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# Evaluation of Radiation Dose to Patients During Mammography Procedure in Selected Hospital in Khartoum State

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## Abstract

This study aimed to evaluate the radiation dose for patients during mammography examination in two different centers (ALNeelain Diagnostic Center and Ahfad Family Health Center). Measurements were performing to estimate Mean Glandular Dose (MGD) and to evaluate the factors affecting the dose in mammography for number of 60 patients. The obtained results shown that The mAs in Ahfad Family Heath Center was higher than NDC, the exposure parameter mAs and mAs within the standard range of parameters exposure in Mammography. The tube voltage should be between (22-35) kVp and the tube current exposure time product (mAs) should be at least (4- 400), take into account all examinations included two CC and two MLO projections per patient. The mean of incident air kerma (Ki) in Ahfad Family Heath Center was higher than NDC due to different mammography x-ray machine, different FFD and used different exposure parameter. The different in values of ESAK were observed in the two hospitals mainly due to kVp accuracy problems.

**Keywords**: Mammography, Patient dose, Procedure, Mean Glandular Dose.

## Introduction

Mammography is the best available examination for the detection of early signs of breast cancer and it can reveal pronounced evidence of abnormality, such as masses and calcifications, as well as subtle signs [1]. Mammography is a distinguished type of x-ray imaging used to create clear images of the breast. It is uses low dose x-ray, with high contrast, high-resolution film and an imaging system designed specifically for breasts imaging, [2] with special accessories that allow only the breast to be exposed to the x-rays. In addition, there is a device that holds and compresses the breast and positions it so we can obtain images from different angles [1].

It is known that, the female breast is a radiosensitive organ and there is risk of carcinogenesis associated with the radiation dose due to mammographic examinations [3]. Thus the assessment and evaluation of breast dose vital important. Because when using ionizing radiation for such an organ containing sensitive glands like breast, it must be optimized to avoid increasing the chances of inducing cancer in the patient. Therefore, it is necessary to evaluate the dose delivered to the breast to minimize the risk of radiation induced cancer. As with any examination that includes x-rays, there is always a small stochastic risk of inducing cancer. Therefore, it is important to evaluate the risk from the dose delivered to the patient during the imaging process to keep the dose as low as reasonably achievable (ALARA) [4]. Usually, mammographic images are taken one from the top (candiocaudal) and one from the side (mediolateral oblique). It has two type digital and conventional mammography. Both of them can be used for screening and for diagnosis. Screening mammogram: is looking for cancer before a person has any symptoms. This process helps to find cancer at an early stage [5]. Diagnostic mammogram, which is performed to evaluate a patient with abnormal clinical findings such as a breast lump or other sign or symptom of the disease. Diagnostic mammogram may also be done after an abnormal screening mammogram in order to assess the area of concern on the screening exam [1].

### Mammography

Mammogram is an x-ray examination used to image and evaluate breast changes. This technique is first used to examine breast tissue since last decades. Modern mammography was existed, when special x-ray machines were designed for breast imaging. Much technological advancement has been occurred in the last century, and today's mammogram is very different even from those designed before few years. The mammograms x-ray machines used today expose the breast to much low radiation level compared to those used in the past. [6]

**Methodology**

A Sweden dose rate meter Piranha (RTI.Ballad,) was used to evaluate the MGD. This detector consists of external probe which designed in the detector to determining the input dose to medium or phantom. Measurements were performed to estimate Mean Glandular Dose (MGD) and to evaluate factors affecting the dose in mammography for 60 patients subjected to mammography test in two different centers. Doses were studied in Nelain Diagnostic Center and Ahfad Family Health Center. A number of parameters were recorded during a diagnostic examination (e.g: exposure factor: charge (I)· mAs, KV and FSD, Patient age, breast thickness, applied clinical spectrum, type of projection for examined breast,). In Nelain Diagnostic Center the mammographic machine is manufactured by Siemens model Mammomat. C Germany with target /filter combination Rh/Al, and the other machine examined in Ahfad Family Health Centre is also from German company (Philips modelDiagnostic UC) with target /filter combination Mo/Mo. The patient doses were estimate using exposure factors through a three-step protocol that includes: X-ray output measurements, incident kerma calculation, and entrance surface air kerma (ESAK) estimation. The average absorbed dose in glandular tissue DG is most appropriate for risk assessments for radiation dose specification in mammography. The following formula was calculated to calculate the machine tube output

$$Y(d, kV) = K_a(d, kV)/P_{It} \qquad (1)$$

Where, Y(d, kV), is the quotient of the air kerma, $K_a$ (d, kV), measured at certain distance, d, from the x-ray tube focal spot (usually 60 cm) by the tube-current exposure–time product, $P_{It}$. and $P_{It}$ is tube-current exposure–time product, and the $K_a$ (d) was Measurement using calibrated Piranha dose rate meter.

The incident air kerma was calculated from the x-ray tube output, Y (d), corrected for the focal spot-to-surface distance, $d_{FSD}$, using the inverse square law and combined with the exposure parameters recorded during patient examinations:

$$K_i = Y(d, kV)P_{It}\left(\frac{d}{d_{FSD}}\right)^2 \qquad (2)$$

Where, $d_{FSD}$, is the focal spot-to-surface distance.

The entrance-surface air kerma is related to the incident air kerma by the backscatter factor, B. Thus

$$ESAK = K_i B \qquad (3)$$

The backscatter factor depends on the x-ray spectrum (kVp and HVL1), the x-ray field size, and the thickness and composition of the patient or phantom. In this study, tabulated B values given in IAEA Dosimetry protocol are used. The incident air kerma combined with conversion coefficients obtained from radiation transport calculations in mathematical models of breast was used to derived The mean glandular dose.

$$D_G = C_{D_{G50},K_i}.C_{D_{Gg},D_{G50}}.S.K_i \qquad (3)$$

The conversion coefficient $c_{DG50,\ Ki}$ for the appropriate value of the HVL and the thickness of the breast. The coefficient $c_{DG50,\ Ki}$ converts the incident air kerma to the mean glandular dose for a breast of 50% glandularity, the coefficient $c_{DGg,\ DG50}$ converts the mean glandular dose for a breast of 50% glandularity to that for a breast of glandularity, *g*, and of the same thickness, S correction factor for the selected target/filter combination and Ki is incident air kerma. [6]

**Results and Discussion**

The data used in this study was collected from two different hospitals; Nelain Diagnosis Center and Ahfad Family Heath Center to evaluate radiation doses to patients during mammography examination.

The Mean Glandular Dose (MGD) resulting from Craniocaudal (CC) and Mediolateral oblique (MLO) views for 60 patients subjected to mammography examination was calculated in two different diagnostic centers. Measurements were performed to estimate Mean Glandular Dose (MGD) and to evaluate factors affecting the dose in mammography. Calculating the MGD depends on different factors such as beam quality and HVL, which depends on the kVp and the target/filter combination. Following X-ray tube exposure parameters were recorded for each patient take diagnostic examination: peak tube voltage (KVp), exposure current–time product (mAs) and focus-to-film distance (FFD). In addition to, the patient information i.e. patient age and thickness of breast for two projections.

**Table (1):** Exposure factors and Patient data for mammography NCD

| Projection | Breast | | Age(y) | T(cm) | Kv | mAs | FSD(cm) |
|---|---|---|---|---|---|---|---|
| **CC** | R | Mean | 43.4 | 4.83 | 26.566 | 14.38 | 55.166 |
| | | Range | 22-65 | 3.5-6.5 | 24-32 | 12.5-18 | 53.5-56 |
| | L | Mean | 43.4 | 4.99 | 26.766 | 14.5 | 55.006 |
| | | Range | 22-65 | 3.5-6.5 | 24-34 | 12.5-18 | 52-56.5 |
| **MLO** | R | Mean | 43.4 | 5.43 | 26.566 | 14.3 | 54.57 |
| | | Range | 22-65 | 4-7 | 24-32 | 10-18 | 53.5-56.5 |
| | L | Mean | 43.4 | 5.62 | 26.733 | 14.43 | 54.3766 |
| | | Range | 22-65 | 4.3-8.3 | 24-33 | 12.5-18 | 53-55.7 |

**Table (2):** Mean and standard deviation for incident air kerma (Ki) mGy at FSD for two projections

| | **CC** | | **MLO** | |
|---|---|---|---|---|
| | R | L | R | L |
| **Mean** | 1.50 | 1.57 | 1.52 | 1.59 |
| **Stdev** | 0.41 | 0.59 | 0.44 | 0.52 |

**Table (3):** Mean and standard deviation for Entrance surface air kerma (ESAK) mGy for two projections

| | **CC** | | **MLO** | |
|---|---|---|---|---|
| | R | L | R | L |
| **Mean** | 1.62 | 1.70 | 1.64 | 1.72 |
| **Stdev** | 0.45 | 0.63 | 0.47 | 0.56 |

**Table (4):** Mean and standard deviation for Mean glandular dose (MGD) mGy for different thickness

| | **CC** | | **MLO** | |
|---|---|---|---|---|
| | R | L | R | L |
| **Mean** | 0.30 | 0.32 | 0.31 | 0.32 |
| **Stdev** | 0.08 | 0.12 | 0.089 | 0.107 |

**Table (5):** Exposure factors and Patient data for mammography Ahfad Family Heath Center

| projection | breast | | Age(y) | T(cm) | kv | mAs | FSD(cm) |
|---|---|---|---|---|---|---|---|
| CC | R | Mean | 47.866 | 3.733 | 33.166 | 35.766 | 56.266 |
| | | Range | 32-62 | 2- 5.5 | 30-35 | 25-50 | 54.5-57.7 |
| | L | Mean | 47.866 | 3.733 | 33.166 | 35.766 | 56.266 |
| | | range | 32-62 | 2- 5.5 | 30-35 | 25-50 | 54.5-57.5 |
| MLO | R | Mean | 47.866 | 4.083 | 33.3 | 35.766 | 55.916 |
| | | Range | 32-62 | 2.8- 6 | 30-35 | 25-50 | 54-57.7 |
| | L | Mean | 47.866 | 4.083 | 33.3 | 35.766 | 55.916 |
| | | range | 32-62 | 2.8- 6 | 30-35 | 25-50 | 54-57.7 |

**Table (6):** Mean and standard deviation for incident air kerma (Ki) mGy at FSD for two projections

| | CC | | MLO | |
|---|---|---|---|---|
| | R | L | R | L |
| **Mean** | 5.663 | 5.725 | 5.798 | 5.798 |
| **Stdev** | 1.325 | 1.377 | 1.396 | 1.396 |

**Table (7):** Mean and standard deviation for Entrance surface air kerma (ESAK) mGy for two projections:

| | CC | | MLO | |
|---|---|---|---|---|
| | R | L | R | L |
| **Mean** | 6.172 | 6.240 | 6.320 | 6.320 |
| **Stdev** | 1.445 | 1.501 | 1.522 | 1.522 |

**Table (8):** Mean and standard deviation for Mean glandular dose (MGD) mGy

| | CC | | MLO | |
|---|---|---|---|---|
| | R | L | R | L |
| **Mean** | 1.235 | 1.249 | 1.265 | 1.265 |
| **Stdev** | 0.289 | 0.300 | 0.304 | 0.304 |

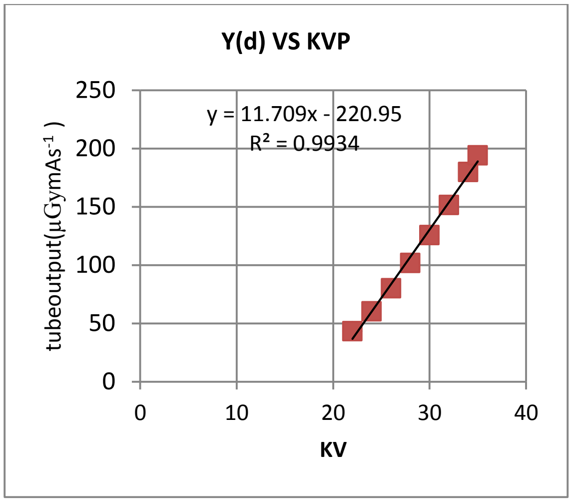


**Figure (1):** Relationship between tube Output versus kVp in NDC

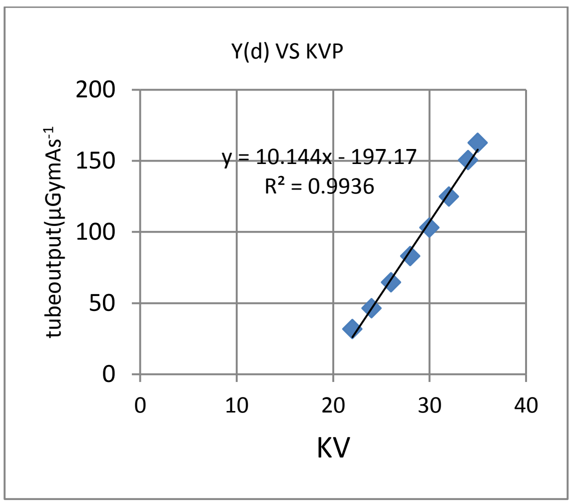


**Figure (2):** Relationship between tube Output versus kVp in Ahfad Family Health Center.

This research was conducted to evaluate the radiation dose to patients during mammography examination. Measurements were preforming to estimate Mean Glandular Dose (MGD) and to evaluate factors affecting the dose in mammography for 60 patients who underwent mammography examination in two different centers (Nelain Diagnostic Center and Ahfad Family Health Center).

**Table (1)** shows patient data and exposure parameters for NDC mammography. The age of tested women lay between (22– 65) years**.** The Mean compressed breast thickness of 4.83 cm (range 3.5-6.5) CC view for right breast, and 4.99 cm (3.5-6.5) CC view for left breast, 4.88cm(range3-7) MLO view for right breast and 5.43 cm(range4-7) MLO view for left breast, the range of tube voltage (kVp) was (24-34) and the range of tube current. Second (mAs) was (10-18) in.

**Table (2)** represented standard deviation **and** Mean for incident air kerma (Ki) mGy at FSD for two projections in NDC. The tube output was measured to calculated Ki. The mean ± stdev was (1.50±0.41) CC for right view (1.57±0.59) CC for left view, (1.52±0.44) MLO for right view and (1.59±0.52) MLO for left view in Nelain Diagnosis Center.

**Table (3)** represented Mean and standard deviation for Entrance surface air kerma (ESAK) mGy for two projections in NDC. The mean ± stdev of ESAK was (1.62±0.45) CC for right view (1.70±0.63) CC for left view, (1.64±0.47) MLO for right view and (1.72±0.56) MLO for left view.

**Table (4)** represented Mean and standard deviation for Mean glandular dose (MGD) mGy for different thickness in NDC. The mean ± stdev of MGD for CC for right view was (0.30±0.08) CC for right view, CC for left view, (0.32±0.12) CC for left view, (0.31±0.089) MLO for right view and (0.32±0.107) MLO for left view.

**Table (5)** represented patient data and exposure factors in Ahfad Family Heath Center. The examined women aged from (32– 62) years**.** Mean compressed breast thickness of was 3.73 cm (range 2-5.5) CC view for right breast, and 4.99 cm (2-5.5) CC view for left breast, 4.083cm(range2.8-6) MLO view for right breast and 4.083 cm(range2.8-6) MLO view for left breast, the range of tube voltage (kV Ahfad Family Heath Center p) was (30-35) and the range of tube current. Second (mAs) was (25-50).

**Table (6):** Mean and standard deviation for incident air kerma (Ki) mGy at FSD for two projections in Ahfad Family Heath Center. The Ki was calculated from the measured tube output. The mean ± stdev was (5.665±01.325) CC for right view (5.752±1.377) CC for left view, (5.798±1.396) MLO for right view and (5.798±1.396) MLO for left view.

**Table (7)** represented Mean and standard deviation for Entrance surface air kerma (ESAK) mGy for two projections in Ahfad Family Heath Center. The mean ± stdev of ESAK was (6.172±1.445) CC for right view (6.240±1.501) CC for left view, (6.320±1.522) MLO for right view and (6.320±1.522) MLO for left view.

**Table (8):** Mean and standard deviation for Mean glandular dose (MGD) mGy in Ahfad Family Heath Center. The mean ± stdev of MGD for CC for right view was (1.23±0.289) CC for right view, CC for left view, (1.249±0.300) CC for left view, (1.265±0.304) MLO for right view and (1.265±0.304) MLO for left view.

The mAs in Ahfad Family Heath Center was higher than NDC, the parameter exposure kVp and mAs within range of the standard range of parameters exposure in Mammography. The tube voltage should be between (22-35) kVp and the tube current exposure time product (mAs) should be at least (4- 400).

Where all examinations included two CC and two MLO projections per patient. . The mean of incident air kerma (Ki) of Ahfad Family Heath Center was higher than NDC due to different mammography x-ray machine, different FFD and used different parameter exposure factors.

Different in values of ESAK were observed in the two hospitals mainly due to kVp accuracy problems.

**Figure (1)** Illustrates the Relationship between tubes Output versus kVp in NDC and **Figure (2)** Relationship between tubes output versus kVp in Ahfad Family Health Center the linearity in both relationship is clear after certain value of KVp (the starting point of this parameter).

## Conclusion

This study aimed to evaluate the radiation dose to patients screened in mammography examination. Measurements were carried out to estimate Mean Glandular Dose (MGD) and also to evaluate factors affecting the dose in mammography for a number of 60 patients in two different centers Nelain Diagnostic Center and Ahfad Family Health Center. According to obtained results from this research we found that The mAs in Ahfad Family Heath Center was higher than NDC, the parameter exposure kVp and mAs within range of the standard range of parameters exposure in Mammography. The tube voltage should be between (22-35) kVp and the tube current exposure time product (mAs) should be at least (4- 400). Where all examinations included two CC and two MLO projections per patient. . The mean of incident air kerma (Ki) of Ahfad Family Heath Center was higher than NDC due to different mammography x-ray machine, different FFD and used different parameter exposure factors. Different in values of ESAK were observed in the two hospitals mainly due to kVp accuracy problems.

## Recommendations

To make enhancement in this area of research we are strongly recommend that:

- Further studies should be done in order to optimize the radiation doses.
- Training for working Staff is vital important to avoid the delivery of high doses for patients and to gain images with high quality.

## References

[1] Radiology Info .org, the radiology information resource for patient, Radiology Info .org, (2012). http://www.radiologyinfo.org

[2] J. Bozek, K. Delac, M. Grgic, Computer Aided Detection and Diagnosis of Breast Abnormalities in Digital Mammography, 50th International Symposium ELMAR, Zadar, Croatia, 2008.

[3] K.O. KO, S. H. PARK, and J. K. LE, Assessment of patient dose in mammography using Monte Carlo simulation, Dep. of Nuclear Engineering Hanyang University, Seoul, Korea, march 2004.

[4] Dance, D., Skinner, C., Carlsson, G. Breast dosimetry. Applied Radiation and Isotopes, vol. 50, pp. 185-203, 1999.

[5] National cancer institute, Breast Cancer Screening, National Cancer Institute at National Institutes of Health,2013.

http://www.cancer.gov/cancertopics/pdq/screening/breast/Patient/page1

[6] American Cancer Society. Mammograms and Other Breast Imaging Tests. Available from: www.cancer.org, 2015.

[7] Faiz. M. Khan, The Physics of Radiation Therapy. 4thEd, Lippincott William& Wilkins, Wolters Kluwer, Philadelphia, 2010.

[8] International Atomic Energy Agency (IAEA). Dosimetry in Diagnostic Radiology: An international Code of Practice Technical Reports Series (TRS) No. 457. (IAEA), Vienna, 2007.

[9] Jerrold T. Bushberg, J. Anthony Seibert, Edwin M. Leidholdt, JR, John M. Bone, The Essential Physics for Medical Imaging second edition-20150929-085027787, printed in USA, 2002.

[10] William Hendee and Russell Ritenour, Medical Imaging Physics-4th Ed, NewYork, 2002.

[11] International Atomic Energy Agency (IAEA). Diagnostic Radiology Physics a handbook for teachers and students. (IAEA), Vienna, 2014.

[12] E.B. Podgorsak. Radiation Oncology Physics: a handbook for teachers and students IAEA, Vienna, 2005.

[13] Yousif M.Y. Abdallah, Abdallah O. Alamoudi, Sami N.A. Elgak,

Appraisal of mean glandular dose (MGD) during mammography examinations, International Journal of Advanced and Applied Sciences, 2017

[14] DU Xiang W. Jin, Y. Chun Yong, Z. Xian Feng, C. Wei, C. Xing Jiang, Z.HOU & YU. Ning, Investigation of Mean Glandular Dose in Diagnostic Mammography in China. Biomed Environ Sci. 27(5): 396-399. China, 2014.

[15] N. JAMAL, K-H NG, DABMP, MIPEM& D. MCLEAN, A study of mean glandular dose during diagnostic mammography in Malaysia and some of the factors affecting it. Bjr. 76, 238–245. Malaysia, 2003.

[16] F. Bouzarjomehri, A. Mostaar, A. Ghasemi, M.H. Ehramposh, H. Khosravi, The Study of Mean Glandular Dose in Mammography in Yazd and the Factors Affecting It, Iran. J. Radiol., 2006.

[17] F. Leyton, M. Do Socorro Nogueira, M. Dantas, M. Paz Duran& C. Ubeda, Mean Glandular Dose in Six Digital Mammography Services in Santiago, Chile: preliminary Reference Level. 'Radiation Protection Dosimetry. Vol. 165, No. 1–4, pp. 115–120. Chile, 2015.

[18] M. K. Shahid, A. Rasool, R. Sabir & M. S. Awan, Dosimetric evaluation of mean glandular dose for mammography in Pakistani women. PJMMS Vol.1 (4), pp.32-38, Pakistan, 2013.

[19] H. Mohamed, H. Osman, A. Sulieman. Estimation Radiation Risk during Mammography in Sudan, Asian J Med Cli Sci. Vol -1. 56 -60. Sudan, 2012.

[20] Pwamang C, Sosu E, Schandorf C, Boadu M, Hewlett, Assessment of Dose to Glandular Tissue of Patients Undergoing Mammography Examinations, J Radiol Radiat Ther 4(2): 1062, 2016.

[21] L. rahmatnezhad, Z. Behrouzkia, A. Zeinali, H. Mohammady & N. Jabari, An Investigation of Mean Glandular Dose from Routine Mammography in Urmia, Northwestern Iran and the Factors Affecting It. Res. J. Appl. Sci. Eng. Technol. 4(18): 3348-3353. Iran, 2012.

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