International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 9 Sep 2021, pp: 1061-1065 www.ijaem.net ISSN: 2395-5252

Assessment of Radiation Dose for Adult Patients during Anterior Posterior Pelvic X-ray Examinations

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Submitted: 10-09-2021 Revised: 19-09-2021 Accepted: 23-09-2021

ABSTRACT: The medical use of ionizing radiation is the largest and a growing man-made source of radiation exposure. The aim of this study is to assess the doses received by patients during radiological examinations in order to standardize the examination procedures and optimize the patient dose. Two most referral hospitals, located in the Capital City of Kebbi State, were investigated. The Patients undergoing Anterior Posterior Pelvic X-ray examinations were involved in this study. Entrance Skin Dose (ESD) and Effective Dose were calculated using the X-ray radiation output and the exposure parameters (voltage, tube loading, focus-patient distance). The Cal Dose _X 5.0 software was used to determine the X-rays radiation output. Conversion coefficients were used to relate ESD to the effective dose (ED). A total of 80 radiographic examinations data were collected from the two hospitals during three months of the year 2021. The highest ESD (mGy) was found for the Anterior Posterior Pelvic projection in Sir Yahaya Memorial Hospital, with an average value of 7.80 mGy. The highest value of ED was also observed for the AP Pelvic projection with an average of 0.447 mSv. The ESDs reported in this study are generally higher than reference dose values published by the ARPNSA, NRPB and EC, while ED was remarkably very low compared to other studies. This trend is an indication that the patient radiation protection practices in these two hospitals need to be justified. The results of this study showed that there is a need for justification and optimization in order to reduce patient radiation dose without affecting the quality of the radiographic image. The data of this work will be useful in contributing to the formulation of regional guidance levels.

KEYWORDS: Entrance Surface Dose, Effective Dose and Pelvis x-ray.

I. INTRODUCTION

Over the past hundred years, X-rays have been used for diagnostic purposes. Diagnostic X-rays are used for identifying diseases and other issues during medical examinations. Indeed, X-ray diagnostics allow the exploration of internal anatomical structures by the image obtained following the patient's crossing by an X-ray beam [1]. However, radiation exposure during diagnostic X-ray examinations can cause at the same time harmful effects to the person undergoing exposure, if its use is not optimized. So, the radiation protection is very necessary. This is the reason why the medical use of ionizing radiation is subject to a significant regulatory control. In Nigeria, the use of the X-ray equipment as a medical diagnostic tool is growing. As the patient Dosimetry study during the radiological examination is as a very important step for dose optimization, this experimental study was performed to investigate the patient dose. Similar studies on Entrance Skin Dose (ESD) assessment had been already carried out in the country for pediatric patient undergoing different X-ray examinations. Results demonstrated that the radiation dose levels for patients in radio diagnostic require optimization process. The objective of this study is to determine the ESD and Effective Dose (ED) for adult patients during radiographic X-ray examinations in the regions of Kebbi State [1]. Patient radiation protection in pelvis X-ray examination has not been given much attention in Nigeria. Therefore this study was set out to provide an estimate of patient dose in pelvic examination being undertaken at selected diagnostic centers in Kebbi as a baseline data for pelvic dose optimization in the region. The estimated mean ESD values were compared with the International organization and countries [2].

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II. MATERIALS AND METHOD

The current work was conducted in the major hospitals of Kebbi State, Nigeria. This includes Sir Yahaya Memorial Hospital and Federal Medical Centre. From two hospitals, two x-ray rooms were included in this study. Before effective dose, exposure factors (physical parameters) were recorded for all patients undergoing AP pelvis radiography (i.e. kVp, mAs and SID) [3]. In this study, the effective dose was estimated using windows based computer software called CALDose_X version 5.0. This software has been developed by Kramer et al. The CALDose_X 5.0 is a tool that enables the researchers to calculate some dosimetric quantities to include incident air kerma (INAK) and entrance surface air kerma (ESAK). The latter quantities are considered keys to be used in diagnostic X-ray. Additionally, this software allows the possibility of assessing body organs doses for different radiographic examinations. All the aforementioned quantities of this software, have been calculated using the FAX06 and the MAX06 phantoms

Study Location

Two referral hospitals were included in this work and are located in Kebbi State, Nigeria. The criteria for the selection of the hospitals considered for this study is the high number of patients that visit the facility for X- ray examinations. And they are the most referral hospital in Kebbi State.

Patient Data Collection

Radiation dose assessment was conducted for 80 patients during the period of study, from March to 2021. Inclusion criteria were the age of patients which were over 20 years and who underwent pelvic radiographic examinations in the two selected hospitals. Data collection was based on three categories:

- The patient data as age and sex
- The X-rays exposure parameters, such as voltage, tube loading, Focus Film Distance (FFD) and focus to skin distance
- Radiographic examinations and projections

III. DATA ANALYSIS

The Data was analyzed using Cal Dose_X soft ware version 5.0. The data collected such as kV, mAs, and FFD were inserted into software for Backscatter factor calculation which later be used to calculate ESD as shown in equation 1 below. starting this work, an ethical approval was obtained from Kebbi State Ministry of Health and FMC ethical Clearance committee. The works started with recording demographic information on each patient gathered on each X-ray unit. These data can be seen in table 1 [3]. To estimate the entrance skin dose and

The tube output was obtained from curve of kV and mAs in the software, while backscatter factor for pelvis examinations was obtained by taking the ratio of ESAK to INAK as determined by Cal Dose X.

Assessment of Entrance Skin Dose

In this study, the ESD for patients was assessed by an indirect method, using soft ware and empirical formula:

$$\mathbf{ESD} = \mathbf{BSF} \times \mathbf{Tube\ Output}\left(\frac{\mathbf{mGy}}{\mathbf{mAs}}\right) \times \left[\frac{\mathbf{kV}}{\mathbf{80}}\right]^{\mathbf{2}} \times \left[\frac{\mathbf{100}}{\mathbf{FSD}}\right]^{\mathbf{2}} \times \mathbf{mAs} \quad \mathbf{(1)}$$

Where tube Output is the beam output in mGy/mAs measured from the X-ray tube at different kvp settings at distance of 1 m divided by mAs which is the product of the tube current (mA) and the exposure time in seconds. The focus-to-skin distance (FSD/cm) was calculated from the Focus Film Distance (FFD/cm) for all projections by subtracting the standard patient thickness for each projection. The patient thickness of 20 cm for all examinations was used. The backscatter factor values (BSF) was recorded for pelvis.

Determination of Effective Dose

The effective dose (ED) is one of the parameters used to assess the relevance of examinations involving ionizing radiation **[1]**. The ED value was obtained using CALDose_X 5.0. The effective dose based on CALDose_X 5.0 is then the average of the sex-specific weighted doses,

E = 1/2 [F + M].CALDose_X 5.0 calculates a weighted female dose (F) and a weighted male dose (M) given at the end of the result.

VIII. RESULT AND DISCUSSION

Exposition Parameters and Entrance Skin Dose

The mean, minimum, maximum, max/min ratio and STDV values of tube potential (kVp), tube loading (mAs), focus - film distance (FFD) and Entrance Skin Dose (ESD) for all examinations were recorded and are shown in table 1. Large fluctuation of the examination parameters has been established. It can be explained by the difference in the examination protocols adopted by each hospital and the patient size. According to previous studies

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made, the patient age is a significant parameter in the selection of the technical parameters and in considering the interpretation of radiological images. The choice of the high voltage, the tube loading and the FFD in this study was done for obtaining good quality according to the different morphology of the patients [4]. The data were recorded for the two hospitals. Both SMH and FMC carried out all the two examinations with AP projections. The average values of the entrance skin dose (ESD) by the two centres for each examination were calculated according to the formula given above and are shown in Table 1.

Table 1 the ESD for each examination by SMH and FMC

Centre	Examination	Exposure Parameters	Minimum	Maximum	Min/Max	Mean	STDEV
SMH	Pelvic	Age	20	75	3.75	40	15
		FFD (cm)	100	120	1.20	101	3.32
		KV (kv)	60	84	1.4	78	3.41
		MAs	18	32	1.78	23.47	3.28
		ESD (mGy)	3.67	12.21	3.33	7.80	1.44
		ED (mSv)	0.19	0.71	3.74	0.45	0.09
FMC	Pelvic	Age	25.00	75.00	3.00	44.00	15.86
		FFD (cm)	100.00	105.00	1.19	105.00	7.13
		KV (kv)	70.00	85	1.00	79	4.01
		MAs	25.00	40	1.25	34	6.53
		ESD (mGy)	2.49	11.28	1.16	7.12	2.42
		ED (mSv)	0.09	0.32	2	0.20	0.07

The most reliable Dosimetry quantities commonly used in diagnostic radiology to give an indication of the typical dose that is being delivered to an average adult patient are the patient Entrance Surface (skin) Dose (ESD) including backscatter for simple X-ray projections. The ESD, in particular, is recommended as the most appropriate dosimetry quantity for simple X-ray projections since it meets the three basic conditions set out by the International Atomic Energy Agency (simple to measure, permits direct measurement on patient during the examination, and is representative of the dose received by the patient). It is also recommended by the Commission of the European Communities (CEC) in the document on quality criteria for the most common radiographic images. In addition, the measurement of ESD permits easy comparison with published diagnostic guidance or reference levels. In comparison with other studies, figure 1 indicated that the Entrance Skin Dose of pelvic radiographic examination in the two centres found to be very high compare to the published studies of international organization and countries such as NRPB, ARPNSA, Iran and Italy.

Table 2 Comparison of the Mean ESD [mGy] with other work

Examination	SMH	FMC	[13]	[12]	[14]	[11]	[10]	[4]	[9] 2007
Pelvic AP	7.80	7.12	2.32	3.34	2.77	4.00	4.0 0	4.7 1	2.40

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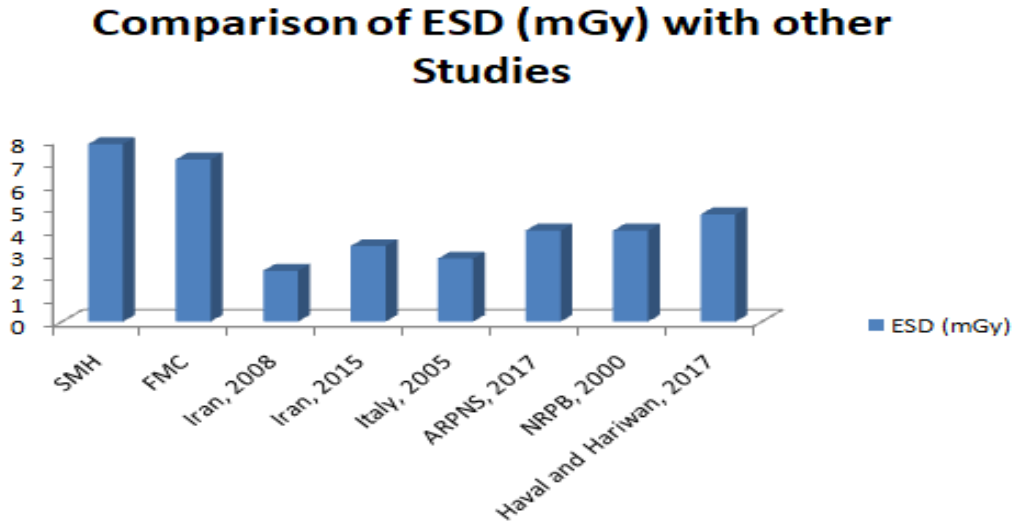

Figure 1 chart showing the comparison of ESD with other works

The average value of the effective dose (ED) by hospitals and for each examination is shown in Table 2.

Table 2 Comparison of the Mean ED [mSv] with other work

Examination	SMH	FMC	[4]	[5]	[6]	[7]	[8]
Pelvic	0.447	0.203	0.83	0.90	0.88	1.12	0.16

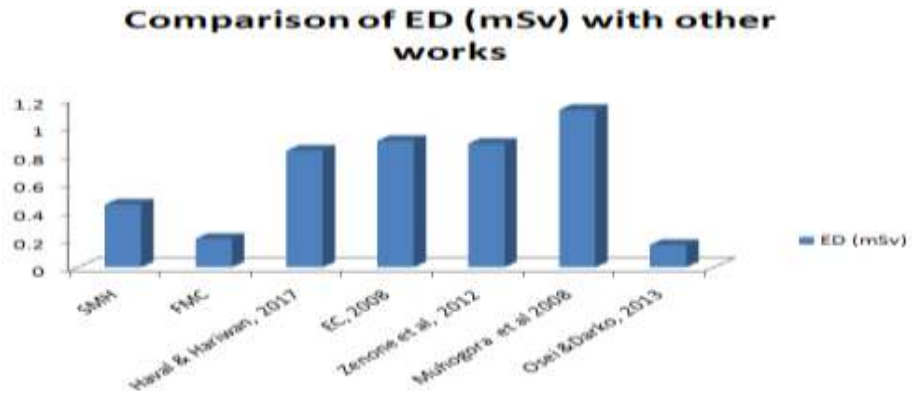

Figure 2 Chart showing the effective dose compare to other studies

The effective Dose calculated by the software was tabulated and compared with European community and other published works as in table 2. The compared results indicated that the value obtained in this study was very low. In figure 2, the effective dose obtained in the two centres was remarkably very low; especially FMC recorded very low ED.

IX. CONCLUSION

This study assessed the Entrance Surface Dose and Effective Dose for patients undergoing AP pelvis x-ray examinations in two selected hospitals in Kebbi State, regions of Nigeria. Effective Dose determination was carried out as it is an effective approach of risk assessment to patient exposed to medical radiation. The results shown that the Entrance Skin Dose is remarkably high compared to the published results, Similarly Effective Dose values obtained in this study is lower than the published value. This implies that the radiation exposure risk for the patients undergoing AP pelvis radiographic examinations in the two hospitals included in this study is relatively low. However, even with such low level, it is always necessary to take precaution, due to the stochastic nature of the X-rays radiation effects. Indeed, the low dose value could anyway causes stochastic risks. From this

study, it is proposed to reduce patient dose while maintaining image quality by using high voltage (kVp) and low charge (mAs). The findings of this work indicate also the need of quality assurance program Clear protocol to describe patient radiation exposure during radiation examination is also suggested to avoid repeating X-ray examination. Finally, this study was carried out only in two referral hospital in Kebbi State. Actions are underway to extend measurements into nationwide level. For this purpose, determination of patient doses through some regional approach and at national level is needed for establishing national diagnostic reference level.

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