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Estimation of Entrance Surface Dose During Diagnostic X-Ray Procedure at Minna General Hospital

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ABSTRACT

The risk of occurrence of cancer in developed and developing nations of the earth has become a major concern in the scientific and medical circle. Ionizing radiation which plays a significant role in x-ray diagnostic procedure has been identified as one of the factors responsible for the risk of cancer. This have therefore called for imperative measures to determine how much of radiation these medical imaging delivers to the patient. The aim of the study is to determine the entrance surface dose for patient undergoing diagnostic x-ray procedure at Minna general hospital. A total of 125 patient participated in the study with different examination such as the lumber (LAT & AP), chest (PA &LAT) and pelvis (AP). Patient parameter collected after all necessary approved consent include the age, sex, height, weight, and the exposure factors which are the kVp, mAs and the focus-to-skin distance. Using the geometric and technical parameters, the ESD were calculated. The obtained ESD ranged from 0.3-1.5mGy for chest (PA), 0.3-1.0mGy for chest (LAT), 1.33-5.67mGy for lumber (AP),1.5-5.4mGy for lumber (LAT), 1.6-5.21.5.2mGy for pelvis (AP). These values when compared with IAEA(1996) and NPRB(2002) values were found to be low which indicates an improvement in optimization and does not pose any health risk to the patient.

Keywords: ESD, cancer, radiology, diagnostic X-ray.

INTRODUCTION

The risk of occurrence of cancer in developed and developing countries has been of major concern. Developed countries has done significantly well in terms of early detection and radiotheraphy but the death rate in developing countries shows that not much has been done either in early detection or radiotheraphy (Ahmedin *et al.,* 2011). An essential energy, ionizing radiation used during diagnostic x-ray procedure is one of the factors responsible for the risk of occurrences of cancer. This has therefore called for an imperative measure to determine how much of radiation these medical Imaging delivers to patients by determining the entrance surface dose. The entrance surface dose which is a deterministic effect is the

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maximum amount of X-radiation dose absorbed by the entrance skin of a living tissue at the central point of the irradiated area (Sharifat & Olarinoye, 2009). Due to the risk of exposure during diagnostic x-ray procedure, minimum amount of x-radiation should be recommended and the entrance surface dose should be measured and monitored (Alatta et al., 2017).

Akinlade (2011) carried out a research on assessment of detrimental health effect of radiation associated with diagnostic x-ray examinations at four centres in Nigeria. ESD and effective dose(ED) was estimated using PCXMC programand obtained results were compared with similar examinations in published studies. From estimated ED in some of the selected facilities, the risk of fatal cancer was higher than the ICRP recommended limit. Abubakar *et al*.(2017) investigated ESD for patient in five different projections in Sebbha city of Libya. The mean ESD values were found to be higher than the mean ESD reference values which indicate the necessity to reduce the patient dose to the acceptable levels recommended by ICRP. Worldwide interest in dose measurement and guidelines includes National Radiological Protection Board (NRPB), International Atomic Energy Agency (IAEA).

The aim of this study is to determine the patient dose arising from diagnostic X-ray procedure in Minna general hospital and the knowledge from this investigation will help to determine if the patient dose in this facility is as low as reasonably achievable.

MATERIALS AND METHOD

Data Collection

General hospital Minna, a government owned health care institution in the capital city of Niger state, is a source of medical aid to more than half of the 300,000 population. It was considered due to the high number of patients that visit the facility for x- ray examination and the number of trained personnel. The facility has a record of two radiographers, one radiologist and three x-ray technician.

The available machine used for x-ray examination in Minna General hospital is the Nortek rotating anode x-ray tube with 1.00 mmAl/75 kv filtration. It is a three-phase x-ray machine, installed and manufactured in the year 2014 which makes use of Agfa digital processor for the X-ray photographic film.

125 adult patients (male and female, between the ages of 18-90 years) were considered in this investigation. The human parameters considered in this study includes sex, age and body mass index (BMI) of every patient under investigation. The body weight and height of each patient from which their respective BMI were calculated, were obtained directly using a weighing balance and tape rule respectively. The five projections of interest to this research in the daily X-ray examination of patients conducted between January and March, 2019 (3 months), are chest (PA & LAT), lumber (AP & LAT) and pelvis (AP). The kVp, and mAs values for each examination was read directly from the

control panel of the x-ray machine. The focus-to-skin distance for each patient was also recorded.

Data Analysis

The entrance surface dose was calculated using the equation (Sharifat & Oyeleke, 2009).The data inputto get the ESD are the kVp, mAs and the focus-to-skin distance.

$$\mathrm{ESD} = \mathrm{Y(d)} \times \left(\frac{\mathrm{kV}}{80}\right)^2 \times \left(\frac{100}{\mathrm{FSD}}\right)^2 \times \mathrm{mAs} \times \mathrm{BSF} \quad (1)$$

where;

ESD is the entrance surface dose

Y(d) is the radiation output $\frac{mGy}{mAs}$, And multiplied by 0.00877/mAs to convert from milliroentgen to air kerma in mGy/mAs

kV is the tube kilovoltage

FSD is the focus-to-skin distance,

mAs is the current-time product and

BSF the backscattering factor which is 1.35 obtained from literature (Suliman *et al*. 2006, Sherifat & Olarinoye, 2009).

The obtained data was analysed using Excel

RESULT AND DISCUSSIONS

Five examinations were considered in this study, with chest x-ray having the largest number of patients (67.2%) and pelvis (8.8%) with the least number. The projections considered are the anteror-posterior (AP), posterior-anteror (PA) for chest and lateral (LAT) projection. The patient geometric data is shown in Table 1 with the mean age as 38years, 66kg as the mean weight, 161.4cm as the mean height and the mean BMI derived from weight/(height)^{2}as 25.5.

Table 1: Patient's geometric information, mean values and ranges indicated.

RADIOGRAPH	PROJECTION	AGE	WEIGHT (KG)	HEIGHT (CM)	BMI (Range)
CHEST	LAT	48.2(33-64)	70.8 (50-98)	164.6 (150-178)	28.7(19.5-38)
CHEST	PA	40.4(18-71)	67 (42-120)	159.5 (148-172)	26.4 (18-53)
LUMBER	AP	46(31-58)	62 (48-76)	158.8(145-177)	30.3(21.3-50)
LUMBER	LAT	36(23-58)	76.5(63-110)	158.5 (140-174)	23.5(20-25.7)
PELVIS	AP	36(29-48)	73.2 (50-110)	164 (146-190)	27.1(22-30.5)

The exposure parameters are presented in Table 2, revealing the range of tube loading (58kVp-78kVp), mAs (8-33) and the focus-to-skin distance (57-106) cm. The use of low mAs and high kVp in this facility is known to substantially reduce patient dose and it is been recommended by many other previous study.

Table 2: exposure factors and ESD, mean values (ranges) indicated.

RADIOGRAPH	PROJECTION	kVp	mAs	FSD(cm)	ESD (mGy)
CHEST	LAT	71.2(70-73)	20.4(12-33)	106	0.42
CHEST	PA	66.1(56-72)	11.3(8-18)	103	0.77
LUMBER	AP	74.1(70-78)	23.4(20-25)	67.4(57-100)	2.24
LUMBER	LAT	74.3(70-78)	25.7(12.5-32)	73.6(57-100)	2.14
PELVIS	AP	71.3(68-75)	20.8(16-25)	63.7(58-75)	2.75

A comparison of patience dose between this study and the study carried out in this facility by Sherifat and Oyeleke (2009) and international established values, IAEA (1996) and NPRB (2002) is presented in Table 3.

Table 3: estimated ESD compared with other published and established values.

RADIOGRAPH	PROJECTION	THIS STUDY	SHERIFAT & OLARINOYE (2009)	IAEA (1996)	NRPB (2002)
CHEST	LAT	0.42	NA	1.5	1.0
CHEST	PA	0.77	4.4	0.4	0.2
LUMBER	AP	2.24	NA	5	6
LUMBER	LAT	2.14	NA	15	14
PELVIS	AP	2.75	NA	10	4

NA- Not Applicable.

A remarkable level of increase in optimization over the years can be deduced from the result obtained and shown in Table 3 after comparing the mean ESD of this study with that of Sherifat & Oyeleke (2009), this is a reflection of reduction in the exposure factors which contribute immensely to the reduction of ESD from 4.4mGy to 0.77mGy(86% decrease). The minimum ESD in this study is 0.42mGy which is the case of chest (LAT) and the maximum dose being 2.75mGy as with the case of pelvis. In all cases of examination, low doses are obtained when compared with international standards. The inverse square law is established as the

intensity of the X-ray beam is a function of distance from the target, hence maximizing distance is the best protection measure from ionizing radiation (Olarinoye & Igwe, 2010). The relationship between higher X-ray tube filtration and low dose is well established (Saeed, 2015), as the absorbing material used for the purpose of an added filtration is to harden the beam and thus eliminate the soft photons that could be detrimental to health when absorbed. The use of inherent filtration 1.0mmAl only for a machine that is barely five years as at the time of this study could be another reason for the increase in patient dose. Diagnostic reference level are not to be exceeded when good and normal procedure regards diagnostic and technical performance is applied, as a result of this comparison, it therefore shows that there is a need for increase in the focus-to-skin distance.

ESDs calculated for pelvis and lumbar spine, 2.75mGy and 2.19mGy respectively were found to be within the corresponding DRLs recommended by NRPB (2002) and IAEA (1996).

CONCLUSION

The entrance surface dose of patients in Minna general hospital is presented in this study, this was to ascertain the level of improvement in the optimization of X-ray procedure. Five common projections were carried out on a total of 125 patients. Comparison were made between the present measurement and a previous study alongside international standards. The mean dose for lumber (AP), lumber (LAT) and pelvis are 2.24mGy, 2.14mGy and 2.75mGy respectively.

The mean entrance surface dose was found to be generally low. However, though variations are observed, the facility employed safe and optimal use of high kVp and low mAs as a means of dose reduction. Although this indicate a level of improvement in the system but a reasonable low dose is still achievable by setting guidelines for hospitals to always compare their dose for better optimization.

RECOMMENDATION

These results showed that there is the need for continual optimized procedure in Minna general hospital especially for chest examination which is the commonest examination. Optimum choice of the technical factors especially the FSD and filtration which can reduce the dose to patient should be put in check.

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