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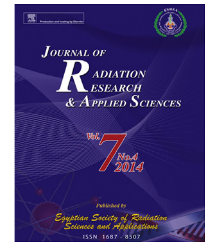

Estimation of adult patient doses for selected X-ray diagnostic examinations

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ARTICLE INFO

Article history:
Received 24 July 2014
Accepted 9 August 2014
Available online 27 August 2014

Keywords:
Entrance skin dose
Effective dose
X-rays

ABSTRACT

The caldose_x 5.0 software has been used to assess the entrance skin doses (ESD) and effective doses (ED) of adult patients undergoing x-ray examinations of the thorax/chest (PA/RLAT), pelvis (AP), cervical spine (AP/LAT), thoracic spine (AP) and lumber spine (AP) in three public hospitals each equipped with constant potential generators (no ripple), an x-ray emission angle of 17° and a total filtration of 2.5 mm Al. In all, 320 patients were surveyed with an average of over 100 patients per a hospital. The patients' data and exposure parameters captured into the software included age, sex, examination type, projection posture, tube potential and current-time product. The mean ESD and ED of seven different examinations were calculated using the software and compared with published works and internationally established diagnostic reference levels. The mean ESD calculated were 0.27 mGy, 0.43 mGy, 1.31 mGy, 1.05 mGy, 0.45 mGy, 2.10 mGy, 3.25 mGy and the mean effective doses were 0.02 mSv, 0.01 mSv, 0.09 mSv, 0.05 mSv, 0.03 mSv, 0.13 mSv, 0.41 mSv for thorax (PA), thorax/chest (RLAT), Pelvis (AP), cervical spine (AP), cervical spine (LAT), thoracic spine (AP) and lumber spine (AP) respectively.

1. Introduction

Diagnostic x-ray radiology is a common diagnostic practice and there has been a substantial increase in the number of examinations recently (Bushong, 2001). Inspite of the increasing hazard of diagnostic x-rays to human beings, studies aimed at achieving low patient doses with sufficient image quality have continued to be of interest in research (ICRP, 1991; UNSCEAR, 2000). All exposures to ionizing radiation needs to justified and optimized in terms of the benefit and risks (ICRP, 1991).

Entrance skin dose (ESD) is an important parameter in assessing the dose received by a patient in a single radiographic exposure. The European Union has identified this physical quantity as one to be monitored as a diagnostic reference level in the hopes of optimizing patient dose (Bushong, 2001; ICRP, 1991).

Patient doses in diagnostic x-ray examinations can be best estimated in terms of entrance surface dose (ESD) per radiograph or dose area product (DAP) for the complete examination (European Commission, 1996). On the other hand, the effective dose is the best quantity for estimating radiation risks to the patients. The major benefit of using the effective

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Peer review under responsibility of The Egyptian Society of Radiation Sciences and Applications.
http://dx.doi.org/10.1016/j.jrras.2014.08.003

Table 1 – Summary of patients' characteristics and technical parameters selected for the various examinations in the five Government hospitals considered for the study.

Examination	Projection	Male patients	Female patients	Total patients	Age Range/mean	kVp Range/mean	mAs Range/mean	FDD (cm) Range/mean
Thorax	PA	45	36	81	43 (25–73)	80.5 (65–90)	25.5 (12.5–30)	105.5 (90–110)
Thorax	RLAT	38	31	69	48 (25–72)	81.7 (65–90)	27.8 (16–40)	165.5 (120–180)
Pelvis	AP	28	19	47	58 (25–75)	77.8 (60–85)	28.0 (12.5–44)	105.8 (100–112)
Cervical spine	AP	11	10	21	45 (25–76)	(74.5) 60–80	24.2 (13.5–40)	104.5 (100–110)
Cervical spine	LAT	10	9	19	38.4 (25–76)	75.4 (60–80)	23.2 (16–45)	105.2 (100–110)
Thoracic spine	AP	9	6	15	57.5 (25–79)	72.2 (70–85)	40.3 (30–60)	135.8 (120–160)
Lumber spine	AP	24	18	42	60.2 (25–78)	(85.9) 70–95	42.5 (20–50)	138.6 (100–165)

dose is that this parameter accounts for the absorbed doses and relative radiosensitivities of the irradiated organs in the patients and, therefore, better quantifies the patient risk (ICRP, 1991).

The aim of this study was to use the caldose_x software to estimate the entrance skin doses (ESD) and effective doses (ED) of adult patients during routine x-ray examinations of the thorax (PA/PA), pelvis (AP), cervical spine (AP/LAT), thoracic spine (AP) and lumber spine (AP/LAT) in three (3) public hospitals.

2. Materials and methods

In all, 328 adult patients were considered for the study. The study was carried out in three public hospitals, each using conventional x-ray units equipped with constant potential generators (no ripple), an x-ray emission angle of 17° and a total filtration of 2.5 mm Al. Before measurements, x-ray generators and equipment were tested for generator type, timer accuracy, HVL, kVp accuracy, output consistency, beam alignment and collimation using multi-function meter with serial number 800391-2674 and model RMI 240 A (for timer and kVp accuracy, generator type), Radcheck plus ionization chamber, Nuclear Associates Div. of Victoreen, Inc., USA with serial number 0000107690 and model 06-526 (for output consistency and HVL determination) and Radiation Measurment Inc., Middleton, WI 53562 US Patent D259,406 with serial numbers 161B-5242 and 162A-4271 (for perpendicularity, alignment and collimation test) as part of the quality control test.

Measurements were concentrated on seven most frequently used examinations of thorax (PA/PA), pelvis (AP), cervical spine (AP/LAT), thoracic spine (AP) and lumber spine (AP/PO) .

The entrance skin and effective doses were calculated using a software called caldose_x 5.0. The software enables the calculation of the incident air kerma (INAK) based on the output curve of an x-ray tube and of the entrance surface air kerma (ESAK) by multiplying the INAK with a backscatter factor, as well as organ and tissue absorbed doses and effective doses for posture-specific female and a male adult phantoms, using conversion coefficients (CCs) normalized to the INAK, the ESAK or the air kerma area product (AKAP) for examinations frequently performed in x-ray diagnosis (Kramer, Khoury, & Vieira, 2008). The software determines the risks of cancer incidence and cancer mortality for the examination selected by the user. The CCs have been calculated for the MASH and the FASH phantoms. The MASH and FASH have organ and tissue masses based on anatomical reference data given by ICRP89 (ICRP, 2002). MASH and FASH were modeled in standing as well as in supine posture and were used in the Monte Carlo calculations posture-specifically according to the protocol of the type of x-ray examination. It covers 24 examinations with 2.5 mm Al standard filtration for standing and/or supine posture. Caldose_x 5.0 examinations are based on focus-to-detector distance (FDD) which can be selected by the user within a given interval.

The software requires the user to manually input the patient's age, sex, select type of examination, posture projections, tube potential, field position and the mAs. Other patients' information recorded were the heights and weights.

In this study the x-ray output curve in mGy/mAs was obtained with Radcheck plus ionization chamber, Nuclear Associates Div. of Victoreen, Inc., USA with serial number 0000107690 and model 06-526. The outputs of the X-ray machines (mGy/mAs) were determined based on the AAPM Task Group no. 61 Protocol (Ma et al., 2001). Once the tube potential, the tube current, the exposure time and the focus to skin distance (d) are known, ESD can be expressed as (Davies, McCallum, White, Brown, & Helem, 1997):

$$ESD = O \times \left(\frac{V}{80}\right)^2 \times \left(\frac{100}{d}\right)^2 CTf \quad (1)$$

where O is the tube output determined units of mGy/mAs, V is the tube voltage in kV, d is the focus to skin distance in cm, C is the current in mA, T is the exposure time in s, and f is the backscatter factor. The tube calibration is performed at 80 kV, 1 m distance and 10 mAs.

Once the entrance skin dose is determined, the effective dose is calculated using the equation: