ORIGINAL ARTICLE

AVERAGE GLANDULAR DOSE (AGD) EVALUATION FOR DIGITAL MAMMOGRAPHY (PATIENT & PHANTOM BASED STUDY, SOUTH PUNJAB- PAKISTAN)

Muhammad Arif,[1] Sidrah Mahmood Ali,[1] Rabia Mahmood Ali,[2] Rubina Mukhtar[1]

[1] Department of Radiology, Multan Institute of Nuclear Medicine and Radiotherapy (MINAR), Multan, Pakistan.
[2] Department of Radiology, Mukhtar A. Shiekh Hospital, Multan, Pakistan.

PJR July - September 2022; 32(3): 148-152

ABSTRACT

BACKGROUND: Evaluation of AGD for a patient undergoing mammography is critical because of the potential risk of radiation-induced carcinogenesis, as the breast is a radiosensitive organ. **OBJECTIVE:** The purpose of study is to evaluate AGD using standard phantoms & patient exposure parameters of women undergoing digital mammography visiting at the institute having catchment area of South Punjab region. **METHODS:** The AGD was determined for 230 views (CC and MLO) using the patient exposure parameters according to the method described in IAEA TRS-457. The incident air kerma, K_{air} was obtained at defined reference point with detector (Piranha, Model: 657) for mostly used kVp & target filter combination (W/Rh). The dose conversion factors were taken according to compressed breast thickness, measured HVL & estimated breast glandularity. The phantom based AGD was determined for ACR Phantom (4.2 cm) & PMMA phantom (3.5 to 6.5 cm) using measured K_{air} & dose conversion factors (given in European guideline & equipment manual). **RESULTS:** The average calculated AGD was found 1.27-mGy & 1.63-mGy for CC & MLO views having average CBT 5.34-cm & 5.93-cm respectively of women undergoing digital mammography at the institute. The calculated AGD for PMMA (4.5 cm) and ACR phantom (4.2 cm) were found to be 1.07-mGy/view and 1.01-mGy/view respectively. **CONCLUSION:** The AGD calculated using the patient exposure parameters and standard phantoms meets the accepted dose criteria (< 3mGy/view).

Keywords: Average Glandular Dose, Half Value Layer, Cranio Caudal view, Medio-Lateral Oblique.

Introduction

Breast cancer is the most common cancer diagnosed in women around the world, with about a million new cases each year.[1] Screening mammography is most widely used available method for early detection of breast cancer among other breast imaging modalities like high resolution breast ultrasound, tomosynthesis and breast MRI thus reducing the number of deaths associated with breast cancer by 25-40%.[2] Early detection of breast cancer by mammogram is important because it is associated with increased treatment options, increased survival and improved quality of life. However, there is a potential risk of radiation-induced carcinogenesis from mammograms because the breast is a radiosensitive organ.[3,4] Average glandular dose (AGD) is the most appropriate dosimetric value to quantify the risk of radiation induced cancers from mammography.[5] The two main methods of mammographic AGD assessment include the use of a standard breast phantom and patient-based measurements.[6] The AGD is then calculated by the product of incident air kerma and dose conversion factors that depend on compressed breast thickness,

Correspondence : Dr. Sidrah Mahmood Ali
Department of Radiology,
Multan Institute of Nuclear Medicine and Radiotherapy (MINAR), Multan, Pakistan.
Email: sidrahibm@hotmail.com

Submitted 18 August 2022, Accepted 12 September 2022

half value layer (HVL), target-filter combination & estimated breast glandularity. The AGD should be <3mGy per mammography view for a standard breast thickness of 5 cm.[7,8]

The objective of this study is to evaluate average glandular dose (AGD) using standard phantoms & exposure parameters of women of South Punjab region (Pakistan) undergoing digital mammography at breast imaging facility of the institute by the method described in IAEA TRS-457 and to ascertain that radiation doses are within permissible limits. The calculated AGD for ACR Phantom is also compared with mammography unit indicated AGD & found in tolerance limit of 25%.

Material & Methods

A total of 230 acquired mammograms (CC & MLO) were evaluated in this prospective study on the digital mammography unit (Hologic Selenia, Dimensions. The mean glandular dose (AGD) was determined based on the patient exposure parameters and standard phantoms. Intra disciplinary peer review of all the cases was made. The study is reviewed and approved by the ethical committee of the institute (ref. 2021-01/012). Patient consent was not required for the study since neither the patient directly involved nor the patient's personal information was used.

a) Patient based AGD

The patient based AGD was determined by recommended IAEA TRS-457 in-direct measurement of incident air kerma.[7] The incident air kerma Kair was calculated by product of recorded tube loading (mAs) of each mammogram, X-ray output of corres-ponding tube voltage (kVp) & inverse square factor relating (ISF) to breast thickness (Equation-1).

$$K_{air} = X_{ref,4.5} * mAs_{patient} * ISF$$

(Equation-1)

The X-ray output, $X_{ref,}$ 4.5 (mGy/mAs) for clinically used tube voltage at W/Rh target/ filter combination was obtained (Tab.1) at a reference point (i.e. 4 cm from the chest wall edge and at height of 4.5 cm from breast support to compression plate) by Piranha detector (Model: 657) calibrated on Mo/Mo beam quality & corrected for W/Rh targe-filter combination (Fig.1). The AGD for both CC & MLO views of women undergoing mammography at the facility was determined by Equation-2 & given in (Tab.2).

$$AGD (mGy) = K_{air} * C_{50} * G * s$$

(Equation-2)

Where, K_{air} is incident air kerma, C_{50} is conversion co-efficient of breast with 50% glandularity, **G** corrects for a 50% glandularity to a breast of other glandularity, **s** is spectral correction factor (1.042) for W/Rh target-filer combination.

b) Phantom based AGD

The phantom based AGD was determined for PMMA Phantom of various thicknesses (3.5 - 6.5 cm) & ACR Mammographic Phantom (Model 156, 4.2 cm thick-

Figure 1: The X-ray Output ($X_{ref,4.5}$) Measurement Set-up

Tube Voltage kVp	Measured X-ray Output, $X_{ref,4.5}$ (mGy/mAs)	$HVL_{measured}$ (mm-Al)
26	0.026	0.517
27	0.029	0.528
28	0.032	0.537
29	0.035	0.544
30	0.038	0.551
31	0.040	0.568
32	0.043	0.586

$HVL_{measured}$: Measured Half Value Layer

Table 1: Measured X-ray Output, $X_{ref,4.5}$ & Half Value Layer (HVL)

View	No of Views	CBT Range (cm)	kVp_{avg}	mAs_{avg}	Calculated Avg. K_{air} (mGy)	Calculated AGD_{avg} (mGy)
CC	15	3.0 - 4.0	27	73	1.98	0.76
	21	4.2 - 5.0	28	91	2.94	0.94
	48	5.1 - 6.0	30	117	4.47	1.24
	31	6.1 - 6.9	31	165	7.29	1.81
MLO	19	4.0 - 5.0	28	89	2.86	0.92
	32	5.1 - 6.0	30	134	5.17	1.39
	64	6.1 - 6.9	32	171	7.75	1.96

CBT: Compressed Breast Thickness, **AGD**: Average Glandular Dose, **K_{air}**: Incident Air kerma

Table 2: Calculated AGD_{avg} for CC & MLO Views

ness, 50/50 glandular-adipose) for CC view only. The AGD for the PMMA Phantom was calculated by equation-2 using conversion factors from European guidelines.[9] The conversion factors were interpolated from tabulated data where required. The AGD for ACR phantom was determined by equation-3 by placing of detector close to phantom just below the compression paddle at 4.2 cm height leveled with phantom (Fig.2a) as given in Selenia Dimensions QC Manual[10] (Tab.3)

AGD (mGy) = K_{air} * factor
(Equation-3)

Figure 2: a) Air Kerma (**K_{air}**) setup of ACR Phantom, **b)** AEC measurement with PMMA Phantom

Phantom	Thickness (cm)	kVp_{avg}	mAs_{avg}	$AGD_{calculated}$ (mGy)	AGD_{Unit} (mGy)
PMMA Phantom	3.5	27	84	0.86	0.78
	4.0	28	92	0.95	0.88
	4.5	28	111	1.07	0.94
	5.5	30	177	1.81	1.74
	6.5	32	250	2.73	2.74
ACR Phantom (4.2-cm, 50/50)	4.2	28	100	1.01	0.90

AGD_{unit}: Displayed AGD of mammography unit

Table 3: $AGD_{calculated}$ for PMMA Phantom & ACR Phantom

Results

The average CBT for CC & MLO views was found 5.34-cm & 5.93-cm and corresponding calculated AGD was 1.27-mGy & 1.63-mGy respectively for the data range of the study (3.0 cm - 6.9 cm) of women undergoing digital mammography visiting at the institute belong to South Punjab region (Pakistan). The calculated AGD for both views (CC & MLO) was found < 03-mGy/view. Similarly, the calculated AGD for PMMA Phantom (4.5 cm) & ACR phantom (4.2

cm & 50/50 composition) were found 1.07-mGy/view and 1.01-mGy/view respectively (Tab.3). The mammography unit indicated AGD was also found within tolerance limit (25%) of calculated AGD.[9]

Discussion

The risk of radiation-induced carcinogenesis to the breast is of great concern; therefore, evaluation of mammography radiation dose is essential in the justification criteria based on risk/benefit analysis.[11] The average glandular dose is an appropriate dosimetric quantity to predict the risk associated with mammography. The factors mostly affect and used for estimation of the average glandular dose are kVp, target filter combination, breast thickness/glandularity and beam quality HVL,[12] which are applied on measured incident air kerma in the study. The averaged AGD calculated for data range of this study for CC view was 1.27-mGy with averaged CBT of 5.34-cm & similarly for MLO view, it was 1.63-mGy with averaged CBT of 5.93-cm which showed that AGD delivered in MLO view is greater than CC view. Increased breast thickness in MLO view and inclusion of pectoral muscle led to an increased AGD.[5] AGD is used to assess the patient's risk of malignancy. The phantom based AGD was calculated to verify the adequate performance of the mammography unit within acceptable limits for most clinically used exposure parameters. However, doses derived from standard phantoms may not be directly related to doses given to women undergoing mammograms because of the variation in breast composition.[13]

Conclusion

The AGD calculation is key to measure the potential carcinogenicity risk of radiation exposure for mammography. The average calculated glandular dose for standard phantoms & using patient exposure parameters of women belongs to South Punjab undergoing digital mammography in the study falls within accepted dose criteria (<3 mGy/view). Keeping the AGD at an allowable limit of <3mGy/view minimizes the carcinogenic risk that also supports the quality services provided.

Conflict of Interest: Declared None

References

1. RMK MA, England A, McEntee MF, Mercer CE, Tootell A, Hogg P. Effective lifetime radiation risk for a number of national mammography screening programmes. Radiography. 2018; **24(3):** 240-6.

2. Suleiman ME, Brennan PC, Ekpo E, Kench P, McEntee MF. Integrating mammographic breast density in glandular dose calculation. Br J Radiol. 2018; **91(1085):** 20180032.

3. Sosu E, Boadu M, Mensah S. Determination of dose delivery accuracy and image quality in full-Field digital mammography. Journal of Radiation Research and Applied Sciences. 2018; **11(3):** 232-6.

4. Mukhtar R, Hussain M, Mukhtar MA, Ali SM. Breast metastasis from medullary carcinoma of thyroid: A case report with literature view. JPMA The Journal of the Pakistan Medical Association. 2020; **70(11):** 2051-3.

5. Xiang D, Jin W, Yang CY, Zhou XF, Wei C, Cao XJ, et al. Investigation of mean glandular dose in diagnostic mammography in China. Biomedical and Environmental Sciences. 2014; **27(5):** 396-9.

6. Ha NT, Thuan ND, Van NT. A study of mean glandular dose during diagnostic mammography in hospitals in Hanoi, Vietnam. The Third International Conference on the Development of Biomedical Engineering in Vietnam: Springer; 2010. p. 263-5.

7. Agency. IAE. Dosimetry in diagnostic Radiology: An international code of practice. Technical reports series number 457. 2007.

8. Berns EA PD, Butler PF, et al. . Digital Mammography Quality Control Manual. In: Reston VACoR, editor. 2018.

9. Perry N, Broeders M, de Wolf C, T rnberg S, Holland R, von Karsa L. European guidelines for quality assurance in breast cancer screening and diagnosis. summary document. Oncology in Clinical Practice. 2008; **4(2):** 74-86.

10. Quality Control Manual DM. Selenia Dimensions System (Hologic). Revision 005, November 2015 (Appendix C)

11. Sulieman A, Serhan O, Al-Mohammed HI, Mahmoud MZ, Alkhorayef M, Alonazi B, et al. Estimation of cancer risks during mammography procedure in Saudi Arabia. Saudi journal of biological sciences. 2019; **26(6):** 1107-11.

12. Behrouzkia Z, Zeinali A, Mohammady MH, Jabbari N. An investigation of mean glandular dose from routine mammography in Urmia, Northwestern Iran and the factors affecting it. Research Journal of Applied Sciences, Engineering and Technology. 2012; **4(18):** 3348-53.

13. Oh KK, Hur J, Kim EK, Choo SS. Dosimetric evaluation of the mean glandular dose for mammography in Korean women: a preliminary report. Yonsei medical journal. 2003; **44(5):** 863-8.