Estimation of Mean Glandular Dose in Patients undergoing Mammography Examination in a Tertiary Hospital in Gombe, Northeast Nigeria.

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Abstract

Background: The International Commission on Radiation Protection (ICRP) recommends that medical exposures should be kept as low as reasonably achievable considering health, economic and social factors and one way of achieving is through estimation of mean glandular dose incurred during mammography examination.

Objectives: To evaluate the mean glandular dose (MGD) as a function of Compressed Breast Thickness (CBT) and composition. To ascertain that the dose received by the patients undergoing mammography screening at Federal Teaching Hospital, Gombe is below the published guideline values of the International Atomic Energy Agency (IAEA).

Methodology: A prospective cross-sectional design was adopted for the study A survey of patient dose measurement was carried out for patients undergoing mammography screening examination from May 2014 to July 2014.

Results: The estimated mean glandular dose ranges from 2.4mGy to 3.4mGy for breast thickness ranging from 3cm to 7.5cm. The mean glandular dose was found to increase linearly with CBT. And the mean glandular dose delivered by the institution was well below the limit of 3.0mGy for the 4.5cm breast according to the IAEA protocol of dose limits.

Conclusion: The MGD ranged from 2.4mGy to 3.4mGy, it was found to vary linearly with CBT, the 4.5cm breast received MGD well below 3.0mGy. These results indicate the state of mammography at Federal Teaching Hospital, Gombe and gives credence to the limit of 3mGy for the standard breast which is the 4.5cm thick breast in accordance with the IAEA standard.

Keywords: Dose, mammography, compressed breast thickness, thermoluminiscent dosimeters.

Introduction

Two-dimensional (2D) mammography currently is the gold standard for detecting breast cancer in an early stage and is used in screening programs in many countries [1]. It is a low cost, fast, noninvasive technique that involves low doses of ionizing radiation. However, 2D images results in tissue superposition [2]. The estimation of breast dose is an important part of mammographic quality control for x-ray mammography. Knowledge of this dose is essential for the optimization of both 2D and 3D x-ray-based breast imaging procedures. In the United Kingdom a standard protocol for dosimetry in conventional (2D) projection mammography was introduced in 1989 with a subsequent extension in 2005 to allow for the use of x-ray spectra from different target/filter combinations (by the introduction of an '*s*-factor') and to provide dosimetry for a range of breast glandularities (by the introduction of a '*c*-factor') [3,4]. Similar methodology has been adopted in the European protocols. All three protocols use conversion factors to relate measurements of the incident air kerma at the upper surface of the breast to the mean dose to the glandular tissue within the breast (mean glandular dose, MGD) taken from the Monte Carlo calculations[5,6].

The risk of low level radiation exposure has usually been provided by studying the effects of higher levels of exposure from accidentally or intentionally exposed population. As a result, there is continuing uncertainty about the exact relationship between risk and exposure in mammographic exposure range. Despite this uncertainty, there is wide acceptance of a linear response relationship from radiosensitive organs such as the breast[5].

The mean glandular dose (MGD) is the special dose quantity used in mammography. It is defined as the mean or average dose to the glandular tissue. The assumption is that the glandular tissue, and not the fat, is the tissue at risk from radiation exposure. The dose parameters used in mammography are the entrance surface dose (ESD) and mean glandular dose (MGD). Thermoluminiscence dosimeters (TLDs) can be used to determine the dose received by patients during mammography examination by estimating the mean glandular dose. Cancer risk is linearly related to mean glandular dose (MGD). However, MGD provides the best indicator of the risk of patient from mammography examinations [7]. It is generally accepted that the glandular tissue of the breast is the most radiosensitive tissue [8]. Studies are needed to determine the radiation dose of patients that are undergoing this emerging procedure to compare with the results obtained with others [9].

Therefore, the aim of this work is to estimate the dose incurred by the glandular tissues of the breast for the two basic projections (craniocaudal and mediolateral oblique views) in women undergoing mammography screening at FTH, Gombe. Also, the study will aid in evaluating the MGD as a function of the compressed breast thickness and breast composition, in addition, to compare the glandular absorbed radiation doses with the international standard doses. There is a paucity of literature on estimation of the mean glandular dose received by patients undergoing mammography examinations in this locality. This necessitates the study.

Materials and Method

A prospective cross-sectional design was adopted for the study. The study duration was from May 2014 to September 2014. A primary source of data was used. A number of 20 Patients that were referred and examined in mammography, radiology department at Federal teaching hospital, Gombe. A convenient sample size of 20 patients was adopted for the study. Patients that were referred for breast mammography screening at federal teaching hospital, Gombe.

Technique

Patient dose measurement involving 20 patients from the Radiology Department, FTH Gombe were reported. The choice of FTH, Gombe as the site of carrying out this research is based on its preference and convenience as a standard teaching hospital with both radio-diagnostic and therapeutic facilities, providing both screening for breast cancer and eventual treatment if detected. Age distribution, radiographic views, distribution of exposure factors and Compressed Breast Thickness (CBT) were also recorded.

Machine specification

The equipment used is a non-digital, automatic exposure control (AEC) facility in a conventional mammography unit. The AEC facility allows the machine to select the optimal exposure factors required to produce good quality with varying CBT in ages. The equipment named Planmed sophie classic nuance code E. manufactured by planmed OY, Helsinki, Finland. It was installed February, 2010 with a total filtration of 0.5mm Al and power source output of 240kV. It utilizes molybdenum, aluminium or rhodium filters. The entrance surface dose (ESD) was measured using lithium fluoride thermoluminiscence dosimeters (TLDs).

Procedure

The measurement was carried out by placing the TLD at the center of the breast between the nipple and the chest wall and also at the center of the side to side of the breast. These dosimeters were calibrated at Lagos state university radiation monitoring and protection services. The TLDs were read out using RE-2000 semi-automatic TLD reader, also at the institute. The doses for the two basic projections, i.e. Medio-Lateral Oblique (MLO) and Cranio-Caudal (CC) views obtained for each patient were recorded along with the parameters. With the x-ray energy ranging from 26 to 32kV. These values were read directly from the control panel of the mammographic equipment. The entrance surface dose read from the TLD chip is used for calculating the MGD received by each patient using the formula:

MGD = ESD x DgN .... Equation 1

Where ESD is the surface dose recorded and read from the TLD and DgN is the normalized glandular dose which is interpolated from the standard. The technical factors used for the interpolation are the half value layer, keV, target filter combination, compressed breast thickness (CBT) and the breast composition[10].

Calculating Mean Glandular Dose (MGD)

Calculating the MGD depends on different factors, i.e. breast thickness and composition, half value layer of the equipment, target filter composition and also the kVp used. 26, 28 and 32 against HVL 0.36, 0.37 and 0.41 respectively.

The measurement of HVLs show the relationship between the increase in x-ray tube voltage kVp and the HVL for molybdenum/rhodium target filter combination. An increase in kVp requires more aluminum to be used to obtain the first HVL. The HVL values at each kVp can be used to determine the MGD. MGD is the mean dose received by the glandular tissue in the whole breast and is an approximation of the actual patient dose. Therefore, MGD is a quantity determined by standard tables with the knowledge of the entrance surface dose, HVL, target/filter combination used, CBT and composition.

The next step for calculating the MGD is by interpolating the normalized glandular dose from the standard tables based on the listed factors, i.e. the HVL, the x-ray tube voltage (kVp) and compressed breast thickness (CBT) Wu et al[10].

Table 1: Normalized Glandular Dose at 32kv for Mo/Rh target filter combination.

HVL AT 32KVP	COMPRESSED BREAST THICKNESS								
	3	3.3	4	4.3	5	5.3	6	7.5	8
0.41	280	262	220	208	179	170	149	119	110

(Wu et al,[11])

From the table, the Normalized glandular dose of the 7.5cm breast thickness at 32kVp and 0.41 half value layer (HVL) is 119mrad/R.

Finding the MGD is the next step after interpolated DgN. In this research, the patient with the highest CBT that incurred the highest dose was a 7.5cm breast thickness.

The entrance surface dose from our TLD reading shows 0.309mSv, before inserting the ESD value into equation 1, its unit have to be converted to RAD. From the international standard (SI units), 10mSv = 1RAD

Therefore, 0.309mSv = 0.031RAD approximately.

Inserting DgN value from table 4.3 and the ESD value in equation 1, we then find our mean glandular dose (MGD) to be 3.4 mGy for the 7.5cm thick breast.

Results

The breast dose varies widely with breast composition and thickness as well as the choice of imaging equipment and radiographic technique. Therefore, there are many protocols e.g. European protocol, the British institute of physical sciences in medicine and methods designed to facilitate and estimate the appropriate value of the breast dose. Each of these methods uses different x-ray energies (kVp), xray tubes and dosimeters. Thermoluminiscence dosimeters are the most common dosimeters in most of these protocols.

S/No.	CBT (cm)	KVp	Number of patients	Mean ESD (mSv)	Avr.MGD (mGy)
1	1	---	---	---	---
2	2	---	---	---	---
3	3	26	3	0.11	2.4
4	4	26-27	3	0.12	2.2
5	5	27-28	4	0.17	2.7
6	6	29-31	7	0.22	2.8
7	7	31	2	0.28	2.5
8	7.5	32	1	0.31	3.4
9	8	---	---	---	---

The table above shows the readings of the TLD badges for women that have been screened for mammography. It shows how the compressed breast thickness determines the exposure factor, in other words, the higher the CBT, the higher the dose received.

From the readings, the patient with the highest CBT measurement of 7.5cm incurred the highest radiation surface dose of 0.31mSv.

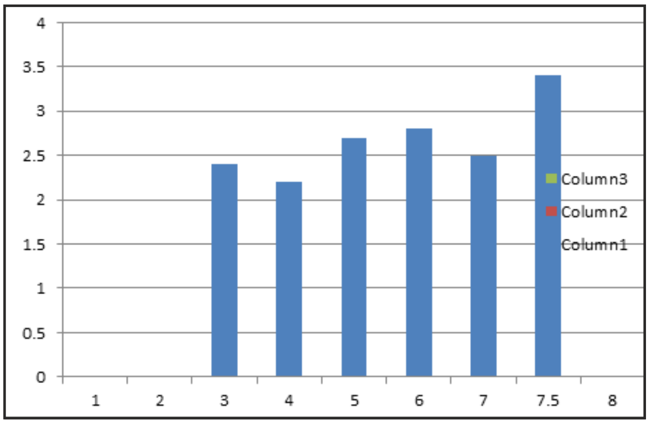

Fig.1: A bar chart showing distribution of MGD against CBT.

Although, the type of breast composition of each patient stands as a factor that can determine how much radiation dose the patient receives due to the fact that a breast with higher glandular tissue content receives more dose than that with a higher adipose tissue content.

From Fig 1 above, it is seen that out of the 20 patients surveyed, 3 patients have the lowest breast thickness with a CBT of 3cm and 1 patient has the highest CBT of 7.5cm.

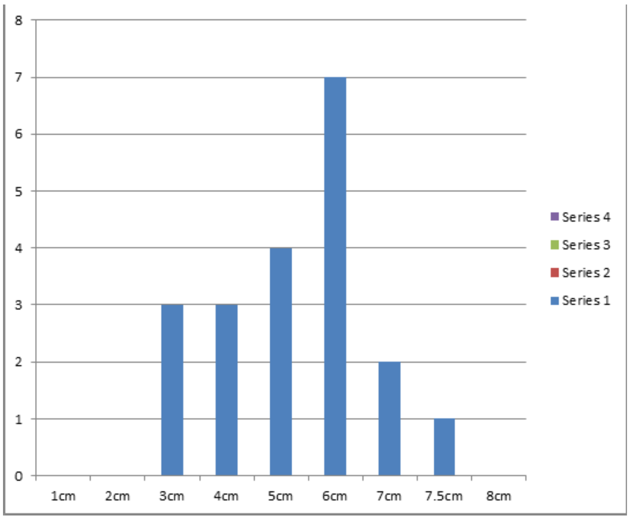

Fig 2: Frequency of CBT.

Table 3: Comparison of present study with IAEA protocol of dose limits**.**

CBT (cm)	Findings (mGy)	IAEA (cm)	Achievable limits (mGy)
3	2.4	3.2	1.0
4	2.2	4.5	1.6
5	2.7	5.3	2.0
6	2.8	6.0	2.4
7	2.5	---	---
7.5	3.4	7.5	3.6

Discussion

There is a substantial and convincing scientific evidence for health risks following high dose exposures. However, below 50-100mSv (which includes occupational and environmental exposures) risks of health effects are either too small to be observed or are non-existent. It is assumed that a 50:50 mixture of adipose and glandular tissue is representative of a typical breast[11]. The results acquired from this research is on the basis of this assumption.

An analysis was presented for the exposures received by TLDs placed on the breast of 20 women obtaining mammograms (screening) at Federal Teaching Hospital, Gombe. The findings obtained from this study shows that the CBT and MGD increase in a linear fashion. In order words, the higher the CBT, the higher the MGD. This is similar to the findings of Young et al [12]. where MGD was found to increase exponentially with CBT.The MGD obtained range from 2.4mGy to 3.4mGy. With the lowest CBT of 3cm receiving the lowest dose of 2.4mGy and the highest CBT of 7.5cm receiving the highest dose of 3.4mGy. This shows a remarkable decrease in dose in comparison with the findings obtained in Serbia which ranges from 0.12mGy to 5.2mGy.

The values in the present study were found to be somewhat below most of the literatures reviewed which used the same conversion factors from the same source as in this study. Thus, the difference may be due to factors such as difference in patient`s anatomies and in x-ray units.Comparing the MGD of the present study which ranged from 2.4mGy to 3.4mGy with the dose achievable from the IAEA dose guidelines which ranges from 1.0mGy to 3.6mGy (achieved for the same range of CBT as that of this study), it`s evident that the dose is well below the guideline protocol[13].

The study being the first of its kind in the locality will serve in improving radiation protection measures on the aspects of both patients and radio-diagnostic staffs, likewise achieving standard radiographic techniques by performing quality assurance program on mammography machine.

Some of the limitations of this study are: Most women are not enlightened on the importance of mammography screening as a tool for early detection and management of cancer, that affected patient`s turn-up for the research. Secondly, high cost of thermoluminiscence dosimeters.

We recommend that women above 40 years of age should be enlightened on the importance of the yearly mammography screening. And also, dose estimation should be practiced more as part of quality assurance programme and to reduce the risk of over exposure to patients. And quality assurance programme prior to radiation dose assessment should be carried out.

Conclusion

The MGD ranged from 2.4mGy to 3.4mGy, it was found to vary linearly with CBT, the 4.5cm breast received MGD well below 3.0mGy. These results indicate the state of mammography at Federal teaching hospital, Gombe and gives credence to the limit of 3mGy for the standard breast which is the 4.5cm thick breast in accordance with the IAEA standard.

Conflict of Interest.

No conflict of interest.

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