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Correlation of Entrance Skin Dose with Body Mass Index of Patients Undergoing Routing X-Ray Examination at Federal Teaching Hospital Gombe, North-Eastern Nigeria

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Authors' contribution

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study was conducted to assess the amount of dose received by patients undergoing routine x-ray examinations 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 were assessed using standard exposure parameters. Data were obtained from eighty (80) patients who were exposed to diagnostic X-ray during their regular X-ray examinations. The patients' age ranged from 1 to 80 years, while the weight was between 20kg and 100kg and height

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of these patients was between 95.0cm and 171cm. The skin dose of each patient was evaluated using a formula, based on the radiographic exposure parameters of kVp, mAS, SSD, the X-ray tube and the total filtration of the beams. The mean entrance skin dose ranged from 0.016 mGy to 3.168 mGy. Eventually, the ESDs measured for these x-ray procedures were found to be below the maximum permissible limits set by Nigeria Basic Ionizing Radiation Regulation and all the examinations conducted showed that there is a good correlation between the entrance skin doses and body mass index for the studied subjects. This implies that patients with higher body mass index will received more dose than the patients with low body mass index.

Keywords: Skin dose; body mass index; X-ray examination; teaching hospital; Gombe.

1. INTRODUCTION

The main purpose of x-ray examination diagnosis is to generate patient's images with important features and adequate image quality to aid proper diagnosis and treatment of patients. Due to the risk associated with the exposure of patients to x-rays during x-ray examinations, it is recommended that images of adequate quality for accurate diagnosis are produced without any need for repetition of exposure [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 needs to be justified and optimized in terms of risk and benefit [2]. One of the major ways of assessing radiation dose received in diagnostic and therapeutic radiography is monitoring of patients during the examination [3].

Diagnostic X-rays are used for diagnosing 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,[4] 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.

2. MATERIALS AND METHODS

The method of surveying in this work was based on the guideline established by the International Atomic Energy Agency (IAEA) [5] protocols. This study covered the most common eight 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 of subjects studied were: 1-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70 and 71-80 years. These intervals were chosen since results in literature follow the protocol [6]. 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. Back Scatter Factor was determined using 30cmx30cmx15cm a three-dimensional (3D) printing technique, anthropomorphic phantom and conversion coefficients in term of surface dose.

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 [7] 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 [8]. In this work, we employed calculation of entrance skin dose (ESD) based on standard exposure data due to unavailability of TLD chips and TLD reader in the hospital. The mean ESD was determine from the x-ray tube parameters and radiographic exposure parameters using mathematical equation by [9] 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 KVp at a FFD 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

Table 1. 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)	FSD (Cm)	O P (mGy/mAs)
1-10	Chest	LAT	2	23	30	12	0.027	0.96	24.96	60.0	0.0023
	Pelvis	AP	3	24	35	12	0.080	1.00	24.00	56.0	0.0067
	Skull	LAT	4	20	30	10	0.146	0.97	21.26	59.0	0.0146
	Abdomen	AP	0	0	0	0	0.005	0.00	0.00	0.0	0.0000
	Lumber Spine	LAT	1	25	30	12	0.061	0.95	27.70	56.0	0.0051
11-20	Chest	LAT	1	36	45	12	0.053	1.22	24.91	62.0	0.0044
	Pelvis	AP	0	0	0	0	0.005	0.00	0.00	0.0	0.0000
	Skull	LAT	3	45	50	12	0.241	1.38	23.63	71.0	0.0201
	Abdomen	AP	2	37	45	10	0.871	1.24	24.96	68.0	0.0871
	Lumber Spine	AP	4	38	50	10	0.274	1.21	25.95	61.0	0.0274
21-30	Chest	LAT	2	70	50	20	0.341	1.51	24.31	113.0	0.0171
	Pelvis	AP	2	58	56	20	0.590	1.51	25.44	91.0	0.0295
	Skull	PA	2	56	61	20	0.563	1.42	30.25	57.0	0.0282
	Abdomen	AP	2	61	63	22	0.509	1.44	30.38	63.0	0.0231
	Lumber Spine	AP	2	55	56	22	0.299	1.49	25.22	76.0	0.0136
31-40	Chest	PA	3	74	76	22	0.429	1.62	28.20	121.0	0.0195
	Pelvis	AP	3	76	75	28	0.501	1.55	31.63	87.0	0.0178
	Skull	LAT	0	0	0	0	0.005	0.00	0.00	0.0	0.0000
	Abdomen	AP	1	67	75	28	0.752	1.67	24.02	79.0	0.0269
	Lumber Spine	AP	3	80	77	32	0.718	1.66	29.03	84.0	0.0224
41-50	Chest	LAT	1	86	60	34	0.379	1.65	31.59	103.0	0.0111
	Pelvis	AP	1	80	74	38	0.812	1.70	27.68	63.0	0.0214
	Skull	PA	2	75	60	38	0.794	1.58	30.04	57.0	0.0209
	Abdomen	AP	4	70	56	41	0.976	1.69	24.51	67.0	0.0238
	Lumber Spine	AP	2	67	84	42	0.971	1.66	30.48	87.0	0.0231
51-60	Chest	LAT	4	89	76	42	0.871	1.71	30.44	123.0	0.0207
	Pelvis	AP	4	90	80	42	0.608	1.69	31.51	91.0	0.0145
	Skull	PA	1	82	66	42	0.894	1.61	31.63	88.0	0.0213
	Abdomen	AP	0	0	0	0	0.005	0.00	0.00	0.0	0.0000
	Lumber Spine	LAT	1	77	50	26	0.987	1.68	27.28	92.0	0.0340

Age Range (Years)	Examination	Projection	Number of Patients	Weight (Kg)	Mean Kvp (Kv)	MEAN mAs (mAs)	Mean Dose (mGy)	Height (m)	BMI (Kg/m²)	FSD (Cm)	O P (mGy/mAs)
61-70	Chest	PA	5	89	60	28	0.773	1.61	34.34	132.0	0.0276
	Pelvis	AP	1	99	72	26	0.654	1.59	39.16	73.0	0.0252
	Skull	LAT	1	88	68	38	0.456	1.68	31.18	76.0	0.0120
	Abdomen	AP	2	71	60	32	1.912	1.69	24.86	96.0	0.0598
	Lumber Spine	AP	1	79	56	30	1.543	1.68	27.99	67.0	0.0514
71-80	Chest	PA	2	100	85	30	0.820	1.71	34.20	114.0	0.0273
	Pelvis	AP	2	97	85	30	0.890	1.69	33.96	67.0	0.2967
	Skull	PA	2	87	80	32	0.609	1.68	30.82	78.0	0.0190
	Abdomen	AP	2	79	50	20	1.998	1.61	30.48	67.0	0.0999
	Lumber Spine	LAT	2	85	78	30	2.996	1.57	34.48	87.0	0.0999

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

$$BMI = Weight(Kg) \div (Height)^2 m^2 \tag{2}$$

Effective dose was evaluated using the equation:

$$H = \sum_T (W_T \times ESD_T) \tag{3}$$

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

3. RESULTS AND DISCUSSION

Table 1 shows the distribution of biodata 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.

Table 2 shows the calculated ESD (mGy) for each range of age for each examination with corresponding values of BMI. The ESD and BMI 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, 31.51, 32.79 kgm^2 respectively. The mean ESD was 0.064mGy for patients in 0- 10 years and 0.289mGy for those in the 11 – 20 years age group. 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 according to 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. Comparison of mean Entrance Skin Dose (mGy) with others published and established ESD for radiographic procedures

Examination Type	Present study	Reference [9]	Reference [10]	Reference [11]
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

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

4. CONCLUSION

In this work, the results of entrance skin doses of patients who underwent x-ray examinations at Federal Teaching Hospital, Gombe correlated with body mass index are presented. The results showed that, the entrance dose is directly proportional to the body mass index that is the higher the body mass index the higher the entrance skin dose received by the patient. In addition, the ESD to patients at federal Teaching Hospital, Gombe was compared to the results previously obtained in Kashan, Iran. [11] and those repoted by [9] and [10]. The values of ESD obtained in this study were found to be lower than that of already established and published references [12].

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

CONSENT

As per international standard or university standard, patient(s) written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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