Entrance Surface Dose Assessment for Postero-Anterior Erect Chest X-ray Examinations of Adult Patients in a Selected Teaching Hospital in Sri Lanka

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Abstract*— The amount of radiation received by the patient who is undergoing X-ray examination needs to be quantified to estimate the possibility of harm. Patient doses in radiography primarily depend on the Entrance Surface Dose (ESD) and the sensitivity of the organs and tissues that are irradiated during the radiographic examination. This study aimed to assess the ESDs to the patients of age over 18years, who are undergoing Postero-Anterior (PA) erect chest X-ray examinations at the Kurunegala Teaching Hospital, Sri Lanka and to determine whether the estimated mean ESD value is higher than the recommended value of International Atomic Energy Agency (IAEA) or not. A quantitative study was done on a convenience sample of fifty (50) patients selected separately for two (2) X-ray machines using an indirect method to estimate the ESD. Mean ESD value was calculated for each machine and finally this calculated value was compared with the recommended mean value given by IAEA using the Z-test. The results have shown that the estimated mean ESDs of 0.018 mGy and 0.023 mGy were less than the recommended value of 0.4 mGy. It is concluded that, the variations in the ESD were due to the patient thickness, the different technical characteristics of radiographic equipment and exposure parameters employed by the radiographers. This emphasizes the need for introducing a standard protocol among the radiographic staff and using the quality radiographic equipment.*

Keywords*— Entrance Surface Dose, Postero-Anterior, Chest X-ray*

I. INTRODUCTION

The X-ray examination with image-receptor (film) represents the first method of radiological investigation for more than one century. Its benefits are immense and have revolutionized the practice of the medicine. The radiation doses received by the patients during such investigations have been very poorly taken into consideration during the first years of using this method(Bogucarskis, *et al.* 2005). With the increase of the radiological investigations and the new approach regarding the risk of cancer development in the long term, following the exposure to ionizing radiations, a much greater attention has been paid to maintaining the doses received by patients at a low level. From the stochastic point of view, there is no evidence of the existence of any threshold for radiation. This means that any radiation dose, regardless of the size, may have a potentially damaging effect. The probability, but not the severity, of the stochastic effects grows up in parallel with the increase of the exposure (Ajayi and Akinwurniju, 2000).

It is important to grasp how much radiation exposure has occurred through radiation diagnosis, in respect to reduce unnecessary radiation to the patients (Sorop and Dadulescu, 2011). The amount of radiation received by the patient who is undergoing X-ray examination needs to be quantified to estimate the possibility of harm. Patient doses in radiography primarily depend on the Entrance Surface Dose (ESD) and the sensitivity of the organs and tissues that are irradiated during the radiographic examination (Fujibuchi, *et al.* 2006). In Sri Lanka, as yet, there are no published studies regarding ESD for patients undergoing chest X-ray examinations. It is important to know whether the ESD for chest X-ray examinations are within the recommended value of International Atomic Energy Agency (IAEA) to keep the patient dose as low as possible.

The results of this study would be useful to reduce the patient dose and also will be used as a baseline value for quality assurance to optimize the patient dose. The general objective of the study was to assess the ESDs to the patients who are undergoing chest X-ray examinations in a selected Teaching hospital. The specific objectives were to estimate the ESD to the patients of age over 18years, undergoing Postero-Anterior (PA) erect chest X- ray examinations at the Kurunegala Teaching Hospital, to determine whether the estimated mean ESD values are higher than the recommended ESD value of IAEA or not, to identify the factors affecting ESD and to assess whether the X-ray machines used in the Kurunegala Teaching Hospital need Quality Assurance (QA) Programmes towards reducing patient dose.

II. METHODOLOGY

A quantitative study was done using a convenience sample of fifty (50) patients selected separately for two (2) X-ray machines. ESDs for patients were assessed by indirect method, using data of radiation output of the X-ray tubes, exposure factors (kVp and mAs) and the anatomical thickness of the patients. In this study the Electronic Pocket Dosimeter (EPD) was used to plot the radiation output graph for each X-ray machine. The range of dose measurement used in the EPD varied from 1-9999 µSv. It has a silicon semiconductor detector with accuracy within ±20% from 10 to 9999 µSv. Ethical clearance was obtained from the ethical review committee of University of Peradeniya.

First, a lead sheet was attached to the erect Bucky holder and then the EPD was attached on that lead sheet at the Focus to Film Distance (FFD) of 180 cm. The radiation output values at different kVp settings were then measured using the EPDas given in Tables 1 and 2.After that the radiation output graphs were plotted by using these radiation output measurementsas shown in Figures 1 and 2. Using those graphs, radiation output values were taken for the selected kV values in the study.

The anatomical thicknesses and radiographic exposure factors (kVp and mAs) used for each examination were recorded on a self-designed sheet. The anatomical thickness (cm) of the patients who met the inclusion criteria was measured using a tape measure of least count of 1mm, at the center point of the exposure field at the level of eighth thoracic vertebrae (i.e. spinous process of seventh thoracic vertebrae assessed by using the inferior angle of the scapula) which in turn was used to estimate the Focus to Skin Distance (FSD) for the examination(Osibote and Azevedo, 2008).All FFD measurements were from the center of the tube to the film. Field sizes were also recorded to obtain Back Scatter factors (BSFs) which were given by International Commission on Radiation Protection (ICRP) 85.

FSDs were calculated by using FFD and anatomical thickness of patients. In order to perform calculations of ESD, information such as selected kV, mAs, and the FSD were entered into an Excel datasheet. ESD was computed by using the following equation (Obed, *et al* 2007).

$$ESD = BSF \times \text{Tube Output } (\mu Gy/mAs) \times \left(\frac{180}{FSD}\right)^2 \times mAs$$

Mean ESD value was calculated for each machine and finally this calculated value was compared with the recommended mean value given by IAEA using the Z-test. P values less than 0.05 was considered as significant.

III. RESULTS

Table 1. The radiation outputs of SHIMADZU type X-ray machine with 400 mA of tube current

kV	**Radiation Output (µGy) in 10 mAs**			**Mean Radiation Output (µGy) in 10 mAs**	**Mean Radiation Output (µGy) in 1 mAs**
	1st Data set	**2nd Data set**	**3rd Data set**		
40	13	11	12	12.00	1.200
50	16	14	14	14.66	1.466
60	17	16	16	16.33	1.633
70	18	16	16	16.66	1.666
80	19	17	17	17.66	1.766
90	19	17	18	18.00	1.800
100	20	18	19	19.00	1.900
110	20	19	21	20.00	2.000
120	20	20	20	20.00	2.000

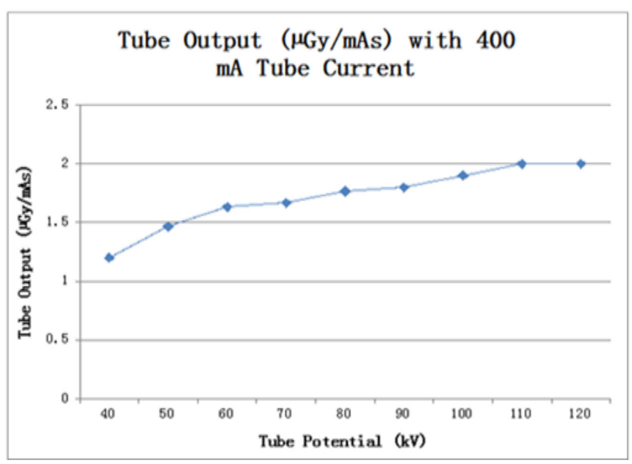

Figure 1. Tube output chart of SHIMADZU type X-ray machine

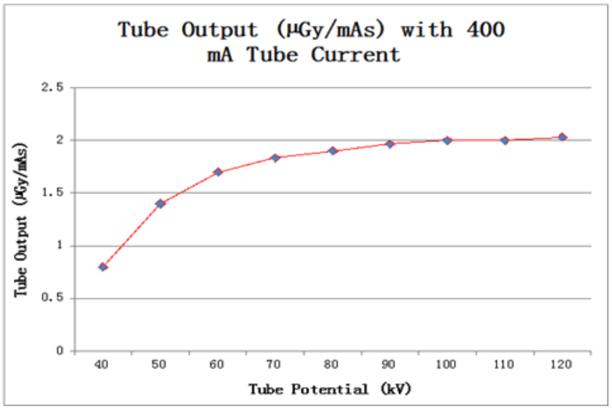

Figure 2. Tube output chart of AMRAD MEDICAL type X-ray machine

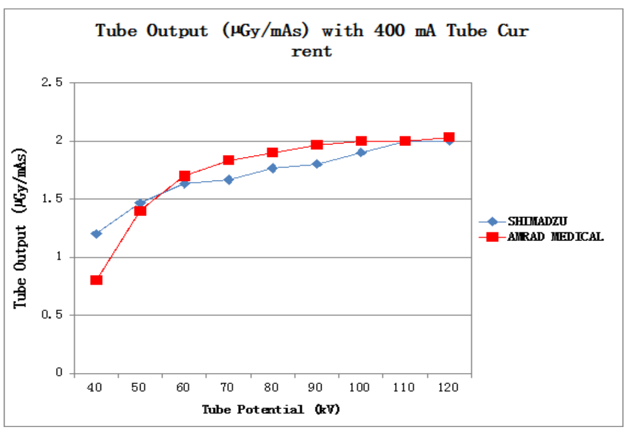

Figure 3.Tube outputs of SHIMADZU and AMRAD MEDICAL machine

Table 3. The values of the ESD with 400 mA tube current

Type of X-ray Machine	**Range of ESD (mGy)**	**Mean of ESD (mGy)**
SHIMADZU	0.01 – 0.032	0.018
AMRAD MEDICAL	0.014 – 0.033	0.023

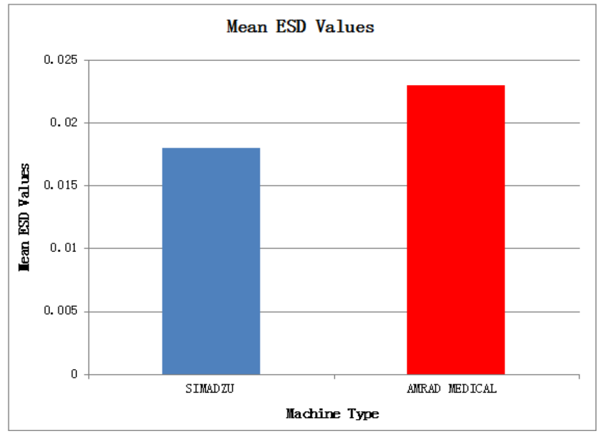

Figure 4. Mean ESD values for machines used

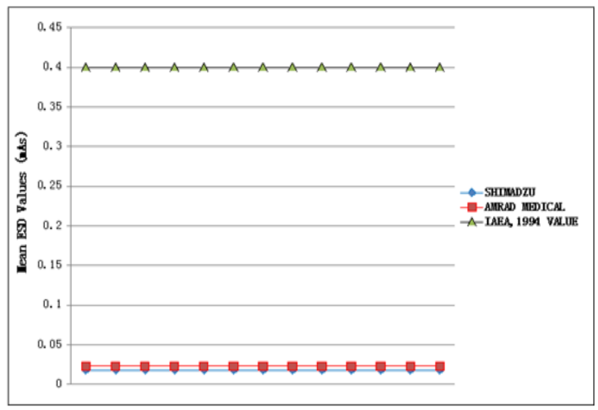

Figure 5. Mean ESD values for machines used and the recommended value

IV. DISCUSSION AND CONCLUSION

This study was carried out to estimate the mean ESD to the patients who did undergo PA erect chest X-ray examinations in X-ray department at Kurunegala Teaching Hospital, Sri Lanka. A total of 50 dose measurements for each machine on PA erect chest examinations were recorded during the study.

Table 4. Mean ESD (mGy) value recommended by IAEA and present study

Type of Examination	**IAEA, 1994 (mGy)**	**Present study (mGy)**
Chest PA	0.4	SHIMADZU machine 0.018 AMRAD MEDICAL machine 0.023

Table 4 shows comparison of reference level dose as recommended by IAEA (1994) and results of the present study.

According to the Z test the mean ESDs of the present study were not equal to the recommended mean ESD value of IAEA 1994. Further, the results showed that the mean ESDs of the study were less than the recommended value.

A similar study conducted in Greece has revealed that the mean value of ESD was 0.044 mGy for chest PA examination and another similar study conducted in Addis Ababa, Ethiopia has revealed that the mean ESDs for PA chest X-ray examination was within the range of 0.076 to 1.48 mGy (Teferis, *et al* 2010).

As the mean ESDs of the present study were less than the recommended value, the kVp range applied by the radiographers is acceptable in terms of patient dose. The results also revealed a decrease of ESD with the increase of kVp. Therefore, use of high kVp settings is appropriate in avoiding unnecessary exposure to the patient.

The other radiographic technique parameter, mAs, showed a significant increase of ESD with the increase of mAs. Therefore, use of low mAs values is useful to avoid high radiation dose to the patient.

Use of gonadal shields and thyroid shields is an important issue regarding radiation protection. Although this is a considerable factor, it was noticed that those protection shields were not in use in the present study. This showed a general lack of awareness of the importance and significance of radiation protection issues at all stages of the study.

This study showed that in the same X-ray room there were variations in the ESDs which could be related to differences in patient size and exposure parameters. In terms of inter-room variations, the mean ESDs showed variations in dose between rooms. These variations in the ESD for the same type of examination between the rooms may be due to the different technical characteristics of radiographic equipment and technical parameters employed as well.

The variations in the data obtained demonstrate the importance of creating awareness of radiation protection and regular quality control testing of radiographic equipment. And also it shows the importance of using standard protocols among the radiographic staff in order to standardize practice and to avoid unnecessary risks of increased radiation dose to patients and staff.The machines used in the study were in good quality in terms of radiation protection. ESD can be further reduced by introducing a standard protocol among the radiographic staff.

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