SCIENCE FORUM (JOURNAL OF PURE AND APPLIED SCIENCES) 21 (2021) 425 – 429

http://dx.doi.org/10.5455/sf.35093

Science Forum (Journal of Pure and Applied Sciences)

journal homepage: www.atbuscienceforum.com

Measurement of entrance skin doses for patients undergoing diagnostic X-ray examination in federal medical centre (F.M.C.) hospital, Azare, Nigeria

Amina Muhammad Danmadami[1*], M. F. Haque[2], Mohammed Garba[2], and M. A. Aliyu[1]

[1] *Bauchi State University, Gadau, Nigeria*

[2] *Abubakar Tafawa Balewa University, Bauchi, Nigeria*

ABSTRACT

The risk associated with exposure to ionizing radiation is dependent on the characteristics of the exposed individual. The size and the structure of the individual influence the absorbed dose distribution in the organs. Although many studies have been conducted on radiation dose from medical exposure, in Bauchi, there is not much data on the assessment of patient entrance skin dose (ESD) and the health risk from conventional radiography in daily clinical practice. In this work, we estimate the ESD for adult patients undergoing X-ray examination in F.M.C. Hospital, Azare. A total of 40 patients were included in this study. ESDs were measured using thermoluminescence dosimeter badges attached to the skin surface of the X-ray beam during chest PA. Pelvic AP, lumbosacral AP, and lumbosacral lateral examinations. Patients' biometric variables (such as age, weight, height, sex, and thickness), X-ray tube parameters (e.g., tube current and tube voltage), exposure time, focus to skin distance, and focus to film distance were recorded. The results showed that the mean values for chest PA, pelvic AP, lumbosacral AP, and lumbosacral lateral were 0.28, 2.71, 3.72, and 7.62 mGy, respectively. The measured ESD for this study ranges from 0.18 to 16.49 mGy. These values were found to be in agreement with the guidance level set by International Atomic Energy Agency and the standard diagnostic reference level.

ARTICLE INFO

Article history:
Received 05 March 2019
Received in revised form
10 December 2019
Accepted 10 December 2019
Published 12 October 2021
Available online 12 October 2021

KEYWORDS

Entrance skin dose
X-ray
Thermoluminescence dosimeter
Exposure factors

1. Introduction

The study and use of ionizing radiation started with the discovery of X-ray by Wilhelm Roentgen in 1895. Since then, ionizing radiation has played an important role in atomic and nuclear physics where it ushered in the era of quantum mechanics, provided the impetus for the development of radiology and radiotherapy as medical specialties and medical physics as a specialty of physics.

Diagnostic X-ray imaging is not only a science but also a tool that helps explore human anatomy, physiology, and biochemistry. It utilizes differences in properties of the various tissues throughout the human body and employs radiation, such as X-rays, gamma rays, and annihilation radiation, to produce images that aid in diagnosing, monitoring, and treating disease (Audra, 2007).

*** Corresponding author** Amina Muhammad Danmadami ✉ aminadanmadami@gmail.com ✉ Bauchi State University, Gadau, Nigeria

The use of ionizing radiation in the medical field contributes significantly to the source of exposure of the population (Cameron and Skofronick, 1978). Worldwide interest for patient dose measurement in diagnostic radiology was stimulated by the 1990 publication of the National Radiological Protection Board (NRPB, 1990) in collaboration with the Institute of Physical Sciences in Medicine and the College of Radiographers (National Radiological Protection Board Report, 1992). Based on the needs for knowledge of the doses absorbed by patients and the consequences of the absorbed doses, the National Occupational Health and Safety Commission (NOHSC, 1995) indicated that dose assessment of employees and members of the public is required to ensure compliance with recommendation. Directives from regulatory bodies stipulate that radiation should be measured in every hospital and compared to the reference doses established by the competent authorities (CEC, 1996; Kepler et al., 2002). Although diagnostic imaging using X-rays produces a net benefit, the potential for radiation-induced injury to the patients exist. As a result, understanding of absorbed doses and the factors that affect them, therefore, are very important (Olowookere, 2009). Several major radiation doses delivered to the patient during diagnostic imaging have been reported, especially from advanced countries (Hart and Wall, 1996; Heggie, 1990; NCRP, 1989; Shrimpton et al., 1986).

In view of the significant benefits obtained from properly conducted medical exposures, the principal concern in radiological protection is the reduction of examinations that are either unlikely to be helpful to patient management or involve those that are not as low as reasonably achievable to meet specified clinical objectives. In order to do this, there is a need to optimize X-ray equipment and logical techniques (NRPB, 1990). Patient dose measurement is an integral part of this optimization procedure (Sharifat and Olarinoye, 2009). Such measurements will reveal X-ray facilities with doses after which possible dose reduction measures may be specified. Dose measurement is also necessary to establish dose constraints, to determine risks to patients, and to justify examination.

There are two categories of doses given to patients, which are important in diagnostic radiology: the effective dose E, which takes into account the equivalent dosage to radiosensitive organs, and the entrance skin dose (ESD). In diagnostic radiology, special interest is concerned with effective dose since this relates to the risk of stochastic effects such as cancer induction.

The objective of any diagnostic X-ray examination is to produce images of a patient with essential details and sufficient image quality so as to guide practitioners for effective and efficient diagnosis and treatment of various conditions. Because of the risks associated with the exposure of the patients to X-rays during the diagnostic X-ray examinations, it is suggested that the minimum amount of X-radiation should be used and the ESD should be measured and monitored.

The objectives of this study are to obtain typical ESDs values for adult patients for four different examinations and to compare the doses obtained with international reference doses and previous studies. The results of this study are presented along with the explanation of the main findings with specific reference to radiographic techniques.

2. Materials and Method

The data used for this work were collected at the Federal Medical Centre Hospital, Azare. The patients were randomly selected from adult patients of both sexes attending medical investigations in the Radiology Department. Available machine-specific data, such as type, model waveform, filtration, year of manufacture, and year of installation, were recorded. In this study, four routine types of X-ray examination were studied: chest (PA), lumbosacral (AP), lumbosacral (LAT), and pelvic (AP). Patient biometric variables such as age, weight, height, and sex were recorded. Technique factors such as kilovoltage peak (kVp), product of X-ray tube current and time (mAs), focus-to-skin distance (FSD), focus-to-film distance (FFD), and thickness of the irradiated regions were obtained with the assistance of radiographers on duty. The thickness of the patient was obtained using: thickness = FFD – FSD. In this study, radiographs and exposure factors of 40 patients were obtained. ESDs were measured with coded TLD_100 attached to the skin surface of the patient, at the centering point of the beam during chest (PA), lumbosacral (AP), lumbosacral (LAT), and pelvic (AP) examinations. The exposed thermoluminescence dosimeters (TLDs) were read using Harshaw 4500 TLD dual reader at the center for energy research and training to obtain the ESD.

3. Results and Discussion

Table 1. Patient biometric variables and X-ray machine parameters. Mean values and range (in parenthesis) are shown.

Examination	Projection	No of patient	Weight (kg)	Height (cm)	Body mass index	Mean kVp (kV)	Mean mAs (mAs)
chest	PA	10	66.3 (50 – 81)	168.05 (145 – 190)	25.6 (19 – 40)	66.5 (50 – 85)	10.3 (9 – 15)
pelvic	AP	10	58.4 (45 – 71)	165.4 (156 – 179)	21.6 (17 – 27)	80.3 (70 – 90)	40.5 (30 – 45)
lumbosacral	AP	10	65.9 (50 – 100)	165.15 (150 – 180)	24.4 (16 – 39)	91.6 (80 – 110)	57.5 (30 – 120)
lumbosacral	LAT	10	65.9 (50 – 100)	165.15 (150 – 180)	24.4 (16 – 39)	109.5 (90 – 140)	82.5 (45 – 120)

Table 2. Distribution of ESD for four common types of X-ray examination from F.M.C., Azare.

Type of exam	view	No. of patient	Mean ESD (mGy)					
			Min.	First quartile	median	mean	Third quartile	Max.
chest	PA	10	0.18	0.24	0.28	0.28	0.33	0.48
pelvic	AP	10	0.70	0.73	1.53	2.71	2.27	13.72
lumbosacral	AP	10	0.45	1.13	1.78	3.72	3.94	13.45
	LAT.	10	0.62	1.97	7.37	7.62	12.89	16.49

Table 3. Comparison of the mean ESD of this work with some published values in the literature.

X-ray exam	Present study ESD (mGy)	Jumaa et al., 2014 ESD (mGy)	Halato et al., 2008 ESD (mGy)	IAEA 1996 ESD (mGy)	DRL 2005 ESD (mGy)
Chest PA	0.18 – 0.48	0.02 – 0.31	0.18 – 1.05	0.4	0.2
Pelvic AP	0.70 – 13.72	0.14 – 1.1	1.18 – 5.75	10	4
Lumbo-sacral AP	0.45 – 13.45	0.31 – 4.2	1.52 – 5.01	10	6
Lumbo-sacral LAT	0.62 – 16.49	0.54 – 6.6	2.48 – 10.41	30	14

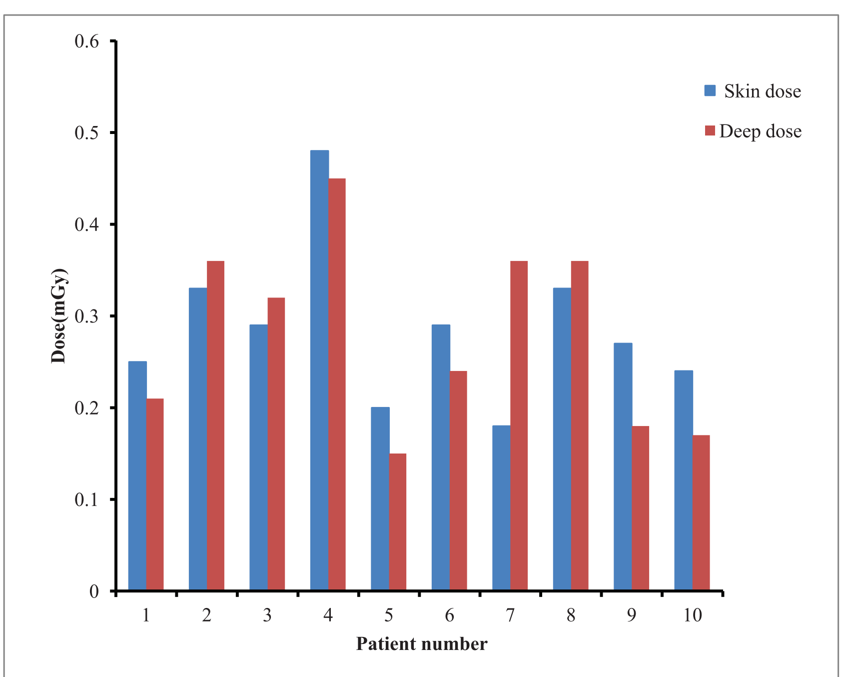

Figure 1. Plots of ESD and depth dose as a function of patients' number for chest PA examination.

4. Discussion

In this study, 40 patients from F.M.C., Azare, were included. Patient information and X-ray machine parameters, such as weight, height, Body Mass Index (BMI), tube voltage, and mAs, are presented in Table 1. The weight of patients ranged from 50 to 100 kg and the average being around 64 kg. The range of tube voltage (50–140) kVp determined in this study is similar to the tube voltage (53–125) kVp reported by Taha et al. (2014). The range of tube voltage used for most X-ray conventional radiography was within the operating conditions of the kilo-voltage settings. The highest kVp was used to image lumbosacral lateral and the lowest value of kVp was used to image chest PA. The range of tube current (9–120 mAs) selected for the examination in this study fall within the range of values reported in the UK survey (5–485 mAs). The variation of tube current was due to variation in patient sizes. Table 2 presents the ESD summary for chest, pelvic, and lumbosacral examination. The maximum absorbed dose is 16.49 mSv; this may be related to the patient's organ thickness. The patient thickness has direct impact on the ESD. The thicker the body part, the higher the ESD. Hospital data were compared with guidance levels set by the International Atomic Energy Agency (IAEA), diagnostic reference levels (DRLs), and previous studies. The estimated ESDs ranged from 0.18–0.48 mGy for chest (PA), 0.45–13.45 mGy for lumbosacral (AP), 0.62–16.49 mGy for lumbosacral lateral, and 0.70–13.72 mGy for pelvic AP. When comparing these values with reference levels and with previous studies (Table 3), the mean ESD values estimated by this work were found to be higher than the reference doses and previous studies in most of the examination. This may be due to the long working age of the machine and differences in technical parameters used. This comparison showed that there is a need for patient dose reduction in the center used for this study. Patient dose reduction has been a long-standing issue, this work shows that despite all the effort there still exist centers where patients' doses can be very high especially in developing countries.

Figure 1 presents the histogram of the ESD as a function of patient number for chest PA examination. The histogram shows that the mean dose received by female patients is higher than male patients. This is due to the presence of breast tissues which increase the chest thickness of female patients.

5. Conclusion and Recommendation

Patient doses arising from X-ray examination of chest, lumbosacral, and pelvic in F.M.C., Azare, have been measured. The ESD values were within the range of 0.18–16.49 mGy, which were found to be higher than the recommended dose by DRLs and IAEA; therefore, it is important for the personnel involved in the radiographic examination to understand the factors that affect patient doses and make necessary effort to select the appropriate exposure parameters such that the doses to the patients are kept as low as reasonably achievable while maintaining the image quality. There is also a need to increase the filtration used for the X-ray machine to reduce the ESD. Also, quality assurance tests should be performed regularly to ensure the accuracy of the machine.

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