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ASSESSMENT OF ENTRANCE SKIN DOSE AND EFFECTIVE DOSE OF COMMON DIAGNOSTIC X-RAY EXAMINATIONS IN FEDERAL TEACHING HOSPITAL GOMBE, NORTH-EASTERN NIGERIA

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ABSTRACT

Recently, there has been a wide application of radiation in medicine. This may have adverse effect of radiation protection regulations if not properly observed. A balance must be struck between the benefits of improving human health, and the risks associated with ionizing radiation exposure by radiation workers, patients and the general public. This study evaluated the entrance skin dose (ESD) and patient effective dose (ED) during X-ray diagnostic examinations at Federal Teaching Hospital Gombe, North-eastern, Nigeria. Twenty (20) patient's data were collected for this study. Five (05) most common performed X-ray diagnostic examinations are Anterior Posterior AP (chest), Posterior Anterior (PA) chest, Anterior Posterior (AP) Abdomen, Posterior Anterior (PA) Skull and Lateral (LAT) Skull. The ESD was determined indirectly through measurement of tube potential (kVp), exposure setting or current (mAs) and Film Focus Distance (FSD) which were then used to analyze the ESD while the effective dose (ED) was obtained by addition of the weighing factor multiplied by the equivalent dose. The mean of entrance skin dose and the effectual dose of chest (PA, AP), abdomen (AP) and skull (AP, LATERAL) were found to be 0.466 *mGy*, 0.509 *mGy*, 1.027 *mGy*, 0.810 *mGy*, 0.928 *mGy* and 0.040 *mSv*, 0.030 *mSv*, 0.006 *mSv*, 0.001 *mSv* and 0.001 *mSv* respectively. The entrance skin dose and effective dose values obtained in this study showed that X-ray diagnostic examinations carried out at Federal Teaching Hospital Gombe were lower compared to reference dose values reported in most literatures. The value of patients absorbed dose undergoing X-ray diagnostic examination at Federal Teaching Hospital Gombe is in agreement with ALARA concepts.

Keywords: Entrance skin dose, X-ray diagnostic examination, Teaching Hospital, Gombe.

INTRODUCTION

Diagnostic X-ray examinations are the most common and highly essential source of all the medical exposures employed in the medical diagnosis for world population (Rubai *et al.*, 2018). As a result of ionizing nature of the X-rays which means that their use is not absolutely riskless, dose measurement is necessary to improve the process of the radiation protection of the patients and to deliver minimum dose during examinations in the field of radiology (Taha *et al.*, 2015). There are two types of doses to patient which are very essential in diagnostic radiology; the effective dose (ED), which takes into account of dose equivalent to radiosensitive organs and the entrance skin dose. The most important in diagnostic radiology is effective dose since this relates to the risk of stochastic effect such as cancer induction (Ibrahim *et al.*, 2014). Entrance Skin Dose (ESD) is a necessary tool used to access the dose received by a patient in radiography. This amount has been established by European Union in other to optimizing the patient's dose as a diagnostic reference. The best value in calculating the radiation risk for patients is Effective Dose (ED). One of the advantages of using ED is that it measures the absorbed doses and the relative radiation of the irradiated organs in patients and thereby determining the risk in the patient. (Ofori *et al.*, 2014). Absorbed dose describes energy deposition by ionizing radiation in an absorbing medium and it applies to all radiation exposures, ionizing radiations, absorbing medium, all biological targets and geometries. In its simplest constitution, the absorbed dose is energy imparted per unit mass (ICRU, 2005) and is given as:

$$D_{(rT)} = \frac{E_{(rT)}}{M_{(rT)}} \quad (1)$$

where E (r T) is the mean energy imparted to a target region (r T), and M (r T) is the mass of the absorbing medium. The units of absorbed dose are joule per kilogram (Jkg^{-1}) in the International

System of Units (SI), where the special name for the unit of absorbed dose is gray (Gy), and 1 Gy equals exactly $10\ Jkg^{-1}$ (ICRU, 2005). Absorbed dose is related to the number of ionization events in the target region, and ionization events are related to physical damage caused. (Darrell & Frederic, 2017). The purpose of this study is to measure ESD and ED from 20 patients in five types of X-ray examinations including skull (PA), skull (lateral), chest spine (PA), chest spine (lateral) and abdomen (AP). To the best of our knowledge, at Federal Teaching Hospital Gombe (FTHG) not much has been done for the calculation of effective dose ED and entrance skin dose ESD in the radiology department and this paper serves as baseline data on effective dose ED and entrance skin dose ESD from Federal Teaching Hospital Gombe (FTHG). Meanwhile, data is still very sparse on effective dose ED and entrance skin dose ESD in Nigeria, despite the wide and common usage of X-rays for medical diagnosis in almost every hospital in Nigeria (Ibrahim *et al.*, 2014; Sulaiman, Abbas & Habbani, 2007). The methods for calculating effective doses have been established, but depend heavily on the ability to estimate the dose to radiosensitive organs from X-ray medical diagnosis procedure(s). This study is centered on the evaluation of entrance skin dose (ESD) and calculation of patient effective dose (ED) during X-ray diagnostic examinations at Federal Teaching Hospital Gombe, Gombe State, Nigeria

MATERIAL AND METHODS

Materials

The data used for this study were secondary data of five (05) most common X-ray diagnostic examinations obtained from Federal Teaching Hospital Gombe, North-Eastern Nigeria. They include: Anterior Posterior (AP) chest, Posterior Anterior (PA) chest, Anterior Posterior (AP) abdomen., Posterior Anterior (PA) skull, and Lateral (LAT) skull. The radiographic or exposure factors included: Tube potential (kVp), Exposure setting or current (mAs), and Film focus distance (FSD). The data corresponding to the stated parameter were obtained from Department of Radiology in the Federal Teaching Hospital, Gombe State.

Methods

The X-ray console machine where the values of kilo voltage peak (kVp) and mill amperage (mAs) are set in other for the patient to be exposed to the radiation which dose value are recorded in the console X-ray machine. At FTHG, there are two different ways of bringing out the output of the X-ray image which are the digital and manual imaging film, although, the formal is the most commonly used. For the manual, a cassette was placed under the X-ray couch in which the X-ray radiation passes through. Then, the expose radiation cassette is taken into the Digital machine which will analyze the image into the computer connected to the machine. For the purpose of this study, two X-ray machines were used both having features of advance dose reduction and enhanced diagnostic capability. Raw data were collected during X-ray and parameters taken include mAs, kVp and focus to skin distance (FSD). Moreover, the focus film distance (FFD) and radiographic exposure factors (kVp and mAs) during the X-ray examinations were also recorded.

Equation 1 was used to calculate dose (D_{rT}) while equation 2 (Taha *et al.*, 2014) was adopted in calculating entrance skin dose (ESD). Parameters such as X-ray dose output, back scatter factor, focus to skin distance and physical parameters such as mAs and kV were inserted into the equation 2.

$$ESD = BSF \times Tube\ output\left(\frac{mGy}{mAs}\right) \times \left[\frac{100}{FSD}\right]^2 \times mAs \qquad (2)$$

where BSF is the back scattered factor, mGy/mAs is the tube output, FSD is the focus skin dose in cm, mAs is the machine current in milli Ampere.

Calibration of the X-ray Machine

The tube calibration was set at 80 kV, 1 m distance and 10 mAs. The kerma was obtained in *m*R directly using the Radiation meter detector.

Equivalent Dose

The entrance surface dose in (mGy) is then multiplied by a radiation weighting factor to give the equivalent dose in (mSv) (Darrell & Frederic, 2017).

$$H_T = ESDW_T \qquad (3)$$

Effectual Dose

This is defined as the sum of all the tissue equivalent doses, each multiplied by the appropriate tissue weighing factor and it gives information about the biological effect on the object being exposed. It was calculated using equation 4 adopted from Darrell & Frederic, 2017.

$$E = \Sigma_T W_T H_T \quad (4)$$

RESULTS

Assessment of entrance skin dose and calculation of effective dose for common diagnostic X-ray examinations in Federal Teaching Hospital Gombe was carried out on twenty patient using five most common X-ray examination which were skull (PA), skull (lateral), chest spine (PA), chest spine (lateral) and abdomen (AP) and the results were presented in Table 1.

From the results presented in Table 1, it was discovered that the lowest tube potential was 65 kVp for lateral skull X-ray examination and the highest was 95 kVp for Anterior-Posterior abdomen. However, the Entrance skin dose obtained from the analysis ranged from 0.266 to 0.924 mGy for chest, 0.936 to 1.140 *mGy* for abdomen and 0.780 to 1.020 *mGy* for skull. The corresponding effective doses ranged from 0.023 to 0.079 mSv 0.005 to 0.007 (mSv) and 0.001 to 0.001 (mSv) for chest, abdomen, and skull respectively. The highest entrance skin dose was 1.140 *mGy* which was recorded in abdomen, the value is comparable with WHO standard. Similar report on entrance skin dose was reported in Bangladesh by Sadeka *et al* (2018), the range was 0.05 to 0.35 *mGy* for chest, the value in the present study is slightly higher than what was reported by Sadeka *et al* (2018). Moreover, the results from the present study were equally compared with similar literatures (Taha *et al.,* 2015; Akbar *et al.,* 2015; Kofi *et al.,* 2014; Ernest & Johnson, 2013, IAEA, 2007, and European Committee, 2005) as presented in Table 2 and Table 3, and Figure 1. The entrance skin dose obtained in this study was generally lower than that of most published studies. However, in few examinations; they slightly exceeded the values of some of the published works. Furthermore, the estimated effective dose obtained in this study was below the values other works in all the examinations except the PA chest examinations which slightly exceeded with the range 0.02-0.03. This differences in the report may be due to the different exposure factors, image receptors, and, most importantly, differences in patient size.

Table 1: Estimated entrance skin dose (ESD) and effective dose for all projections.

S/N	Examination Projection	Entrance skin Dose (mGy)	Equivalent Dose (mSv)	Effective dose(mSv)
1	PA Chest	0.3733	0.0448	0.0322
2	PA Chest	0.2703	0.0324	0.0233
3	PA Chest	0.3893	0.0467	0.0336
4	PA Chest	0.3733	0.0448	0.0322
5	PA Chest	0.9240	0.1108	0.0798
6	AP Chest	0.3733	0.0448	0.0322
7	AP Chest	0.3893	0.0467	0.0336
8	AP Chest	0.6352	0.0762	0.0548
9	AP Chest	0.2666	0.0320	0.0230
10	AP Chest	0.3733	0.0448	0.0322
11	AP Abdomen	1.0201	0.0408	0.0065
12	AP Abdomen	0.9360	0.0374	0.0059
13	AP Abdomen	1.0201	0.0408	0.0065
14	AP Abdomen	1.1401	0.0456	0.0072
15	AP Abdomen	1.0201	0.0408	0.0065
16	Lat. Skull	0.8400	0.0084	0.0003
17	Lat. Skull	0.7800	0.0078	0.0003
18	AP Skull	0.9240	0.0092	0.0003
19	AP Skull	0.8400	0.0084	0.0003
20	AP Skull	1.0201	0.0102	0.0004

*Values are the results of all the various projections of the examination.

Table 2: Estimated mean entrance skin dose (ESD) for all projections and examinations compared with reported values in the literature.

S/N	Examination Projection	Current study, ESD (mGy)	EC, 2005 (mGy)	IAEA, 2007 (mGy)
1	PA Chest	0.4661	0.3	0.3
2	AP Chest	0.5096	-	-
3	AP Abdomen	1.0273	10	-
4	AP Skull	0.8100	5	2.5
5	Lat. Skull	0.9280	-	-

*Values are the results of all the various projections of the examination.

Table 3: Comparison of estimated mean effectual dose (ED) for all examinations and reported values in some existing literatures.

S/N	Examination Projection	Current study, (*mSv*)	Ernest & Johnson (2013) (*mSv*)	Taha *et al.,* (2015) (*mSv*)	Kofi *et al.,* (2014) (*mSv*)	Akbar *et al.,* (2015) (*mSv*)
1	PA Chest	0.0402	0.0204	0.018	0.02	0.04
2	AP Chest	0.0304	-	-	-	-
3	AP Abdomen	0.0065	0.14	0.300	-	0.28
4	AP Skull	0.0003	-	-	-	0.01
5	Lat. Skull	0.0003	-	-	-	0.01

Table 4: Comparison of estimated effective dose (ED) and World Health Organization (WHO, 2001) standards.

S/N	Examination Projection	Current study, (*mSv*)	W.H.O Standards
1	PA Chest	0.040	0.10
2	AP Chest	0.030	0.10
3	AP Abdomen	0.006	0.35
4	AP Skull	0.001	0.01
5	Lat. Skull	0.001	0.01

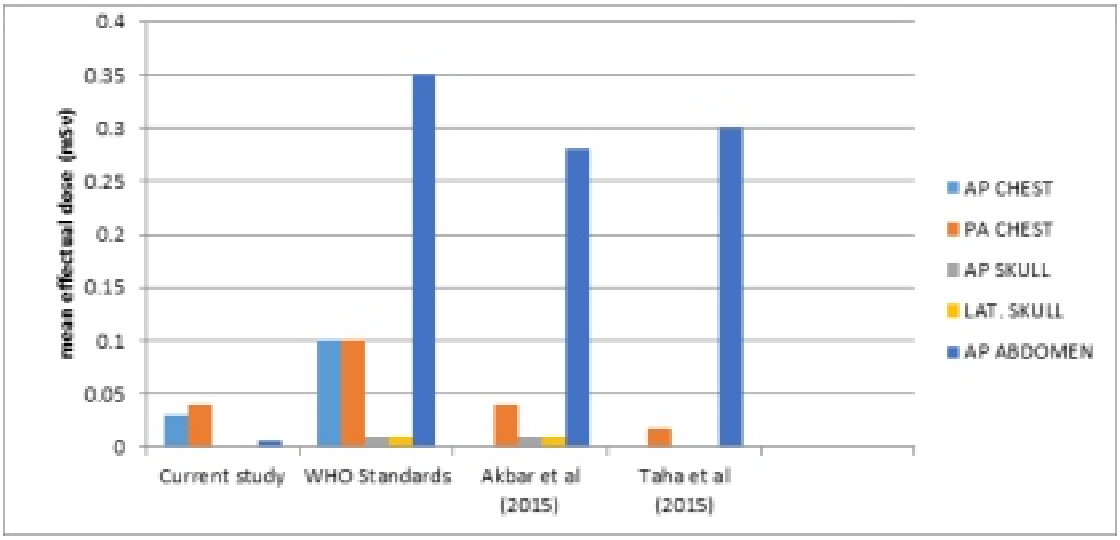

Figure 1: Comparison of estimated mean effective dose for all the examinations and the projected reported values.

CONCLUSION

Considering the range of entrance skin dose obtained in this study, the mean ESD values for each of the examination to rooms differ due to patient's size and exposure parameters. The effective dose received by patients at Federal Teaching Hospital, Gombe, North-eastern, Nigeria is within the World Health Organization (WHO) standards. This study being a novel study, the results of entrance skin (ESD), effective dose (ED) could serve as a baseline study and basis for more comprehensive studies.

RECOMMENDATIONS

Record data should be kept for each patient so as to have record of dosage being given to each patient at the tertiary health institutions to ensure that WHO standards are met. Further study is suggested on a large number of patient's data in order to add to the existing knowledge.

REFERENCES

Aliasgharzadeh, A., Mihandoost, E., Masoumbeigi, M., Salimian, M. and Mohseni, M. (2015). Measurement of Entrance Skin Dose and Calculation of Effective Dose for Common Diagnostic X-Ray Examinations in Kashan, Iran. *Glob. J. Health Sci.*, 7(5), 202–207.

Fisher, D.R. and Fahey, F.H. (2017). Appropriate Use of Effective Dose in Radiation Protection and Risk Assessment. *Health Phys.*, 113(2), 102–109.

Osei, E.K. and Darko, J. (2013). A survey of organ equivalent and effective doses from diagnostic radiology procedures. *ISRN Radiol.*, 2013, 204346.

European Commission (1996). Quality criteria for diagnostic radiographic images in pediatrics. Report EUR16261, office for official publications of the European communities Luxembourg, 1–35.

European Commission (2005). European Guidance on Estimating Population Doses from Medical X-ray procedures. Radiation Protection n.154 International Atomic Energy Agency (2005). Technical Reports Series No. 267 Dosimetry in Diagnostic Radiology: An International Code of Practice. Vienna.

Ibrahim, U, Daniel, I. H., Ayaninola, O., Ibrahim, A., Hamza, A. M. and Umar, A. M. (2014). Determination of Entrance Skin Dose from Diagnostic X-ray of Human Chest at Federal Medical Centre Keffi, Nigeria. *Science World Journal*, 9(1), 14–18.

International Atomic Energy Agency [IAEA] (1996). International basic standards for protection against ionizing radiation for the safety of radiation source. IAEA Safety Series, Vienna.

International Atomic Energy Agency [IAEA] (2007). Technical Reports Series No. 457 Dosimetry in Diagnostic Radiology: An International Code of Practice. Vienna.

Patient Dosimetry for X Rays Used in Medical Imaging (2005). *Journal of the ICRU*, 5(2), iv-vi.

Kofi, O., Samuel, W. G., Emmanuel, A., Adriana, A. and Emmanuel, O. D. (2014). Estimation of adult patient doses for selected X-ray diagnostic examinations. *Journal of Radiation Research and Applied Sciences*, 7(1), 459–462.

Ofori, E.K., Antwi, W.K., Scutt, D.N. and Ward, M. (2012). Optimization of patient radiation protection in pelvic X-ray examination in Ghana. *J. Appl. Clin. Med. Phys.*,13(4), 160–171.

Rubai, S. S., Rahman, M. S., Purohit, S., Patwary, K. A., Meaze, N. H. & Mamum, A. A. (2018). Measurement of entrance surface dose and effective dose of patient in diagnostic radiography. *Biomed. J, Sci & Tech. Res.*, 12(1), 8928–8924.

Suleiman, I. I., Abbas, N. & Habbani, F. I. (2007). Entrance surface doses to patients undergoing selected diagnostic X-ray examinations in Sudan. *Radiation Protection Dosimeter*, 123(2), 209–214.

Taha, M. T., Al-Ghorable, F. H., Kutbi, R. A. and Saib, W. K. (2015). Assessment of entrance skin doses for patients undergoing diagnostic X-ray examinations in King Abdullah Medical City, Makkah, KSA. *Journal of Radiation Research and Applied Sciences*, 8, 100–103.

World Health Organization (WHO) (2001). Quality Assurance in Diagnostic Radiology. Geneva, Switzerland: World Health Organization.