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Research Article

Assessment of Peadiatric Radiation Dose from Routine X-Ray Examination: A Hospital Based Study, Taif Pediatric Hospital

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Abstract: Radiological imaging is an important part of today's overall healthcare practicum, Imaging can begin as early as the first day of life but as children are more sensitive to radiation than adults special care should be in place. The main aim of the current study was to determine Entrance Surface Dose (ESD) to pediatric patients as the result of imaging procedure, in main pediatric hospital in Taif city –Saudi Arabia for the first time. 110 patients underwent different examinations (chest, abdomen, skull, and extremities), age range from 0-15 years .The patients biodata (age, weight, height, gender) were recorded. The exposure factors ,focal skin distance, tube output and back scatter factor were entered in special soft ware known by DOS CAL in order calculate the ESDs. The mean ESD obtained ranged 0.18 -0.32 mGy per radiograph for different ages and groups. No correlation coefficient was found between patient size (age or weight) and ESD, but significant correlation detected between ESD and tube potential difference (kV) encountered in these examinations. The results for pediatric radiation dose were agreed and compatible with literature. The radiation dose can be reduced more by optimization of each investigation and hence more studies is required for this task The results presented will serve as a baseline data needed for deriving local reference doses for pediatric X-ray examinations in this local department and hence it can be applied in the whole Kingdom.
Keywords: Taif, Pediatric, radiation dose, KSA

INTRODUCTION

Radiation protection in pediatric radiology deserves special attention as children are supposed to be more sensitive to radiation than adults. United Nation Scientific Committee on Effects of Atomic Radiation (UNSCEAR) has reported that children exposed to radiation at an age below 5 year are 2 to 3-fold sensitive when compared with adults [1]. There is substantial evidence to suggest that children are more susceptible to the effects of ionizing radiation than that of adults. As a consequence of the longer life expectation this places an added burden on radiologic staff to attain the best possible results every time. The probability of late radiation effects is also higher. Exposures to ionizing radiation are dependent on the age at which exposure occurs. Thus it is important that radiation dose to children arising from diagnostic medical exposure is minimised. Additionally, pediatric radiology infants and children constitute 10% of the total number of radiological examinations [2]. The purpose of the present work was to assess the radiation dose delivered to paediatric patients in some common x-ray examinations in Taif peadiatric hospital in Saudi Arabia. It was motivated by the increasing concerns about the risk to infants and children from ionising radiation, particularly in a country with currently increased and developed in radiologic services such as Saudi Arabia. In Saudi Arabia, as in many other developing countries, not much data are available on radiation doses in diagnostic radiology and paediatric x-ray examinations in particular. The entrance surface dose (ESD) for chest, the skull posteroanterior (PA), skull lateral (LAT), occiptofrontal for paranasal sinuses, pelvis AP, abdomen and hip presented in this study are determined for the first time. Comparison with reference doses and previous studies should help optimising radiographic examinations in Taif hospitals. The results presented will serve as a baseline data needed for deriving reference dose levels (DRLs) for paediatric x-ray examinations in Saudi Arabia.

MATERIALS AND METHODS

The present work was performed to evaluate the ESDs of patients undergoing some common diagnostic x-ray examinations in the largest paediatric public hospitals in Taif city, Saudi Arabia. ESDs were evaluated for chest, skull, abdomen, upper, and lower extremities AP, PA and LAT projections. Doses were estimated from x-ray tube output parameters in the aforementioned hospital comprising two units and a sample of 150 radiographs. Taif Pediatric Hospital has an approximated average workload that ranges from 39 to 48 examinations per day. The followings radiographic equipment informations were collected: equipment manufacturer, model, year of installation, filtration, film type, screen type and film speed. Table 1 shows the radiographic equipment data of the hospital under study. The film type and speed used was Kodak/400. Anti scatter grid was used for children with age ranged between 10 -15 years old, while the grid was not used for the mobile machine because the x-ray couch was without a bucky. For each patient, the age, weight, height, body mass index (BMI) and exposure parameters: peak tube voltage (kVp), exposure current–time product (mAs) and focus-to-film distance (FFD) were recorded. ESDs in this study were calculated using DoseCal software developed by the radiological protection centre of Saint George' Hospital, London [3]. The software was extensively used for patient dose measurements in diagnostic radiology and also produced reliable results [1]. For dose measurement using the software, the relationship between x-ray unit current time product (mAs) and the air kerma free in air was established at a reference point of 100 cm from tube focus for the range of tube potentials encountered in clinical practice. The x-ray tube outputs, in mGy (mA s)$^{-1}$, were measured using Unfors Xi dosemeter (Unfors Inc., Billdal, Sweden). This dosemeter was calibrated by the manufacturer and reported to have accuracy better than 5%. ESD is calculated using the DoseCal software according to the following equation [4]:

$$\boldsymbol{ESD = OP * \left(\frac{kV}{80}\right)^2 * mAs * BSF * \frac{100}{FSD}} \qquad (1)$$

where OP is the output in mGy (mA s)$^{-1}$ of the X-ray tube at 80 kV at a distance of 1 m normalised to 10 mAs, kV the tube potential, mAs the product of the tube current (in mA) and the exposure time (in s), FSD the focus-to-skin distance (in cm) and BSF the backscatter factor. The normalisation at 80 kV and 10 mA s was used as the potentials across the x-ray tube and the anode current are highly stabilised at this point. BSF is calculated automatically by the DoseCal software after all input data were entered manually in the programme. The tube output, the patient anthropometrical data and the radiographic parameters (kVp, mAs, FSD and filtration) are initially inserted in the software [4]. The kinds of examination and projection are selected afterwards.

The study of Davies *et al.* [5] showed that ESDs calculated using DoseCal software are within 20% when compared with ESDs measured using thermoluminescence dosimeters (TLDs). Other reasons for using DoseCal software were the minimum radiation dose that can be measured with TLD100, Lif: Mg, Ti is about 100 mGy. ESDs in paediatric radiology can be as low as 50–80 mGy that makes TLDs inappropriate for this kind of dose surveys [1]. To determine ESD, kV and weight for the interested ages (0, 1, 5, 10 and 15 y), these data were initially plotted graphically as a function of age for all examinations after which values corresponding to the age of interest are determined. ESD, kV and weight were determined for these ages to be compared with the established international DRLs that are provided for these ages [1] and for kV to be compared with examples of good technique.

Table 1: X-ray machines specifications

Machine manufacturer	X ray unit model	Max kVp	Actual Filtration (mm Al)	Tube output at 1 m @80 kVp (mGy)
Toshiba	0.6/1.2p38DE-85	150	2.5	5.93
Toshiba Mobile	DRX-3724HD	150	2.3	6.32

Extensive quality control test to evaluate kVp accuracy (Tolerance: Maximum deviation should not exceed 10%, Good :± 5 % or 5 kV, whichever is greater [6]. Timer accuracy, exposure linearity and reproducibility, filtrations check and darkroom evaluation tests were performed as a part of this study. The two x-ray units successfully passed the predefined tolerance levels.

RESULTS AND DISCUSSION

Figures 1, 2 and 3 show ESDs for individual patients for chest, skull plus par nasal sinuses and abdomen respectively, is plotted as a function of kV applied. In each figure, equation of a linear relation between ESDs and kV applied, coefficient of determination (R^2) and sample size (N) are shown. These investigations are selected because of high exposure factors encountered in comparison to upper and lower extremities.

Figures 4, 5 and 6 show the ESD for individual patients for the same aforementioned investigations, plotted as a function BMI. In each figure, equation of a linear relation between ESDs and kV applied, coefficient of determination (R^2) is shown.

Correlation coefficients for the relationships between patient dose and size (age and weight) and between patient dose and tube voltage are tested. In addition, the relationships between patient dose, size and tube voltage were tested for significance.

No correlation coefficient was found between patient size (age or weight) and ESD and this might be attributed to technique employed in each investigation, and this results disagree with the with the results from UK for abdomen (n = 37), chest (n =24) and pelvis (n =46) examinations, where the correlation between patient age and logarithm of ESD was (0.84, 0.87 and 0.80, respectively. The results of the present study showed statistically significant correlation between ESD and tube voltage ($p < 0.05$) for the selected investigations (chest abdomen and skull plus P.N.S) and agree with the study carried by Osman *et al.* [7] and Suliman *et al.* [1].

Table 2: Investigations clinical indication

Clinical Indication	Gender		Total
	Male	Female	
Trauma	35	17	52
Abdominal pain	19	8	27
Foreign Body (F.B)	4	0	4
Rheumatic disease	7	9	16
Chest infection	15	11	26
Tonsillitis	7	8	15
Renal stones	6	4	10
Total	93	57	150

Table 3: Statistical summary of ESD (mGy), tube voltage (kV) and patient weight (Kg) in each investigation

Exam	ESD (mGy)	Tube voltage (kV)	Weight (kg)
Chest	0.30(0.35-0.22)	56.42(61-49)	9.0(21-2.5)
Skull + P.N.S	0.38(0.59-0.33)	59.6(71-56)	5.7(16-2.8)
Abdomen	0.35(0.48-0.31)	57.7(68-55)	7.1(15-2.4)
Upper limb	0.24(0.33-0.19)	52.7(59-49)	13.5(18-11)
Lower limb	0.38(0.39-0.37)	60.4(61-60)	10.6(12-9)

P.N.S = par nasal sinuses

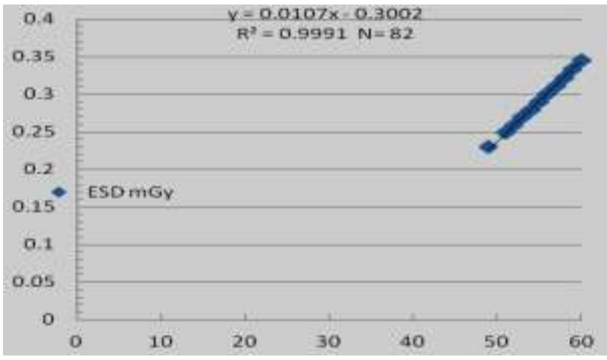

Fig. 1: The correlation between ESD and kV in chest investigations

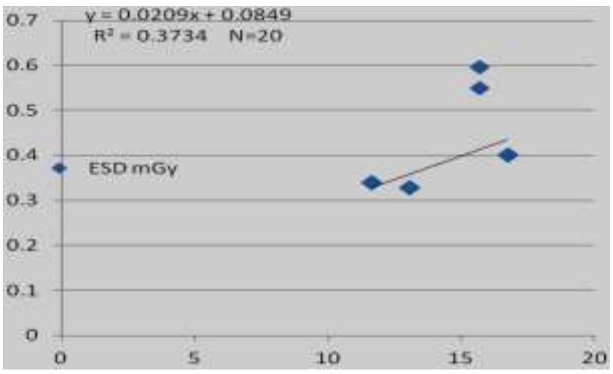

Fig. 2: The correlation between ESD and kV in skull plus P.N.S investigations

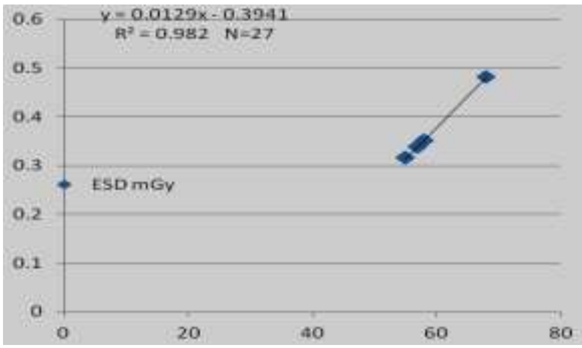

Fig. 3: The correlation between ESD and kV in abdomen investigations

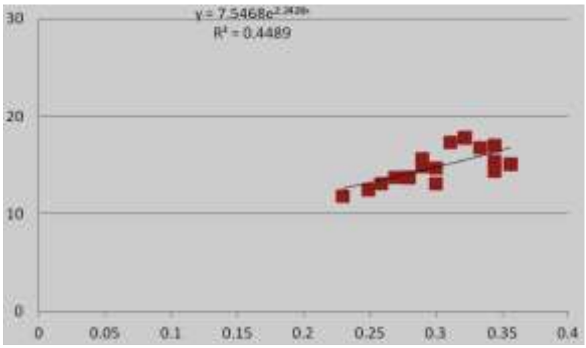

Fig. 4: The correlation between ESD and BMI in chest investigations

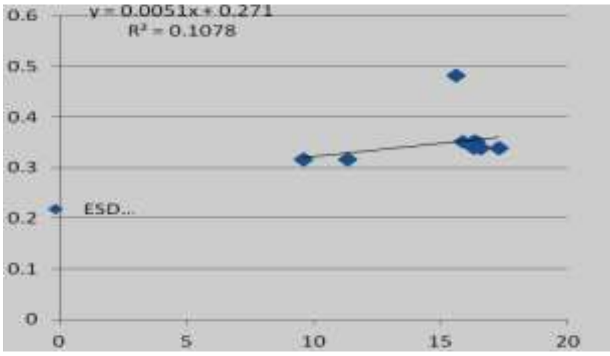

Fig. 5: The correlation between ESD and age in abdomen investigations

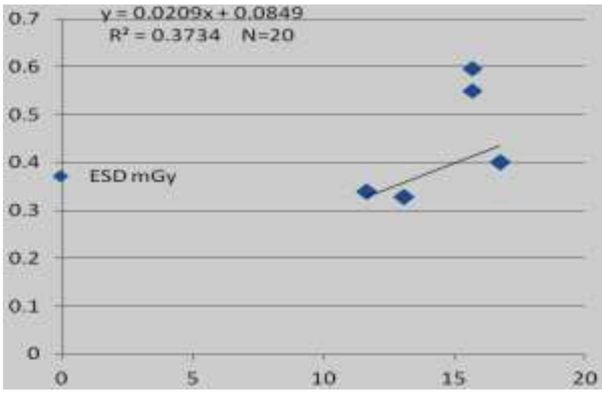

Fig. 6: The correlation between ESD and BMI in abdomen investigations

The significant correlation detected in this study between ESD and kV allows determination of these parameters for interested age.

Suliman *et al.* [1] reported that dose is dependent on the generator type filtration and film processing condition , in this study both generator were of high frequency one that would have lower radiation dose, no significant variation in radiation dose were detected from mobile machine to fixed unit despite that there is variation in filtration thickness used, and this might attributed to that radiographers are not used grid with mobile machine because of in availability of the Bucky, and the grid increased the patient dose.

Table 4: Mean ESD (μGy) and DRL (μGy) in chest, abdomen and skull compared to literature

	Parameter	**Chest**	**Abdomen**	**Skull**
This study	Mean ESD	298	348	376
	DRL 3rd quartile	323	351	401
Toossi MTB *et al.* [8]	Mean ESD	76.3	61.5	N.A
	DRL 3rd quartileb	88	98	N.A
Gogos KA *et al.* [9]	Mean ESD	179	489	717
	DRL 3rd quartile	216	496	909
EC [10]	DRL	100	900	1500

From Table 4 there were difference in the mean ESD and DRL from this study and other studies for chest, abdomen and skull examinations and this difference might be attributed to the technique employed or equipment specifications. But all these are were blow the European countries DRL except for chest examination and this might due to that EC DRL is calculated for child and infant under 2 years, and this study estimated the dose up to 15 years old. So in conclusion there were no differences in ESDs values.

CONCLUSION AND RECOMMENDATIONS

The results for pediatric radiation doses were agreed and compatible with literature. The results presented will serve as a baseline data needed for deriving local reference doses for pediatric X-ray examinations in this local department and hence in the whole Kingdom.

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