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ENTRANCE SKIN DOSE TO PATIENT UNDERGOING CHEST, LUMBOSACRAL, PELVIS AND KNEE EXAMINATION AT NATIONAL ORTHOPEDIC HOSPITAL ENUGU, NIGERIA.

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ABSTRACT

Background: There is a growing concern about public exposure to harmful radiation from medical sources, and this could dispose patients to radiation induced diseases. International bodies have come up with dose reference levels as the standard exposure allowed for some medical examinations, and radiography departments are expected to ensure that daily examinations do not exceed these limits.

Objective: The entrance skin dose (ESD) for patients undergoing chest, lumbosacral, pelvis and knee x-ray examinations were measured to determine the quantity of radiation dose delivered to the skin during routine radiological examinations and compare the results with those recommended by international regulatory agency (IRA).

Materials and methods: This was a cross-sectional prospective study involving 40 purposively sampled patients, with .each examination comprising of 10 patients. A thermoluminiscent dosimeter was used to measure the ESD of the region being examined. Other anthropological information obtained include the weight, height, and body mass index. All exposures were carried out with a mean kilovoltage peak (kVp), milliampere second (mAs), focus to film distance (FFD) and total skin dose (TSD) for the study were 72.68 kVp, 26.10 mAs, and 112.75 cm and 100.63 cm respectively

Results: The mean ESD to patients undergoing chest, lumbosacral, pelvis and knee x-ray examinations were 1.07 mGy, 3.87 mGy, 2.06 mGy and 2.04 mGy respectively. The mean ESD value for chest examination was higher than recommended doses of National Radiological Protection Board (NRPB), IAEA and EC; the mean ESD for knee was higher than NRPB. The mean values for lumbosacral and pelvis were all lower than recommended values of NRPB, International Atomic Energy Agency (IAEA) and European Commission (EC).

Conclusion: The ESD of chest and knee examinations are unacceptably higher than internationally recommended standards. There is a need to review the exposure factors used to meet with international requirements for those examinations.

INTRODUCTION

X-radiation, since its discovery by Wilhelm Rontgen in 1895 has become an integral part and indispensable diagnostic tool in modern medicine [1]. This stems from the fact that x-rays forms the basic diagnostic tool from which many other imaging modalities took its root. Due to its double prong purposes of serving as diagnostic as well as therapeutic modality, it can be used for imaging internal structures of the body for diagnostic purpose as well as being used to destroy cancerous tissues in cases of radiotherapy. Diagnostic x-ray sources operate with low energy of between 25 - 120 keV while the therapeutic x-ray sources operate with high energy ranges in the excess of 25 MeV [2]. Robb-Nicholson[3] noted that since the discovery of x-ray, exposure of patients to ionizing radiation for diagnostic purposes is at ever increasing frequencies. It is also pertinent to know that exposure to ionizing radiation is not only limited to diagnostic or therapeutic sources but can come from naturally occurring background radiation, cosmic radiation and natural disaster [4,5]. Despite these benefits of X-radiation in diagnostic and therapeutic medicine, they are not without its attendant risk as its detrimental effect was clear soon after its discovery[6]. Exposure to ionizing radiation can cause DNA damage with its attendant consequences on biological tissues where it triggers cell death and mutation which ultimately result in cancer formation[7]. The first adverse effect of ionizing radiation was a case of human dermatitis of the hand which was recorded in 1896[8]. Also, the first solid cancer from ionizing radiation was reported in 1902 from an ulcerated area of the skin while the first leukemia was reported in 1911 in five radiation workers[9]. These effects were classified into deterministic and non-deterministic effects [10]. Since this discovery of its adverse effect, the international Commission on Radiological Protection (ICRP) has come up with some recommendations which are geared to adopting the appropriate level of protection against the detrimental effect of radiation exposure without necessarily reducing the benefit accruing from such exposure[11]. This led to the adoption of ALARA principle of radiation protection which is hinged on justification of radiation dose administered to a patient, optimization of protection to patient and personnel and dose limitation to patients[12].

To ensure reduction in the dose to patient and personnel, it is paramount to optimize the diagnostic procedures to deliver as low dose as reasonably achievable to obtain image of optimum diagnostic quality. Patient dose measurement is an integral part of the optimization of the diagnostic procedure[13]. In diagnostic imaging, patient dose measurement can be classified into two groups which are effective dose and entrance dose. Entrance skin dose (ESD) measurement is often used as a guide in quality control and optimization of diagnostic procedure as it measures the radiation dose that is absorbed (mGy) by the skin[14]. However, it is not a good indicator of radiation risk as it does not consider tissue sensitivity, penetration and area of the beam like the effective dose. Several studies have been conducted on ESD for routine diagnostic examinations, which guides radiation dose administered and consequently the exposure factors selected during each examination. Due to the nature of the hospital, the National Orthopedic Hospital, Enugu attends to several cases of chest, pelvis, knee, and lumbosacral examinations. The volume of patients exposed to radiation daily requires the ESD of these examinations to be known. This will inform the radiographer on the need to adjust the exposure factors accordingly. However, no data exists on the ESD of these examinations in the hospital. This study is therefore aimed at determining the ESD for the selected routine examinations and compare the findings with recommendations from international regulatory agencies.

MATERIALS AND METHODS

This is a prospective cross-sectional study involving 40 patients referred for radiographic examinations of the chest, lumbosacral, pelvis, and knee at the radiography department of National Orthopedic Hospital Enugu between May - August 2018. All examinations were carried out with a floor mounted, three-phased Toshiba Rotanode X-ray equipment (Rotating anode, Model DR-1824B with 1.3AI/75 permanent filtration and 1.2mm ALeq at 70KV, first half value layer: 2.5mmAL; range of 40-150KVp, 100mA, focal spot 1.2/0.6, manufactured in June 2015). The focus to skin distance used was according to the standard for each procedure done (Table 1). Informed consent was obtained from each patient and anthropological data obtained include age, sex, height and weight. One Lithium Fluoride thermoluminiscent dosimeter (LiF-TLD) which has been annealed at 800 degrees centigrade for 24 hours was wrapped in cellophane envelope and strapped to the patient's body with a masking tape in the direction of the primary beam in such a way that it will not obstruct any vital structure. The range of exposure factors used for the various procedures are listed in table 1. After exposure, the TLD was recovered, labeled, and taken away to a storage location far from any other source of radiation. At the end, they were taken for reading with a Hashaw 45100 TLD reader at the Centre for Energy Research, Department of Physics, Ahmadu Bello University, Zaria, Kaduna State.

RESULTS:

Ten patients each were recruited for chest, lumbosacral, pelvis and knee x-ray examination bringing the total number of patients for the study to forty. The anthropological and exposure parameters used for the study are shown in table 1 The entrance dose range measurement for chest examination ranges from 3.000 – 0.246 mGy while that of lumbosacral, pelvis and knee are 6.960-1.520 mGy, 4.010 -.155 mGy and 7.060 -0.640 mGy respectively. Mean ESD to patients undergoing chest, lumbosacral, pelvis and knee x-ray examinations are 1.06 mGy, 3.87 mGy, 2.06 mGy and 2.04 mGy respectively. A comparison between the mean ESD and international reference levels are shown in table 2. The ESD values for chest and knee were higher than standard benchmarks, while that of the lumbosacral and pelvis were lower.

Table 1: Range of exposure factor values

Exam	Projection.	kVp	mAs	FFD (cm)	FSD (cm)
Chest	PA	68-85	16-32	110-180	107-155
Knee	AP	55-69	4-10	94-100	82-93
Lumbosacral	AP	70 -85	20 -72	98-150	89-123
Pelvis	AP	72 -85	25 -40	90 -100	70-97

Table 2: Mean ESD with 75th Percentiles for different routine x-ray examination

Exam	Projection	Mean ± SD (mGy)	Min (mGy)	Max (mGy)	75th (mGy)
Chest	PA	1.06 ± 0.27	0.25	3.00	1.48
Knee	AP	2.04 ± 0.64	0.52	7.06	2.80
Lumbosacral	AP	3.87 ± 0.55	1.52	6.96	5.59
Pelvis	AP	2.06 ± 0.38	0.16	4.01	3.99

Table 3: Comparison of ESD of respective body regions with International Reference Levels

Body Region	ESD range	Mean ESD (mGy)	NRPB	IAEA	EC (1999)
Chest (PA)	0.25 - 3.00	1.06	0.2	0.33	0.4
Lumbosacral (AP)	1.52 - 6.96	3.87	5.7	4.07	10.0
Pelvis (AP)	0.16 - 4.01	2.06	4.0	3.68	10.0

DISCUSSION

Over the years, x-radiation has been used medically to produce diagnostic images which is used in the treatment of diseases. During diagnostic radiographic procedures using x-ray, doses of radiation are deposited on the patients according to the procedure conducted, equipment used and the patient's morphology. In view of the detrimental effect of ionizing radiation on the body, efforts are not only channeled towards the production of images with diagnostic value, but also on the reduction of radiation dose to patients. This, therefore, necessitates the need for regular assessment of dose delivered to patients against reference dose levels set by international communities to ensure that such limits are not exceeded. It is also pertinent to note that adherence to diagnostic reference levels do not signify good practice as balance has to be struck between dose and quality.

In this study, the mean ± SD of ESD for all radiographic procedures studied was 1.06 ± 0.27 (mGy), which were higher than recommended levels by IRSN (0.3 mGy) and NRBP (0.2 mGy). Comparing our findings with similar studies in other countries, our values were higher than what was reported in Sudan (0.53 ± 0.24 mGy) and Iran (0.70 ± 0.38 mGy)[15]. From these results, it can be deduced that patients undergoing these examinations received higher dose of radiation than was necessary, a situation which should be addressed urgently. From our findings, the mean and standard deviation for patients who underwent knee x-ray using standard AP projection is 2.04 ± 0.64 mGy. This is higher than the value obtained in a similar study in a different hospital[16] which is 0.50 mGy. For lumbosacral and pelvis x-ray, the DRLs obtained are 3.87 ± 0.55 mGy and 2.06 ± 0.38 mGy respectively. Satisfactorily, these values are lower than recommendations from NRPB, IAEA and EC. However, we think that these low doses could be as a product of chance rather than adherence to the regulations, since the same personnel and equipment carried out all the exposures.

We are of the opinion that the reason for the high ESDs measured is because there are either no regulations guiding the administration of radiation in the hospital, or it is not being implemented. Other factors that might contribute to this may be lack of training of personnel on radiation protection[17] or low levels of knowledge of radiation protection procedures to be implemented as at and when due despite existing regulations[18].

As x-ray imaging continues to be used in the diagnosis of diseases, effort should not be concentrated in the production of quality images since current technology on digital imaging could compensate for it. Efforts rather, should be directed at optimization of dose delivered to patients, bearing in mind the linear No threshold principle. Laws on optimization of dose delivered to patient during radiological examinations should be enacted and where that is in existence, should be enforced by setting up regulatory teams to monitor compliance and institute a framework to train and retrain radiographers on the need to abide by the international standards. In conclusion, this study has shown that the radiation dose received by patients during most radiological examination is higher than the dose level recommended by international agencies on radiation protection. This, therefore, stress the need for enactment of law on radiation protection or enforcement of it where the law exists to avert the danger of radiation induced diseases associated with over exposure.

CONCLUSION

The ESD of chest and knee examinations are unacceptably higher than internationally recommended standards. There is a need to review the exposure factors used to meet with international requirements for those examinations.

Conflict of Interest: None

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