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Patient Radiation Dose Assessment in Routine Pelvic X-Ray Examination in Selected Hospitals in Khartoum State

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Abstract: ***The aim of this study was to assess patient doses for pelvic x-ray examination being conducted at selected diagnostic centers in Khartoum state, Sudan. Dose was calculated on 122 patients (70 male, 52 female). ages between 18 to 86 years. The Entrance Surface Dose (ESD) was determined by an indirect method, using the patient's anthropometric data (age, gender) and exposure factors (kVp, mAs) utilized for the specific examination. To generate the ESD values excel was used. There were variations in the technique factors used in all the centers. The average in all selected hospitals recorded lower ESD values below IAEA recommended diagnostic reference levels (10 mGy) and the average of ESDs of the all hospitals exceeded the UK national reference value (4mGy). The variations in ESD found among diagnostic centers in this survey showed that there was a need to standardize radiological techniques of pelvis X-ray examination among different diagnostic centers in Khartoum State. This would ensure optimal protection of patient against excessive radiation dose as protecting the gonads of patients is of particular importance during x-ray diagnostic imaging of the pelvis, since evidences suggest that x-ray could cause direct damage to the gonads which results in mutation so the effective way of reducing dose to patients reproductive organs and reduce the risk of genetic effects in the future generation is gonad shielding during x-ray procedure. This work has therefore provided a baseline against which further dose measurement could be compared. It could also help increase staff awareness to patients radiation dose levels and adjustment of such dose levels where necessary leading to reduction in patient dose.***

Keywords: Pelvic x-ray, ESD

1. Introduction

Over the past hundred years or so, X-rays have been used for diagnostic purposes. The use of X-rays for imaging purposes, however, exposes patients to ionizing radiation. The increasing use of X-ray in hospitals has made medical exposure an important source of radiation in the population collective dose. Ionizing radiation has the ability to break apart biologically important molecules such as DNA in exposed cells and can cause harm. As a result, the amount of radiation received by patients undergoing X-ray examinations needs to be quantified to estimate the possibility of harm. Patient doses in radiography primarily depend on the entrance surface dose and the sensitivity of the organs and tissues that are irradiated during the radiographic examination. Radiation protection is concerned with the control of the manner in which sources of ionizing radiation are used so that the user of the sources and also members of the public are not irradiated above acceptable levels recommended by the International Commission on Radiological Protection. [1]

Protecting the gonads (testes, ovaries) of children and adults is of particular importance during diagnostic imaging of the pelvis [2,3,4]. Evidence suggests that X-rays could cause direct damage to the gonad which could result in mutation. Gonad shielding during diagnostic X-ray procedures is an effective way of reducing dose to patients' reproductive organs and reducing the risk of genetic effects in future generation, and given this unavoidable potential harmful effects associated with exposure to ionizing radiation, it is important not just to provide gonads shielding in pelvic x0ray examination, but also to measure patient doses, and reduce them where possible [2].

Radiation doses to patients in diagnostic radiography are normally expressed in terms of entrance surface (skin) dose (ESD) per radiograph including back scatter for simple x-ray projection, and dose area product (DAP) for complete examination.

The ESD in particular, is recommended as the most appropriate method. These quantities have the advantages that they are easy to measure (permits direct measurement on patient during the examination, and representative of the dose received by the patient), and measurement of ESD permits easy comparison with published diagnostic guidance or reference levels [2, 3].

The patient radiation protection in X-ray examinations may has not been given much attention. therefore The aim of this study was to provide an estimate patient dose in pelvic x-ray examination being conducted at selected diagnostic centers in Khartoum state as a baseline data for pelvic dose optimization, and estimated mean ESD values by comparing them with the International Atomic Energy Agency, the

European union (EU) guidance on diagnostic reference levels for medical exposures, and the 2005 United Kingdom reviewed reference levels [2].

Radiation is an energy that travels through space or matter. Two types of radiation used in diagnostic imaging are electromagnetic (EM) and particulate [5].

2. Materials and Method

2.1 Materials

2.1.1 Study area
The data were collected from seven selected hospitals in Khartoum state, where coded by 1, 2,…. and 7 hospital

2.1.2 Study population
Patient Radiation dose assessment was conducted on 122patients 18 years old and above, who underwent pelvic examinations during the study period.

2.1.3 X-ray equipment:
In this study we use seven X-ray machines in different selected hospitals as shown in table 3.1 all of which were constant potential generators at 80 kVp, for purposes of ethical consideration the study sites were coded 1, 2,.... and 7.

Two manufacturer's cassettes were in use during the study, namely (Agfa and Kodak) with two different screen–film combination speeds.

2.2 Methods

2.2.1 Collection of data
Data were collected on 122 patients who underwent anterior-posterior (A-P) pelvic x-ray examinations in 7 selected hospitals. The number of radiographers and radiographic technicians participated in the study was same to the number of hospitals.

The patients' anthropometric data (age, gender) were recorded and then they were centered by technician to record the parameters such as peak tube voltage (kVp), exposure current and time product (mAs) and focus to surface distance (FSD) at the time of the examination for each patient undergoing the pelvic x-ray examination. The kVp and mAs was changed according to the patient age and weight.

2.2.2 Patient radiation dose assessment:
In this study the entrance surface doses (ESD) for patients undergoing pelvic x-ray examination were calculated by using the mathematical equation.

The ESD is defined as the absorbed dose measured in air on the x-ray beam axis at the point where the x-ray beam enters the patient. The exposure factors were fed in excel program and then the mean, standard and also minimum and maximum values for kV, mAs, and age were decided (in tables), and the data were compared with internationally recommended reference values. The ESD was calculated in the present work using the following relation:

ESD = OP× (kV/80)^2× mAs × (100/ FSD)^2×BSF **(Equation 1).**

Where (OP) is the tube output per mAs measured at a distance of 100 cm from the tube focus along the beam axis. kVp is peak tube voltage recorded for any given examination. mAs is the tube current and time product, FSD is the focus-to-patient entrance surface distance and BSF is the back scatter factor, with a value of 1.35 in this study [6], The data were analyzed using excel program.

2.2.3 Data Analysis
The entrance surface dose (ESD) measured and other data collected were analyzed using descriptive statistics (minimum and maximum, average, and standard deviation).
The average ESD value for projection was obtained by summing up the individual ESD values and dividing by the number of projections. It was computed from the formula,
AV = Σ(X)/N **(Equation 2).**
Where Σ = Sum of
X = Individual ESD values.
N = Sample size (number of projections).

Table 1: features of X-ray machines in three examination rooms used for the study.

Characteristic of the X-ray generator

Power rating	*Manufacture date*	*Exposure setting*	*type*	*Room no.*
40-150	2007	AEC and Manual	Shimazdu	1
40-133	2003	AEC and Manual	Siemens	2
40-150	2010	AEC and Manual	Shimazdu	3
40-150	2008	AEC and Manual	Shimazdu	4
40-150	2006	AEC and Manual	Shimazdu	5
40-150	2012	AEC and Manual	Shimazdu	6
40-133	2007	AEC and Manual	Siemens	7

Exposure Control AEC: Automatic

The standard deviation is the most common measure of variability, measuring the spread of the individual ESD values and the relationship of the mean to the rest of the data. If the individual ESD values are close to the mean, indicating that they are fairly uniform, then the standard deviation will be small.
Conversely, if the individual ESD values are far from the mean, indicating that there is a wide variance, then the standard deviation will be large. If all the data values are equal, then the standard deviation will be zero. The standard deviation is calculated using the following formula:
SD = Σ(X-M)^2/n – 1 **(Equation 3).**
Where Σ = Sum of
X = Individual ESD values
M = Mean of the measured ESD values
n = Sample size (number of projections).

3. Results

The age range for all patients in the hospitals was 18.0–86.0 years, with average 47.39 yrs., standard deviation 19.72 yrs. for males, and with average 48.58 yrs., standard deviation

17.82 yrs. for females. The Descriptive statistics on patient's age were shown in Table (3), and the number of patient's in selected hospitals based on age group was illustrated in table (3).

The descriptive statistics maximum, minimum, average and the Standard Deviation (SD) of the Entrance Surface Doses (ESD) based on age group and gender estimated for the all examinations in all selected hospitals were calculated and are presented in table (4).

Table 2: shows the gender distribution frequency and percentages

Gender	Frequency	Percentage
Male	70	57.4 %
Female	52	42.6 %

Table 3: Descriptive statistics on patient's age/ years

Gender	*Descriptive statistics of patients age/year*		*Average + SD for all patients*
	Max	*Min*	
Male	86	19	48.58 + 17.82
Female	77	19	47.39 + 19.72

Table 4: number of patient's based on age group

Age group/ year	*Gender*	
	Male	*Female*
18 – 28	13	7
29 – 38	14	12
39 – 48	11	10
49 -58	8	8
59 – 68	7	5
69 – 78	10	6
79 – 88	7	4

Table 5: Descriptive statistics of ESD based on age group and gender in all selected hospitals / mGy

Age	*Male*			*Female*	
group/years	*Max*	*Min*	*Average+SD*	*Min*	*average+SD*
19 – 28	18.45	2.8	6.1+4.5	1.9	3.6 + 1.6
29 – 38	18.5	3.9	7.6+6.1	1.9	4.7 + 2.1
39 – 48	6.2	1.9	4.5 + 1.5	4.2	5.9 + 1.6
49 -58	17.5	1.6	6.2 + 5.0	2.5	5.7 + 3.9
59 – 68	7.6	3.0	5.3 + 1.6	3.5	7.4 + 2.2
69 – 78	12.1	1.4	5.3 + 4.6	2.8	3.9 + 0.9
79 - 88	0	0	0	0	0

Table5 mean ESD (mGy) for all gender in present study and previous studies as compared with DRLs for (IAEA, EU,1996) and (UK,2005),[7,8.9].

Table 6: Descriptive statistics of ESD based on age group and gender in all selected hospitals / mGy

Countries	*ESD(mGy)*
Present study	5.5
Kofi Ofori(2014)	1.31
Ghana(Ofori EK,2013)	6.85
Aliasgharzadeh(2015)	1.76
IAEA, EU	10
(NRPB, (Uk2005),	4

4. Discussions

This study intended to evaluate the radiation doses for patients undergoing pelvis x-ray examination in Khartoum state, Sudan. It was anticipated that the study would help in the optimization of radiation protection of the patient. A total number of 122patients radiographs were included in this study. The data were collected from three major hospitals in Khartoum. The x-ray machines used to imaging were of two type from Shimadzu, and a third one was Siemens, by different kVp and mAs.

The estimated ESDs to pelvis AP ranged from (1.8 – 8.9) mGy for hospital 1, (1.4 – 7.4) mGy for hospital 2, (3.2 – 18.5) mGy for hospital 3, (4.47 – 6.45) mGy for hospital 4, (2.73 – 4.82) mGy for hospital 5, (3.18 – 3.67) mGy for hospital 6 and (2.53 – 3.16) mGy for hospital 7.

When comparing these values with reference levels, table 5 performed in Sudan the average ESDs evaluated by this work were found relatively lower than reference levels in all selected hospitals under study, The maximum dose value (18.5 mGy) in this study was found in C-hospital while the minimum dose value (1.4 mGy) was found in B-hospital.

The results in this study found variations in ESD among diagnostic centers, some of the average values did not exceed the reference values and they are expected to encourage further dose surveys in the area of diagnostic radiology that will eventually lead to possible establishment of DRLs, and for that values exceeding DRLs it could help to increase staff awareness to patient radiation dose levels and adjustment of such dose levels where necessary leading to reduction in patient dose.

5. Conclusion

ESDs were estimated in the study for patients undergoing routine pelvis X-ray examinations in seven hospitals in Khartoum state. In all selected hospitals the average of ESD was within the recommended value from EU/ IAEA, and in hospitals A and B average of ESDs was higher by low value than recommended DRLs of UK-2005 comparing by C hospital which was much higher than DRLs of UK-2005. Due to the tube output difference from hospital to other and the focus-to-skin distance (FSD) used to calculate ESD which was usually different from patient to anther because of the patients' sizes which have a direct impact on ESD.

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