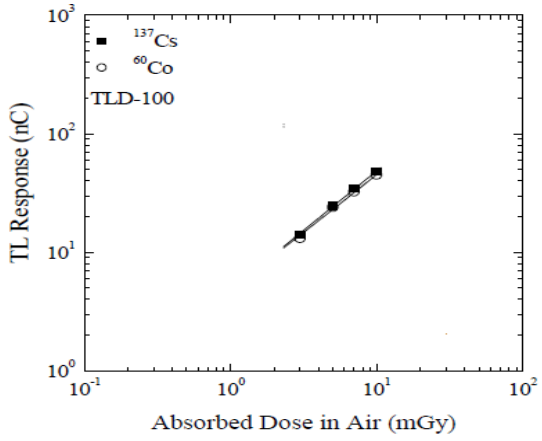

Figure (1): Calibration curves obtained for TLD-100 samples at ^{137}Cs and ^{60}C

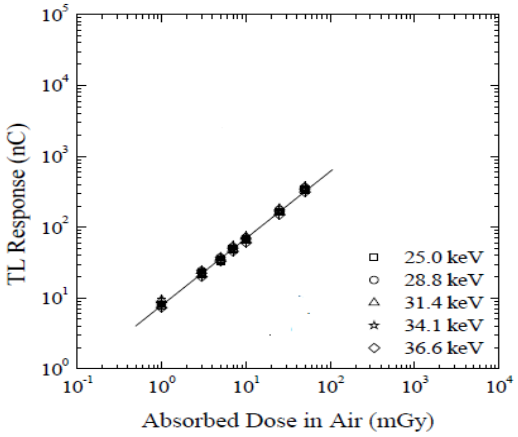

Figure (2): X Ray Energy dependence of TLD-100 sample

Table (2): Technical parameters used to perform radiographic studies and measured ESD in this work (age < 1 year)

Examination	***Distance (cm)**	**Voltage (kV_p)**	**Current (mA)**	mAs Product	**Mass (Kg)**	ESD (µGy)
Chest	**150**	**48**	**150**	**0.04**	**3-6**	**40**
Abdomen	120	54	150	0.05		210
Skull	120	48	150	0.08		52

***Focus to Phantom Surface Distance (cm) and the field size (9x9cm)**

Table (3): Technical parameters used to perform radiographic studies and measured ESD in this work (age 1 – 5 year)

Examination	***Distance (cm)**	**Voltage (kV_p)**	**Current (mA)**	mAs Product	**Mass (Kg)**	ESD (µGy)
Chest	**150**	**55**	**150**	**0.04**	**6-16**	**51**
Abdomen	120	50	150	0.10		200
Skull	120	58	150	0.15		200

***Focus to Phantom Surface Distance (cm) and the field size (10x10cm)**

Table (4): Technical parameters used to perform radiographic studies and measured ESD in this work (age 5 – 10 year)

Examination	***Distance (cm)**	**Voltage (kV_p)**	**Current (mA)**	mAs Product	**Mass (Kg)**	ESD (µGy)
Chest	**150**	**46**	**150**	**0.06**	**15-29**	**100**
Abdomen	120	55	150	0.20		400
Skull	120	60	150	0.20		920

***Focus to Phantom Surface Distance (cm) and the field size (10x10cm)**

Table (5): Technical parameters used to perform radiographic studies and measured ESD in this work (age 10 – 15 year)

Examination	***Distance (cm)**	**Voltage (kV_p)**	**Current (mA)**	mAs Product	**Mass (Kg)**	ESD (µGy)
Chest	**150**	**58**	**150**	**0.15**	**20-45**	**400**
Abdomen	120	60	150	0.30		1100
Skull	120	66	150	0.25		1300

***Focus to Phantom Surface Distance (cm) and the field size (12x12cm)**

Table (7): Comparison of Egyptian Pediatric Radiographs of Entrance Skin Dose with international reference values

Examination	***E.C Average ESD (**mGy) (5-yr old)	****NRPB Average ESD (**mGy) Age group (0.1 -15year)	**Egyptian Present work Average ESD (**mGy) Age group (0.1 -15year)
Chest	**0.200**	**0.050- 0.120**	**0.040 – 0.400**
Abdomen	**1.000**	**0.400- 1.200**	**0.200- 1.100**
Skull	**1.500**	**0.800- 1.100**	**0. 500- 1.300**

*European Communities 1996b,1999a REF (9)
National Radiological Protection Board (November 2000) **REF(9)

Conclusions

Thermo Luminescence dosimeters LiF: Mg, Ti (TLD-100) showed an adequate performance for entrance skin dose measurements in conventional radiographic procedures. However, the knowledge about the beam energy is essential for the conversion from the TL response to the appropriate dosimetric quantity, avoiding overestimation of ESD values.

The following mean Entrance Skin Dose (ESD) has been obtained for:

- Skull-from 0 .06 to 1.30m-Gy (with ESD mean value of 1.10m Gy±19%)
- Abdomen - from 0.20 to 1.10 m - Gy (with ESD mean value of 1.00 mGy ± 15 %)
- Chest - from 0.05 to 0.40 m - Gy (with ESD mean value of 0.20 mGy ± 15 %)

The mean ESD values were found to be within the range of ESD reference values, except those obtained for the chest examination.

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