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DETERMINATION OF ENTRANCE SKIN DOSE FROM DIAGNOSTIC X-RAY OF HUMAN CHEST AT FEDERAL MEDICAL CENTRE KEFFI, NIGERIA

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ABSTRACT

A study was carried out to establish the trend of dose received by patient during x-ray examination in Federal Medical Centre, Keffi in Nasarawa state, Nigeria. Entrance skin doses (ESDs) for a common type of x-ray procedures, namely chest AP/PA (anterior/posterior) were measured. A total of 200 data were collected from patients who were exposed to diagnostic X-ray during their routine chest X-ray examinations. The age of the patients ranged from 15 to 68 years old while the weight and height of these patients ranged from 37.5kg to 98.5kg and 130.0cm to 175cm, respectively. The patent's skin dose were 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 0.013 ± 0.01mGy to 0.851 ± 0.023mGy. In general, the ESDs measured for this type of x-ray procedures were found to be lower than or in agreement with the guidance level set by the Nigerian Basic Ionizing Radiation Regulation (NBIRR, 2003) standard and other international bodies and does not pose any significant health risk to the patience or the workers.

Keywords: Entrance skin Dose, X-ray, Anterior-Posterior, Exposure, and Radiation.

INTRODUCTION

In medicine, ionizing radiation is used for two main purposes; diagnosis and therapy. Consequently, individuals and the populace at large receive significant exposure to radiation. Diagnostic radiology is a leading cause of man-made radiation exposure to the population. It was estimated that diagnostic radiology and nuclear medicine contributed 96% to the collective effective dose from man-made sources in the U.K (National Radiology Protection Board, (NRPB, 1993). Similar estimate showed that this contribution was 88% in the U.S.A (National Council on Radiation Protection and Measurement (NCRP, 1987).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. In view of the significant benefits from properly conducted medical exposures, the principal 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 in order to meet specified clinical objectives. In order to do this, there is a need to optimize x-ray equipment and logical techniques (NRPB 1990). Patient dose measurement is an integral part of this optimization procedure (Faulkner, *et al* 1999). Such measurements will reveal x-ray facilities with doses after which possible dose reduction measures may be specified. Dose measurement is also necessary so as to: establish dose constraints, determine risk to patient and to justify the examination. The current philosophy of the International Commission on Radiological Protection (ICRP) in medical practice is that any use of radiation should be justified. After justification, it is important to optimize the procedure. In radiography this means using as low a dose as reasonable to obtain an optimum image of diagnostic quality.

There are two categories of doses to patient which are important in diagnostic radiology; the effective dose E, which takes into account of dose equivalent to radiosensitive organs and the entrance skin dose. Most interest in diagnostic radiology is concerned with effective dose since this relates to the risk of stochastic effect such as cancer induction.

Drek, (2010) suggested that for public health management of radiation emergencies, one of the essential components of integrated risk assessment is to quickly and accurately assess and categorize the exposure .Radiation safety, monitoring, and assessment have become issues of great concern, since at high doses, ionizing radiation is carcinogenic and clinical symptoms are known to be associated with low-dose exposure. The injuries and clinical symptoms induced by exposure to ionizing radiation include, direct chromosomal transformation, indirect free-radical formation, radiation catractogenesis, cancer induction etc. (Serro, 1992).

Diagnostic X-rays are used for identifying diseases and other problems during medical examinations. The objective of any diagnostic X-ray examination is to produce images of patients with essential details and sufficient image quality so as to guide practitioners for effective and efficient diagnosis and treatment of various disease conditions. Because of the risks associated with the exposure of the patients to X-rays during the diagnostic X-ray examinations, it is suggested that minimum amount X-radiation should be used and the entrance skin dose should be measured and monitored. It has been demonstrated by Edmonds, 1984 that X-radiation to patients depends on the exposure parameters of kVp, mAs, SSD and the filtration.

Standard chest examination consists of Posterior-Anterior (PA) Anterior Posterior (AP) and lateral chest X-ray. The films are read together in radiology department, a chest radiograph commonly called chest X-ray (CXR) is used.

The two fundamental objectives of this research are; first to measure the patient entrance skin dose in order to have a means for setting and checking standards of good practice as an aid to the optimization of patient protection. Secondly, to estimate the absorbed dose to tissues and organs in the patient in order to determine the risk so that diagnostic techniques can be properly justified and cases of accidental over exposure will be properly investigated.

CHEST RADIOGRAPHY

Chest radiography, commonly called chest X-ray (CXR) is a projection radiograph of the chest used to diagnose condition affecting the chests, its content and nearby structure. Chest radiographs are the most common examinations taken as a therapeutic tool for many clinical conditions. It is used to diagnose many conditions involving the chest walls, bones of the thorax and structures within the thorax including the lungs, heart and great vessel. Pneumonia and congestive heart failure are very common diagnose by chest-radiograph. Chest radiograph are also used to screen for job related lung disease in industry such as mining where workers are expose to dust and like all methods of technique, chest radiograph employs ionizing radiation in the form of X-ray to generate image of the chest. The typical radiation dose to an adult from a chest radiograph is around 0.02mSv for a front (PA) view, or 0.04mSv for a side (lateral) view. Thus different views of the chest can be obtained by changing the relative orientation of the body and the direction of X-ray beams.

A survey on 171 patients in three public hospitals in Nigeria undergoing chest, abdomen and lumbar spine x-ray examinations were carried out. The technical parameter used are tube potential, exposure FFD using TLD chips to measure the radiation dose which was found to varied widely. One unit exposed patient to whipping 120m red per x-ray (Ogundare, 2004).

Investigation on the effect of exposure factors on the quality of the skull radiograph in Jos university teaching hospital and was found that the exposure factor to obtain a quality skull x-ray radiograph at minimum dose are 60-70kV, 300-50mA and 0.6 – 1.6s (Nwankwo *et al.*, 2004).

In Nigeria, Radiographers, Radiologist and Medical Physics are required to undergo a two weeks radiation protection compulsory training in order to handle or work with x-ray machines. This regulation was introduced by the NBIRR (Nigeria Basic Ionizing Radiation Regulation) under NNRA (Nigeria Nuclear Regulatory Authority) to ensure the safety of patients and workers.

Radiation Dose to Tissue or Organ

Expressing the size of a radiation dose is most conveniently done by specifying the amount of energy deposited by the incident radiation. The basic measure of radiation dose is called absorbed dose (Sato et al., 1995).

Absorbed Dose

The interaction of radiation with matter involves a transfer of energy from the radiation to the matter. Ultimately, the energy transferred either to tissue or to a radiation shield is dissipated as heat. The radiation dose depends on the intensity and energy of the radiation, the exposure time, the area exposed and the depth of energy deposition. The Absorbed Dose is given by:

$$\text{Absorbed Dose (D)} = \frac{dE}{dm} \qquad (1)$$

The unit is J/kg or Gray (Gy) formally rad.

1Gy = 100 rad.

It is possible to calculate the absorbed dose in a material if the exposure is known.

$$D\,(Gy) = f \cdot x\,(Ckg^{-1}). \qquad (2)$$

Where f is the conversion coefficient depending on the medium (Sato et al., 1995)

Equivalent Dose

The absorbed dose does not give an accurate indication of the damage that radiation can do. An absorbed dose of 0.1Gy of alpha radiation, for example, is more harmful than an absorbed dose of 0.1Gy or beta or gamma radiation. To reflect the damage done in biological systems from different types of radiation, the equivalent dose is used.

$$H = W_R \cdot D(Gy) \qquad (3)$$

Where H is the equivalent dose in tissue, and W_R is the radiation weighting factor (Sato et al., 1995).

The unit is sievert (Sv) formally rem.

1Sv = 100rem.

MATERIALS AND METHODS

Patient Dose Survey

The survey method in this work was based on the guidelines established by the NBIRR protocols. Federal Medical Centre, Keffi was used in this survey. In the x- ray machine used, specific data such as type, model, waveform, filtration, film-screen combination and output were recorded. In this paper, we only considered the posterior anterior (PA) view. For each patient and x-ray unit, the following parameters were recorded: sex, age, weight, height, body mass index, focus-to-film distance (FFD), film size, chest thickness, kVp and mAs.

The diagnostic x-ray machine used in this project work is anode rotated with tungsten target. Chest radiograph examinations of some patient were considered. The x-ray examinations of patients were carried out using posterior-anterior radiographic view using grade. The x-ray exposure to patients was given from a control room where exposure parameters of kVp and mAs were selected for each patient. 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.

SSD = FFD – thickness of the patient's chest (4)

The radiograph of the chest involves two major viewings of positioning of patients during medical examinations; the posterior anterior (PA) view and the lateral view but in this investigation, we only considered the posterior anterior (PA) view.

A loaded x-ray films cassette (35cm x 42cm) is fixed on an erect, Bucky or chest stand. The patients stand facing the erect Bucky with the chest in contact with the Bucky, the arms placed on both side of the hips with the shoulder rolled forward (this is to displace the scapulae from a lungs field). A horizontal x – ray beam 90cm to the films is centered to the lower border of the scapulae. The beam is collimated to the area of interest. The exposure factors are carefully selected with an FFD of 150cm – 180cm.
The data collected mere based on the exposure parameters and the total filtration of the beam from the machines. Entrance skin dose is the maximum amount of x-radiation absorbed 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 Edmonds (1984) skin dose formula which is given as:

$$skin\ dose(\mu Gy) = 418(KVp)^{1.74} mAs \frac{\left(\frac{1}{T}+0.114\right)}{(SSD)^{\wedge}2} \qquad (5)$$

Where kVp is the peak voltage responsible for the quality of penetration mA is the tube current, responsible for quantity of electrons from the filament, T is the total filtration of the beams always a constant (2.9mmAl), and SSD = FFD – thickness.

RESULTS

Table 1: Patient information and x-ray machine parameters.

NO OF PATIENTS	MEAN CHEST THICKNESS (cm)	AGE RANGE (years)	MEAN DOSE (mGy)	WEIGHT (Kg)	HEIGHT (cm)	MEAN kVp (kV)	MEAN mAS (mAS)
6	7.0	15-17	0.013	37.5-38.5	145-147	50.0	32.8
7	8.0	18-19	0.187	39.5-40.5	148-151	50.0	57.6
6	9.0	20-21	0.253	41.5 -43.5	152-156	50.0	51.2
10	10.0	22-23	0.363	44.5-47.5	157-158	50.0	70.4
3	11.0	24-26	0.367	48.5-50.5	159-160	50.0	80.0
2	12.0	27-29	0.371	51.5- 52.5	161-172	50.0	80.0
6	13.0	30-31	0.422	53.5- 54.5	167-170	50.0	96.0
5	14.0	32-33	0.428	55.5-56.5	160-167	50.0	70.4
7	15.0	34-36	0.481	57.5- 59.5	160-170	50.0	80.0
40	16.0	37-46	0.536	60.5-98.5	167-172	50.0	70.0
23	17.0	47-50	0.543	68.5-91.5	169-172	50.0	70.4
34	18.0	51-56	0.624	72.5-98.5	167-174	50.0	96.0
22	19.0	57-60	0.632	79.5-82.5	160-171	50.0	80.0
15	20.0	61-62	0.768	69.5-78.5	165-169	50.0	906.
7	21.0	63-64	0.777	62.5-70.5	171-178	50.0	80.0
5	22.0	65-66	0.787	65.5-68.5	165-174	50.0	70.4
2	23.0	67-68	0.851	58.5-67.5	168-172	50.0	80.0

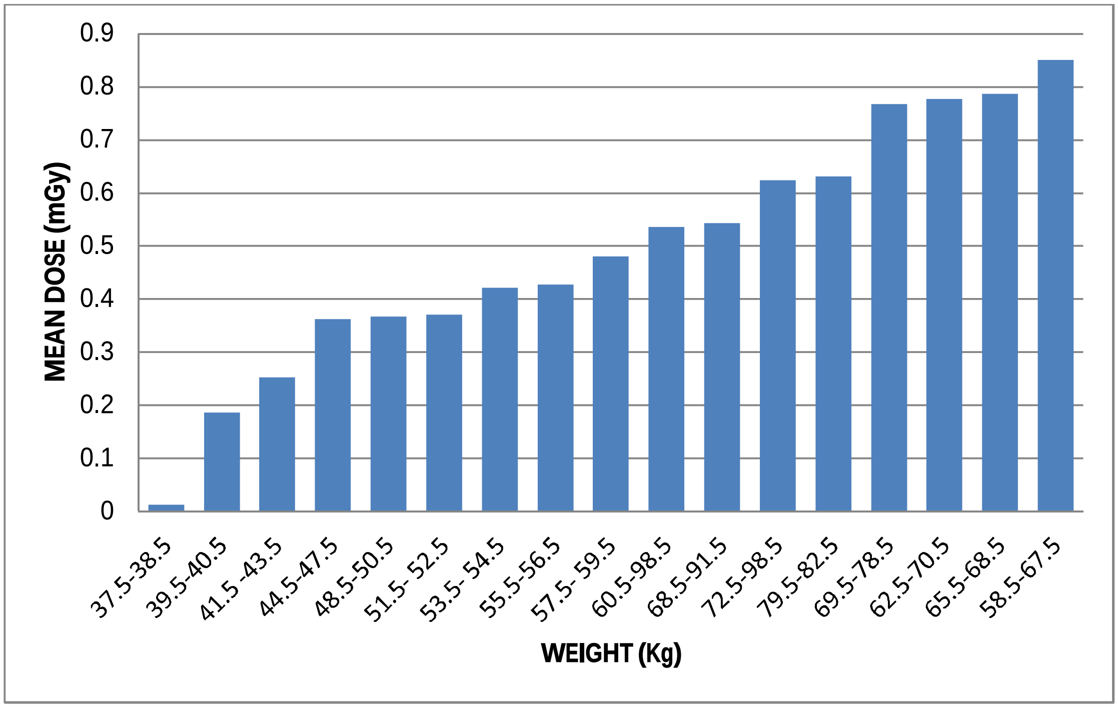

Fig. 1: Chart Showing Absorbed Dose against Weight

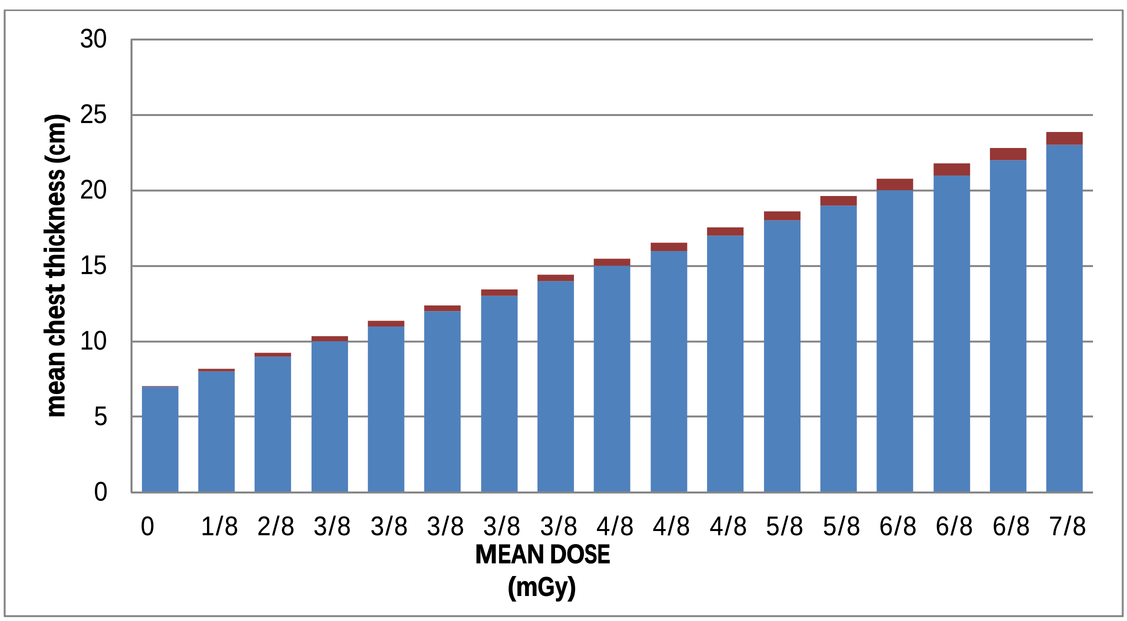

Fig.2: Chest Thickness against Dose Absorbed

DISCUSSION

In this survey, biographical data such as patient age, weight, height and machine parameters were recorded. This is shown in Table 1. The weight of the patients ranges from 37.5 to 98.5 kg and the average being around 65.0kg. The maximum absorbed dose recorded is 0.851mGy; these may be attributed to the patients' chest thickness or ages which were also high. Hospital data were compared with the guidance levels set by the International Atomic Energy Agency (IAEA) and other international bodies.

The histogram in figure 1 shows that the mean doses received by the patient increases with increased in weight and body mass. Similarly, figure 2 shows that the mean dose received by the patient varies with the patients' chest thickness. Another influencing factor that causes high ESD obtained in this examination is probably due to the aging effect of X-ray tube.

CONCLUSIONS

The results presented in this research work indicate that the ESDs received by patients undergoing x-ray examination in medical centre Keffi were within the guidance levels of 0.4mGy set by radiation protection bodies. Considering the condition of the machine used for this examination, a reference skin dose of 1mGy can still be compared with the skin doses evaluated in this research. It is possible that the x-ray machine is properly maintained, although all x-ray machines have to pass through quality control evaluations after each three months before it be allowed to operate. Owing to the fact that the maximum absorbed dose recorded in this research is 0.851mGy which is a bit higher than the guidance level, we therefore have to make the following recommendations.

RECOMMENDATION

Under age patients undergoing radiological examinations should be given special considerations by cutting down doses using high kilovolt technique and lower mAs. The ALARA (as low as reasonably achievable) principle should be used when carrying out x-ray activities. Consistency in Quality Assurance program and training of personnel will go a long way in reducing the radiation doses received by the patients. The estimation of stochastic risk to Keffi population as a result of X-ray diagnostic procedures and the establishment of dose reference levels in Keffi Medical Centre Radiological Unit are guide for future monitoring and studies.

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