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Determination of Diagnostic Reference Level for Pelvis X-Ray Procedures in Some Radiological Facilities in Abuja Metropolis, Nigeria

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Abstract: The worldwide increase in the use of radiation in diagnostic radiology practice has increased the need for organizations that deal with radiation protection to focus on improving patient protection via the establishment of DRLs. This study was aimed at determining the diagnostic reference level for the pelvis anterior-posterior in some radiological facilities in Abuja metropolis, Nigeria for the establishment of a local diagnostic reference level for Abuja Metropolis. Entrance surface air kerma of 48 mature patients who undertook pelvis anterior-posterior examinations in five centers in Abuja Metropolis, Nigeria using indirect methods were evaluated and used to determine the diagnostic reference level in these centers. The mean values of entrance surface air kerma in each center were 2.39mGy, 2.23mGy, 2.76mGy, 2.75mGy and 3.04mGy with observed variations across different centers and the estimated diagnostic reference level from the five centers included in this study were 2.90mGy, which was found to be lower than the established international reference levels. This implies that radiation risk to average patients in the centers included in this study is low.

Keywords: Entrance surface air kerma, diagnostic reference level, pelvis X-ray examination, and radiological facilities.

1 Introduction

Medical X-ray imaging is extensively used worldwide, making the practice the most significant source of medical exposure to ionizing radiation compared to therapeutic components [1]. It contributes to more than 90% of medical procedures, as seen in the large number of diagnostic examinations conducted worldwide [1]. As such, the highest contributor to population exposure from man-made radiation exposures is medical exposure of patients from ionizing radiation, constituting 95% [2].

The use of medical X-ray imaging in both developed and developing countries of the world has increased rapidly mainly due to continuous advancements in the quality of images from X-ray machines even though other machines such as MRI and ultrasound are increasingly being used for diagnosis [3].

Data obtained from NNRA Stakeholders in Nigeria such as Radiation Safety Advisers (RSA) during a Stakeholders' meeting held in 2018 revealed that an average of 100,000 people undertook X-ray procedures in Abuja annually, with the most prevalent ones being pelvis anterior-posterior, extremities, cervical spine anterior-posterior, chest posterior-anterior and lumbar spine anterior-posterior [4].

Analysis of medical exposures over the years showed that the number of diagnostic radiology procedures increased by 130% from 1988-2008, in contrast to a mere 26% increase in the worldwide population during the same period [5].

Thus, there is a need for these radiation doses to be optimized by the determination of diagnostic reference levels [1]. Patient dose optimization is vital for radiation protection and also when this DRL is established it will assist the diagnostic radiology centres in implementing and

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complying with radiology regulations.

2 Materials and Methods

2.1 X-Ray Machines

This research work was undertaken in five diagnostic radiology centers in Abuja metropolis, Nigeria that have NNRA authorizations and included five X-ray machines from these centers subsequently referred to as L, M, N, O, and P. The selections of these centers were based on the significant number of pelvis X-ray procedures carried out daily.

2.2 Parameters and Calculations

The parameters of the patients and the X-ray exposure factors used for the selected patients who underwent the pelvis AP procedures were taken, recorded, and used to calculate ESAK.

2.3 Calculation of ESAK:

$$ESAK = K_i B \quad (1)$$

Where Ki is the Incident Air Kerma and B is the backscatter factor using tabulated B values given by IAEA [1].

$$K_i = Y(d, KV)\, P_{it} \left(\frac{d}{D_{FSD}}\right)^2 \quad (2)$$

Where D_{FSD} is the focal spot distance and was calculated from the focus to film distance (FFD) and thickness of the patient (t_p) using the equation:

$$D_{FSD} = FFD - t_p \quad (3)$$

Patient thickness was deduced from patient weight (W) and height (h) [6].

$$t_p = \sqrt[2]{\frac{W}{\pi h}} \quad (4)$$

$$Y(d, KV) = \frac{K_a(d, KV)}{P_{it}} \quad (5)$$

Where Y(d, KV) is the tube output measurement from the X-ray, k_a is the air KERMA quotient measured with the aid of Cobia Smart R/F (semiconductor detector) manufactured by RTI Group with serial number CB3-19098461 calibrated to measure tube potential between 18 – 150KVp at specified distanced (d) 100cm, and P_{it} is the tube current exposure – time product also called mAs.

2.4 Samples of Patients

Forty-eight (48) mature patients who underwent the pelvis X-ray procedures were selected randomly in the five (5) centers and the required data were collected. The data were collected using a template that captured the date, sex, age, weight, type of exam, X-ray equipment details, tube focus to patient surface distance, tube focus to film distance, type of X-ray procedure, and exposure details (KV and mAs or mA and time). Table 1 captured the machine's details.

Table 1: Specification of machines in selected centers.

Centers	Equipment Type	Manufacturer	Serial No.	Model No.
L	Mobile X-ray	GE Company USA	46270615p3	46-270615
M	Mobile X-ray	Elgin Medical, England	1560	----
N	Fixed X-ray	EcoRay Co. Ltd, Korea	COL-1411431	SMS-CM-N
O	Fixed X-Ray	G E Haulun Medical System, China	143603BC9	5331186
P	Fixed X-ray	Toshiba, Japan	11K1130	E725X

2.5 Data Analysis

Data were analyzed using Excel version 2007 to compute the first and third-quartile values of the mean distribution. DRLs were computed as the third quartile value of the distribution of the mean ESAK from the selected centers, while the first quartile value was used as the lower limit below which centers are recommended to review their parameters to check if they are not using very low doses that produce poor-quality images [7,1].

3 Results

Table 2 shows the patients' parameters and exposure factors of patients who underwent pelvic AP in the selected five centers. The patients' parameters recorded were age (yrs), weight (kg), and Height (m) while the exposure factors recorded were KVp, mAs, and FFD.

The age of patients for the five centers L, M, N, O, and P ranged from 32yrs to 70yrs with a mean weight of 61kg, 65kg, 71.5kg, 67.3kg, and 70.2kg respectively. The height of patients was between 1.5 and 1.8 m in all centers. The KVp used for patients that underwent the Pelvis AP in the centers ranged from 70 to 85, while the mAs or P_{it} ranged from 20 to 60 as given in Table 2. The FFD was the same in centers L, M, N, and O at 100 while center P was 90cm.

Tube Output of X-ray for centers L, M, N, O, and P are 0.0673mGy/mAs, 0.0445mGy/mAs, 0.0593mGy/mAs,

Table 2: Mean (range) Values of Patients' Parameters and X-ray exposure factors for Pelvis AP Examination.

Centers	No.	Age (yrs)	Weight (Kg)	Height (m)	KVp	mAs	FFD (cm)
L	10	40(32-55)	61 (44-71)	1.52(1.5-1.7)	79.5(78.0-85.0)	23.3(20-32)	100(100-100)
M	8	48(43-51)	65(60-75)	1.6(1.55-1.7)	68.5(65.0-75.0)	33.0(30-60)	100(100-100)
N	15	57(56-65)	71.5(65-80)	1.6(1.45-1.6)	87.2(85.0-90.0)	29.5(28-32)	100(100-100)
O	10	50(47-70)	67.3(62-76)	1.55(1.5-1.8)	86.7(85.0-90.0)	26.5(20-45)	100(100-100)
P	5	45(44-58)	70.2(65-80)	1.6(1.47-1.7)	75.0(70.0-85.0)	22.6(20-25)	90(90-90)

0.0660mGy/mAs, and 0.0694mGy/mAs respectively. The distance of focal spot to surface distance calculated from the values of film focal distance (FFD) and patient thickness (t_p) shows the values for centers L, M, N, O and P are 92.9cm, 92.8cm, 92.5cm, 92.6cm and 82.5cm respectively. The calculated Incident Air Kerma were1.8169mGy, 1.7052mGy, 2.0445mGy, 2.0397mGy, and 2.3044mGy respectively for centers L, M, N, O, and P as presented in Table 2.

The mean values of Entrance Surface Air Kerma for centers L, M, N, O, and P as presented in Table 3 are 2.39mGy, 2.23mGy, 2.76mGy, 2.75mGy, and 3.04mGy respectively. There were observed variations in mean ESAK values across different centers. The minimum was 2.23mGy and the maximum was 3.04mGy. These variations may be ascribed to the variations of exposure factors used within the centers and also to the different equipment technologies used which have different detective quantum efficiency and exposure latitude [8.9].

Furthermore, the equipment used in the different centers differed in age. Equipment that has been in use for a long time would have aged and the X-ray tube target would have roughened and worn out resulting in self-filtration according to observations by IAEA [10].

3 Discussions

DRL was calculated as the third quartile distribution of the mean ESAK distribution from the five centers, the same approach was adopted by several organizations including the NRPB, ICRP, and IPSM. The DRL for the Pelvis AP examination was 2.90mGy which was lower than IAEA [11] which was 10mGy, UK [12] at 5.70mGy, and Japan [13] at 4mGy but higher than Sudan [14] at 2.80mGy.

However, this value obtained in this study, still indicates an improvement in optimization of patients doses when result obtained in this study is similar to the work of Olaide et al. [15] who obtained ESAK of 2.75mGy using the indirect compared to IAEA [11], UK [12], and Japan [13]. The indirect method in Niger State, Nigeria. This result is also similar to the findings of other researchers reviewed in this study such as Awad [14] who obtained 2.4mGy at Khartoum, Sudan, and Bakir *et al*. [3] who obtained 1.82mGy at Al-Najaf, Iraq. However, this finding is not in line with the findings of Abdullah [16] who obtained ESAK of 8.10mGy using the indirect method at Khartoum, Sudan.

This may be ascribed to the variations of exposure factors used in the study and also to the different equipment technologies used which have different detective quantum efficiency and exposure latitude. Also not in line with the findings of Ncube [17] who obtained an ESAK of 9.04mGy using the indirect method at Bulawayo Metropolitan Province, Zimbabwe.

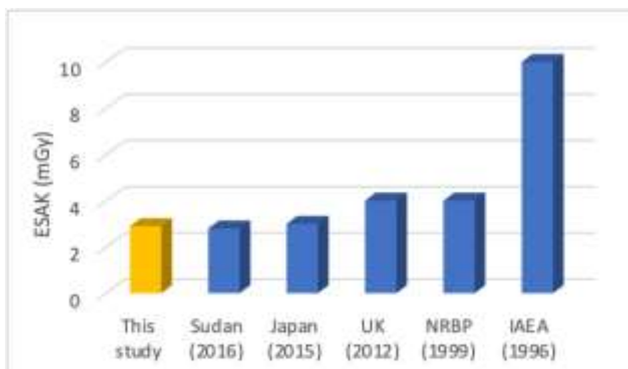

Fig. 1: Comparison of the determined DRL for Pelvis AP procedure with established DRLs.

5 Conclusions

Entrance Surface Air Kerma (ESAK) for 48 mature patients who undertook pelvis AP examinations in five centers in Abuja Metropolis, Nigeria using indirect methods were evaluated and used to determine the DRL for pelvis AP in these centers. The determined DRL was found to be lower than the established international reference levels. This implies that radiation risk to average patients in the

Table 3: Variation of Determined Mean ESAK for the Different Centres for Pelvis AP Examination.

Centres	t_p(Kg/m)	Y(d,KV) (mGy/mAs)	D_{FSD} (cm)	K_i (mGy)	BSF (IAEA, 2007)	ESAK (mGy)
L	7.1	0.0673	92.9	1.8169	1.32	2.39
M	7.2	0.0445	92.8	1.7052	1.31	2.23
N	7.5	0.0593	92.5	2.0445	1.35	2.76
O	7.4	0.0660	92.6	2.0397	1.35	2.75
P	7.5	0.0694	82.5	2.3044	1.32	3.04

centers included in this study is low and hence, the results obtained can be used to propose the establishment of local DRLs for pelvis AP in Abuja Metropolis, Nigeria. Also, the findings showed that when technical and clinical factors are optimized, it can lead to a substantial patient dose reduction. Furthermore, the findings should be used for the establishment of local DRL for pelvis AP in Abuja Metropolis, Nigeria to aid optimization of patients' doses

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Competing Interests

There are no competing interests.

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