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RESEARCH ARTICLE

VARIATION IN ENTRANCE SKIN DOSE AND SCATTERED RADIATION IN PAEDIATRIC PATIENTS UNDERGOING X-RAY EXAMINATION IN SOME NIGERIAN TEACHING HOSPITALS

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Abstract

Objective

There is no known data in the literature concerning the Entrance Skin Dose (ESD) and scattered radiation (SR) from paediatric in Nigeria. This work measured the variation in ESD and SR of importance to radiation protection for commonly performed X-ray examinations such as chest, abdomen, skull and pelvic in three Nigerian tertiary health institutions.

Methods

Data were collected from 970 paediatric X-ray examinations using well-calibrated thermoluminescent dosimeters (LiF-100) attached to the skin in the path of the primary X-ray beam and SR for the same examinations. Relevant information about tube voltage, current-time products values and focus to skin distance used in the examinations were collected. How these parameters can affect the ESD was discussed.

Results

The ESD values obtained from the three hospitals ranges from 0.47-1.22 mSv for abdominal, 0.22-1.83 mSv for chest and 0.13-0.98 mSv for skull. The tube voltage ranges from 48-74 kVp for abdomen, 43-73 kVp for chest and 40-74 kVp for skull. Similarly, the current-time products ranges from 3.3 – 25.5 mAs for abdomen, 4.8-12 mAs for chest and 3.5-25.5 mAs for skull. The level of SR measured in the three hospitals in not negligible.

Conclusion

Choice of exposure parameters and hence ESD are known to vary inter and intra institutions. The need for the establishment of reference values is advised.

Advances in knowledge

This work provides preliminary data in justifying some hospitals representative of tertiary health institutions in the country.

Introduction

Medical exposure during paediatric radiology attracts particular interest because of the increased opportunity for expression of delayed radiogenic cancers as a consequence of relative longer life expectancy and the high radiosensitivity of the actively growing tissue. Diagnostic radiograph is associated with an increased risk of cancer induction and exposure to ionizing radiation is one of the few established risk factors for childhood cancers [1]. The yield of certain forms of radiation-induced cancer, particularly leukemia, appears to be some five times higher in children than in adults [2]. Reduction of exposure levels in paediatric diagnostic X-ray examinations have been of concern to various national and international organizations involved in radiation measurement, monitoring and safety. Therefore, exposure with ionizing radiation to paediatric patients if it cannot be avoided must be justifiable. Also, it is important that X-ray examinations are conducted using techniques that keep the patients exposure as low as possible but still compatible with the medical purposes of the examinations, IAEA 1996 [3]. In order to achieve this, it is necessary to understand the factors that affect the exposure and to be able to assess the patients' doses. Patient's Entrance Skin Dose, (ESD) which is measured on the patient's skin at the centre of the X-ray beam is an indicator of Patient dose

Ribeiro et al., carried out a survey of paediatric radiological examinations in a reference paediatric hospital of the city of São Paulo, in order to investigate the doses to children undergoing conventional X-ray examinations. Relevant information about kVp and mAs values used in the examinations was collected, and they discussed how these parameters can affect the ESD [4]. Suliman et al., estimated Entrance Surface Doses (ESDs) to patients undergoing selected diagnostic X-ray examinations in major Sudanese hospitals. ESD per examination was estimated from X-ray tube output parameters in four hospitals comprising eight X-ray units and a sample of 346 radiographs [5]. In another publication, Suliman et at., measured radiation doses to patients from some common paediatric X-ray examinations in three hospitals in Khartoum state, Sudan [6]. They estimated the Entrance surface dose from exposures settings using DosCal software.

In Nigeria some research work have been done in the area of Entrance Skin Doses (ESDs) for some radiological procedures for the adult and paediatric patient [7-9]. To the best of our knowledge no work has been done to measure the ESD received by paediatric patients in clinical practice and this work address such.

Materials and Methods

Materials used

The X-ray machine used at the Obafemi Awolowo University Teaching Hospital Complex (OAUTHC) and University of Ilorin Teaching Hospital (UITH) are General Electric floor mounted model manufactured in year 2007 and installed in 2010 at the two hospitals, while that of Lagos University Teaching Hospital (LUTH) is a Quantum Q-Vision model manufactured in 2010 and installed in 2011. The X-ray machine at OAUTHC and UITH make use of 1.7 mm Al while that of LAUTH is 2.0 mm Al total filtration. None of them employs additional filtration for the procedure used in the project.

Dosimeter chips reading were carried out at the the National Institute of Radiation Protection and Research (NIRPR), University of Ibadan (UI) using Harshaw Reader (model 4500). The TLD chips were oven-annealed using TLD – Rapid cooling oven (TLD/3). All exposures for calibration of reader and dosimeter chips were done in the secondary standards dosimetry laboratory at NIRPR where a national radiation dose standard was maintained. The NIRPR serves as the custodian of the national secondary standards traceable with traceability to the IAEA standard laboratory in Vienna. The purpose for calibrating TLD Dosimeters is to ensure that all dosimeters in a system will give essentially the same response to a given radiation.

Methods

4.2.1. Annealing process: The TLD chips were annealed inside a Carbolite oven, TLD – Rapid cooling oven (TLD/3) by heating the oven from room temperature to 400˚C. The temperature 400˚C was maintained for 1 hour after which samples were allowed to cool rapidly within the furnace to ambient temperature using force air cooling prior to any exposure.

4.2.2. Measurement of entrance skin dose: After the annealing process, each of the calibrated TLD chips was enclosed in a black cellophane bag. Doses from typical radiological examinations for paediatric patients were measured with three (3) of this thermoluminescent dosimeters (TLD) chips located on the subjects at the point of entrance of the primary beam to the measure the Entrance Skin Dose (ESD). Average of the three chips reading was recorded as the ESD for that examination.

4.2.3. Measurement of the scattered dose: Three (3) of the calibrated thermoluminescent dosimeters (TLD) chips were placed on the subjects at the examination area to measure the ESD from the incident radiation while three (3) of the dosimeter chips were also placed near other various critical organs such as the gonad/pelvic, chest and the head depending of the type of the examination, in order to monitor the scattered radiation from the incident radiation to the critical organ situated in the head such as eye and brain and the gonad where the sensitive reproductive organs resides.

4.2.4. Other radiological parameters: Relevant information about sex, age, patient height, weight, kVp, mAs values and focus to skin distance used in the examinations were collected. How these parameters can affect the entrance surface dose (ESD) will be discussed later. The ESD values that were measured in this work were compared to reference levels published by relevant publications for paediatric patients.

Results

The sample size for the conventional X-Ray examinations

The sample size for this project is nine hundred and seventy (970) children for X-ray radiography. Four hundred and twenty four (424) representing 43.71%, were from OAUTHC, two hundred and twenty two (272) representing 28.04% were from UITH, and the remaining two hundred and twenty four (274) representing 28.25% were from LUTH. Out of the 424 patients from OAUTHC, 221 are male while 203 are female of age ranging from 2 months to 15 years; 106 male and 66 female from UITH are of age ranging from 1 hour to 15 years while 93 male and 81 female from LUTH are of age between 4 days to 15 years. The age distribution is as presented in Table 1 and Table 2, Figure 1 and Figure 2.

Discussion

Table 1: Age Distribution of Patient at Various Hospitals

Age range (year)	OAUTHC	UITH	LUTH
< 1	65 (15.33%)	71 t(26.10%)	67 (24.45%)
1 – 5	171 (40.33%)	52 (19.12%)	97 (35.40%)
6 – 10	89 (20.99%)	51 (18.75%)	51 (18.61%)
11 – 15	99 (23.35%)	98 (36.03%)	59 (21.53%)

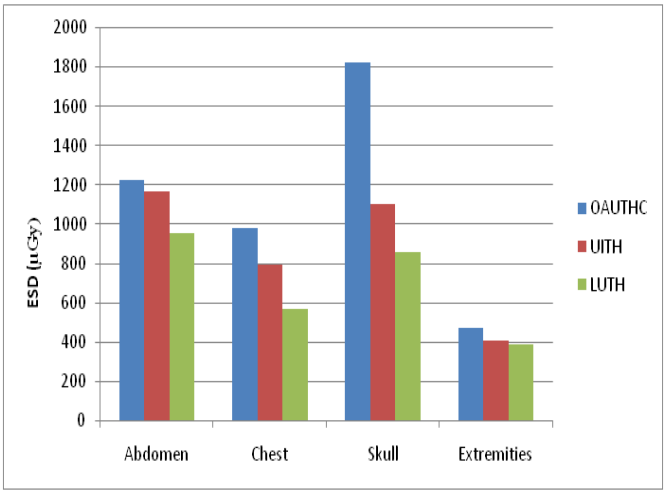

Figure 1: Comparison of ESD at the Teaching Hospitals for Patient with the Same BMI for various radiological procedures.

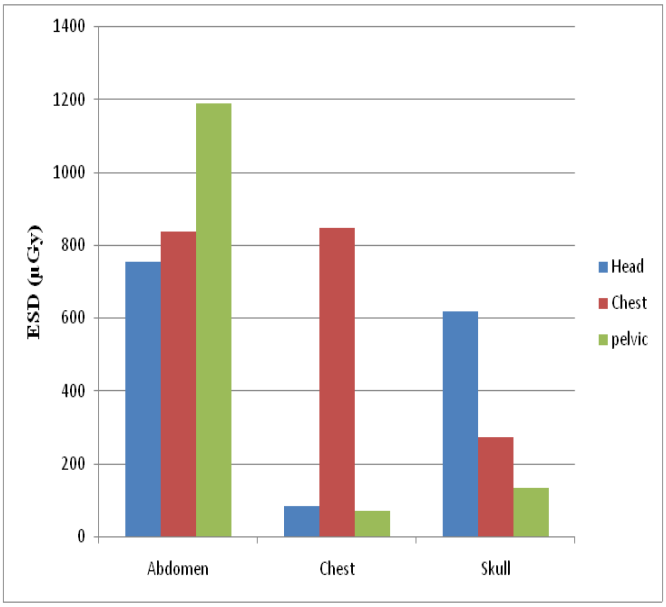

Figure2: Comparison of the Main ESD to the Scattered ESD for a X-ray Examination.

The energy of the X-ray beam (beam quality) is determined by the applied tube kilovoltage (kV_p) and the extent to which the beam is filtered (beam hardening). The X-ray machines from the three

Table 2: Comparison of the Voltage tube (kVp) Current-time Product (mAs) and ESD (μGy) for Patient with the Same BMI for various radiological procedures.

Exposed Area		OAUTHC	UITH	LUTH	Mohamadain et al (2009) Brazil
Abdomen	kV_p	58 – 68	50 – 70	45 – 65	
	mAs	20.0–25.5	12.5 – 16.0	12.0 – 20.0	
	ESD (μGy)	754.94–1224.22	586.53– 1166.91	466.16–953.73	400.00 –1200.00
Chest	kV_p	47 – 69	48 – 74	40 – 60	50 – 90
	mAs	3.3 – 25.5	4.0 – 12.5	3.6 – 10	4.0 – 16.0
	ESD (μGy)	202.13–982.16	263.47 – 794.20	127.27–569.65	50.00-1200.00
Skull	kV_p	55 – 75	65 – 73	50 – 70	50 – 80
	mAs	5.0 – 33.0	8.0 – 16.0	4.8 – 12.0	16.0 – 32.0
	ESD (μGy)	631.87– 1825.74	295.68– 1105.68	217.89–856.90	500.00 – 1100.00
Extremities	kV_p	43 – 59	43 – 63	40 – 45	-
	mAs	4.0 – 8.0	1.6 – 8.0	1.6 – 3.0	-
	ESD (μGy)	156.30 – 470.17	137.61 – 409.53	117.68–389.64	-

studies centers possessed X-ray tube with aluminium filter. The use of aluminium filter in all the X-ray machines considered in this study is consistent with the practice in UK [10,11]. Adequate filtration of radiation beam is meant to eliminate most of the low energy photons from reaching the patient. The amount of aluminium filter (1.7mm Al) used at OAUTHC and UITH and 2.0 mm Al at LUTH are within the recommended HVL for the KV_pat which the generators are operated.

X-ray exposure parameters are basic machine settings used for making radiation exposure. They include the applied tube voltage of the beam (kV_p), tube current-time product (mAs). The tube current determines X-ray beam intensity and patient dose. For a given applied kVp, the number of photons produced is directly proportional to the x-ray tube current.

Table 1 showed the various combinations of kVp and mAs selected by the operators at the different centers for similar X-ray examinations and their corresponding ESD values. The parameters used at OAUTHC are higher than any other centers while that of the LUTH is the lowest in this work. It is not immediately apparent why OAUTHC is higher than UITH since they use the same type of machine manufactured and serviced by the same company. This may be related to other factor such as film processing techniques. This implied that the children examined at OAUTHC received higher doses of radiation than the other two centers.

The X-ray examination of the skull for the children with the same BMI showed that the dose at the OAUTHC doubled that of LUTH, while that of UITH is 1.5 times higher that LUTH. These have

to do with the parameter settings by the radiographers at each hospital because the magnitude of ESD is directly proportional to the square of tube voltage, the tube current mA, the duration of exposure (sec) and inversely proportional to the square of the distance from the radiation source [13].

In the X-ray examination of lower and upper extremities, all the centers used combination of high kVp with low mAs. The technique of using high kVp and low mAs were reported to be commonly used for chest radiography in Europe and the USA (Fung et al. [11], was used at LUTH while OAUTHC and UITH did not.

The ESD obtained from X-ray examination of abdominal region in this study ranges from 0.75 – 1.22mSv for OAUTHC, 0.59 – 1.17mSv for UITH and 0.47 – 0.95mSv for LUTH. The values of ESD obtained from OAUTHC and UITH is very close to that of Mohamadain et al. [12], and the parameters used are almost the same.

The ESD obtained from X-ray examination of the skull and chest are presented in Table 1. These values are in agreement with Mohamadain et al. [12], of Brazil though it is high when compared with UNSECEAR [13] and in Sudan Sulaiman et al [8].

The values of the ESD for X-ray examination of the chest is higher than any of these country, X-ray examination of the head is comparable to UK, lower than Brazil and higher that Sudan and UNSECEAR 2000, the X-ray of the abdomen is lower than Brazil comparable to Ribeiro et al. [4], but higher than Sudan, UK and UNSECEAR [14]. The ESD for X-ray examination of the pelvic is lower than UK and Brazil but lower that Sudan.

The aim of radiation protection to keep the radiation to the exposed area as low as reasonable achievable (ALARA), while reducing the radiation scattered to the other areas which are not part of the examination. The result presented in Figure 2 showed that the scattered radiation is not negligible in conventional X-ray radiograph for all the exposure in all the three centers.

Conclusion

The results of this work showed that there are variations in the ESD from one teaching hospital to the other. The variations depend on the parameters and the techniques used at the hospitals. This work provides the preliminary data in these hospitals justifying the need to determine what goes on in other hospitals in Nigeria. It also, showed that there is an urgent need for the standardization of radiological X-ray examination in OAUTHC and UITH. There is urgent need for the standardization of the procedures for Paediatric undergoing abdominal X-ray examinations in view of their sensitivity to radiation induced hazards.

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