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A comparative study of patients radiation levels with standard diagnostic reference levels in federal medical centre and bishop murray hospitals in Makurdi

F.O. Ujah[1], N.B Akaagerger E. H. Agba[2] and T. J. Iortile

[1]Department of Physics, College of Pure and Applied Sciences, Kwararafa University, Wukari, Taraba State
[2]Department of Physics, Faculty of Sciences, Benue State University, Makurdi, Benue State
[3]Nigerian Army Institute of Technology and Environmental Studies, Makurdi, Benue State

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ABSTRACT

In this work, the Thermoluminescence Dosimetry (TLD) technique was used with phantoms to measure the amount of radiation received by patients during routine Posterior-anterior (PA) chest X ray examination in Federal Medical Centre and Bishop Murray Hospital Makurdi, The results obtained were compared with the diagnostic reference level set by International Atomic Energy Agency (IAEA) and International Commission for Radiological Protection (ICRP). At Federal Medical Centre, twenty eight TLDs were exposed and the average skin dose measured was 0.152 ± 0.01mGy. For Bishop Murray Hospital, nine measurements were carried out and the average skin dose measured was 4.207 ± 0.5mGy. The skin dose measured at Federal Medical Centre, Makurdi is found to be within safe radiation dose limit for patients as well as members of the general public. For Bishop Murray Hospitals, the mean dose measured was above the recommended dose by ICRP both for patients and members of the public.

Keywords: X-ray, *Thermoluminescence Dosimetry, Posterior-anterior, Makurdi.*

INTRODUCTION

The widespread use of X- rays for medical diagnosis ensures that diagnostic medical radiology represents by far the most Significant man- made source of exposure to ionizing radiation for populations in the western world (**1**). This observation also applies to both developing and developed countries (**2**)(Faulkner *et al,* 1999).

In view of the significant benefit to patients from optimized medical exposures, the principal concern in radiological protection is the reduction of unnecessary exposures (**2**). These are examinations that are either unlikely to be helpful to the patient management or involves doses that are not as low as reasonably practicable in order to meet specified clinical objectives. It has been estimated(**3**) that, over 70% of the world population is expose to medical X – rays annually, and that over 95% of all man – made radiation is from diagnostic X-rays (**4**). It is instructive to note that, the objective of any diagnostic X-ray procedure or examination is to produce images of patients of sufficient quality, in order to provide adequate diagnostic information for a clinician (**1**). However, the somatic and genetic health risk associated with exposures to X – rays dictate that, these examinations should be achieved with minimum amount of radiation levels (**4**).

Radiation levels associated with radiological procedures in hospitals has come under increasing scrutiny, requiring quantitative monitoring and accurate measurement (**5**). This is necessary to ascertain whether the radiation levels in our hospitals are within the maximum permissible dose limit set up by International Radiation Regulatory Agencies

(**4**). The guiding principles recommended by the international commission on radiological protection (ICRP) for medical exposures are the clinical justification of practice and subsequent optimization of patient protection.

Patient radiation level refers to the amount of ionizing radiation an individual receives during an X-ray examination or therapy. This can be achieved by measuring the skin dose using thermoluminescence dosimeters (TLD) or the output factor method, the dose area product (DAP) and the computed tomography dose index (CTDI) could also be checked to ascertain radiation dose to patient.

The objective of an X-ray examination is to produce images of sufficient quality of the patient's organ in order to produce adequate diagnostic information for a clinician (**6**). However, the somatic and genetic risks associated with exposures of the patient to X-rays dictates that this should be achieved using minimum amount of X-radiation level (**2**). It has been estimated (**3**) that, over 70% of the world population is expose to medical X – rays annually, and that over 95% of all man – made radiation is from diagnostic X – rays (**4**). In view of the significant benefits to patients from properly conducted medical exposures (**1**), the use of X-ray cannot be completely ruled out from medical practice hence the need for patient dosimetry which gives a proper insight into the amount of radiation a patient receives since over exposure could result in serious health problems like cancer and gene mutation.

In radiation measurement, the most important parameter of interest is radiation dose (**4**), this is defined as the energy absorbed by a unit mass of an absorbing medium. The SI unit of dose is gray(Gy) and is defined as to be equal to 1 joule of energy absorbed per kilogram of the absorbing tissue i.e. 1Gy=1J/Kg. The old unit is rad and 1rad= 0.01Gy= 10mGy. It is the general radiation principle that the dose given to patients should be as low as reasonably achievable. This is the ALARA Principle.

From the result of this work, an attempt can be made to establish patient reference dose level in these Hospitals. This will provide a means of monitoring radiation levels to patients during diagnostic X-ray examinations and will assist in keeping patient radiation levels at minimum during examinations. The objective of this work is to measure the skin dose of patients undergoing chest X-ray examination using the TLD technique and compare the results obtained with the standard diagnostic reference level set by ICRP and IAEA. The radiation doses measured will also serve as reference level for the various hospitals investigated

In most hospitals in Makurdi town, there is absence of radiation protection programmes to monitor patient's exposures. There exist some fears that many people may have been overexposed in the course of X-ray examinations. There is therefore the need to investigate the levels of exposures of especially posterior-anterior X-ray exposures, this study will provide a reference index to the amount of radiation that patients are exposed to and possible risk involved.

MATERIALS AND METHOD

The X-ray machines used for this work are situated at the Federal medical centre and Bishop Murray Hospital Makurdi. Other materials include calibrated TLDs – LiF enclosed in sachets from the centre for energy research and training (CERT) Zaria, Harshaw 4500 TLD reader situated at CERT Zaria, Phantoms of various sizes(24cm, 20cm, 18cm, and 16cm), Cellophane or surgical tape, Measuring tape and Lead apron.

Table 1. Machine Specifications in Bishop Murray Hospital and Federal Medical Centre Makurdi

PARAMETERS	MACHINES SPECIFICATION	
	FMC Makurdi	**Bishop Murray Hospital**
Total filtration	2.0 mmAl > 2.7mmAl	≥ 2.5 mmAl
Manufacturer	Italray –Italy	TRILP
Year	November, 2008.	September, 2006
Model	Compact 4006	HXT51- 2040nx
Type	R105	TR300A
Anode type	Rotating anode with 1.0mm focus.	Rotating anode
Exposure time	Selected by the processor according to mA selected.	0.5-6.3 secs
KV range	40-125KV	0-125kVp
Serial number	043/25299	061005
Phase type	Single-phase.	Single

The skin dose is directly measured using annealed and calibrated TLDs attached to the patient's skin/phantom. Only phantoms were used for this work since attaching the TLD to the patient skin will create an image (artefact) of the TLD on the film which will interfere with the result of the examination. The annealing was carried out at the Centre for Energy Research and Training (CERT) Ahmadu Bello University Zaria using Harshaw 4500 TLD reader. The measurement was made by first positioning the phantom and X-ray equipment for the desired examination (chest X-ray) and selecting the same exposure parameters (kVp, tube current, exposure time, field size etc) used during the actual patient X-ray examinations in the Hospital. The TLD badges are attached as close as possible at the centre of the X-ray beam on the front view of the phantoms filled with water facing the X-ray source and their corresponding SSD, KVp, mAs and the average thicknesses of the Phantom recorded on a worksheet. A sachet of the TLDs is retained so that a background correction may be made. The exposed TLDs were read as well as those used for background readings at the Centre for Energy Research and Training – CERT, ABU Zaria and the results expressed in the chart below.

The phantom should be of material that absorbs and scatters photons in the same way as tissue. It was discovered that phantom materials have the same density as tissue and contain the same number of electrons per gram. Water and wet tissues absorb photons in almost the same way, and for this reason water has been used in many investigations (8). The materials used for the construction of phantom were; polyvinyl glass, RTV Silicone sealant, hawk saw, measuring tape and a transparent cello- tape.
A graduated measuring tape and a lead apron are used in measuring the SSD and as a shield for workers respectively.

RESULTS AND DISCUSSION

Experimental data from Federal Medical Centre Makurdi
Twenty eight (28) TLDs were exposed on phantoms of different sizes (24cm, 20cm, 18cm and 16cm) for chest posterior anterior (PA) projection view using the range of radiographic parameters normally used for adult patients of various sizes and the results tabulated.

The measured skin dose is the dose read directly from the exposed TLDs.

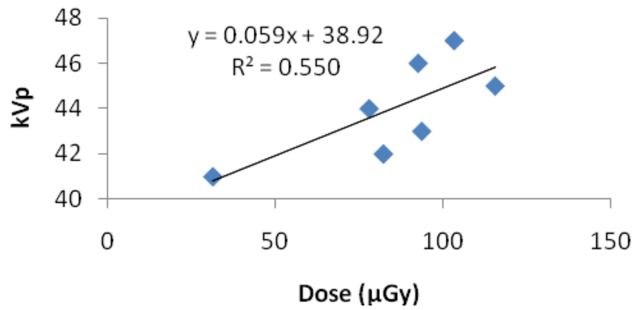

Figure 1; Graph of kVp against dose for 24cm phantom

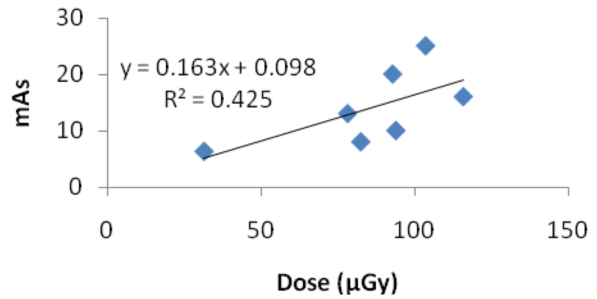

Figure 2; Graph of mAs against dose for 24cm phantom

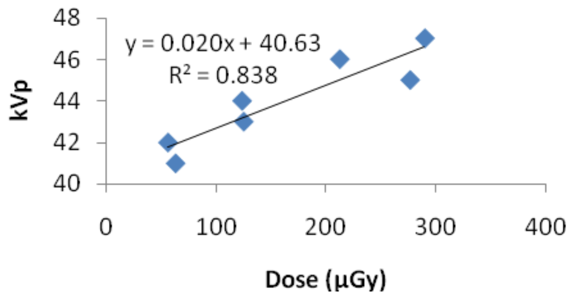

Figure 3; Graph of kVp against dose for 20cm phantom

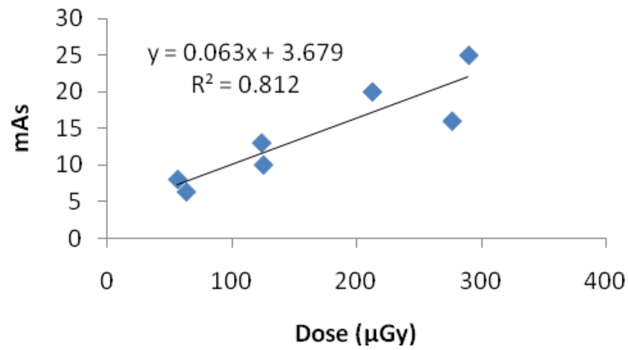

Figure 4; Graph of mAs against dose for 20cm phantom

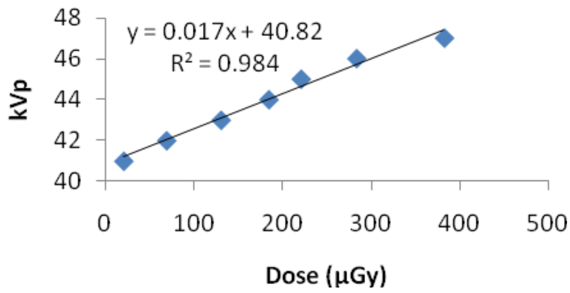

Figure 5; Graph of kVp against dose for 18cm phantom

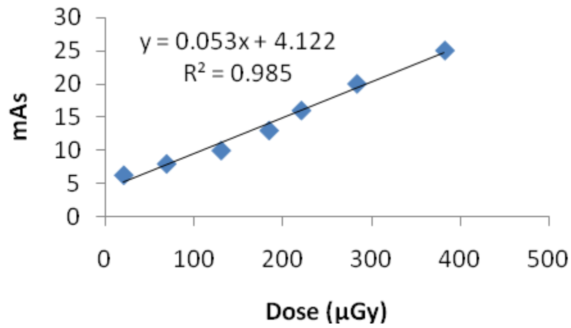

Figure 6; Graph of mAs against dose for 18cm phantom

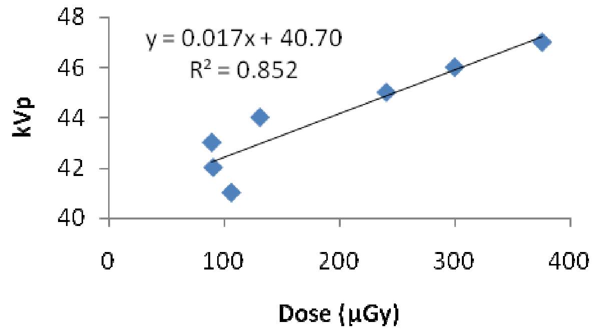

Figure 7; Graph of kVp against dose for 16cm phantom

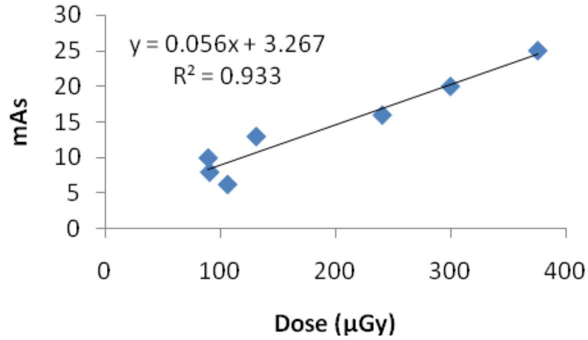

Figure 8; Graph of mAs against dose for 16cm phantom

Experimental data from Bishop Murray Hospital Makurdi

Nine TLDs were exposed on phantoms of different sizes (24cm, 20cm and 18cm) for chest PA projection view using the range of radiographic parameters normally used for adult patients of various sizes and the results summarised in the chart below

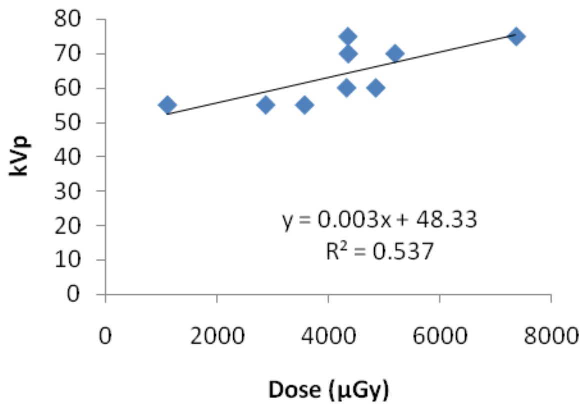

Figure 9; Graph of kVp against dose for Bishop Murray Hospital Makurdi

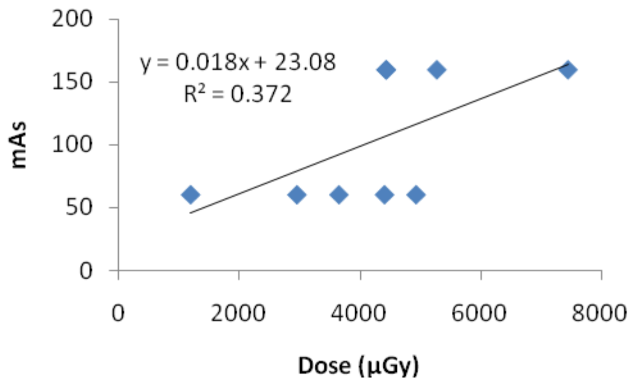

Figure 10; Graph of mAs against dose for Bishop Murray Hospital Makurdi

The result of this work has shown that patients who underwent chest posterior anterior (PA) examination in Federal Medical Centre Makurdi, their mean skin dose measured were 0.152 ± 0.01mGy. This was found to be within the recommended skin dose limit of 1mGy for members of the general public (9) as well as within the reference skin dose of 0.4mGy recommended for patients undergoing PA chest examination by ICRP/IAEA. The graph of kVp/dose and mAs/dose for the18cm phantom as shown in figure 4.5 and 4.6 respectively gives the best regression coefficient. That is, R^2 = 0.984 for kVp/dose and R^2 = 0.985 for mAs/dose. This result confirms the linearlity between kVp/dose and mAs/dose. For the 16 and 20cm phantoms used to simulate small and medium sized patients respectively, the regression coefficient obtained from the graphs were significant. That is, the values are above 0.5 and it shows that the result is consistent with the basic physical principles that govern the linearlity between kVp/dose and mAs/dose. For the 24cm phantom size used to simulate large chest, the regression coefficient for kVp/dose is significant but that of mAs/dose is insignificant that is, R^2 =0.425, this indicates that there is no linearlity between mAs/dose. A little increase in the mAs used for patients with large chest could yield a better result.

For Bishop Murray Hospital, Makurdi; the mean skin dose measured was 4.207 ± 0.50mGy. This is far above the recommended dose by ICRP both for members of the public and patients undergoing chest PA examination and this can be traced to the closeness of the X-ray source to the patient's skin (small SSD used). The SSD measured during the experiment ranges from 63cm to 69cm, therefore if the SSD is increased in line with the inverse square law a better result may be obtained. The regression values obtained from the graphs were 0.537 for kVp/dose which is significant that is, there is linearlity between kVp and dose and 0.372 for mAs/dose which is insignificant and shows non-linearlity between the mAs and dose.

Other possible reasons why the doses measured in some Hospitals are high include poor choice of technical factors, incorrect film processing procedure, the age of the machines used and lack of quality assurance tests.

Other inconsistencies in the results obtained in this work such as variation in measured doses for the same values of kVp and mAs, an increase in kVp and mAs not yielding a corresponding increase in dose sometimes may be as a result of the workload of the machine - as the electrons released hits the focus on the anode, a lot of heat is experienced at the point which increases the scattered radiation and reduces the transmitted rays, which in turn decreases the efficiency. Also, insufficient trained man-power in those hospitals, that is, qualified Medical Physicists and Radiographers and the fluctuations in power supply contribute to the nature of result obtained.

CONCLUSION

The mean skin dose values obtained in this work shows that the X-ray machine parameters used for routine PA chest X-ray examination in Federal Medical Centre Makurdi is safe for both the patients and members of the general public. In Bishop Murray Hospitals, there is need to apply quality control measures to reduce the radiation dose. Reduction in dose could be achieved by increasing the FFD to 180 – 200cm and the X ray filtration to at least 3.0mmAl equivalent (**5**). These measures would significantly reduce the entrance skin dose to patients without a reduction in the quality of diagnostic information obtained.

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