A COMPARATIVE STUDY OF PATIENTS DOSE LEVEL WITH STANDARD DIAGNOSTIC REFERENCE LEVELS IN TWO DIAGNOSTIC CENTERS IN EKITI STATE, NIGERIA

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ABSTRACT

The objective of this study is to obtain typical ESD values for patients undergoing four common X-ray examinations in two diagnostic centers in Ekiti State, and to determine the level of conformance of current practice in the two centers with the UK practice.

Thermoluminesence dosimeters (TLDs) were used to measure the ESDs for 80 patients, undergoing chest (PA), abdomen (AP), lumbar spine (AP) and lateral and pelvis (AP). Descriptive statistics (mean, standard deviation, min and max) of the measured ESDs, including t he range factor ws obtained and compared with the mean ESD of UK reference values.

The mean ESDs obtained for all examinations range from a minimum of 0.70 mGy to a maximum of 2.19 mGy. The mean ESDs obtained from this study is found to be generally lower than the corresponding mean values (0.15-11.7mGy) obtained from the UK study, except for PA chest which is 0.70 and 0.75 for FMC and R-Kay respectively. Some spread was also which range from 1.64 mGy to 4.95 mGy.

Typical ESDs values ranging from 0.70-2.19mGy was established for patients undergoing common x-ray examinations in two diagnostic centers in Ekiti State. It was also observed that current practice in Ekiti State partly conform to the UK practice.

Keywords: Entrance Skin dose, Diagnostic reference levels, Thermoluminesence dosimeters, X-ray Examinations

INTRODUCTION

X-ray used for medical diagnosis delivers some percentage of its energy to the patient body, the quantity that expresses that concentration of this energy in the body is the absorbed dose. It has been shown that this absorbed energy causes genetic and other harmful effects to the human cells (Bushberg et al 2002). Previous study has also shown that patient doses are high and vary from one radiology centre to the other (Gray et al, 2005). On this note intensive efforts have been geared towards producing radiographs of acceptable image quality and of diagnostic value from doses that are compatible with safety and health in compliance with ALARA principle (UNSCEAR, 2000).

When these x-ray examinations are conducted appropriately, the medical benefits they provide generally outweigh the risks. If proper precautions are not taken during these procedures, patients may be exposed to radiation without clinical benefits. Unnecessary radiation exposure therefore, results from the use of radiation dose above what is optimal to meet the clinical need in a given procedure. The quality of the images produced during these procedures depends partly on how much radiation is used, which is under the direct control of the radiographer. To a point, using a higher radiation dose can produce a higher resolution image not be to make an accurate clinical diagnosis. So the centre of x-ray examinations today is hinged on two very mutual & fundamental factors: image quality and dose. An optimal radiation dose is one that is as low as reasonable achievable while maintaining sufficient image quality to meet the clinical need.

The radiation protection system for patients subjected to medical exposure in diagnostic radiology is generally governed by the principles of Justification and optimization, including the consideration of diagnostic reference levels (ICRP, 1990). Diagnostic x-ray examinations are justified if the clinical benefit outweighs the risk associated with the exposure to ionizing radiation. The ultimate objective is to perform only useful procedure which result being positive or negative is expected to change patient management otherwise, the practice is not justified. Once a medical exposure has been justified, the principle of optimization is applied – that is, the dose of radiation which is delivered to the patient must be kept as low as reasonably achievable (ALARA) but high enough to obtain required diagnostic information, taking into account economic and social factors. This value is interpreted as being the lowest dose possible, which is consistent with the required image quality, necessary for obtaining the required diagnostic information. It is important to note that there is not dose limits for patients undergoing radiological examinations. Hence, the principle of optimization is an essential control mechanism used to shield patients from unnecessary radiation exposure.

In order to evaluate that x-ray examinations are effectively optimized and remain optimized as time passes, it is necessary to establish quantitative indicators regarding the doses delivered. These indicators are also meant to provide an evaluation of the performance of the medical examination and thus could be used to continuously improve the procedures. This can be accomplished by a longitudinal monitoring of the indicator in a given institution for a given medical device, and by making comparison of these dose indicators between different institutions of the same or of different countries. For these indicators to be useful, the following criteria must be fulfilled:

They must be clearly defined and be easy to measure or to calculate.
They must give directly to the operators, an indication of the importance of the dose delivered.
They must be adapted to all types of radiological equipments.
They must allow easy correlation with the technical parameters of the medical examination.
Such perfect indicators applicable to diagnostic radiology meets the definition of diagnostic reference levels. (DRLs)

The concept of DRLs was recommended for use in radiology by both the International Commission on Radiological Protection (ICRP) and International Atomic Energy Agency (IAEA), following the results of radiation dose survey conducted by Shrimpton et al. (1986) and Faulkner and Corbelt (1998). The result showed a wide variation in patient dose levels for the same x-ray examination up to a factor of 100. The result of the study conducted by the Nationwide Evaluation of X-Ray Trends (NEXT) survey program in the United States also, show that patient doses in radiology are high and vary from 1 facility to the next (Gray et al, 2005). Other studies reported wide variations in patient dose for the same radiographic examinations within and among hospitals in the United Kingdom and in Europe (Johnston & Brennan, 2000; Carroll & Brennan 2003).

The reference levels were intended to act as threshold to trigger investigations or corrective action in ensuring optimized protection of patients and maintaining appropriate levels of good practice (CEC, 1996). They provide guidance for radiologists or radiographers regarding the appropriateness of patient's radiation doses for specific X-ray projections and imaging procedures. They are defined by the Council Directive 97/47 Euratom as dose levels in radiodiagnostic practices for typical examinations for group of standard procedures when good and normal practice regarding diagnostic and technical performance is applied''. (CEC, 1997). However exceeding the levels does not mean an examination is inadequately performed, and meeting this level does not automatically equate with good practice, as the image quality may be poor. The goal is clearly to use DRLs to control the level of optimization of procedure.

Diagnostic reference levels (DRLs) are conventionally set in dose quantities that are relatively readily available to the user of x-ray equipment. In conventional radiography, the most important parameters increased are the total dose area product (DAP) and the entrance surface dose (ESD). Entrance surface dose is defined as the absorbed dose in mGy measured in air at the intersection of the axis of the x-ray beam and the patient's skin surface; it includes backscatter rays. It is quantity that can be measured directly and can easily be compared with previous measurements and with that obtained at other practices and countries. It can also be used as an indicator of effective dose for particular radiographic projections. Another reason for evaluating ESD is that the dose is greatest at the surface where radiation enters the body of the patient and the skin is therefore the main organ for which there is a possibility of deterministic effect (skin burn). The ESD has been recommended by the International Atomic Energy Agency (IAEA) in 1995 and the European Union in 1997 as the dose descriptor for guidance level in diagnostic radiography.

DRLs alone, while indicating values of how well a particular department is performing in terms of levels of radiation delivered, do not offer much constructive information about how to reduce excessive levels of radiation. This is why in most DRL studies a comprehensive array of accessory information is gathered to identify the causes of high doses. Such information is usually categorized into examination specific and examination room specific data. Key features that often are linked to high doses are type of image receptor, exposure factors (particularly beam energy), number of images, types of anti-scatter grid and level of quality control.

This work is therefore geared towards the determination of a preliminary patient dose report in Ekiti State, which will add to the pool of information on national Radiation Dose Data Base (NRDD), sine none of the available literatures has reported ESD measurement for patent undergoing common x-ray examinations in Ekiti State.

MATERIALS AND METHODS

The ESD received by 80 patients who consented to participate were included in this study. This dose survey was conducted between October 2012 and December 2012. The patients were randomly selected from adult patients of both sexes undergoing x-ray examinations in two radiological centers in Ekiti State. These centers include Federal Medical Centre Ido-Ekiti and R-Kay diagnostic Ado Ekiti. These centres were chosen for this study because they are the only functional radiodiagnostic centres as at the time of the study. And by implication, the dose values obtained from this study to a large extent represents a good estimate of population dose from Ekiti State as at the time of the study.

Critically ill patients were excluded from this investigation. This is due to the difficulties in subjecting such patients who are at imminent risk of death to the process involved in obtaining the required parameters such as weight and height. These groups of patients are so frail that they cannot stand erect for their weight or height to be taken. Patients who were under the age of 18 years were also excluded because of large variation in sizes of patients from 18years down the line.

The common x-ray examination studied includes; Chest (PA), abdomen (AP) lumbar spine (AP) and (LAT) and pelvis (AP). Cases considered were those for which the images were diagnostically acceptable. Acceptability of diagnostic images was purely subjective and was assessed by the radiographers. Before the commencement of the study quality assurance test was done on each of the machines. The quality control kit used is piranha 500, version 3.1 Manufactured by RTI Electronics Inc, USA.

For each patient examined the following data were obtained; Sex, age, weight, height and body part thickness. The weight of each patient was measured with weighing scale with a maximum capacity of 120kg. Patient height was taken with tape marking on the wall. Body mass index (BMI) derived from weight/ (height)2, which is a useful classification scheme for size and shape of a person (Gibson 1990), was also recorded.

The exposure parameters used for each patient includes; kilovoltage peak (KVp), product of tube current and time (mAs), focus-film distance (FSD) and focal spot size.

In this study TLDs were used to measure the ESDs to patients undergoing common x-ray examinations (PA chest, AP abdomen, lumbar spine AP and lateral and pelvis). The TLDs were annealed before use to erase the residual signal. The annealing was carried out at the Centre for Energy Research and Training (CERT) Ahmadu Bello University Zaria using Harshaw 4500 dual TLD reader, produced by Thermo-Fischer Scientific Inc. Well established and reproducible annealing cycles of 400oC for 1h and then at 80oC for 18h was employed. The aim of the annealing is to empty the phospore traps and thereby stabilize the electron traps. The annealed TLD are then exposed to cobalt 60 source of known radiation dose at specific distance and for varying durations for the purpose of calibration. The TLDs were also read using Harshaw 4500 dual TLD reader.

RESULTS

The tables below show the results of the data collected during the study. Table 1 shows the results initial quality control test performed on the equipments. Table 2 show personnel and technical data of x-ray machine used in both centers under study. It shows that the total filtration of the unit in FMC is 1.5mmAl, which is lower than the recommended filtration of 2.5mm Al (CEC, 1990) for voltage above 75kv., while the total filtration of the unit at R -KAY is 2.5mmAl.

Table 3 shows the mean and range (in parenthesis) of patient information for different x-ray examinations from both diagnostic centres under study. The age range (21-85 years) of patients considered in this study was wider than the age range used in provious patient dose survey (40-85years) conducted in Nigeria (Ogundare et al 2004) as shown in table 2. The range (12-34) of patient thickness as obtained in this study is similar to those used in previous study in Nigeria (Oluwokere et al 2012).

Table 4 shows that the range of tube voltages, kVp (70-105kVp) selected for most of these examinations were within the range of values used in the UK (50-150kVp) survey, Shrimpton et al (2003). In the case of tube loading (mAs) settings, the range of values selected for most projections in this study (14-125mAs) is narrower but still fall within the range of values reported in the UK survey (5 – 484 mAs).

Descriptive Statistics (Mean, Median, Minimum, Maximum, and Standard deviation) of ESD values obtained in this study is shown in table 5. The mean ESD were found to be within the range of 0.7mGy to 2.18mGy and 0.7mGy to 2.19mGy for FMC and R-Kay respectively as shown in table 4. The range factor highlights the spread/variation in the ESD values for the same type of examination either within or between the two centers.

While table 6 compares the mean ESD obtained from this work with that obtained in the establishment of DRLs in Brazil, United Kingdom Switzerland and Slovenia. It also includes a work done locally by Obed et al (2007) in the south western state of Oyo and Osun in Nigeria. The range of individual ESD with their mean values in mGy as obtained in the UK study is compared with the mean ESD of this work in tabe7.

DISCUSSION

It is clear from the foregoing that the mean ESD for each examination was found to be lower than those obtained in the UK study as shown in table 5, except for PA chest. The PA chest was found to have the mean ESD of 0.7mGy and 0.75mGy for FMC and R-Kay respectively, and appear to be higher than 0.15mGy as obtained in the UK study. This is attributable to the use of antiscatter grid which resulted in the use of mAs (28mAs) which is lower than 2.5mAl as recommended by European Council (2003) in FMC. The high value of 0.75 as seen in R-Kay diagnostic could be caused by the use of FFD of 97cm which is shorter than the recommended value of 115cm by the European Council (2003).

It was also observed that the ESD values for the same type of examination in the same X-ray centre generally vary due to differences in patient size and in the radiographic technique used by different radiographers as shown by the range factor of 2.14 to 4.95 in FMC and 1.64 to 2.13 in R-Kay. Variations of the means ESD values for individual X-ray examination between different X-ray centers are also due to difference in radiographic equipment, film type sensitivity, processing chemicals and processing conditions.

From the table 6 above, it is seen that even though the mean ESD for PA chest as obtained in this study exceeds that of the UK study, all other examinations as shown above are below but still fall be, and the mean ESD still fall within the range of individual ESD values of the UK study. It can therefore be established that the current practice in Ekiti State partly conform to the UK practice.

CONCLUSION

The ESD values for four common x-ray examinations in two diagnostic centers in Ekiti State were measured and typical ESD of 0.70 to 2.19mGy established for these examinations. The mean ESD was generally found to be below the mean ESD as reported in the UK studies, except that of PA chest, which were found to be higher than the UK mean ESD values. The level of current practice in this two centers was found to partly conform with the UK standard of practice. The result will serve as a useful baseline against which future dose measurements will be compared.

RECOMMENDATION

I hereby recommend:

- That radiographic techniques employed during x-ray examinations be standardized. eg the FFD used in R-Kay Medical diagnostic center during chest examinations be increase, while the filtration in Federal Medical Centre should also be increased. This will help to reduce the mean ESDs for PA chest and make it comparable with those reported in the UK study. Further dose reduction could be achieved by reducing mAs and increasing the KVp.
- That our health institutions should be retraining our radiographers through conferences, workshops and refresher courses so as to be aware of latest developments in the field and thereby improve their techniques. This will also help to harmonize radiological techniques of common X-ray examination among diagnostic centre and in no doubt further optimize radiological practice since written examination protocols were found lacking in the two centers under study.

Table 1: Quality control test results

Table 3: The mean and range (in parenthesis) of patients information for different x-ray examinations obtained from FMC and R-Kay diagnostic centres.

Table 4: mean and range (in parenthesis) of Technical Parameters used for x-ray examinations obtained from FMC and R-Kay diagnostic centres.

Table 5: The mean and range (in parenthesis) of patients information for different x-ray examinations obtained from FMC and R-Kay diagnostic centres.

Table 6: Comparison of the mean ESDs of this work with the work done in the UK, Brazil, Slovenia

Switzerland and Nigeria.

Table 7: The range of Individual ESD with their mean value in mGy as obtained in the UK study compared with the mean ESD of this work.

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