

A Methodology for Obtaining the Mean Glandular Dose in Mammography Exams

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Abstract. This study proposes to validate measurements of mean glandular dose quantity (D_G) for a given thickness and glandularity of compressed breast based in a PMMA phantom. 10 exposures were made in an ionization chamber in conventional mammographic equipment for a research. It obtained an average value for the incident air kerma, $K_{a,I} = 9.59$ mGy leading to a $D_G = 1.82$ mGy. Experimental results too were obtained for the acquisition of this quantity in other mammography clinics and these results were also reported and discussed. After the comparison of the results the methodology was validated.

1. Introduction

In Brazil, estimates for 2014, reported the appearance of about 57,000 new cases of breast cancer [1], being estimated that approximately 30 thousand of these findings still are found late, which in the year of 2010 has led to almost 13 thousand deaths among the female population. According to publication of the International Commission on Radiation Units (ICRU) [2], the incidence of breast cancer in the age between 45 to 64 and more than 65 years is 51 % and 39 %, respectively. Early diagnosis, through equipment's adjusted in relation to their basic operation [3,4] parameters, together with the radiographic image quality, allows besides the detection of diseases at an early stage with lower radiation doses to the patient. Even if this dose is from recall due to an inappropriate image.

Absorbed dose (D) at the entrance of the skin is a very important in the evaluation of quality control in mammography [4] and is obtained from the measurement of incident air kerma - $K_{a,i}$, multiplicand by the backscattering factor. This quantity is also known as Entrance surface air kerma - $K_{a,e}$ [5]. Already the mean glandular dose - D_G , is dosimetric quantity which best characterizes the carcinogenic risk induced by X rays in mammography exams; it is recommended by the International Commission on Radiation Protection ICRP, and adopted in the European Protocol of Dosimetry in Mammography [6,7]. This study aims to validate a representative average value for measurements of D_G to the phantom measurements in mammography equipment's.

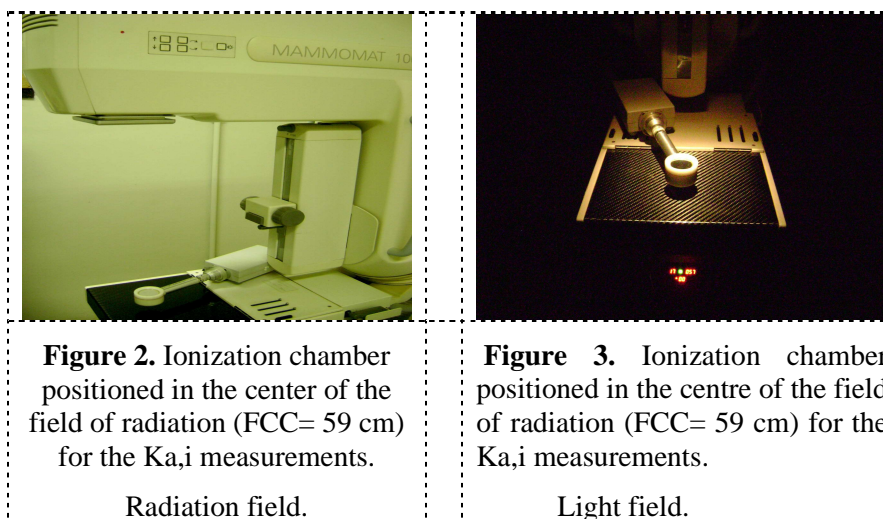
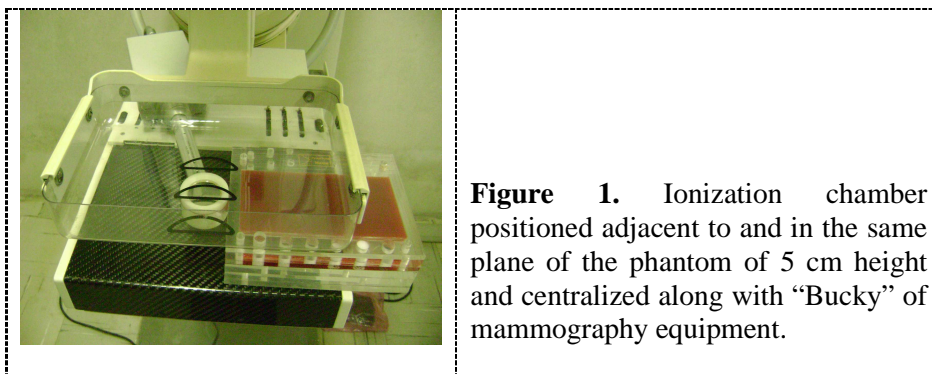
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2. Methods and Measurements

It were used for the measurements in the laboratory: a mammography equipment Siemens mammomat 1000 model, a dosimeter manufacturer Radcal (model 9015, 910506 series), coupled to ionization chamber (modelo10X56M), calibrated by the National Laboratory of Metrology of Ionizing Radiation (LNMRI - IRD /CNEN) and aluminum (Al) filters (purity of 99%) with thickness of 0.1 mm for measurement of half-value layer (HVL), getting to this basic parameter the value of 0.38 mm in Al. The methodology adopted here was to associate quality control procedures of the radiographic image with experimental determinations and other mathematical models for the dosing quantities $K_{a,i}$, D ($K_{a,e}$) and D_g [8.9]. For the determination of $K_{a,i}$, 10 exposures were carried out yet in the ionization chamber.

This experimental arrangement occurred in accordance with the sequence shown in Figs. 1 and 2, respectively. It was used the radiation quality with x-rays tube voltage of 28 kV, for a $< 2\%$ reproducibility. In turn, the product current x milliamperage (mAs) ranged from 56 to 63 to manual and automatic modes. For the set Molybdenum-Molybdenum (Mo-Mo) target - filter this remained constant throughout the experiment, so as not to significantly change the beam spectrum.

The "Phantom mama", as adopted by the Brazilian College of Radiology, is composed of acrylic with dimensions for width, height and depth of 12, 5 and 16 cm, respectively, where are found the objects related to the quality of radiographic image[10], was positioned next to and in the same plane of ionization chamber positioned perpendicular to the central axis of the primary x-ray beam in the following dimensions: Focus to the center of the ionization chamber - Camera Center (FCC= 59 cm) and radiation field size of 24 x 18 cm on the surface of the Bucky, as can be seen in these images (Figs. 1, 2 and 3). These parameters will not have too changed.



For the determination of HVL and D_G , with proper procedures, methodologies were already described in the literature [9, 11] for the quantity incident air kerma, the estimated uncertainty has been reported for $k = 1$. For the calculation of the D_G were used: one computerized mammography equipment (CR) and four screen-film systems.

3. Results and Discussion

The value $K_{a,i} = 9.59 \pm 0.1\%$ mGy was obtained from ten to exposures in the ionization chamber. This result was multiplied by the scattering factor (1.09), in accordance with the TEDOC-1517, IAEA, 2006, being obtained $10.45 \text{ mGy} \pm 0.1\%$ for the value of the D ($K_{a,e}$).

In this study we obtained the calculation of D_G , 1.82 ± 0.2 , based in a PMMA phantom where the conversion factor ($g.c = 0.190$) [9] and the fibro-glandular percentage equivalent to 20% and 5.0 cm of the compressed thickness, adopting: $S = 1$; to set target anode (Mo-Mo); $K_{a,i} = 9.59 \text{ mGy} \pm 0.1\%$, which was interpolated to a HVL 0.38 mm of Al (obtained experimentally).

Respect to Table 1, the D_G values are in accordance with the reference level below of 3.0 mGy to an acrylic phantom of 4.5 to 5.0 cm [12]. This shows the validate the calculation model adopted to the D_G values obtained in this study.

For the level of uncertainty associated with the D_G , this proved to be up to 5 times greater than the estimated uncertainties for measurements in each clinic, based on quality control tests. However, this result was expected because here were considered other components of significant uncertainty in its composition: so it was consistent with the practices and negligible in relation to the ultimate given quantity.

Table 1. D_G for four screen-film systems and one CR equipment based in a PMMA phantom with 5 cm of compressed thickness equivalent.

DATE ORIGIN	D_G (mGy \pm %)
This study	$1.82^a \pm 0.2$ ($k=2$)
Clinic A ^h	$2.33^b \pm 0.04^e$
Clinic B	$1.63^c \pm 0.08^f$
Clinic C	$1.53^d \pm 0.08^g$
Clinic D	$1.83^j \pm 0.07^i$

^a Value calculated from the obtaining K_i and HVL obtained experimentally in mammography equipment. In this calculation were also considered: $S=1$ and the conversion factor (product $c.g = 0.190$) [9].

^b Value obtained in accordance with report methodology [8].

^{c, d, j} Values obtained from these same tests [8]. In the clinics (B) and (C) are conducted about 15.600 and 8.500 annual exams, respectively.

^{e, f, g, i} Expanded uncertainty (%) obtained by combined standard uncertainty value multiplied by the supply factor ($k=2$), to a level of confidence of 95.45%. Were here considered the uncertainty components due to the $K_{a,i}$ values measured in each clinic (0.02, 0.01, 0.02, 0.14) % and the values for the uncertainties of the certificate (0.02, 0.04, 0.04, 0.02) %.

^h Computadorized Radiography (CR).

Already, for the absorbed dose at the entrance of the skin (D), so named by technical regulation 453 of the Ministry Health 453, it should be recalled that, as long as they do not take effective measures in relation to quality control practices, as well as the mistakes made in the positioning of the breasts

during the exam, news exposures due to repetitions of the following may occur, leading to unnecessary radiation dose to the patient.

4. Conclusions and Recommendations

According to the results shown in Table 1, the DG values obtained in this study are consistent with those reported in the available literature, in relation to reference levels for such quantity, which validates the methodology presented here.

This study is relevant due the necessity to contemplate others phantom with different features (glandularity and thickness of compression), also increasing the number of measurements in the mammographic equipment with other technologies (digital radiography and tomosynthesis). Furthermore, it is observed an increase in the DG due to the changes on the mammography equipment, i.e. of conventional technology to the CR, mainly in state of Rio de Janeiro - Brazil. It is known that such technology has been causing an increase of at least 20 % between the values found for such quantity.

5. References

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Acknowledgments

Authors have also to express our thanks to Bárbara Fernandes Gonçalves Cristiano for the suggestions and comments.