Entrance Skin Dose Calculation for Adult X-ray Examinations: A Quality Assurance And Quality Control Approach For Radiological Safety

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Abstract

In keeping radiation dose to a safe minimum, it is useful to be able to appropriate, prior to examination, the ranges of dose to the patients as a function of the machine parameters. For this purpose, the study carried out some measurements on the thickness of adult chest X-ray, for adults totaling twenty, which came for examination at the hospital as prescribed by the physician. The measurement was carried out using a tape rule and recorded. Parameters of the X-ray machine and the measured thickness was used in the Edmond's equation for skin dose, to calculate the amount of entrance skin dose in milligray (mGy). The results of the dose range from 0.005664 mGy to 0.053149 mGy, while the chest thickness ranges from 72 cm to 109 cm. The results of the dose were found to be within the prescribed value of 0.4 mGy, as recommended by international radiation protection bodies. For Quality Assurance (QA) and Quality Control (QC) purpose, the research work can be appropriate for entrance skin dose monitoring of medical X-ray imaging in diagnostic and treatment purposes, to safeguard against overdose or poor quality image outcome.

Keywords: Radiation dose, examination, chest X-ray, skin dose, image

Introduction

The use of X-ray radiation in medical applications, is for diagnosis and treatment purposes. Hence there is the need for proper evaluation and monitoring of the amount of dose administered to patients, for safety, Quality Assurance (QA) and Quality Control (QC).Global annual records show that clinical uses of X-rays account for 98% of man-made emission [1]. Therefore healthcare workers concerned with the handling or operation of radiological machines and materials for procedures such as conventional radiography, mammography, fluoroscopy, angiography, computed tomography, etc., are on a daily basis saddled with the responsibilities of ensuring with the strict compliance to the proper and safe use of these various modalities, for diagnostic and treatment purposes.Frequent exposures to low-dose X-rays can lead to hematological cells / tissues exhibiting high sensitivity to ionizing radiation, and serve as intrinsic indicators for health effects [2]. Basic blood cell include; poyikilocytes, anisocytes, codocytes, atypical lymphocytes, etc. X-ray image - guided interventions are increasingly used to treat surgically inaccessible anomalies. Many of these interventions can be prolonged and result in a significant exposure to the patient's skin [3]. In X-ray diagnostics, a difference distinction is made between three techniques: radiography, fluoroscopy and computerized tomography (CT). X-ray diagnostics is chosen by the doctore when other procedures such as laboratory tests, ultrasound or endoscopy would fail to provide a precise diagnosis. Radiology often is the first procedure to permit or confirm diagnosis or to specify findings [4]. It was found also that ionizing X-ray radiation exposure can cause DNA damage and the development of cancer, yet people are constantly exposed to x-rays and other forms of radiation from many different sources [5]. Because radiation exposure is ubiquitous and can vary gently across populations, it is important to fully understand the effects of low and high dose radiation on all human tissue and cell types to recognize and prevent detrimental effects. Exposure from different sources has various total doses, exposure rates, linear energy transfer, and spectral features, which make certain aspects more harmful or more beneficial than others [6]. Medical radiation sources such as linear accelerators used for cancer treatment are designed to destroy cancerous tissue by the use of focused high does (several 10s of Gy over the course of a treatment) of high-energy radiation (in the MeV photon range) while sparing healthy tissue in the regions of low-dose [7]. Diagnostic X-ray sources operate with lower energy (around 100 keV) radiation which has higher linear energy transfer (LET) than therapeutic devices, but these X-ray sources are considered to have acceptable risk of damage due to low-dose (on the order of 0.1 mGy to 400 mGy) employed [8,9]. In order to minimize the unwanted damage that ionizing radiation sources produce, the physical and biological processes involved need to be understood with properly characterized systematic measurements, especially in the low-dose region [10, 11, and 12]. Hence there is a need for proper and regular control of doses applied for X-ray diagnostics and treatment purposes, which is the purpose of this research work, to enhance the Quality Assurance (QA) and Quality Control (QC) of the radiation.

Materials and Method

The survey method in this work was based on the guidelines established by the NBIRR protocols [13]. A state hospital was used in this survey. In the X-ray machine used, specific data, such type as type, filtration, mean kVp, mean mAs, focal film distance (FFD) and total filtration (T) were recorded. In this paper, we only considered the measurement with a tape rule graduated in centimeter (cm), of adult's chest X-ray posterior anterior (PA) view, for a total of twenty five (25) patients. For each patient, the following parameters were recorded: chest thickness (cm), mean kVp (kV), mean mAs (mAs), focal film distance (FFD) (cm) and total filtration (mm later converted to cm). The source skin distance (SSD) was obtained for each patient from the focal film distance (FFD) and the thickness of the patient's chest.

$$SSD = FFD - thickness\ of\ the\ patient's\ chest \qquad (1)$$

The data collected were based on the exposure parameters and the total filtration of the beam from the machine. Entrance skin dose is the maximum amount of X-radiation absorbed on the skin by living tissues during medical examinations. The skin dose to patients was determined by calculation from the X-ray tube parameters and exposure radiographic parameters using Edmond's [14] skin dose formula, which is given as:

$$skin\ dose\ (\mu Gy) = 418(kVp)^{1.74} mAs\, \frac{\left(\frac{1}{T}+0.114\right)}{(SSD)^2} \qquad (2)$$

Where kVp is the peak voltage responsible for the quality of penetration, mAs is the tube current responsible for the quality of electrons from the filament, T is the total filtration of the beams, always a constant, for this machine it is 2.5 mm AL (0.25 cm AL) and SSD is already given by equation (1) above.

Results and Discussion

Table 1 presents the results of the calculation of the entrance skin dose, based on the Edmonds formula of equation (2).

Table 1: Entrance skin dose calculation results for each patient

Patient S/N	Chest Thickness (cm)	Mean kVp (kV)	Mean mAs (mAs)	Focal Film Distance (FFD) (cm)	Total Filtration T (cm)	Source to Skin Distance (SSD) (cm)	Entrance Skin Dose (mGy)
1	92	70	25	150	0.25	58	0.020749
2	95	74	40	150	0.25	55	0.040667
3	94	76	30	150	0.25	56	0.030818
4	79	74	30	150	0.25	71	0.018302
5	78	74	30	150	0.25	72	0.017798
6	109	70	32	150	0.25	41	0.053149
7	92	65	20	150	0.25	58	0.014591
8	75	65	20	150	0.25	75	0.008726
9	75	65	20	150	0.25	75	0.008726

10	72	65	20	150	0.25	78	0.008068
11	90	70	25	150	0.25	60	0.019389
12	78	55	16	150	0.25	72	0.005664
13	78	60	20	150	0.25	72	0.008237
14	98	70	25	150	0.25	52	0.025813
15	79	60	20	150	0.25	71	0.008471
16	84	65	25	150	0.25	66	0.014085
17	82	60	20	150	0.25	68	0.009235
18	103	70	30	150	0.25	47	0.037917
19	87	65	25	150	0.25	63	0.015459
20	84	65	20	150	0.25	66	0.011268

In this survey, data of the adult patients, such as chest thickness and machine parameters were recorded as is shown in Table 1.The chest thickness ranges from 72 cm to 109 cm and the entrance skin dose ranges from 0.005664 mGy to 0.053149 mGy. The dose value is directly proportional to the chest thickness. Hospital data were compared with the guidance levels set by the International Atomic Energy Agency (IAEA) and other international bodies. The bar graphs in Figure 1 and Figure 2 shows that the entrance skin dose received by the patients increases with increase in the chest thickness. So, therefore there is a need to set the parameters of the machine to the standard levels per each patient before imaging is done, because of the varying thicknesses, to ensure proper doses are used.

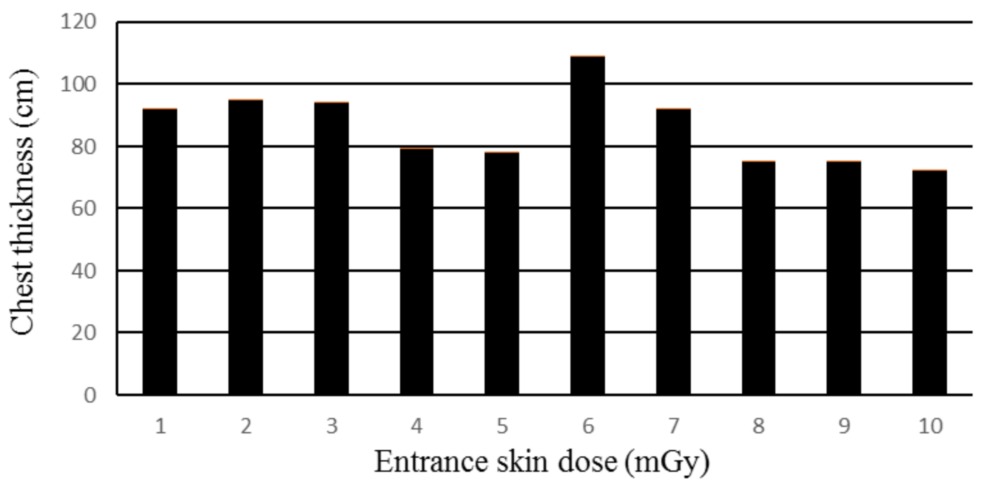

Figure 1: Chest thickness against entrance skin dose for patients S/N 1 to 10

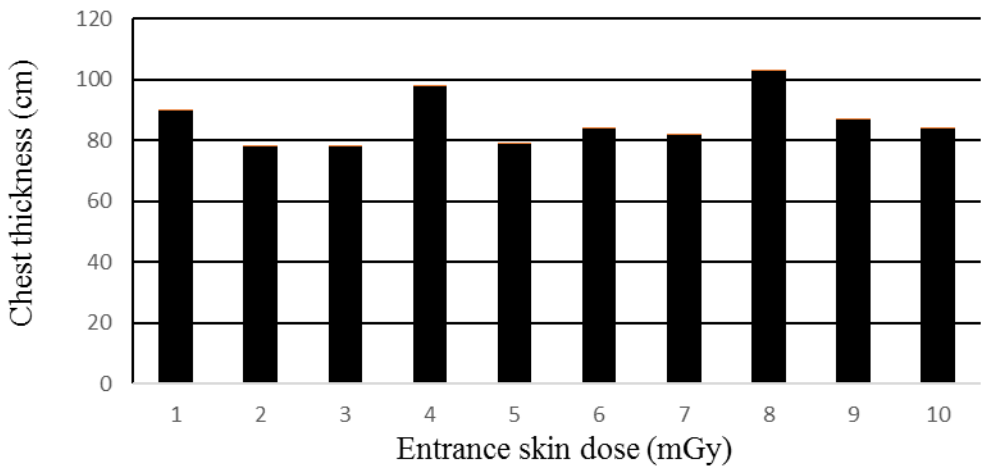

Figure 2: Chest thickness against entrance skin dose for patients S/N 11 to 20

Conclusions

The results of the research work indicate that the entrance skin dose (ESD) received by the adult patients that underwent X-ray examination the hospital were within the guidance level of 0.4 mGy set by radiation protection bodies. This could be that the X-ray machine was properly maintained, although X-ray machines have to pass through quality control evaluations after each three months, before it is allowed to operate. It can be seen that the maximum entrance skin dose was 0.053149 mGy, which could go up if the machines was not properly maintained and monitor. The required dose per patient has to be administered, by selecting the appropriate machine parameters and the dose. The research work, thus serves as the mode of operation for the Quality Assurance (QA) and Quality Control (QC) in X-ray radiography and radiology.

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Conflicts of interest

The authors declare that there is no conflict of interest on the research work and that it was privately sponsored solely by them.

Ethics

The corresponding author hereby confirms that ethics were considered for this research and that the article is original, and its contents are unpublished. The co-authors has read and approved the manuscript for submission.

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