RESULTS OF AN INNOVATIVE METHODOLOGY TO THE DOSIMETRY IN MAMMOGRAPHY EXAMINATIONS

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Abstract: Female breast is a radiosensitive organ and the main procedure to assess the carcinogenic risk associated the mammographic practices has been indicated by the mean glandular dose (MGD) measurements. However, this dosimetric quantity may not provide the accuracy required for such measurements due to the heterogeneity of glandular tissue. So twenty-one exposures happened in a phantom mammographic using a CR equipment. Results were compared with data from the literature and was found an accuracy rate 15% lower than the recommended level. Experimental values reached below the IAEAôs acceptable levels for 3.0 to 6.0 cm thickness of the compressed breast.

Keywords: Mammographic phantom, Mean glandular dose , Medical radiodiagnostic, Metrology.

1. INTRODUCTION

At least 20 % of the world's population may borrow some kind of life long cancer [1]. In the case of breast cancer, 51 % of the cases would occurred in the age group between 45 to 64 years [2]. In 2009, the Brazilian Southeast region held the leadership as to the appearance of breast cancer per 100 thousand women with index of 68.1% [3] and about 57 000 new cases of breast cancer are expected to be detected in 2015 [3]. The increase in the number of mammographies [4,5] with digital technology (CR) in Rio de Janeiro (RJ), compared to other technologies, which can raise the patient dose in these practice of radiodiagnostic. This patient dose is associated to a dosimetric quantity, i.e., the Mean Glandular Dose (MGD), that is also associated by other hand to the cancer risk due to x-rays exposure [5,6]. To Compare procedure the semi-empirical and experimental measurements of MGD, combined to the permissible control of levels for this dosimetric quantity, covering a larger range to the compressed thickness in an realistic breast phantom [7]. The develop an experimental methodology for obtaining MGD in different thicknesses of compression and depths in this phantom that can improve the quality control practices in the mammographic exams.

2. METHODOLOGY

The MGD methodology compare measurements in an breast phantom - "Breast Tissue Equivalent" (BTE) - with literature data [7], associating a validation model of this dosimetric quantity in different studies [8,9,10]. Thus, obtained the air kerma incident ($K_{a,i}$) and the appropriate conversion factors in order to determine the semi-empirical MGD[8,9]. The phantom was irradiated by 21 times in a mammographic equipment Siemens, model mammomat 1000, with conventional and digital technology. The exposures occurred in the cranio-caudal projection (CC) using the semiautomatic mode by "bucky" inserting in the an Kodak brand chassis model M2000. The 63.5 cm distance focus -"bucky", 24 x 18 cm radiation field of 24 x 18 cm, centralizing the phantom according to 3 semi-circles of the Automatic Exposure Control (AEC) indicated in the compressed plate figure 1.

The started exposures started with a 3.0 cm thickness going to up 6.0 cm in equivalent compression. To measure the MGD, experimental, 6 thermoluminescence dosimeters, TLDs - LIF 100, were placed in the BTE, 3 at phantom top of the phantom for the Ka,i measurement of and others 3 in the diferent depths to compare required with semi-empirical results for each thickness of compression.

The glandular percentage, glandularity of the phantom [7] to 3.0 cm to 6.0 cm thicknesses ranging from is of 46%. 176 TLDs has been calibrated, obtaining individual sensitivity factors after exposures of 10 mGy with ^{137}Cs source calibrated in standard laboratory.

Also obtained the calibration and correction factors, energy dependence, of the TLDs, transforming nannocoulomb (nC) arbitrary reading to the MGD (mGy) and correcting the different depths energy in the measurements for the phantom. The final result of 3 readings for $K_{a,i}$ and other 3 to MGD resulted an average values and one standard deviation, already discounted the backscattering factor and the background [11,12]. The TLDs readings and thermal treatments were performed in a reader Harshaw, 5500 model with "softer WinRem" associated with an PTW oven . The results of the 3 measurements for each quantity, the appropriate literature comparisons, besides the correlation with the (mA) x exposure time (s) product are showed in table 1 and 2. This mAs product and half value layer, HVL, were controlled by following the IAEA procedures [13]. These measurements were made using an ionization chamber and electrometer Radcal coupled, and a solid state detector, manufactured by Unfors company, both tracked to the Laboratório Nacional de Metrologia das Radiações Ionizantes (LNMRI / IRD).

3. RESULTS AND DISCUSSION

MGD results, shown in table 1, draw especially attention when it comes to thickness between 4.0 to 6.0 cm ,frequent thicknesses in a large public hospital in the Rio de Janeiro-Brazil [4]. In these compressed breast thickeness can be observed that, in 4.0, 5.0 and 6.0 cm, five of the six measurements as compared with other authors, are below 15%, which is the appropriate results [8]. It suggests that other breast thicknesses shall be tested new depths for MGD measurements of in the BTE. According Andy et Ali [14], mainly 3.5, 4.5 and 5.5 cm, the MGD values may not provide the accuracy required for such measurements due to the heterogeneity of glandular tissue.

Table 2 shows the results concerning to the $K_{a,i}$ values**,** with the respective mAs, between 3.0 to 6.0 cm of compressed breast in the phantom. The linear correlation coefficient of $R^2 = 0.9989$ was found. These quantity thickness values of 4.5 and 5.0 cm are according with the recommended levels for the absorved dose on the patient skin entrance [13-15]. Finally, in Figure 2 are shown values comparisons of the experimental doses (BTE) and literature reported. It can be observed that the greater part of the measurements (3.0 to 6.0 cm) are below the acceptable levels [10], meaning that the results obtained are consistent according to the adopted methodology.

Table 1. MGD Experimental compared with semi-empiric values.

phantom thickness (mm)	MGD (mGy)	2 SD [a]	Accuracy (%) (b) - (c)
30	0.704	0.192	8.0 - 18.0
35	1.044	0.060	17.0 - 29.0
40	1.026	0.186	6.3 - 4.3
45	0.901	0.068	54.0 - 38.0
50	1.92	0.10	13.0 - 27.0
55	2.89	0.04	24.0 - 16.3
60	2.90	0.11	5.1 - 7.8

a Standard Desviation (SD) to MGD; b Dance et al ;
c R Klein et al .

Table 2. $K_{a,i}$ Experimental values of with the respective mAs for each compression thickness.

phantom thickness (mm)	$K_{a,i}$ [d] (mGy)	1SD [f]	mAs [e]	1SD [g]
30	1.90	0.01	18.00	0.05
35	2.94	0.12	26.27	0.065
40	4.15	0.03	37.25	0.086
45	5.87	0.21	51.6	1.0
50	8.07	0.22	71.9	0.1
55	12.16	0.05	101.3	0.3
60	17.47	0.06	140.3	0.2

d, e $R^2 = 0{,}9989$; correlation coeficiente ($K_{a,i}$ x mAs)
f, g $K_{a,i}$ and mAs Standard Desviation (SD)

Figure 1. BTE centralized on the bucky of the equipment.

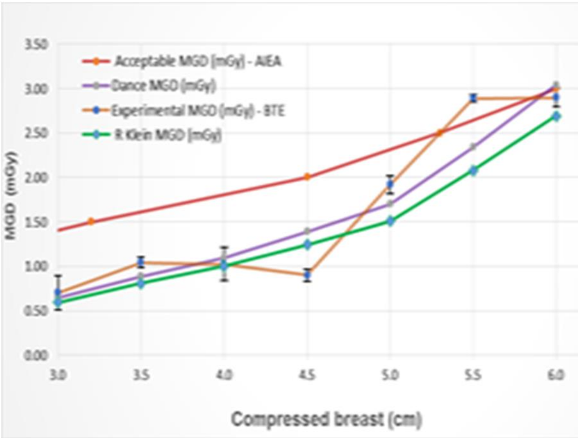

Figure 2. MGD measurements in this study and values of this quantity reported by literature.

4. CONCLUSIONS

It was developed a compare methodology MGD results of obtained in a real breast phantom (BTE) with semi-empirical results available in the literature. When consider the most frequently used thicknesses (4.0, 5.0 and 6.0 cm) in a large public hospital in RJ city, five of the six MGD measurements for were found below the accuracy level recommended and six of seven MGD experimental results were to acceptable level [10]. Also, the $K_{a,i}$ results, in addition to presenting a good correlation with the values of mAs to the compression thicknesses studied being consistent too with absorbed dose levels in the skin of the patient according literature for the reference thicknesses of 4.5 and 5.0 cm [13, 15]. After all the results obtained indicate the efficiency of the applied methodology, validating this study. In this way, the method can be used in conjunction with other mammography quality control procedures involving the BTE, replacing PMMA Phantoms, accompanying and controlling with the accuracy and precision required, these important dosimetric quantities for mammographic exams.

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