



Determination of Entrance Skin Dose from Diagnostic Human Chest X-ray in General Hospital Minna

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ABSTRACT

This study was carried out to determine the trend of dose received by patient during x-ray examination in General Hospital, Minna in Niger State, Nigeria. Entrance skin doses (ESDs) for chest PA (posterior anterior) examination were measured. A total of 67 data were collected from patients who were exposed to diagnostic X-ray during chest X-ray examinations. The age of the patients ranged between 10 to 70 years old while the weight and height of these patients ranged between 45.6kg to 75.6kg and 145.6cm to 163.3cm, respectively. The patient's skin dose was determined using Edmond's formula, which is based on the X-ray tube and the radiographic exposure parameters of kVp, mAS, SSD and the total filtration of the beams. The calculated mean skin dose ranges from 0.9mGy to 1.3mGy. The results obtained were high compared to other established work which indicated that there is need to optimize service in the General Hospital.

Keywords: X-ray, Skin Dose, Exposure and Optimization

INTRODUCTION

Medical X-ray is by far the largest man-made source of exposure to ionizing radiation (Ng *et al.*, 1998). In medicine, ionizing radiation is used for two main purposes; diagnosis and therapy. Consequently, individuals and the populace at large receive major exposure to radiation. Diagnostic radiology is a leading cause of man-made radiation exposure to the population. National Radiology Protection Board (NRPB, 1993) estimated that diagnostic radiology and nuclear medicine contributed 96% to the collective effective dose from man-made sources in developed country like U.K.

Ionizing radiation is a form of radiation with sufficient energy to remove electrons from their atomic or molecular orbital shells in the tissues they penetrate Canadian Nuclear Safety Commission (CNSC, 2012). These ionizations received in sufficient quantities over a period of time can result in tissues damage and disruption of cellular functions at the molecular level. The dose delivered to tissue from ionizing radiation can either be from the radiation absorbed over a few hours or day or radiation absorbed over a longer period of months, years or over a lifetime. The energy is deposited in tissue where it remains over a period longer than few days, so that the exposure to the surrounding tissue is of a chronic duration. The health of the population

would decline if ionizing radiation techniques were not available to diagnose disease and detect trauma. Nevertheless, there is no excuse for complacency and it is a basic premise of radiation protection practice that any exposure should be justified by weighing the potential harm against the perceived benefit Ibrahim *et al.*, (2014) and National Aeronautics and Space Administration (NASA, 2014). In view of the major benefits from properly conducted medical exposures, the primary concern in radiological protection is the reduction of examinations that are either unlikely to be helpful to patient management or involve those that are not As Low As Reasonably Achievable (ALARA) in order to meet specified clinical objectives. In order to achieve this, there is a need to optimize X-ray equipment and logical techniques (NRPB, 1990).

The need for radiation dose assessment of the patients during diagnostic X-ray examinations has to be highlighted by increasing knowledge of hazard of ionizing radiation (Joseph *et al.*,

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2014; Olowookere *et al.*, 2012). Because of the deleterious effect of X-rays, it is necessary to protect patients undergoing diagnostic and therapeutic procedures. In keeping radiation dose to patients to a minimum in hospitals, it is useful to be able to estimate prior to medical examinations the dose to patients as a function of radiographic exposure parameters (Taha *et al.*, 2014). According to Ibrahim *et al.*, (2014) by Edmond's formula, radiation dose to patients from diagnostic X-ray machine assures a simple functional dependence on radiographic exposure parameters of tube potential (kVp) tube current (mA), time of exposure (mAs), Source to Skin Distance (SSD), filtration and thickness. Monitoring of patients during the examination has been a major way of assessing radiation dose received in diagnostic and therapeutic radiography (Egbe *et al.*, 2009).

METHODOLOGY

The study was performed in a single academic center (General Hospital, Minna), using a single static rotating X-ray machine manufactured 2014 with serial number M132003 with a source to skin distance (SSD) of 100cm and a filtration thickness of 1.2mm Al (inherent 0.5, added 1.0 mm). The focal spot reduced to small so as to cover just the chest the patient is positioned facing the receptor with the chin extended and centered to the middle of the top of the receptor. The median sagittal plane is adjusted at right-angles to the middle of the receptor; the shoulders are rotated forward and pressed downward in contact with the receptor or vertical stand. This is achieved by placing the dorsal aspect of the hands behind and below the hips with the elbows brought for-ward, or by allowing the arms to encircle the vertical Bucky

device. Using horizontal beam, the collimated ray is directed at right-angles to the receptor and center at the level of the 7th thoracic vertebrae which correspond to T7. Exposure is made in full normal arrested inspiration.

The survey method in this work was based on the guidelines established by the Nigerian Nuclear Regulatory Authority (NNRA). The data collected were based on the exposure parameters and the total filtration of the beam from the machines. The skin dose to patients was determined by calculation from the X-ray tube parameters and exposure radiographic parameters using Edmonds (1984) skin dose formula which is given as:

$$ESD(\mu Gy) = 418(kVP)^{1.74}mAS \left(\frac{T^{1+0.114}}{(SSD)^2} \right)$$

(NCRP, 1987).

Where kVp is the peak voltage responsible for the quality of penetration, and mAS is the tube current responsible for quantity of electrons from the filament. While T is the total filtration of the beams always a constant (1.2mmAl). The source to skin distance (SSD) was obtained for each patient from the focal –film distance (FFD) and the thickness of the patient's chest.

The human patients involved were interacted with and a written informed consent was obtained from all the patients. Also, due permission was obtained from the facility management before they were used. The studied population included 67 adult patients of both genders referred to posteroanterior (PA) projection of chest radiography during a period of 1 month.

RESULTS

Table 1: Patient information and X-ray machine parameters

S/N	NO OF PATIENTS	AGE RANGE (YEAR)	MEAN WEIGHT (kg)	MEAN HEIGHT (cm)	MEAN kVp (kV)	MEAN mAs (mAs)	MEAN DOSE (µGy)	MEAN DOSE (mGy)
1	10	10-15	49.6	145.6	63.9	15.4	906.5706	0.906
2	9	16-20	64.7	157.1	65.3	13.4	789.7723	0.79
3	9	21-25	58.9	159.7	68.9	17.8	1118.236	1.118
4	4	26-30	52.5	156.5	69	18	1131.938	1.132
5	10	31-35	65.6	160.3	70.1	20.9	1354.062	1.354
6	4	36-40	75.6	159.8	70	21.3	1366.182	1.366
7	4	41-45	58.3	160.5	66	15.1	887.1863	0.887
8	8	46-50	69.3	159.8	69.3	18	1138.263	1.138
9	2	51-55	63	158	69	18	1131.938	1.132
10	3	56-60	72	163.3	70	20	1285.819	1.286
11	1	61-65	66	162	70	20.4	1311.5349	1.312
12	3	66-70	62.7	162.7	69.7	16.3	1040.181	1.04

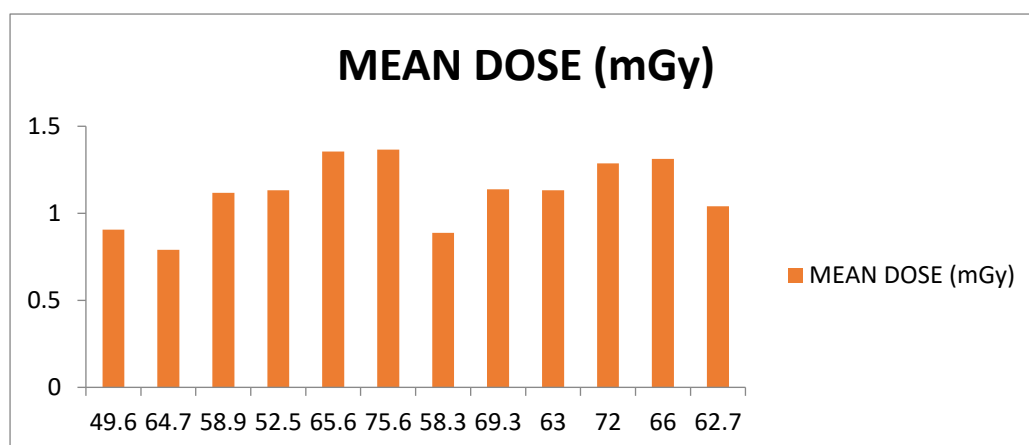


Figure 1: Histogram of Mean Weight Against Mean ESD (mGy).

Table 2: Exposure parameters for three age persons

Chest PA	1 st patient	2 nd patient	3 rd patient
Age (years)	10	12	13
Kvp (Kv)	58	60	58
mAs (mA)	8	12.5	8
FSD (cm)	100	100	100

Table 3: Entrance Surface Dose from this study compared to other works

Projection	Chest PA
This work	0.45
Ghana	0.2
FMC Keffi, Nigeria	0.851
Serbia/Montenegro	0.4

Table 4: comparison of ESD (mGy) with previous published data and International Recommended values

Reference	Examination	kV/ mAs	Mean ESD (mGy)
This work	Chest PA	58.6/9.5	0.45
NRPB 1999	Chest PA	-	0.2
IAEA 1999	Chest PA	-	0.4

DISCUSSION

Results in Table 1 show ESD for chest X-ray examinations and the guidance levels that recommended by International Atomic Energy Agency (IAEA), International council for Radiation Protection (ICRP). The maximum absorbed dose recorded is 1.366 mGy, these may be attributed to the patient's chest thickness or ages which were also high. It showed ESD values that are higher than IAEA, ICRP reference dose. This could be attributed to the relatively high exposure parameters used in the general hospital. It is also possible that radiographers experience has some impact. Based on the results obtained recommendations will be made on how to bring the doses below the international recommended dose levels. In general, all values of ESD in this study within IAEA recommendation and exceed with fraction in some cases.

The histogram in figure 1 shows that the mean doses received by the patients increased in body mass, another influencing factor that causes high ESD obtained in this examination is probably due to the aging effect of the X-ray tube.

Table 2 shows the exposure factors of three patients that undergone chest PA examination and how it varies with years. The patients' information and exposure technical parameters for the projection considered are tabulated according to age groups and were presented in Table 2. There is wide variation in technical parameters (kVp and mAs) used in the hospital, which shows that there is no standard of procedure. For example, mAs vary from 8-12.5mAs for chest PA in age range 10-13 years.

Table 3 shows the ESD this study compared to other works. The mean entrance surface dose for this study 0.45mGy was compared to other works. Table 4.3 show the results from this study are lower than FMC Keffi and Serbia Montenegro respectively and higher than the Ghana ESD. This could be attributed to the use of different exposure factors like kV and mAs used in the study. Other reason could be that, the studies presented were carried out using conventional X-ray machines. Given that operator training and knowledge could also influence the criteria for the selection of exposure factors as well as the performance of the X-ray system on the output of selected factors, the result presented could have differed due to any of these factors. However, since the goal of patient protection is to reduce doses to patient while retaining the required image quality for diagnostic purposes. It is conclusive to say that from the radiation protection standpoint, this present low doses to patients thereby reducing the risk of stochastic effect to them.

The mean ESD in chest PA for the age range 10-13 was estimated to be 0.45 mGy which is higher than the reference level of 0.2 and 0.4 mGy recommended by NRPB and IAEA, respectively. The comparison of mean ESD in the hospital for all chest PA projections for age range 10-13 is shown in Figure 4.3. Chest PA examination was chosen for showing the comparison in the hospital because it's the most frequent examination in the hospital and even worldwide NRPB 1999 reference levels and European commission reference levels are used as reference to compare the results of ESD obtained. The reasons for the variation in ESD may be due to performance of equipment, type of X-ray generator, the processing system and radiographic techniques used in the hospital It is difficult to compare this reference with the results of this study where age range had been used to evaluate the mean ESD values but can still provide useful information for comparison.

Conclusion

The results presented in this research work indicate that the ESDs received by patients undergoing x-ray examination in General Hospital Minna were higher than the guidance levels of 0.4mGy set by radiation protection bodies (IAEA 1999) and (NRPB 1999). The mean entrance doses, obtained

from measurements carried out on 67 patients ranges from 0.79mGy and 1.366mGy. the high doses indicate that dose delivered to patients were not As Low As Reasonably Achievable in the hospital. The major contributor to these high doses in this research work is the patient body mass or size, maintenance and sub optimal usage of the machine considering the fact that the image quality is good.

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