



Original Article

Assessment of radiation equivalent dose to pediatric patients during chest radiography

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ABSTRACT

Objectives: The study investigated the equivalent dose delivered during pediatric chest radiography.

Material and Methods: This study adopted a prospective and cross-sectional research design and was conducted between April 26 and July 2, 2021, at the University of Calabar Teaching Hospital, Calabar, Cross river state, Nigeria. A total of 85 pediatric patients aged 0–15 years, referred for chest X-ray examination, were recruited into the study. The chest radiography was taken for each child in erect or supine positions. Children, who needed some form of immobilization, were immobilized and respiration (breathing) was observed to take exposures at end-expiration. Exposure factors used ranged between 40 and 80 kVp, 1–2 mAs, source-to-image distance; 110 cm. Patient demographics and chest X-ray exposure factors for each exposure were recorded using a spreadsheet. The equivalent dose was calculated using the NUTECHRX software version. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 21.0. Statistical significance was set at $P < 0.05$.

Results: The estimated mean equivalent dose was 0.0046 ± 0.0026 mSv, while the mean of weight (kg), kVp, and mAs was 15.04 ± 14.51 kg, 58.28 ± 10.58 V, and 1.79 ± 1.56 mAs, respectively. Mean equivalent dose was 0.00447 mSv (uncertainty 0.0027) for female and 0.00464 mSv (uncertainty 0.0026) for male, with no significance difference between them. The mAs showed strong positive correlation with equivalent dose ($r = 0.71$, $P = 0.05$), while weight demonstrated a strong negative correlation with equivalent dose ($r = -0.98$, $P = 0.05$).

Conclusion: Current-time product (mAs) and the weight of a child are important determinants of equivalent dose in pediatric chest radiography.

Keywords: X-radiation, Equivalent dose, Pediatric, Chest X-ray

INTRODUCTION

Radiation protection in pediatric patients deserves special attention due to their increased sensitivity to radiation. United Nations Scientific Committee on Effects of Atomic Radiation^[1] has reported that early childhood exposure to ionizing produces a 2- to 3-fold more sensitivity than in adults.^[1] This understanding has precipitated the establishment of guidance level or reference doses for pediatric patients undergoing diagnostic X-ray examinations, as it is a concern to various national and international organizations involved in radiation measurement, monitoring, and safety. It is therefore important that radiation dose to children arising from diagnostic medical exposure is minimized, due to their rapidly dividing cells and longer life expectancy.^[2] Despite the advent of new imaging modalities such as ultrasound, computed tomography, and

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magnetic resonance imaging, the plain chest radiography remains the mainstay of pediatric chest imaging.^[3]

Pediatric imaging is quite challenging for radiographers due to their smaller size, positioning difficulties, and vulnerable nature to radiation damage. Hence, certain skills, careful techniques, and a good understanding of their anatomy and psychology are critical to optimizing practice and reducing radiation burden during pediatric imaging.^[4,5] Technically, pediatric chest radiography differs from an adult's, as their small-sized chest, faster respiratory rate, and difficulty in observing required respiratory maneuvers are taken into consideration to adapt chest radiography to obtain diagnostically acceptable image quality, at a significantly reduced radiation dose.^[5] As a result, very fast screens, short exposure time, and maximum source-to-image distance (SID) are used to improve imaging and reduce unsharpness due to movement or respiratory blur. Furthermore, careful collimation of the X-ray beam to the area of interest is applied. In addition to that, the radiographer must be aware of the radiation exposure to the gonad of the child and a lead strip must be placed over the gonadal area.^[6] Overall, about 9.07% of the total number of pediatric chest radiographs consists of a non-thoracic structure resulting in radiation exposure to these areas, the radiation exposure to these structures increases as the patient decreases.^[7] There is no gainsaying that there is a risk involved in every X-ray examination in pediatric patients.^[6] There is therefore a need to optimize pediatric chest radiography, as it is one of the most common in pediatric imaging.

This study sought to investigate radiation equivalent doses during pediatric chest examinations.

MATERIAL AND METHODS

This study adopted a prospective and cross-sectional research design and was conducted between April 26 and July 2, 2021, at the University of Calabar Teaching Hospital, Calabar, Cross river state, Nigeria. Approval was sought from the Department of Radiography and Radiological science, University of Calabar, Calabar. A total of 85 pediatric patients (both males and females) aged 0–15 years, referred for chest X-ray examination in this facility (hospital), were recruited into the study. The chest radiography was taken for each child in erect and supine positions using the erect/table bucky. The head was kept straight and chin raised out of the field of view. The shoulders rolled anteriorly to throw off both scapulae from the lungs fields. A horizontal beam was centered to the seventh thoracic vertebra, which corresponds to the inferior angle of the scapulae. X-ray beam was collimated to include C7/T1 vertebrae, just inferior to the thoracolumbar junction, lateral to the skin margins. Children, who needed some form of immobilization, were immobilized and respiration (breathing) was observed to take exposures at

end-expiration. Exposure factors used ranged between 40 and 80 kVp, 1–2 mAs, SID; 110 cm. No grid was used.

Patient demographics and chest X-ray exposure factors for each exposure were recorded using a spreadsheet. The equivalent dose for each chest radiography was calculated using the NUTECHRX software version. Synthesized data were analyzed using a pie chart for gender distribution of the pediatric patients and a bar chart to represent age groupings. Mean and standard deviation was calculated for the weight of pediatrics, age, kVp, mAs, and equivalent dose. Pearson's χ^2 test, Mean and standard deviation demonstrate the relationship between equivalent dose and other variables (weight, kVp, and mAs). All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 21.0. Statistical significance was set at $P < 0.05$.

RESULTS

The proportion of females in the study was 55% ($n = 47$), while the male accounted for 45%, ($n = 38$) of the total number of children [Figure 1]. About 60 of the patients in the study were between 0 and 5 years of age, while the group with the smallest number was aged 10 and above [Figure 2]. The estimated mean equivalent dose was 0.0046 ± 0.0026 mSv, while the mean of weight (kg), kVp, and mAs were 15.04 ± 14.51 kg, 58.28 ± 10.58 V, and 1.79 ± 1.56 mAs, respectively [Table 1]. Mean equivalent dose was 0.00447 mSv (uncertainty 0.0027) for female and 0.00464 mSv (uncertainty 0.0026) for male, with no significance difference between them [Table 2]. (Mean plot) shows the mean values of Equivalent dose by age group. No difference exists in equivalent dose across the age grouping ($P > 0.05$) (one-way ANOVA) [Figure 3]. The mAs showed strong positive correlation with equivalent dose ($r = 0.71$, $P = 0.05$), while weight demonstrated a strong negative

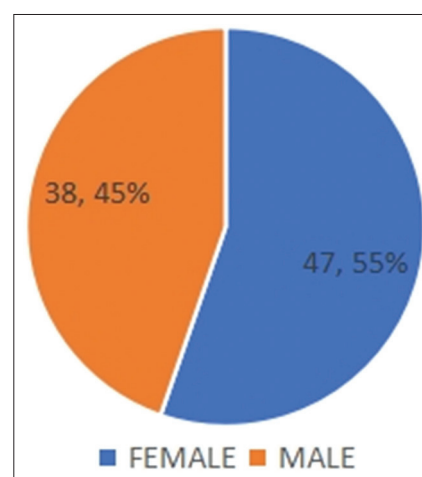


Figure 1: The frequency and percentage distribution according to gender.

correlation with equivalent dose ($r = -0.98, P = 0.05$). The kVp indicated no statistical correlation with equivalent dose ($P > 0.05$) [Table 3].

DISCUSSION

The equivalent dose quantity represents the stochastic health effect of low-level ionizing radiation on the human body and the probability of radiation-induced cancer and genetic damage. It is a concept employed for radiation protection as it attempts to measure the long-term biological consequence of a given exposure to radiation expressed in millisievert (mSv).

In this study, the mean equivalent dose to the pediatrics was comparable with results of similar research, and dose measurements were statistically the same across age grouping, in contrast to the findings of Ward *et al.*^[8] and Roy

et al.^[9] In their study, a substantial difference in radiation dose across age groupings was reported, and this difference between the aforementioned study and the present study may be underlain by factors such as sample size, X-ray unit, and characteristics. In addition, Asoqwaetal *et al.*^[10] in his study noted that SID and field size could have a significant effect on entrance skin dose and equivalent dose.

A similar result in terms of equivalent dose measurements was obtained by comparing equivalent doses between males and females, and this was in consonance with a related study by Alatts *et al.*^[2] and Roya *et al.*^[9] In their study on entrance skin dose, they found no statistical difference in the mean doses for both male and female gender. This could imply that the equivalent dose from X-ray may not be dependent on tissue gender-specific factors, but rather a function of absorbed dose and the radiation weighting factor for each type of radiation.^[11]

The equivalent dose to the pediatric was seen to increase with the current-time product (mAs), and decrease with the child's body weight. This implies a higher radiation equivalent dose to children with smaller weights, especially at higher mAs. Alatts *et al.*^[2] report a similar outcome in the relationship between mAs and equivalent dose, while a contrary yield to the result of Bagherzadeh *et al.*^[12] was observed between weight and equivalent dose in the present study. Since pediatrics have very high chances of cancer induction in the future from early radiation exposure, it is important for facilities to adopt measures to curtail unnecessary radiation exposure during pediatric radiography. Besides controlling exposure setting like mAs, a child's weight could be factored into dose-limiting protocols in chest radiography to reduce undue exposures.

Table 1: The statistical variance of the equivalent dose and other variables.

	N	Range	Minimum	Maximum	Mean
Eq Dose	85	0.0087	0.00100	0.00970	0.0046±0.0026
Weight (kg)	85	64.2	2.8	67.0	15.04±14.51
kVp (v)	85	44.0	40.0	84.0	58.28±10.58
mAs (A)	85	7.88	0.12	8.00	1.79±1.56

EqDose: Equivalent dose

Table 2: Correlation between equivalent dose and other variables.

Correlations	R	P-value
EqDose* mAs	0.71	0.05**
EqDose* kV	-0.035	0.0749
Eqdose* Weight	-0.98	0.0370 **

**Correlation is significant at $P < 0.05$. EqDose

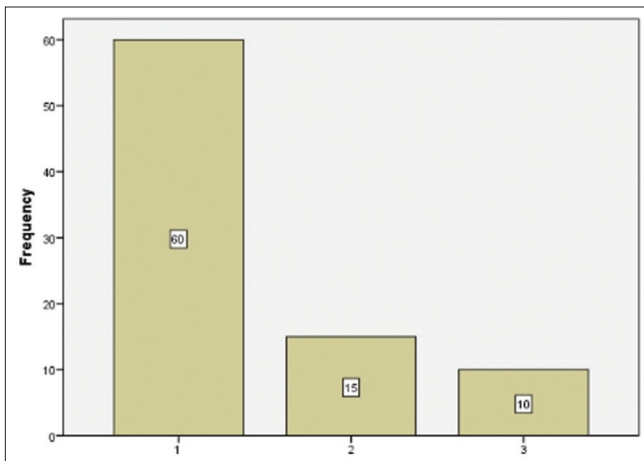


Figure 2: Age grouping of pediatric patients for chest examination.

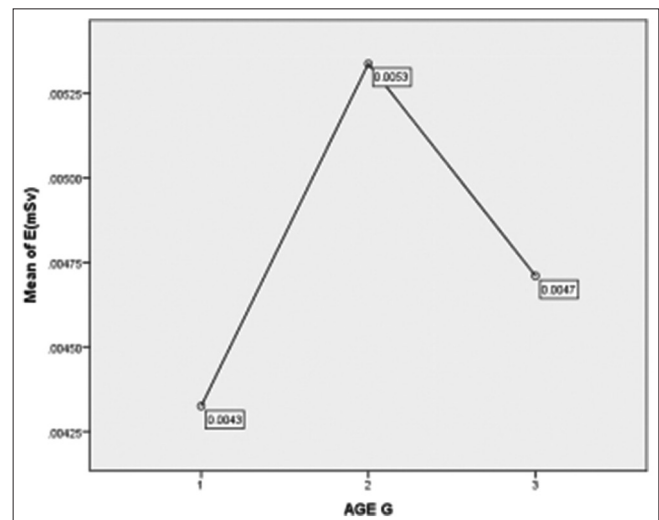


Figure 3: (Mean plot) shows the mean values of equivalent doses by age group. No difference exists in equivalent dose across the age grouping ($P > 0.05$) (one-way ANOVA).

Table 3: The mean equivalent dose.

Equivalent dose between male and female					
	Gender	n	Mean	t	P-value
EqDose (mSv)	F	55%	0.00447±0.0027	2.96	0.768
	M	45%	0.00464±0.0026		
EqDose: Equivalent dose					

The mAs and pediatric weight are important determining factors of the equivalent dose during pediatric chest radiography and could be adapted to optimize practice, improve diagnostic yield, and reduce the dose to the pediatrics during pediatric chest radiography. The limitations of this study are the absence of exposure index (EI), which is a current metric for determining the level of exposure from a given radiographic investigation, particularly, the extrapolation of radiation dose from EI during exposure and the provision of the reference range and benchmark by which facilities can depend on for optimization of pediatric chest radiography and dose mitigation.

Recommendation

There is a need for facilities to adapt pediatrics-specific protocol based on a child's weight in combination with mAs to improve practice in pediatric chest radiography.

CONCLUSION

The current-time product (mAs) and the weight of the child affect the equivalent doses for pediatrics during chest examinations. The weight of a pediatric in combination with the current-time product (mAs) could be useful in establishing a weight-specific protocol for pediatric chest radiography to control and optimize radiation dose and image quality.

Declaration of patient consent

Patient's consent not required as patient's identity is not disclosed or compromised.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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