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Radiation Dose Estimation to Adult Patients Undergoing Diagnostic Chest X-Rays Examinations in Kebbi State, North-Western Nigeria

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Abstract: The hyperconsciousness of radiation dose delivered to the patient during chest radiological X-ray procedures are prerequisite to negate menace of exposure. The pinpoint of this research is to inquest radiation doses received by the patient for routine individual radiological chest x-ray procedures in health care system associated to Kebbi State Government, Nigeria. Entrance Surface Dose and effective dose in accordance with the exposure factors collected for the real examinations were estimated by Cal Dose_X 5.0 software. Diagnostic reference levels [75th percentile] and other statistical parameters were calculated by the use of M. S excels spread sheet. The results obtained for ESD in this research work were 2.95mGy, 2.24mGy & 2.25mGy and 1.71mGy, 1.77mGy & 2.55mGy for Chest anteroposterior [AP], posteroanterior [PA] and lateral [LAT] respectively for Sir Yahaya Memorial Hospital (SYMH) and Federal Medical Centre (FMC), Birnin Kebbi. The effective doses were 0.68 mSv, 0.18 mSv& 0.09 mSv and 0.31 mSv, 0.13 mSv & 0.14 mSv for Chest AP, PA & LAT for SYMH and FMC respectively. Similarly, diagnostic reference level for chest AP, PA, & LAT were 2.34, 3.32 & 2.82, and 2.02, 1.88 & 3.19 respectively for SYMH and FMC. The results were compared with national and international studies. The ESD and DRLs reported in this research work for chest examinations were remarkably higher than that of the European Commission (2010), Australia (2017), NRPB (2000), UNSCEAR (2008), Iran (2008) and other research work reported elsewhere. For effective dose, the results were comparatively high except for few research work published in literatures. Therefore, the obtained results in this work revealed that the variations in the results among the two centres and other studies may likely be due to the improper selection of exposure parameters, patientbody sizes, and technical know-how of the staff. Finally, proper selection of radiological parameters and educational training to the staff can significantly reduce the risk of absorbed dose to patients.

Keywords: Exposure Parameters, Chest, Dose, X-ray

1. Introduction

The chest radiological procedure is the most common performed medical x-ray examination in hospitals [1]. The report issued by ICRU indicated that approximately 25% of all radiological x-ray examinations were contributed by Chest procedures. Since there's an increase in x-ray imaging, it is important and necessary to determine and revise the exposure factors selections. The patients' exposures to ionizing radiation due to medical setting have great benefits. It is mandatory to develop method to assess radiation doses delivered to patient during chest radiography due to the potential risk associated to it [2]. The ionizing radiation received many attentions worldwide being it significant tool for improving health status of patient in medical settings [3]. The medical application of ionizing radiation is the largest source of exposure to the people. Frequent patient dosimetry is highly recommended for optimization and justification in order to protect patients from the radiation risk [3]. The

technology with capability to decrease the patient radiation doses in chest radiography is highly recommended [1]. In nowadays many x-ray centres have been digitalized and patient dose are considerably decreased, in Kebbi State digital radiography system are rapidly increasing. Much research has not been done to assess exposure parameters, entrance skin dose, effective dose and diagnostic reference levels in Kebbi State. The best dosimetric quantity to determine hazard of exposure to ionizing radiation was considered to be the above mentioned parameters [1].

International organization such as International Atomic Energy Agency (IAEA) and International Commission on Radiological Protection (ICRP) proposed guidance levels and guidance principle for radiological x-ray procedure in order to standardize the level of radiation exposure by the patients. The recording of patient exposure and establishing the local diagnostic reference levels were not documented in Kebbi State. National and international (ICRP) organizations made it necessary for radiologists, radiographers and x-ray technicians to ensure that exposure to medical x-ray examinations are optimized, justified and limited. In Nigeria, due to the formation of Nigerian Nuclear Regulatory Agency [NNRA] effort was made to standardize the use of x-ray in radiological practices [2]. Therefore, periodical review of radiation exposure is of great importance in order to protect patient effectively [2].

Many scientists especially those working in radiation related areas have done several work across various modalities with indications of differences between the centres as part of the effort to address the issue of radiation in Nigeria [4]. The variations for similar and same radiological procedure lead to creation of reference dose levels. From National and International literatures on ESD, ED, and DRLs are lower than 1 mGy for some literature but less than 10 mGy for both the centres and other literature [2]. The radiation dose estimation was performed to investigate the amount of doses delivered to the patient during x-ray procedures in the centres [3]. This research work is among the first local investigation made with the aim of estimating the patient radiation doses delivered during chest AP, PA & LAT radiological examinations.

2. Material and Method

The study is prospective in nature that involved a total of 384 male and female adult patients aged between 20 -80 years, who were referred to Sir Yahaya Memorial Hospital and Federal Medical Centre Birnin Kebbi, for radiological chest X-ray examinations between 2021 to 2022. Majority of the patients had PA view while others had AP, lateral or in combination of PA & LAT or AP & lateral. The study was approved by the Ethical Research committee of SMH and FMC. The Standard height and weight of patients were considered by the monte-carlo software [Cal Dose _X 5.0]. The sources of radiation were SHIMADZU Mobile X-ray machine with model No: collimator R-20CA, and nominal kVp of 150 Kv made in Japan used in Sir Yahaya Memorial Hospital. In Federal Medical Centre, mobile x-ray with model No: 2185226 and Nominal kV of 125kV made in India used. The inherent filtrations of the two machines are 1.0mmAl and 0.8mmAl for SMH and FMC respectively [4, 5]. All the two centres were equipped with qualified and some registered radiographers and technicians. The data was collected in a data collection form designed by the researcher. The data recorded for each patient were kV, mAs, FFD, FSD, age and sex. The ESD and ED were automatically calculated by inserting the above mentioned parameters in Cal Dose_X 5.0 software. The diagnostic reference level [75th percentile] was decided based on ESD and estimated by using a statistical software package called Minitab and excel spread sheets.

3. Result and Discussion

The estimation of radiation doses in this research work was done on adult patients. In table 1; a statistical summary of the patient age, ESD, ED and exposure parameters [such as kV, mAs, FFD, FSD] selected for different chest x-ray projections as prescribed for the patients from both centres. It can be observed from the table 1 that the kV applied for various procedures differ with respect to the types of projections. The mAs for both SYMH and FMC ranged between 18-40 for PA and LAT respectively, while mAs for AP ranged from 18 – 25. The mAs for PA and LAT are remarkably high in both centres. For each types of projection ESD, ED and DRLs values was estimated in both centres. In all radiological projections for the chest, the patient age ranged between minimum of 20 years to maximum of 80 years in this study. The tube voltage ranged from 65 minimum to 85 maximum for all chest projections. Entrance Skin Dose estimated in this work was ranged from 0.65mGy to 7.88mGy while effective dose ranged from 0.09mSv-0.68 mSv. Similarly, the range of diagnostic reference levels was 1.88 – 3.32 for AP, PA and LAT in the two centres. Table 2 summarizes comparative analysis of ESD results with other studies.

Table 1. *Statistical distributions of exposure parameters for individual Centres.*

Examination	SMH						FMC					
	Min	Med	Mean	Max	Mx/mn	STDEV	Min	Med	Mean	Max	Mx/Mn	STD
ChestPA												
Age (years)	20	40	45.00	80	4.00	17.40	20.0	45.0	46.0	80.0	4.0	17.6
FFD (cm)	100	150	148.66	160	6.40	1.60	140	160	163.9	200	1.43	16.0
FSD (cm)	83	129	127.14	140	7.47	1.68	95	130	135.3	185	1.95	18.3
KV	70	78	77.61	84	1.20	2.00	67	80	78.8	85	1.27	3.87
MAs	18	18	18.60	32	1.78	1.51	16	21	22.98	40	2.50	4.43

Examination	SMH						FMC					
	Min	Med	Mean	Max	Mx/mn	STDEV	Min	Med	Mean	Max	Mx/Mn	STD
ESD (mGy)	1.53	2.17	2.24	6.10	3.99	0.48	0.65	1.55	1.77	7.88	12.08	0.92
ED (mSv)	0.06	0.10	0.18	2.24	37.33	0.21	0.05	0.12	0.13	0.3	6.0	0.05
DRLs [75thpercentile]			2.34						1.88			
Chest AP												
Age (years)	40	45	44	50	1.25	4.18	23	60	55	80	3.70	22.3
FFD (cm)	100	100	100	100	1.00	0	113	120	136	177	1.57	24.7
FSD (cm)	70	85	80.60	88	1.26	7.70	86	110	115	153	1.78	26.1
KV	70	75	74	75	1.07	2.23	68	74	73.5	80	1.18	4.48
MAs	18	18	18.8	20	1.11	1.09	16	20	21.2	25	1.56	3.34
ESD (mGy)	1.86	2.87	2.95	3.81	2.05	0.72	0.79	1.59	1.71	2.62	3.32	0.57
ED (mSv)	0.64	0.71	0.68	0.71	1.11	0.04	0.07	0.39	0.31	0.61	8.71	0.20
DRLs [75thpercentile]			3.32						2.02			
Chest LAT												
Age (years)	30	45	46	65	2.17	13.97	25	42	44	67	2.68	21.96
FFD (cm)	150	150	150	150	1.00	0.00	150	150	156.3	175	1.67	12.5
FSD (cm)	100	106	106	112	1.12	6.32	109	113	122	154	1.41	21.5
KV	76	77	77.20	80	1.05	1.39	70	79	78.3	85	1.21	6.24
MAs	18	19	19.80	22	1.22	1.99	20	26.5	28.25	40	2.0	9.54
ESD (mGy)	1.66	2.12	2.25	3.09	1.86	0.63	1.39	2.51	2.55	3.77	2.69	1.05
ED (mSv)	0.07	0.09	0.09	0.11	1.57	0.01	0.07	1.15	0.14	0.20	2.86	0.06
DRLs [75thpercentile]			2.82						3.19			
TOTAL NUMBER OF PATIENTS = 266							TOTAL NUMBER OF PATIENTS = 118					

Table 2. *Comparison of mean ESD [mGy] with national and international studies.*

Present study/other studies	Chest AP	Chest PA	Chest LAT
SMH	2.95	2.24	2.25
FMC	1.71	1.77	2.55
Hamza & Lamara, 2020 [Gombe] [6]	-	0.36	0.18
Nsika & Obed, 2015 [Akwa-Ibom] [7]	-	0.59	0.61
Gholami*et al.*, 2015 [Iran] [8]	-	0.56	1.76
Gaetano *et al.*, 2005 [Italy] [9]	-	0.15	0.45
ARPNSA, 2017 [Australia] [10]	-	0.20	1.0
NRPB, 2000 [11]	-	0.20	1.0
Osib & Azevdo, 2008 (Brazil) [12]	-	0.19	0.48
Asadinezhad & Toossi, 2008 [IRAN] [13]	-	0.41	2.70
IAEA, 2007 [Vienna] [14]	-	0.33	-
Hart *et al.,* 2010 [UK] [15]	-	0.15	0.50

Table 3. *Comparison of mean Effective Dose [mSv] with national and international studies.*

Present study/other studies	Chest AP	Chest PA	Chest LAT
SMH	0.68	0.18	0.09
FMC	0.31	0.13	0.14
Olowookere *et al*., 2011 [16]	-	0.20	0.10
Haval&Hariwan, 2017 [17]	-	0.45	-
Mettler*et al*., 2008 [18]	-	0.02	0.10
Kharita*et al.,* 2010 [19]	-	0.13	-
Durga&Seife, 2012 [20]	-	0.10	-
Akbar *et al.,* 2015 [21]		0.04	0.10
UNSCEAR, 2008 [22]		0.05	0.2

Table 4. *Comparison of DRLs [75th percentile] with national and international studies.*

Centres/other studies	Chest AP	Chest PA	Chest LAT
SMH	2.34	3.32	2.82
FMC	2.02	1.88	3.19
Joseph *et al.*, 2017[Nigeria] [23]	-	0.59	1.02
EC, 1999 [24]	-	0.40	1.50
Asadinezhad&Bahreyni, 2008 [Iran] [25]	0.97	0.41	2.07

The ESD in this research were found to be higher than the results obtained in the research conducted in Gombe, Akwa-Ibom, Iran, Italy, Brazil, UK and Australia [6, 7, 10, 12, 15] may likely be as a results of variation of exposure factors and distance setting between patients and x-ray tube (table 2).

Table 3 indicates that the effective dose obtained in this

work were remarkably higher than the results obtained in a research conducted by Mettler *et al*, Durga & Seife; Akbar *et al* and Kharita *et al* [18, 19, 20, 21]. It is lower than the research work conducted by Haval & Hariwan; Olowookere *et al*. and UNSCEAR [16, 17, 22]. The effective dose estimated in this study referred to as dose descriptor that enable direct comparison of the hazard related to various radiological procedures. The use of effective dose concept permits the estimation of radiation risk to patients. With the increase of tube potential, the value of ED will increase thereby increasing ESD. Similarly table 4 summarize the diagnostic reference level for the three chest projections, the values estimated in this study are greatly higher than the values obtained in other research conducted in Nigeria and European commission [23, 24]. It was observed that increasing exposure factors may lead to the increase in ESD thereby increasing DRLs in all chest x-ray examinations.

4. Conclusion

The indirect method was employed in this research to estimate ESD, ED and DRLs. The values estimated were comparably higher than recommended values by European commission, International Atomic Energy Agency and those reported in literatures. But in all chest projections, the effective doses are lower than 1.0 mSv recommended by Nigeria Nuclear Regulatory Agency. The high radiation dose recorded may be attributed to old technology (techniques) used by X- ray units and technical know-how of radiographers and x-ray technicians. Entrance Skin Dose and effective dose varies within the same centres due to size of patients, different technical characteristics of radiographic equipment and technical parameters employed as well as exposure factors selection. The variations in the data obtained demonstrate the importance of creating awareness of radiation protection and regular quality control testing of radiographic equipment to avoid unnecessary risks of increased radiation dose to patients and staff. The DRLs estimated in this research work can encourage changes in working procedures and equipment by showing what is possible and achieved in other departments. Therefore, effort should be made to lower patient doses during chest X-ray examinations by introducing a standard protocol in various X-ray facilities. The need to provide relevant education and training to staff in radiology departments is of great significance. The findings can be used as baseline data on the basis of which future dose estimation may be compared.

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