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ORIGINAL: Determination of Entrance Surface Dose of Digital Radiography for Adults at Public Medical Imaging Centers, Erbil

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ABSTRACT

Introduction: Diagnostic X-ray is one of the ionizing radiations, the level of radiation dose received by the patient during medical examination is essential to prevent cancer risks. The aim of this study is to calculate entrance surface dose (ESD) and effective dose (ED) were estimated during chest, and lumber spine for adult patients in three hospitals in Erbil, using NOMEX MULTIMETER and PCXMC software.

Material and Methods: The study was conducted in three public hospitals, in Erbil on (250) adult patients, whose ages between (18-70) years, based on the results study, ESD and ED were calculated for chest (PA, lateral), and lumbar spine (AP, lateral) examinations. NOMEX MULTIMETER (PTW, Freiburg), used in measurement of tube voltage, dose, dose rate, time product current, and total filtration automatically during examination. ED was calculated by using PCXMC software (version 2.5).

Results: The results of this work are compared with published international literatures. The mean entrance skin dose for examinations of chest (PA, Lat), and lumber spine (AP, Lat) 1.02, 1.06, 2.61 and 3.92 mGy respectively. ED value was from 0.08, 0.19, 0.32, and 0.33 mSv, for chest (PA, Lat), and lumber spine (AP, Lat), respectively.

Conclusion: The ESD, and ED were calculated in this work were found to be agreement with the published reference values for chest, and lumber spine set by international levels. ALARA principle should be considered by radiographer, to reduce absorbed dose of adults' patient undergoing imaging radiography.

Introduction

The risks of ionizing radiation with X-ray needed measurement of patient radiation dose by increasing supervision of hazards of radiation exposure during medical imaging. The patient dose measurement and optimization are most important tasks in radiation reduction (1). The X-ray dose dependent on equipment and technical parameters. Therefore, ALARA concept states in radiation protection mean radiation dose should be justified and optimize As Low As Reasonably Achievable (2). National Council on Radiation Protection and Measurements. 1990, to issue the base line of reference dose values for patients undergoing X-ray examinations (3, 4) especially for child, who is more sensitive to ionizing radiation than adults. So, entrance surface dose is the quantity representative of the dose received by the patient (5–7). The calculation of radiation dose received by the patient during the X-ray examination is essential to avoid risks of exposures that may involves unnecessary amount of ionizing radiation (8). Medical imaging is performed by different radiological systems including CT, MRI, and Fluoroscopy, are still a powerful diagnostic tool with great benefits for the patient (9). Therefore, patients' exposure to ionizing radiation has been increased in general to this diagnostic radiography (5, 10, 11).

The aim of this study was to measure the entrance surface dose (ESD) for chest (Posterior-Anterior, Lateral), and lumber spine (Anterior-Posterior, Lateral) X-ray projections of adult patients and to compare this result with published international studies.

Methods

This study included the most examination performed diagnostic X-ray examinations, that is chest Posterior-Anterior (PA), chest Lateral (Lat), lumber spine Anterior-Posterior (AP), and lumber spine (Lat), on 250 adult patients, whose ages were between 18-70 years. Radiographic parameters included tube voltage (kVp), exposure setting (mAs), and focus distance (FSD) that were used by radiographers for adult patients for better quality images as distinct by the radiologist (2).

This study was carried out in three medical imaging centers in Erbil. NOMEX MULTIMETER (PTW, Freiburg), calibrated by PTW company for measuring the air kerma in the range of energy between 40-150 kVp, highly sensitive device with multi – channel semiconductor detector located in the center of X-ray beam of the X-ray unit at a distance of 100 cm from the focal points, of the X-rays, the detector area must be fully irradiated during the examination, used in measurement of tube voltage, dose, dose rate, and total filtration in one single exposure automatically, data export to Excel directly. Total filtration ranged from 2.00 to 3.00 mmAl, energy range from 50 to 120 kVp, focus distance (FSD) (105-140), (104-120) cm for patients undergoing chest (pA, Lat) examinations. Lumber spine (AP, Lat) focus distance ranged (70 -94) cm

To calculate, the amount of ESD was achieved from multiplying the air kerma quantity, which measured by NOMEX multi meter firstly in the central axis of X-ray beam at the same focus distance (FSD) in back scatter factor (BSF) coefficient (the value of BSF, from by the European Commission report is 1.2) based on equation

$ESD = D\ air \times BSF \times (FDD/FSD)\ 2$

D air is the reading value of the NOMEX MUILTIMETER in (mGy), BSF is backscatter factor (the value of BSF, from by the European Commission report is 1.2), FDD the distance of the focal spot to a detector is referred to as FDD, and FSD is the distance of x-ray focal spot to the patient body. Analysis of data was carried out using the available statistical package of SPSS-22 (12).

Effective doses (ED) calculated by using PCXMC software version 2.5 to obtain organ doses. This software data weight, height, peak voltage and film distance to the tube, ESD value is recorded to extract ED values for radiographic examination.

Results

Table 1 distinctly shows the distribution of patient ages, weight, and height who undergoing X-ray examinations in the present study. ***Table 2*** shows mean values of X-ray potential (kVp), time product (mAs), and focus distance (FSD), along with their range for each type of radiological examination obtained in the three hospitals. Table- 3- shows the mean of ESD (mGy) values of four radiographic examinations obtained in the three hospitals. The lower mean Entrance surface dose (ESD) in PAR hospital for chest PA as seen in ***Table 3***, while the highest mean ESD were seen in Hawler hospital for chest PA and Lat projections. ***Table 4*** compares the mean values of measured ESDs (mGy), for each of examinations in this study with corresponding values reported in the other studies (13–15).

Discussion

The present study was to evaluate ED and ESD in digital radiology in Erbil hospitals. In the present study, ESD and the ED were evaluated in four common digital radiology examinations. Mean values of kVp, mAs, and FSD, for the four projections for patients undergoing X-ray examinations with their ranges, indicated a variation in the exposure factors in three public hospitals are given in ***Table 2***.

Table 1. Patients' information for the four projections considered (range in parenthesis)

Radiograph	Projection	Mean age year	Mean weight year	Mean height cm
Chest	PA	40 (18-55)	70 (55 -80)	1.60 (1.56-1.66)
	Lat	55 (18-65)	65 (60-90)	1.60 (1.55-1.70)
Lumbar spine	AP	50 (27-70)	85 (65-85)	1.63 (1.60-1.68)
	Lat	58 (20-70)	89 (60 -99)	1.65 (1.58-1.70)

Table 2. Mean patient exposure parameters, including range values for four projections

Examination	Hospital	Mean (kVp)	Mean mAs	Mean Focus Distance FSD cm
Chest PA	PAR	60 (55-70)	20 (12-25)	135
	Rizqary	75 (50-80)	22(14-24)	120
	Hawler	70 (60-85)	24(20-30)	130
Chest Lat	PAR	80 (75-86)	30(24-35)	110
	Rizqary	77 (70-86)	28(25-35)	100
	Hawler	80 (75-100)	32(30-38)	120
Lumbar spine AP	PAR	75 (65-90)	25(20-35)	88
	Rizqary	77(70-85)	22(20-45)	90
	Hawler	80(75-100)	30(20-40)	85
Lumbar spine Lat	PAR	85(70-90)	36(31-38)	90
	Rizqary	80(77-95)	35(30-45)	80
	Hawler	80(80-100)	38(30-44)	80

Table 3. Average Entrance surface dose (ESD) (mGy) in three hospitals for the four radiographic examinations

Examination	PAR	Rizqary	Hawler
Chest PA	1.0 (0.01)	1.05 (0.02)	1.07(0.01)
Chest Lat	0.81 (0.01)	1.02 (0.08)	1.36(0.23)
Lumber spine AP	2.62 (0.07)	2.53 (0.05)	2.73 (0.24)
Lumber Spine Lat	3.83 (0.03)	3.88 (0.07)	4.07 (0.04)

Table 4. Comparison of calculated mean Entrance Surface Doses (ESD) (mGy) values with other international References for chest (PA, Lat) and Lumber Spine (AP, Lat) radiography

Projections	Present study	Shamsi et al. (13)	Nahangi et al. (14)	Mohsenzadeh et al. (16)	Khoshdel et al. (15)
Chest PA	1.02	1.05	0.32	0.6	0.49
Chest Lat	1.06	1.56	1.56	0.85	1.06
Lumber Spine AP	2.61	2.59	2.59	2.36	2.81
Lumber Spine Lat	3.92	3.85		3.62	4.28

Table 5. Comparison of calculated mean effective dose (ED) (mSv) with other literature

Examination	Present study	Aliasgharzadeh et al. (17)	Shamsi et al. (13)
Chest PA	0.08	0.04	0.08
Chest Lat	0.19	0.1	0.26
Lumber Spine AP	0.32	0.23	0.29
Lumber Spine Lat	0.33	0.13	0.2

The highest ESD was related to the lumbar spine (lateral) examination and the least to the lumber spine (lateral) examination. The mean values of ESD ranged from 0.86 mGy for chest (Lat) in PAR to 4.88 mGy for lumbar spine (lateral) in Rizqary hospital. ESD variation are a result of quality control of the x-ray equipment, the distance of x-ray focal spot to the patient body, and the obese patients examined may need increase in the exposure condition. The mean ESD values chest (PA) obtained in this study was 1.02 mGy, that is higher than Mohsenzadeh et al. (16), Nahangi et al. (14), and Khoshdel-Navi et al. (15) their mean ESD values chest (PA) are 0.61, 0.32, and 0.49 mGy respectively, but lower than Shamsi et al. (13) 1.05 mGy.

Table 5 shows the Effective Doses (ED) range in chest (PA) examination is 0.07 (mSv) and the highest ED in the lumber spine (AP) examination is 0.37 (mSv). The reason for the over dose value in these four radiographic examinations is due to the high technical parameters and the number of sensitive organs especially in lumber spine (AP) area are irradiated. ESD and ED in digital radiology examination are higher than based radiation dose level due to potential values, focus distance FFD, and used ALARA protocol to reduce the effective of radiation dose (9).

In ***Table 2*** the focal distance (FDD) values varied from 80 cm to 135 cm these values are set by radiographer in three hospitals, the mAs vary from 20 mAs to 24 mAs for chest (PA) examinations, and from 30 to 32 for chest (Lat), these variation in technical parameters may change the values (ESD) and (ED) from guide lines of radiation doses.

Table 4 Comparing the calculated (ESD) values obtained in this study with other reference levels. Shamsi et al. (13) reported (ESD) were 1.05 mGy, and 3.85 mGy for chest (PA), and lumber spine Latrial respectively (11) from low to high values. In the present study, the ESD were found to be 1.02 mGy and 4.62 mGy in the chest (AP) and lumbar spine (lateral), respectively. But (ESD) for chest (PA) is above than (14–16).

In the study of Shamsi et al. and Aliasgharzadeh et al. published the ED of adults undergoing X-ray examinations it was reported that the highest ED was related to the lumber spine (AP) and lumbar (Lat) and the lowest was related to the chest (PA) (13,17). The result of highest mean effective dose (ED) because of high voltage (kVp), higher mAs, and short focus distance in these hospitals.

Conclusion

According to the results in the present study, it can be concluded that use of the proper exposure parameters, high potential, low tube current, and the large focus distance, reduce radiation risks, to the patients undergoing X-ray examination in Erbil hospitals. ALARA, guidelines should be considered, on patient ED and ESD, while preserved better image quality.

The results were found to be higher in Chest PA and Chest Lateral examinations which is most performed radiograph in Erbil. The results also show that the Lumbar spine (AP, LAT) ESD are agreement with international reference values. Replace the old units by digital equipment. ALARA principle should be used by radiographer in Chest X-ray imaging. The radiation risk is low for patients performed radiography in the three hospitals included in this study. The study results, show that when technical parameters (high kVp and low mAs) are optimized, patient doses will reduce substantially.

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Conflicts of interest

The author declares that he has no conflict of interests.

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