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Evaluation of Patient Radiation Dose from Skull X–Ray Diagnostic Examinations in Some Nigerian Health Facilities

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Abstract

The use of ionizing radiation in diagnostic examinations can pose a health risk to the patient if it is not properly managed. Although ionizing radiation has many beneficial applications it has to be optimized. In this study, the patient doses in the radiographic examination of skulls in ten health facilities in Nigeria were assessed. A total of 140 adult patients comprised of 80 males and 60 females with age ranges from 30 years to 46 years who underwent skull x-ray examinations were considered in the study. The entrance dose air kerma (ESAK) was calculated using the patient's anatomical data and exposure parameters used during specific examinations. The mean value of ESAK ranged from 0.88 mGy to 6.42 mGy for skull AP/PA and ranged from 1.07 mGy to 4.61 mGy for skull LAT. The result obtained shows a significant variation of the ESAK values within the same health facility and among the various facilities. A comparison of the results obtained in this study, with published international established reference levels (DRLs) shows that 50% of the health facilities have higher dose values in skull AP/PA.

Keywords: Patients, Radiation doses, ESAK, Skull.

1. Introduction

Radiographic imaging is the frequently applied diagnostic instrument in developing countries like Nigeria. The application of ionizing radiation in radiological examination causes health risk to the patient and medical personnel. The health effects may be immediate or later and it can lead to cancer induction, hereditary effects, and malignant conditions. Therefore, there is a need to evaluate the patient's radiation dose during radiographic procedures which will help in quantifying the health risks associated with patient radiological examinations [1]-[2] The justification and optimization principles of protection in the use of ionizing radiation in medical activities were recommended by the International Commission for Radiological Protection (ICRP) to reduce radiation hazards in patients [3]. The integral part of the optimization principle is regular monitoring of radiographic equipment and assessing radiation dose to patients to evaluate their exposure level.

In Nigeria, various surveys on patient doses have been carried out and have shown wide inter- and intra- x-ray units patient dose variations for the average patient size undergoing similar examinations [4]-[17]. These variations showed that the techniques employed during radiographic procedures were not fully optimized and that unwanted radiation doses had been delivered to the patients and these necessitate the constant monitoring and evaluation of patient radiation doses in diagnostic procedures in Nigeria.

The skull diagnostic examination is of paramount importance, since it may have direct damage to the patient's eye lens, which can lead to detectable opacities or visual impairment such as cataracts. [18]. Therefore, a skull X-ray examination needs thyroid shielding and patient dose assessment to minimize radiation doses to the patient.

In this survey, the entrance surface air kerma (ESAK) for the skull (AP/PA, LAT) examinations will be determined using the International Atomic and Energy Agency (IAEA) code of practice as stated in IAEA protocol and guidelines on indirect patient dose measurements.

2. Materials And Method

The present study was conducted between 2018 and 2021 and ten (10) health facilities in four states in southern Nigeria. These facilities include University Teaching Hospital (UTH) Ado–Ekiti; Two Tees Diagnostic Center (TTS), Ibadan; Obafemi Awolowo University Teaching Hospital Complex (OAUTHC) Wesley Guild Ilesa; Seventh Day Adventists Hospital (SDH), Ile – Ife; Oba Adenle Memorial Hospital (OAMH) Ilesa; the

University of Benin Teaching Hospital (UBTH) Benin – City; Ayinke Diagnostic Center (ADC) Ilesa; Federal Medical Center (FMC) Ido Ekiti; Ladoke Akintola University Teaching Hospital (LTH) Osogbo and Central Hospital (CH), Benin – City.

A total of 140 adult patients comprised of 80 males and 60 females with age ranges from 30 years to 46 years who underwent skull x-ray examinations were considered in the study. For each patient the following information was obtained and recorded: age, sex, weight, exposure parameters (tube potential kVp, tube loading mAs); filtration, focus–film distance (FFD), Irradiation site thickness (t_p). Calibrated quality control (QC) kit NERO^{TM} 600 was used to measure x-ray output (mGy/mAs) in each unit at a distance of 1 metre.

Entrance surface kerma was calculated using the IAEA code of practice as follows:

$$K = Y(d) \times P_t \left[\frac{d}{d_{FTD} - t_p}\right]^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where Y(d) = output (mGy(mAs^{-1}) of the x-ray tube

d = the focus on chamber distance

P_t = the tube loading during patient exposure

d_{FTD} = the focus to table distance

t_p = the patient thickness at the irradiation point and

Entrance Surface Air Kerma (ESAK) was calculated using the relationship:

ESAK = K X BSF ………………………………(2)

Where BSF = the backscatter factor, which was 1.35, as recommended in the European Guidelines [19]. Microsoft Excel 2007 was used to carry out data analysis of the study.

3. Results And Discussion

In this study, 140 adult patients underwent skull (AP/PA, LAT) x-ray examinations in ten (10) health facilities in four states in Southern Nigeria. Table 1 shows patient information and exposure parameters in health facilities.

Table 1: Patient information and exposure parameters of skull (AP/PA) in health facilities

Health Facilities	Number of Patients	Patient Age Mean (range) Years	Patient weight Mean (range)kg	FFD Mean(range) cm	kVp mean (range)	mAs mean (range)
SDH	07	43(27-46)	67(65-77)	88(80-122)	73(67-80)	40(16-45)
OAUTH	10	38(30-45)	71(70-74)	112(106-115)	74(70-80)	38(32-40)
UBTH	12	34(30-42)	75(61-85)	124(100-150)	72(70-78)	33(30-40)
FMC	08	42(31-76)	69(65-72)	111(93-153)	75(70-80)	29(20-40)
TTS	06	44(18-73)	64(60-76)	101(70-140)	80(60-94)	58(15—60)
ADC	06	55(43-65)	75(72-80)	107(105-110)	76(72-80)	37(30-50)
UTH	10	54(43-62)	69(68-72)	120(110-140)	74(70-75)	37(32-40)
CH	07	38(23-65)	70(65-75)	93(90-95)	87(85-90)	77(60-100)
LTH	13	33(26-48)	63(60-65)	101(100-104)	72(70-75)	34(30-35)
OAMH	10	39(26-44)	73(60-80)	93(70-100)	103(100-110)	40(40-43)
UK Guideline	NA	41(16 -98)	71(70–80)	NA	71(70 – 80)	20(1-246)

From Table1, the patient's mean weights in the study are within $70 \pm 10\ kg$ which represents standard-sized patients as recommended by European guidelines and International Commission on Radiation Protection as in [19] and [3]. The patient's age ranged from 18 to 76 years. The FFD employed in the radiological unit were within the values stipulated by European guidelines except in CH where the FFD used ranged from 900.0 to 95.0cm and a mean value of 93.0cm and also in OAMH and TTS where FFD was as low as 70.0cm were employed instead of FFD of 100.0cm to 150.0cm with a mean value of 115.0cm recommended in European guidelines for good practice. The kVp and mAs employed in all health facilities were comparable with those employed in the UK 2010 review [20].

Table 2: Patient information and exposure parameters of skull (LAT) in health facilities

Health Facilities	Number of Patients	Patient Age Mean (range) Years	Patient weight Mean (range)kg	FFD Mean(range) cm	kVp mean (range)	mAs mean (range)
SDH	08	47(36-67)	68(65-75)	108(80-125)	73(67-80)	40(16-45)
OAUTH	14	39(30-46)	70(61-74)	110(106-115)	72(63-85)	28(25-32)
UBTH	10	34(30-42)	75(61-85)	123(100-150)	68(70-76)	25(20-30)
FMC	08	34(31-36)	68(65-72)	100(95-116)	73(63-80)	24(16-40)
TTS	06	44(18-63)	68(65-76)	100(75-125)	73(67-80)	58(15-100)
ADC	06	55(43-65)	75(72-80)	107(105-110)	77(72-85)	36(25-50)
UTH	10	51(43-58)	70(68-72)	111(110-115)	74(73-76)	33(25-40)
CH	07	38(23-65)	70(65-75)	93(90-95)	83(80-89)	68(60-80)
LTH	13	33(26-48)	63(60-65)	103(102-106)	73(68-75)	29(27-32)
OAMH	10	35(20-44)	68(65-70)	105(100-110)	85(70-100)	33(25-40)
UK Guideline	NA	47(16-98)	70	NA	66(63-74)	11(2-49)

Table 2, shows the Patient information and exposure parameters of skull (LAT) in all health facilities considered in this study. The mean kVp values employed in all facilities were found to be comparable with UK values. Also, the FFD values used in most health facilities were within the values stipulated by European guidelines for good practice.

Table 3 indicates the statistics distribution of ESAK (mGy) values for the skull (AP/PA) in all health facilities in this study. From the table, the ESAK value ranges from 0.51 to 1.52 mGy with a mean value of 1.20 at SDH. ESAK value ranged from 1.52 to 2.92 mGy with a mean value of 2.36 mGy at OAUTH. It ranged from 1.08 to 2.62 mGy and a mean of 1.89 mGy at UBTH. For FMC, the ESAK Value ranged from 0.56 to 1.35 mGy with a mean value of 0.88 mGy and in TTS it varies from 0.65 to 1.35 mGy with a mean value of 1.12 mGy. For ADC, the ESAK value ranged from 1.50 to 2.73 with a mean value of 2.10 mGy, and in UTH the ESAK value ranged from 0.69 to 1.37 mGy with a mean value of 1.14 mGy. The ESAK value for CH varied from 4.45 to 8.89 mGy with a mean of 6.42 mGy and for LTH, the value varied from 0.61 to 1.50 mGy with a mean value of 1.19 mGy. The ESAK value in OAMH ranged from 2.77 to 6.23 mGy with a mean value of 3.65 mGy. From the results obtained, 50% of the health facilities had higher dose values than 1.8 mGy obtained in the UK in 2010 as in [20]. Also, the range factor which is the maximum to minimum ratio varies considerably having a maximum value of 2.5 when compared with other studies.

Table 3: Statistical distribution of entrance surface air kerma (mGy) for skull (AP/PA)

Health Facilities	Number of Patients	Min	1st quartile	Median	Mean	3rd quartile	Max	Max/Min
SDH	07	0.51	1.04	1.14	1.20	1.46	1.52	2.4
OAUTH	10	1.92	2.12	2.39	2.36	2.54	2.92	1.5
UBTH	12	1.08	1.66	1.80	1.89	2.18	2.62	2.4
FMC	08	0.56	0.57	0.65	0.88	1.27	1.38	2.5
TTS	06	0.65	1.02	1.24	1.12	1.32	1.35	1.9

Health Facilities	Number of Patients	Min	1st quartile	Median	Mean	3rd quartile	Max	Max/Min
ADC	06	1.50	1.75	2.14	2.1	2.52	2.73	1.8
UTH	10	0.69	1.05	1.25	1.14	1.35	1.37	1.9
CH	07	4.45	5.57	6.14	6.42	6.99	8.98	2.0
LTH	13	0.61	1.08	1.34	1.19	1.48	1.50	2.4
OAMH	10	2.77	2.96	2.97	3.65	3.76	6.23	2.3

Table 4 indicates the statistics distribution of ESAK (mGy) values for the skull (LAT) in all health facilities in this study. From the table, the ESAK value varied from 1.45 to 2.63 mGy with a mean value of 2.11 at SDH. ESAK value ranged from 1.92 to 2.90 mGy with a mean value of 2.36 mGy at OAUTH and it ranged from 0.64 to 2.62 mGy and a mean of 1.43 mGy at UBTH. In FMC, the ESAK Value ranged from 0.73 to 2.02 mGy with a mean value of 1.10 mGy, and in TTS it varied from 0.65 to 1.34 mGy with a mean value of 0.86 mGy. For ADC, the ESAK value ranged from 1.22 to 3.45 mGy with a mean value of 2.26 mGy, and in UTH the ESAK value ranged from 0.87 to 2.35 mGy with a mean value of 1.53 mGy. The ESAK value for CH varied from 3.42 to 6.43 mGy with a mean of 4.71 mGy and for LTH, the ESAK value varied from 0.90 to 1.25 mGy with a mean value of 1.12 mGy. The ESAK value in OAMH ranged from 2.75 to 4.03 mGy with a mean value of 3.25 mGy.

Table 4: Statistical distribution of entrance surface air kerma (mGy) for skull (LAT)

Health Facilities	Number of Patients	Min	1st quartile	Median	Mean	3rd quartile	Max	Max/Min
SDH	07	1.45	1.75	2.13	2.11	2.50	2.63	1.8
OAUTH	10	1.92	2.12	2.39	2.36	2.54	2.90	1.5
UBTH	12	0.64	1.09	1.31	1.43	2.18	2.62	4.1
FMC	08	0.73	0.81	0.83	1.10	1.12	2.02	2.8
TTS	06	0.65	0.54	0.63	0.86	1.25	1.34	2.1
ADC	06	1.22	1.71	2.19	2.26	2.74	3.45	2.8
UTH	10	0.87	1.24	1.45	1.53	1.74	2.35	2.7
CH	07	3.42	3.87	4.49	4.71	5.32	6.43	1.9
LTH	13	0.90	0.94	1.07	1.12	1.19	1.25	1.4
OAMH	10	2.75	2.91	3.11	3.25	3.45	4.03	1.5

The results obtained from the ESAK values for the skull (LAT) show that the values obtained in this study are higher than the ESAK value of 1.1 mGy obtained in UK studies as in [17].

4. Conclusion

Entrance surface air kerma (ESAK) of 140 adult patients undergoing skull plain radiography in ten health facilities in four states in the southern part of Nigeria have been investigated in this study. It was shown that the tube potential (kVp) employed in the study and mean loading (mAs) used in all the health centers for both skulls (AP/PA & LAT) are comparable with those used in the 2010 UK review except in two centers, where the mAs employed are higher. Also, there are intra-radiological unit patient dose variations, as revealed by the range factor. This shows that the operation technique employed was not fully optimized and that radiation dose reduction is possible without altering image quality. Therefore, there is a need for constant monitoring of radiographic equipment and periodic surveys of the patient dose. Also, there is a need to institute programs, conferences, and workshops aimed at reducing patient dose in Nigeria.

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