EVALUATION OF ENTRANCE SKIN DOSE FOR ADULT PATIENTS UNDERGOING DIAGNOSTIC X-RAY EXAMINATION USING C-SHARP SOFTWARE IN SOME PROMINENT HOSPITALS IN OYO STATE, NIGERIA

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A B S T R A CT

A total of 700 patients were surveyed using C-sharp software to determine entrance skin dose (ESD) of patients undergoing x-ray examination of the chest (PA/LAT/AP), cervical spine (AP/LAT), thoracic spine (AP/LAT), lumbar spine (AP/LAT) and pelvis (AP) in eight radiological units of both public and private owned hospitals. The study considered body weight 50-70kg adults. The patients' characteristic and exposure parameters such as examination type, projection type, sex, age, weight, tube voltage (kV) and product of the current and time (mAs) were scripted into the software. The mean of the determined ESD were 0.27 mGy, 0.25 mGy, 0.38 mGy, 1.20 mGy, 3.07 mGy, 2.25 mGy, 2.02 mGy, 2.80 mGy, 3.35 mGy and 2.01 mGy and the mean effective doses as presented: 0.032 mSv 0.030 mSv, 0.046 mSv, 0.048 mSv, 0.015 mSv, 0.090 mSv, 0.242 mSv, 0.274 mSv, 0.402 mSv and 0.161 mSv for chest AP, chest PA, chest LAT, cervical spine AP, cervical spine LAT, thoracic spine AP, thoracic spine LAT, lumbar spine AP, lumbar spine LAT and pelvis AP respectively. The results were compared with published studies and international established diagnostic reference levels (DRLs).

1. Introduction

Diagnostic x-ray is a common diagnostic practice which contributes by far as one of the largest man made source of ionizing radiation exposure for the population. There has been a substantial increase in the number of examination in the recent time more than ever before.(Bushong,2001) More so constant increase in the number and frequency of x-ray examinations, and increase in availability of the x-ray facilities in developing countries. In Nigeria, almost every state owned hospitals has at least an x-ray unit. The University Teaching hospitals and Federal medical centers have between two and four x-ray units. The private hospitals (including mission hospitals) have at least an x-ray unit. (Oluwafisoye *et al*., 2009). Meanwhile, these hospitals which spread all over contributes certain doses of ionizing radiation to the existing background radiation dose level, it is expected that patients dose needs to be monitored at a frequency that will ensure safe working conditions. Hence, the aim of this study was to use the C-sharp software to estimate the entrance skin doses (ESD) and effective doses for adults patients in the range 50Kg-70Kg.

The surveyed revealed large dose output variations for patients undergoing the same type of diagnostic x-ray examination and also, findings clearly showed a need for improvements that would produce an image containing all the necessary information needed for accurate diagnosis which should result in the minimum dose to the patient (Skrk *et al.*, 2006).

2. Materials and methods

The exposure parameters to determine the ESD were taken from certified x-ray machines in eight radiological units in Oyo State. A total of 700 patients were surveyed. The model for computing the ESD was scripted to a computer code using C-sharp programming language. The developed computer package was used to assess the ESD of patients of body weight 50-70kg (range of adult human being) undergoing x-ray examinations of the chest (PA/LAT/AP), cervical spine (AP/LAT), thoracic spine (AP/LAT), lumbar spine (AP/LAT) and pelvis (AP) in eight radiological units.

The software requires the user to manually input the patients' characteristic and exposure parameters captured into the package such as examination type, projection type, sex, age, weight, tube voltage (kV) and product of the current and time (mAs). The mean ESD of ten different examinations considered were obtained. The mathematical equation by Ofori *et al..(2012)*

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

BSF is the back scatter factor usually ranging from 1.2 to 1.4 for x-ray spectra, tube output is the beam output in mGy/mAs of the tube at different kVp settings at distance of 100 cm, FFD is focus to film distance, FSD is the focus to skin distance and mAs is the product of the tube current with time. The entrance skin dose is determined as presented and the effective dose is calculated using the equation:

$$\textbf{H} = \sum_T (W_T \times ESD_T) \ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

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

The effective dose based on the software is then the average of the sex-specific weighted doses specified in the International Commission on Radiological Protection report 103 (ICRP,2007).

3. Results and Discussion

The distribution of the mean values ESD for individual patient exposures for ten projections shown in Table 1. The determined mean for entrance skin doses and the mean effective doses for chest AP, chest PA, chest LAT, cervical spine AP, cervical spine LAT, thoracic spine AP, thoracic spine LAT, lumbar spine AP, lumbar spine LAT and pelvis AP were 0.27, 0.25, 0.38, 1.20, 3.07, 2.25, 2.28, 2.80, 3.35, 2.01 mGy and 0.032 mSv 0.030 mSv, 0.046 mSv, 0.048 mSv, 0.015 mSv, 0.090 mSv, 0.242 mSv, 0.274 mSv, 0.402 mSv and 0.161 mSv respectively.

Table 2 presents the approximately physical characteristics of patients' undergoing x-ray diagnostic examination and exposure parameters for the various examinations in eight radiological units considered in this study. It indicates the total number of patients for the males and females. The mean for the age, kVp, mAs and FDD for the respective examinations have been estimated and stated. The age ranged from the minimum of 20 years to the maximum of 75 years. For the kVp, have the minimum of 54 kV to the maximum of 90 kV. The mAs ranges from the minimum of 12-60 mAs and for the FDD, from the minimum of 90 cm to the maximum of 185 cm. The mean range for the age kVp, mAs and FDD were 43-64 years, 70-85 kV, 23-41 mAs and 105-170 cm respectively. The wide ranges of the kVp, mAs and FDD were as a result of various patient body weight and radiographic techniques used by the radiologist.

The estimated entrance skin dose for the various examinations were presented in Table 2 for all examinations and projections, the mean ESD ranged from a minimum of 0.25 mGy for chest PA to the maximum of 3.35 mGy for lumbar LAT among the examinations considered in this study.

The mean ESDs were compared with international established diagnostic reference levels and some published works of Shrimpton et al., 1986; Padovani et al., 1987; European Commission, 1996; UNSCEAR, 2000 and Ofori et al., 2014 in Table 3. Except for the chest AP, thoracic spine LAT and lumbar spine LAT with values 0.27 mGy, 2.02 mGy and 3.35 mGy respectively. Most of the results from the study are in agreement with other international established and published works diagnostic reference levels except for the chest PA with value 0.25 mGy which was slightly higher than Shrimpton et al., 1986 and also thoracic spine AP with value 3.07 mGy which is slightly higher than the published work of Ofori et al,. 2014. The variation in doses may be due to patient size (weight) and radiographic techniques employed by the radiologists.

Table 1: Estimated entrance skin dose(ESD) for all projections.

Examination type	Projection type	Age Mean/ Range	Weight Mean (kg)	Mean (mGy)	Effective Doses (mSv)
Chest	AP	45 (20-70)	63	0.27	0.032
Chest	PA	50 (20-71)	65	0.25	0.030
Chest	LAT	49 (20-73)	65	0.38	0.046
Cervical spine	AP	47 (20-75)	62	1.20	0.048
Cervical spine	PA	44 (20-72)	60	3.07	0.015
Thoracic spine	AP	60 (20-74)	65	2.25	0.090
Thoracic spine	LAT	43 (20-75)	68	2.02	0.242
Lumbar spine	AP	64 (20-72)	66	2.80	0.274

Lumbar spine	LAT	61 (20-70)	63	3.35	0.402
Pelvis	AP	53 (20-71)	68	2.01	0.161

AP (anterior posterior); PA (posterior anterior); LAT (lateral)

Table 2: Patient's physical characteristics and exposure technical parameters for the various examinations

X-ray Examination	Projection type	Male patients	Female patients	Total patients	Age Mean/range	kVp Mean/range	mAs Mean/range	FSD (cm) Mean/range
Chest	AP	56	38	94	45 (20-70)	81 (57-88)	25 (14-32)	105 (90-110)
Chest	PA	53	30	83	49 (20-73)	78 (54-90)	29 (16-36)	107 (100-115)
Chest	LAT	57	36	93	50 (20-71)	84 (58-90)	27 (17-42)	170 (120-185)
Cervical spine	LAT	43	31	74	47 (20-75)	75 (58-85)	25 (16-48)	110 (100-110)
Cervical spine	AP	33	20	53	44 (20-72)	73 (58-80)	23 (12-40)	105 (100-110)
Thoracic spine	AP	31	20	51	60 (20-74)	70 (65-90)	37 (28-60)	125 (115-160)
Thoracic spine	LAT	34	21	55	43 (20-75)	71 (57-82)	25 (15-50)	105 (100-110)
Lumbar spine	AP	40	23	63	64 (20-72)	83 (65-90)	39 (18-45)	125 (120-155)
Lumbar spine	LAT	43	22	65	61 (20-70)	85 (60-90)	41 (15-48)	130 (115-165)
Pelvis	AP	40	28	68	53 (20-71)	75 (55-80)	30 (14-46)	105 (100-110)

AP (anterior posterior); PA (posterior anterior); LAT (lateral); FDD (focus to detector distance)

Table 3: Comparison of mean ESD (mGy) with others published and established radiographic procedures reference levels

Examination Type	Present study	Reference (Shrimpton et al., 1986)	Reference (Padovani et al., 1987)	Reference (EC, 1996)	Reference (UNSCEAR, 2000)	Reference (Ofori et al., 2014)
Chest AP	0.27	-	-	-	-	-
Chest PA	0.25	0.16	0.57	0.30	0.31	0.27
Chest LAT	0.38	0.57	1.88	-	-	0.43
Cervical spine AP	1.20	-	-	-	9.91	1.05
Cervical spine LAT	3.07	-	-	-	-	0.45
Thoracic spine AP	2.25	4.7	-	-	9.91	2.10
Thoracic spine LAT	2.02	-	-	-	-	-
Lumbar spine AP	2.80	6.1	8.9	10.0	5.95	3.25
Lumbar spine LAT	3.35	-	-	-	-	-
Pelvis AP	2.01	4.4	7.77	10.0	-	1.31

4. Conclusions

Application of C-sharp programming package was used to assess the entrance skin dose of ten selected x-ray examinations in eight government and private owned hospitals. Patient physical characteristics and selected exposure parameters were scripted into the software package developed by the authors of this study that was used for estimations of the patient doses. However, the estimated values were compared with international established diagnostic reference levels and published works. The obtained values were below the international established diagnostic reference level. The result of this study will be helpful and that the application of C-sharp developed by the authors be used by radiology because it controls undue exposure of patients, minimum time and other challenges that may arise during diagnosis.

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