ORIGINAL ARTICLE

ESTIMATION OF ENTRANCE SURFACE DOSE TO ADULT PATIENTS UNDERGOING PLAIN CHEST RADIOGRAPHIC EXAMINATIONS IN A NORTHERN NIGERIAN POPULATION

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ABSTRACT

Objective: The entrance surface doses (ESD) to adult patients undergoing postero-anterior (PA) chest radiography were measured at Shika Ahmedu Bello University Teaching Hospital (ABUTH) Zaria, Northern Nigeria.
Method: A total of 30 patients were prospectively considered in the study. The ESDs were obtained using thermo luminescence dosimeter (TLDs) chips, and Kumar's formula.
Results: The estimated ESD obtained were 1.08 mGy and 0.76 mGy for TLD chips readings and Kumar's formula respectively. Comparison was made between the two readings, and a statistically significant difference was noted (p<0.029).
Conclusion: Procedural changes are suggested in order to lower the ESD and enhance the image quality of the radiographs. ESDs in this study were found to be generally higher compared with those reported in similar studies in Southern Nigeria, UK, and CEC. The results call for improved operators technique and application of quality Assurance Programme (QAP) in radiology departments, to ensure that doses are kept as low as reasonably achievable, and also for the formulation of local diagnostic reference levels (LDRL).

Keywords: Entrance Surface Dose, Chest Radiography, Thermo luminescence Dosimeter, Adult patient.

INTRODUCTION

Ionizing Radiation has been used for diagnostic purposes in medicine for more than a century. The benefits are immense and certainly exceed the risk.[1,2] The more recent development in imaging modalities, such as multi detector row computed tomography (MDCT), magnetic resonance imaging (MRI) and nuclear medicine imaging studies have improved the lives of our patients. However, it is important that the radiation dose to patient arising from diagnostic medical exposures are assessed in order to provide valuable guidance on optimization of radiological technique, and to ensure that the required diagnostic information is obtained with minimum radiation hazard.[3]

Despite rapid development in medical

imaging, including the advent of computed radiography (CR) and digital imaging, conventional chest radiography remains the most frequent radiological examination.[1]

To the best of the researcher's knowledge, no study was carried out to estimate entrance surface doses to patients undergoing plain radiography examinations in Zaria, Northern Nigeria. Few studies were done in the southern part[4,5], yet no national Diagnostic Reference Levels (DRLs) set for the country, data are usually compared with those of the international communities such as (United Kingdom [UK]), and Council of European Commission (CEC). DRL is recommended to be set for the most common projection, and chest X-ray is the most requested projection in this centre.

This study aimed to determine the entrance absorbed dose to adult patients in plain chest radiography using both TLD chips and KUMAR's calculation method, for the purpose of developing local DRLs.

METHOD

This was a prospective study conducted at the tertiary institution situated at Zaria Northern Nigeria. Ethical clearance to conduct the study was obtained from the hospital ethical research committee. Only consented adult patients that met the inclusion criteria were included in the study. The participant's weights were measured and recorded.

Entrance surface dose (ESD) measurements were made by attaching a sachet containing 2 thermo luminescent (TLD) chips to the changing gown of the selected participants on the central axis of the X-ray beam. The lithium floride chips used were (TL 100, Harshaw) type, and were read using a TLD reader (Solaro 680, Vinten)[6] at the centre for energy research and training, ABU Zaria. The TLD reader was calibrated by the national radiation laboratory, Denmark and found to be performing within the recommended levels of precision and accuracy.

Chest radiography projections were taken using a 3-phase, 6-pulse general purpose X-ray unit (silhouette VR system, USA, 2004). It has a maximum tube voltage and current of 150 kVp and 630 mA respectively, with a minimum inherent filtration of 1.5 mm Al at the tube housing. All the chest radiographs were taken with 180 cm focus to film distance (FFD).

Mediphot x-ray cassettes with calcium tungsten ($CaWO_4$) intensifying screen materials were used for the study. The films were processed using an automatic processor with a model number (Mediphot 903).

ESD is defined as the amount of the absorbed dose to air at the centre of the beam including backscattered radiation.[7]
Therefore, according to Jones et al[8].

Where ID= incident dose in air, BSF= backscatter factor, which is the ratio of the incident dose in tissue to the incident dose in air.

Where Do is the dose measured with water in the phantom, and Dair is the dose measured in air

$$BSF = \frac{Do}{Dair}$$

In this study, BSF was determined by attaching a sachet containing 2 TLD Chips on the central axis of the water phantom where the beam strikes. Another sachet of TLD chips was also taped on the side of the water phantom where the beam will be scattered, this was placed 10 cm away from the central axis, and angled 45^0. Two exposures were made; one with the phantom filled with water, and the other with the phantom emptied.

The BSF was measured to be 1.35, and was multiply with average readings of the TLD chips in each sachet of the participating patients to obtain the resultant ESD.

Similar measurements were computed using Kumar's formula. According to Kumar et. al[9], incident dose to patient;

$$IDair = \frac{K(mAs)(kVp)^n}{D^2 f\Phi}$$

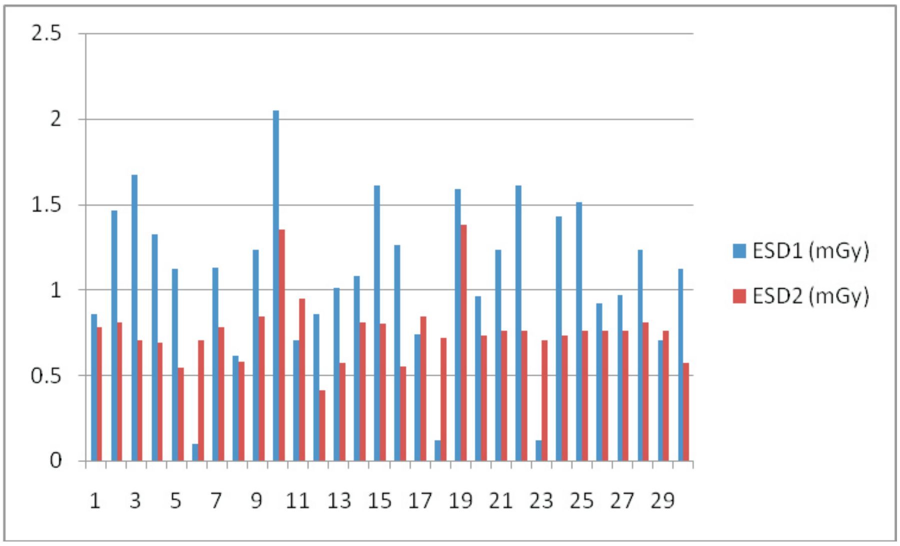
where mAs is the tube current, kVp is the applied voltage, D is the focus –to-skin-distance, F is the total filtration of the X-ray tube, and Φ is the machine phase factors, K is equal to 0.239, and n is an integer which is approximately 2. Comparison was made between the values obtained using the TLD chips and those from the Kumar's formula. Data was analyzed using SSPS version 16 statistical software.

RESULTS

A total of 30 patients consisted of 10 males and 20 females were recruited for the study. The age ranged from 19 – 70 years (mean age 42.6). ESD were obtained and compared from both TLD chips readings and KUMAR'S formula (Figure1). Statistically significance correlation was obtained between the TLD chips readings and calculated values using the KUMAR'S formula ($p<0.029$, $r^2=0.398$) (fig.2). Table 1 shows descriptive statistics of the variables namely ESD obtained with TLD chips, ESD computed with the KUMAR'S formula, patients weight, mAs, and kVp used with their respective mean (s) and standard deviation (s).

Table 1: descriptive statistic of the variables

VARIABLE	Range of values	Mean ± standard deviation
ESD1 (mGy)	0.10-2.05	1.08 ± 047
ESD2 (mGy)	0.41-1.38	0.76 ± 0.20
KVp	64-85	70.90 ± 3.77
MAs	10-20	15.78 ± 2.73
WEIGHT	38-127	65.53 ± 17.55



Where:
ESD1= Doses obtained from the TLD reader.
ESD2= Doses calculated using KUMAR's method

Fig. 1: Comparison of ESD1 and ESD2

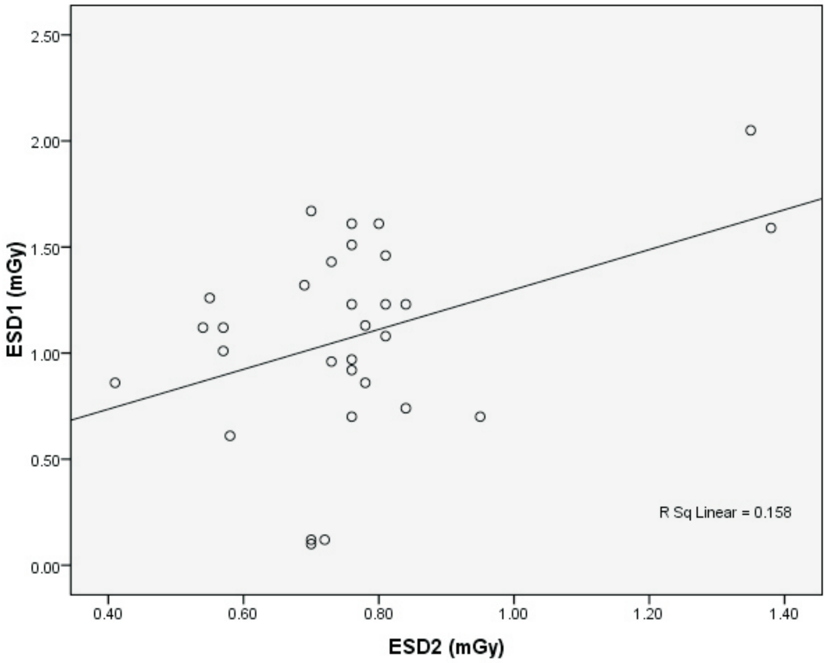


Fig. 2: Correlation of ESD1 with ESD2

DISCUSSION

Radiography using film has been an established imaging technique for over century. Surveys carried out during the 1980s identified a wide range in patient doses in the practice of radiography, mainly due to the use of different exposure parameters. Regular checks of patient's dose and comparison with the diagnostic reference levels, provide a guide representing good practice which enables units for which doses that are higher to be identified. Cause can then be investigated and changes implemented. Application of this method has led to a gradual reduction in doses in many countries.[2]

The idea of "reference doses" for the common X-ray examinations was initiated in the UK in 1990, at a joint conference between the Royal College of Radiologists (RCR), and the National Radiological Protection Board (NRPB) tagged: Patient Dose Reduction in Diagnostic Radiology.[10] A similar concept to reference doses was subsequently adopted by the International Commission on Radiological Protection (ICRP), contained in ICRP 1990 recommendation Publications 60 titled "diagnostic reference level"(DRL).[11]

The department of Health (DH) UK stated that, the use of Diagnostic Reference Levels (DRLs) has been established in medicine as the key factor for regulating the use of ionizing radiation. The Ionizing Radiation (Medical Exposure) Regulation 2000 requires employers to establish DRLs and to undertake appropriate reviews if these values are consistently exceeded. The regular review of these DRLs at national and local level provides a feedback loop that ensures good practice in medical exposure is maintained.[12]

The use of DRLs has been included in the European Directive as part of the requirements for the countries in the European Union. Several studies have shown that, dose reduction of 50% is possible without losing image quality when CEC guidelines are well established.[13] However, adoption of an optimisation strategy using national and local

DRLs in the UK has lowered patients' doses, as demonstrated by the gradual reduction in values derived from UK-wide surveys of mean doses for large number of hospitals by the NRPB.[2] For the countries in the European Union. Several studies have shown that, dose reduction of 50% is possible without losing image quality when CEC guidelines are well established.[13] However, adoption of an optimisation strategy using national and local DRLs in the UK has lowered patients' doses, as demonstrated by the gradual reduction in values derived from UK-wide surveys of mean doses for large number of hospitals by the NRPB.[2]

According to Arun C[14], the reference dose level for chest radiograph was set at 0.3 mGy, and 0.4 mGy for both NRPB and CEC respectively. In the present study the DRLs obtained for chest radiographs using TLD chips was 1.08 mGy ± 0.47, however, measurement computed using Kumar's formula shows similar results but lower values than the TLDs readings 0.76 mGy ± 0.20 (table1). Statistically significant difference was obtained between the two readings ($p<0.029$) (figure 2). However, no significant difference noted between the two sexes. The disparity of the two readings may be as a result of uncertainty in the TLDs measurements. This could be because the TLD chips were not appropriately annealed to read 0.00 levels after the read out had been recorded. This causes possible increase in value in the subsequent patient when taking reading with the same TLD chip.

Similar study carried out in the South western part of Nigeria by Obed et al[4] reported ESD of 0.35mGy for chest x-rays examinations. Low doses of 0.13 mGy and 0.075 mGy for chest x-rays were however, computed by Nwokorie[15] and Vassilera[16] respectively.

All the values reported in the literature were lower than those obtained in the presence study. The difference could be due to the absence of quality assurance programme on the X-ray equipment prior to the study, and lack of adequate knowledge by the personnel managing the equipment, being most of the general radiography examinations are done by the x-ray technicians in the study area.

CONCLUSION

Entrance skin doses (ESD) for patients undergoing chest x-rays were measured using TLD chips, values were compared with those obtained with the Kumar's formula. Statistically significant difference was noted between the two readings. The results obtained were consistently higher than the recommended values from IAEA, ICRP, NRPB (UK) and CEC. This could probably due to lack of routine quality control checks on the equipment, coupled with lack of proper personnel to carry out the examinations. The study suggested procedural changes in order to lower ESD and improve on the image quality of the radiographs.

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