CORRELATION OF ENTRANCE SKIN DOSE WITH BODY MASS INDEX OF PATIENT UNDERGOING ROUTING X-RAY EXAMINATION AT FEDERAL TEACHING HOSPITAL GOMBE, NORTH-EASTERN NIGERIA

Abstract

A study was conducted to confirm the amount of dose received by patient undergoing routing x-ray examination at Federal Teaching Hospital, Gombe in Gombe state, Nigeria. Entrance skin doses (ESDs) for different kinds of x-ray procedures, include Posterior Anterior (PA) and Lateral (Lat) chest, Anterior Posterior (AP) Abdomen, AP pelvis, AP and Lat lumber spine and PA and Lat skull. The sum of eighty (80) data were obtained from patients who were being exposed to diagnostic X-ray during their regular X-ray examinations. The patient's age falls between 1 to 80 years, while the weight is between 20kg to 100kg and height of these patients fallen between 95.0cm to 171cm. The skin dose of each patient were evaluated using a formula, which is based on the radiographic exposure parameters of kVp, mAS, SSD, the X-ray tube and the total filtration of the beams. The enumerated mean entrance skin dose falls between 0.016 mGy to 3.168 mGy. Eventually, the ESDs measured for this type of x-ray procedures were found to be below the maximum permissible limits set by Nigeria Basic Ionizing Radiation Regulation [8] and all the examinations conducted shows that there is a good correlation between the entrance skin doses with body mass index during diagnostic X-ray examination. This shows that patients with higher body mass index will received more dose than the patients with low body mass index.

Key words: Skin dose, Body Mass Index, X-Ray Examination, Teaching hospital, Gombe

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Introduction

The main purpose of x-ray examination diagnosis is to generate patient's images with important and adequate image quality in order to serve as a guide for practitioner to carry out an effective and efficient examination and treatment of different bad health conditions. Due to the danger related to the exposure of patients to x-ray while undergoing x-ray examinations, it is recommended that images of adequate quality for accurate examination are produced without any need for repetition [1].

Although, patients would definitely obtain great advantage from diagnostic x-ray examinations, but their use is not completely without risks. As a result of this, every exposure to diagnostic x-rays need to be justified and optimized in terms of risk and benefit [3]. One of the major ways of assessing radiation dose received in diagnostic and therapeutic radiography is monitoring of patients during the examination [4].

Diagnostic X-rays are used for identifying diseases and other problems during medical examinations. The objective of any diagnostic X-ray examination is to produce images of patients with essential details and sufficient image quality so as to guide practitioners for effective and efficient diagnosis and treatment of various disease conditions. Because of the risks associated with the

exposure of the patients to X-rays during the diagnostic X-ray examinations,[6] suggested that, there would be a need for improvement in producing an image containing all the necessary information required for accurate diagnosis which should lead to minimum dose exposure to the patient.

Materials and Method

The method of surveying in this work was based on the guideline established by the International Atomic Energy Agency (IAEA) protocols. This study comprises of eight most common performed diagnostic x-ray examinations, which are Posterior Anterior (PA) and Lateral (LAT) chest, Anterior Posterior (AP) Abdomen, AP pelvis, AP and LAT lumber spine and PA and LAT skull. The age range/interval considered were: 1-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70 and 71-80 years. If the patient age is > 10 than it was put in range 11-20, >20 in 21-30, >30 in 31-40, >40 in 41-50, >50 in 51-60, >60 in 61-70, >70 in 71-80. These intervals were chosen since results in literature follows the protocol [7]. Automatic exposure control **(**AEC) was positioned between the patient being x-rayed and the x-ray film cassette. X-rays passing through the patient also pass through this "AEC detector" before they strike the x-ray film. BSF was determined using 30cmx30cmx15cm phantom and conversion coefficients in term of surface dose. It depends on the type of the x-ray machine, the x-ray machine in the Federal Teaching Hospital was estimated as 2.9mmAl, that is the value for the BSF were determined to be 1.24gray/sievert

For each patient; age, sex, weight, height and chest thickness were recorded and corresponding technical parameters of exposures (kV, mAs and focus to skin distance FSD) were also recorded. Although the National Radiological Protection Board [9] recommended that measurement of patients' dose be directly measured on Thermo-Luminescent Dosimeters (TLDs), free-air measurement of a tube's radiation output together with the calculation of Entrance Skin Dose using standard factors can also be employed in appropriate circumstances. [5]. In this work, we employed calculation of entrance skin dose (ESD) based on standard exposure data due to unreadily availability of TLD chips and TLD reader in the hospital. The mean ESD was determine by evaluation from the x-ray tube parameters and exposure radiographic parameters using mathematical equation by [10] for calculating entrance skin dose.

$$ESD = BSF \times T \times OP \times \left(\frac{FFD}{FSD}\right)^2 \times mAs \qquad (1)$$

Where: OP = the output in mGy/mAs of the x-ray tube at 80 KV at a focus distance of 1m normalized to 10mAs

mAs= product of the tube current (in mA) and the exposure time (s).

FSD= focus to skin distance (in cm)

FFD = focus to film distance

BSF= the back scatter factor ranging from 1.2 to 1.4 for x-ray spectra

The body mass index (BMI) is then calculated by dividing the subject's weight by the square of his/her height.

$$BMI = Weight(Kg) \div (Height)^2 m^2 \quad (2)$$

While effective dose is evaluated using the equation:

$$H = \sum_T (W_T \times ESD_T) \quad (3)$$

Where W_T is the weighting factor and ESD_T is the entrance skin dose of the respective tissue

Results and Discussion

Table 1 shows the distribution of biographical data of the patients, based on different age group and some machine parameters were also recorded. The determined mean for tube potential (KV), tube current and exposure time (mAs), output of x-ray (OP) and focus distance surface for chest LAT, pelvis AP, skull LAT, abdomen AP and lumber spine LAT were recorded.

Table1: patients' information and exposure parameters for x-ray examinations. (Ranges in parenthesis)

Age Range (Years)	Examination	Projection	Number of Patients	Weight (Kg)	Mean Kvp (Kv)	MEAN mAs (mAs)	Mean Dose (mGy)	Height (m)	BMI (Kg/m²)
1-10	Chest	LAT	2	23	30	12	0.027	0.96	24.96
	Pelvis	AP	3	24	35	12	0.080	1.00	24.00
	Skull	LAT	4	20	30	10	0.146	0.97	21.26
	Abdomen	AP	0	0	0	0	0.005	0.00	0.00
	Lumber Spine	LAT	1	25	30	12	0.061	0.95	27.70

11-20	Chest	LAT	1	36	45	12	0.053	1.22	24.91	
	Pelvis	AP	0	0	0	0	0.005	0.00	0.00	
	Skull	LAT	3	45	50	12	0.241	1.38	23.63	
	Abdomen	AP	2	37	45	10	0.871	1.24	24.96	
	Lumber Spine	AP	4	38	50	10	0.274	1.21	25.95	
21-30	Chest	LAT	2	70	50	20	0.341	1.51	24.31	
	Pelvis	AP	2	58	56	20	0.590	1.51	25.44	
	Skull	PA	2	56	61	20	0.563	1.42	30.25	
	Abdomen	AP	2	61	63	22	0.509	1.44	30.38	
	Lumber Spine	AP	2	55	56	22	0.299	1.49	25.22	
31-40	Chest	PA	3	74	76	22	0.429	1.62	28.20	
	Pelvis	AP	3	76	75	28	0.501	1.55	31.63	
	Skull	LAT	0	0	0	0	0.005	0.00	0.00	
	Abdomen	AP	1	67	75	28	0.752	1.67	24.02	
	Lumber Spine	AP	3	80	77	32	0.718	1.66	29.03	
41-50	Chest	LAT	1	86	60	34	0.379	1.65	31.59	
	Pelvis	AP	1	80	74	38	0.812	1.70	27.68	
	Skull	PA	2	75	60	38	0.794	1.58	30.04	
	Abdomen	AP	4	70	56	41	0.976	1.69	24.51	
	Lumber Spine	AP	2	67	84	42	0.971	1.66	30.48	
51-60	Chest	LAT	4	89	76	42	0.871	1.71	30.44	
	Pelvis	AP	4	90	80	42	0.608	1.69	31.51	

	Skull	PA	1	82	66	42	0.894	1.61	31.63	
	Abdomen	AP	0	0	0	0	0.005	0.00	0.00	
	Lumber Spine	LAT	1	77	50	26	0.987	1.68	27.28	
61-70	Chest	PA	5	89	60	28	0.773	1.61	34.34	
	Pelvis	AP	1	99	72	26	0.654	1.59	39.16	
	Skull	LAT	1	88	68	38	0.456	1.68	31.18	
	Abdomen	AP	2	71	60	32	1.912	1.69	24.86	
	Lumber Spine	AP	1	79	56	30	1.543	1.68	27.99	
71-80	Chest	PA	2	100	85	30	0.820	1.71	34.20	
	Pelvis	AP	2	97	85	30	0.890	1.69	33.96	
	Skull	PA	2	87	80	32	0.609	1.68	30.82	
	Abdomen	AP	2	79	50	20	1.998	1.61	30.48	
	Lumber Spine	LAT	2	85	78	30	2.996	1.57	34.48	

Table 2 shows the evaluated entrance skin dose (mGy) for each range of age examination with corresponding values of Body Mass Index were 0.064, 0.213, 0.312, 0.481, 0.556, 0.511, 0.824, 1.428 (mGy) and 24.48, 24.48, 27.12, 28.22, 28.86, 30.22, 31.51and 32.79 kgm^2 respectively. Comparative account on the mean entrance skin dose received by different age groups with corresponding body mass index values are presented numerically in **table 2** and **figure 1**. The mean entrance skin dose received by patient belonging to age groups of 0–10 years and 11–20 years, respectively, ranged from 0.064 to 0.213 mGv and body max index 24.48kg/m^2. Likewise patients between (21–30 years age group) and 31 – 40 years were found to receive an mean entrance skin dose ranging between 0.460 and 0.481 mGy and 21.07–22.58 kg/m^2 respectively. The table have clearly shown that a patient with high Body Mass Index received high Entrance Skin Dose that is, if the Body Mass Index decrease Entrance Skin Dose also decreases (that is, Body Mass Index is directly proportional to Entrance Skin Dose).

Table 2: Mean ESD and BMI corresponding to the age range

Age Range/ Interval	BMI (kg/m^2)	Mean Entrance Skin Dose (mGy)
1-10	19.58	0.064
11-20	19.89	0.289
21-30	21.07	0.460
31-40	22.58	0.481
41-50	28.86	0.786
51-60	24.17	0.673
61-70	31.51	1.068
71-80	32.79	1.463

Table 3 shows the estimated values entrance skin dose values compared with international established diagnostic reference levels and published works. The obtained values were below the international established diagnostic reference level.

Table 3: Comparison of mean Entrance Skin Dose (mGy) with others published and established radiographic procedures

Examination Type	Present study	Reference [10]	Reference [11]	Reference [2]
Chest PA and LAT	0.46	0.43	0.31	0.99
Abdomen AP	0.88	-	-	2.01
Pelvis AP	0.52	1.31	-	1.76
Lumber AP and LAT	0.98	3.25	5.95	2.18

Skull PA and LAT	0.46	-	-	1.91

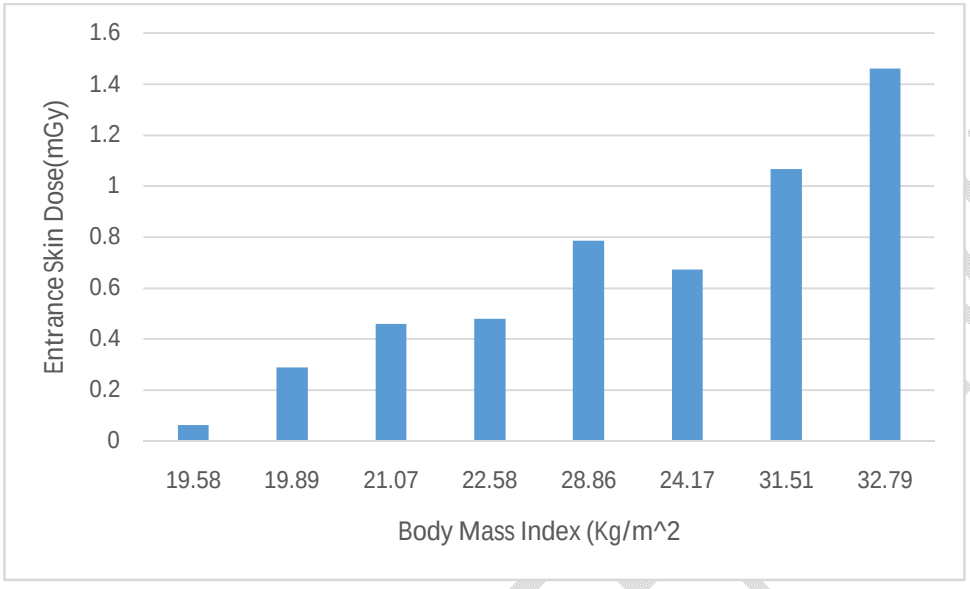

Figure 1: Chart showing Entrance Skin Dose against Body Mass Index

It is clearly shown from figure 1, that a patient with high Body Mass Index received high Entrance Skin Dose that is, if the Body Mass Index decrease Entrance Skin Dose also decreases (that is, Body Mass Index is directly proportional to Entrance Skin Dose).

Conclusion

At this work, the results of entrance skin dose of patient undergoing routing x-ray examination at federal teaching hospital correlated with body mass index are presented. The results showed that, the amount of entrance dose is directly proportional to the body mass index, that is the the higher the body mass index the higher the amount of entrance skin dose received by the patient. In addition, the results of this study showed that the ESD of patients at federal teaching hospital, Gombe was compared to the results previously presented in Kashan, Iran. [2] and those repoted by [10] and [11]. The values of ESD obtained in this study were found to be lower than that of already established and published reference

References

[1] P. Allisy-Robert, J. Willamss, Farrs. Physics for medical imaging, second edition Saunder, 43-6 (2008)

[2] Akbar A, Ehsan M, Mahboubeh M, Morteza S, & Mehran M, (2015): Measurement of Entrance Skin Dose and Calculation of effective Dose for common Diagnostic X-ray Examinations in Kashan, Iran.

[3] International Commission on Radiological Protection (ICRP) 2014. Radiological protection against radon exposure. ICRP Publication 126. Ann. ICRP, 43(3).

[4] Joseph D, Obetta C, Nkubli F, Geofrey L, Laushugno S, Yabwa D. (2014). Rationale for implementing dose reference levels as a quality assurance tool in medical radiography in Nigeria. *IOSR Journal of dental*

and medical sciences. 13(12): 41-45

[5] Taha Abdel Aziz and Allah Hanbury. Metrics for evaluating 3D medical image segmentation: analysis, selection and tool. BMC medical imaging (2015) 15:29. DOI 10.1186/s 12880-015-0068-x

[6] Damijan Skrk, Urban Zdesar, Dejan Zontar. Diagnostic reference levels for x-ray examinations in Slovenia. Radiol Oncol 2006; 40(3) pp 189 – 95.

[7] Azeveo, A.CP, Osibote. O.A, and Baechat. M.C.B. paeditric x-ray examination in Rio de janeiro (2006). IOP science, physics in medicine and biology, V51, n15. DOI. 10.1088/0031-9155/51/15/008

[8] Nigeria Basic Ionizing radiation Regulation NBIRR (2003).

[9] National Radiological Protection Board, (NRPB). (1993**)** `` Radiation Exposure of the U.K. Population'' NRPB Report R263- 1993 Review. NRPB, Chilton, U.K

[10] Ofori, E.K., William, K.A, Diane, N.S. optimization of patient radiation protection in pelvic X-ray examination. Ghana Journal of Applied Clinical Medical Physics, 13 (4) (2012), p.165

[11] UNSCEAR, (2000). Sources and effects of ionizing radiation. United Nations Scientific Committee on the Effects of Atomic Radiation. Report on the General Assembly on the effects of Atomic Radiation. United Nations, New York.

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