

Evolution of Patient Dose in Chest Radiotherapy Planning

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Abstract— Radiographic image has been used for patient positioning, target localization radiation beam alignment, and subsequent verification of treatment delivery in radiotherapy. Radiographic imaging as all medical use of ionizing radiation can give significant exposure to the patient.

The aim of this study was to determine the radiological dose for chest imaging. Imaging dose during course of radiotherapy add dose to high therapeutic dose therefore this raises the issue of the balance between the benefit of these additional imaging exposures and the associated risk of radiation induced cancer arising from them. Therefore, estimation of imaging doses and possibility of its risk is necessary to provide adequate justification of this exposure. In this dissertation the main investigated type of the X-ray simulation were chest AP and PA, the total number of patients was 10 (62 radiographs). The fluctuation of the entrance surface dose (ESD) was relatively ranging from 0.35 μ Gy to 8.43 μ Gy for AP projection, and from 0.12 μ Gy to 0.46 μ Gy for PA projection.

The mean values of ESD were found to be within guidance limits which was proposed in some countries (CEC 2004, and Germany 2003).

Keywords— Chest Radiotherapy, ESD, X-ray.

I. INTRODUCTION

X-ray examinations play an important role in diagnostic as well as for treatment of some diseases. Radiographic imaging has significant role for patient positioning, target localization, and external beam alignment in radiotherapy. Although widely varied in modality and method, all radiographic techniques have one thing in common, they can give a significant radiation dose to the patient. As with all medical uses of ionizing radiation, the general view is that this exposure should be carefully managed. The philosophy for dose management adopted by the diagnostic imaging community is summarized by ALARA. But unlike the general situation with diagnostic imaging, X-ray

simulation adds the imaging dose to an already high level of therapeutic radiation. The imaging dose that received as part of a radiotherapy treatment has long been regarded as negligible, and thus, it has been quantified in a fairly loose manner. The introduction of more intensive imaging procedures in radiotherapy context now obligates the evaluation of therapeutic and imaging dose in a more balanced manner (AAPM, 2007).

The biological effects of radiation depends on the absorbed dose and expressed in Gray (Gy). The absorbed dose of radiation can be measured and/or, calculated and form abasic evaluation of the probability of radiation induced effects.

The Patient dose has often been described by the Entrance Skin Dose (ESD) as measured in the Centre of the X-ray beam. As a result because of the simplicity of its measurement, ESD is considered as widely as the index to be assessed and monitored. ESD is measured directly by using Thermo-Luminescence Dosimeter (TLD) placed on the skin of the patient or indirectly from the measurements of dose-area product using a large area Transmission Ionization Chamber (TIC) placed between the patient and the X-ray tube. The use of TLD method in ESD assessment is a time consuming process. On the other hand, TIC method does not provide direct measurement of skin dose and mathematical equations are needed to convert TIC reading into Skin dose.

II. MATERIALS AND METHODS

2.1 Material

This experiment was carried out in the National Cancer Institute (NCI) - Wad madani - Gezira state. Patient anthropometrical data (age, weight, and height) and exposure parameter (kVp, mAs and FSD) were used and were collected from simulator room at the time of each examination.

The Terasix simulator is adapted and equipped to suit the respective purpose. The simulator is derived analogically

from radiation instruments. Which is consisted of gantry head equipped with a diagnostic X-ray tube (Industry Application Elettroniche IAE - RTM90HS/C52), focal spot size (0.6/1.2), total filtration 2mm Al), and an X-ray television chain (Toshiba Electron Tubes & Devices) opposite that tube.

2.2 Methods

Radiotherapy treatment of the Chest tumors was achieved through the use of parallel opposed fields anteriorly and posteriorly, beside the simulation process to get the reference image. Data analysis was performed using the SPSS version 16 software.

2.3 Entrance skin dose

To calculate the ESD X-ray exposure parameters were record for each patient undergo chest radiotherapy simulation, those parameters was peak tube voltage (kVp), exposure current time product (mAs) and focus to patient skin distance (FSD). The ESD is defined as absorbed dose to air at point of intersection of the x-ray beam axis with the entrance surface of the patient, including back scatter factor (NRBP, 1992). The equation used to calculate ESD expressed as follows (Mohamadain et al, 2015):

$$ESD = op \times \left(\frac{kV}{80}\right)^2 \times \left(\frac{100}{FSD}\right)^2 \times mAs \times BS$$

Where: OP is output of X-ray tube (mGy/mAs), kV is a peak tube voltage recorded for each examination, mAs is a tube current time product, FSD is the focus to patient skin distance, and BSF is back scatter factor.

The Output in mR/mAs was measured at a distance of 100 cm from the x-ray tube using RAD-CHECK PLUS; model 06-526 exposure meter (Nuclear Associates, Victoreen Division, NY, USA). In order to convert output from mR/mAs to output in mGy/mAs dosimeter readings were multiply by 0.0088 to apply conversion. BSF for radiation qualities typically used in diagnostic radiology has a value

that range from 1.2 to 1.4. EC recommend the use of an average value of 1.35 for the BSF which was used in this study (CEC, 2004).

The tube output was measured in a scatter free geometry, for a peak tube voltage of 80 kVp, exposure current-time product of 18 mAs and a focus-to detector distance of 100 cm.

X-ray simulator (TERASIX) equipped with optical distance indicator (ODI) to indicate focus to skin distance (FSD), Exposure parameters were registered and dose calculations were performed on a sample of 62 radiographs, for adult patients with age > 20 years. Microsoft excel was used for ESD calculations.

III. RESULTS AND DISCUSSION

Before estimating the patient doses tube output have been measured which is represent one of the most important QC tests. This test must yield a straight line relationship between $(kVp)^2$ and output (mR/mAs). The results then were used to calculate ESD for different projections. Table.1 show measurement of output at different kVp settings at (18 mAs and 100 cm SDD). The plotted output vs. kVp was found to be linear as shown in (Figure.1).

Table.1: Output vs tube voltage

kVp	Output (mR)	$(kVp)^2$	Output/mAs (mR/mAs)
40	15	1600	0.83
50	23.5	2500	1.3
60	33.8	3600	1.88
70	46	4900	2.6
80	60	6400	3.34
90	76.2	8100	4.23
100	94	10000	5.22

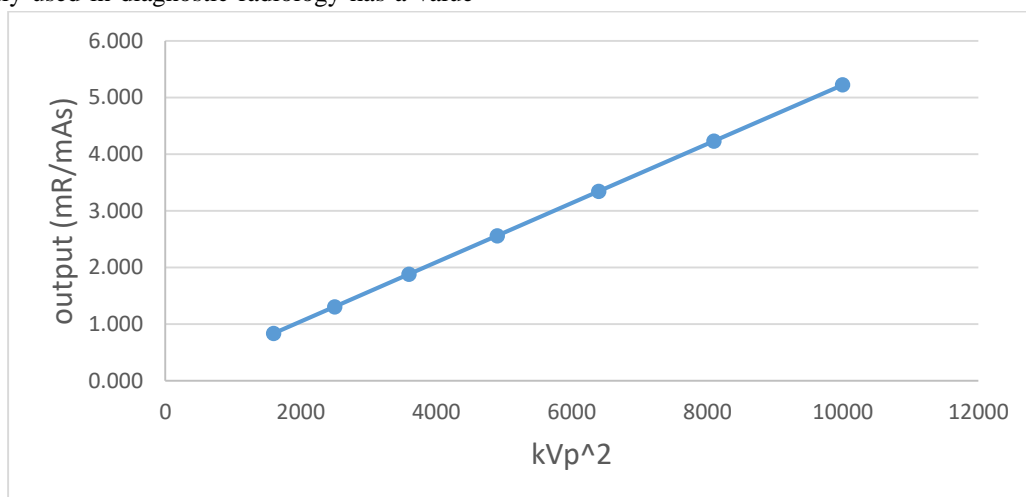


Fig..1: Relation between $(kVp)^2$ and output

3.1 ESD calculations

The results of patient data and exposure parameters were tabulated in table.2, the results of ESD calculation and their comparison with previous studies were presented in tables (3 &4). Histograms for ESD results also were indicated (figures.2 &3).

Table.2: The mean and range of patient data and exposure parameters

Radiograph	Projection	Patient age (yrs)	Height (cm)	Weight (kg)	Tube voltage (kVp)	mAs	FSD (cm)
Chest	AP	61.5 (45-80)	159.6 (151-178)	48.3 (34-69)	79.5 (62-93)	35.4 (11.6-144)	90
	PA				78 (62- 91)	6.96 (4- 8.3)	90

Table.3: The descriptive statistics for ESDs

Radiograph	Projection	Mean ESD mGy					
		Mean	Median	Min	Max	1 st quartile	3 rd quartile
Chest	AP	1.7	1.3	0.35	8.43	1.05	1.8
	PA	0.33	0.34	0.12	0.46	0.26	0.40

Table.4: Comparison of mean ESDs estimated in this work to that reported as DRL in some countries (previous studies)

Examination	This work	UK	CEC	Germany
ESD mGy				
Date of study	2016	2009	2004	2003
Chest PA	0.33	0.15	0.3	0.3

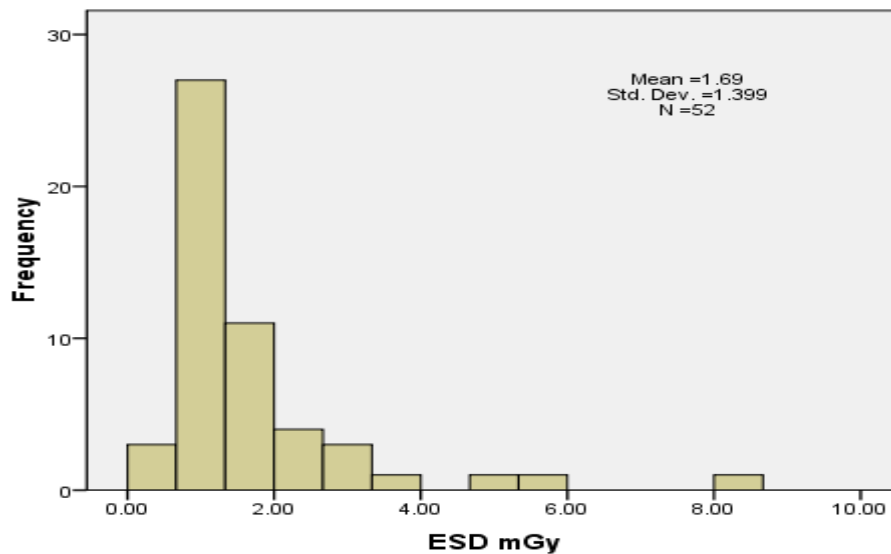


Fig..2: Histogram for ESD per radiograph for AP projection

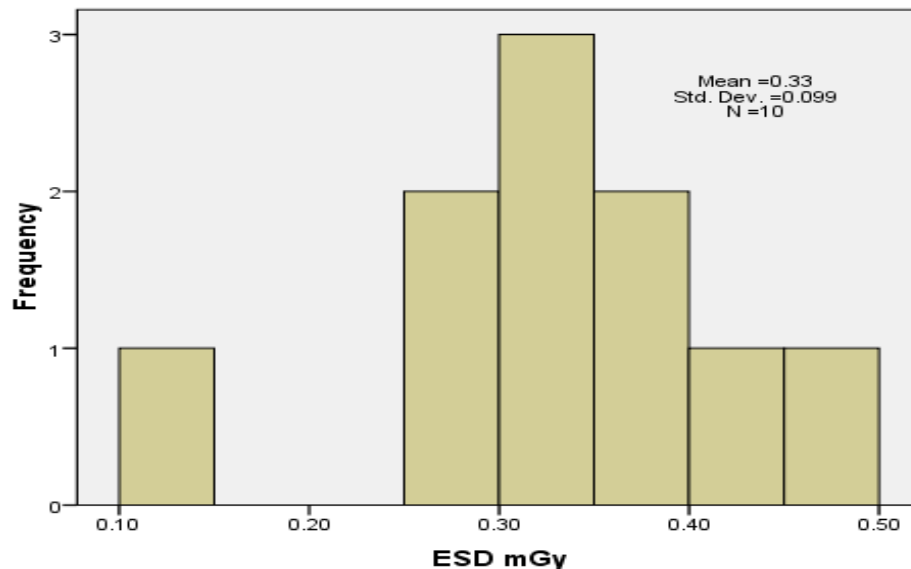


Fig.3: Histogram for ESD per radiograph for PA projection

In this study the Entrance Skin Doses (ESDs) for Chest were measured during fluoroscopic examinations of selected cancer patients in simulator at National Cancer Institute (NCI) - Wad madani. the total number of patients was 10 (62 radiographs) undergo radiotherapy for the chest tumor. Radiotherapy fields arrangement which considered here was parallel opposed fields, the average number of radiographs for individual patient for AP projection was 5 radiographs. The reason for this multiple exposure was to get the optimum patient set-up. For, the other field PA usually single exposure required to get reference image (single radiograph per patient).

The kVp range was (62 - 93), and mAs range was (4 - 144). The mean FSD was used (SAD technique) was 90cm, and it depend on patient separation. These large variations in exposure parameters may be attributed to variation in patient's size and also as a result of using automatic exposure control. ESD values varied from 0.35 mGy to 8.43 μ Gy for AP projection and 0.12 μ Gy to 0.46 μ Gy for PA projection presented in Table -3.

The mean ESD values were compared with some international DRLs (Hart et al 2009, CEC 2004, and Bundesamt fur Strahlenschutz 2003), for PA projection only as shown in Table.4, the mean ESD evaluated values were found to be within the corresponding DRLs recommended in publications by CEC 2004 and Germany 2003, and higher than that established by UK 2009. The reason of relatively high ESDs calculated resulting from using of short FSD distance (90 cm) in simulation process compare to that stablished by CEC (140 - 200 cm). (CEC 2004).

The variations in ESDs may be attributed to several factors differences in patient weights, exposure parameters, and

focus-to-skin distance. Equipment performance can be a major factor contribute positively to the results.

3.2 Conclusion

Patient dosimetry is often applied as an instrument for optimization of radiological techniques, and improveing of radiation protection to the patients, interhospital, interregional and international comparisons provide insight in the radiation exposure of patients. We conclude that the mean ESDs were found to be within DRLs established in (CEC 2004, and Germany 2003), equipment performance and use of digital X-ray systems were contribute positively to these results. The findings in present work may encourage further doses survey to involve all other projections used in radiotherapy.

For further reduce imaging dose without reducing image information required narrowing fields of view. Use of modern imaging modalities also may reduce the patient imaging dose in the course of radiotherapy. The required of high contrast image elevate the exposure level to the patient, the beam alignment information derived from images used for tumor targeting is depend on imaging frequency rather than image quality, increase in the number of images may add more imaging doses than that eliminated by improve field alignment therefor the staff well identify the point at optimum balance between the imaging dose and alignment error.

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