EVALUATION OF THE ENTRANCE SURFACE AIR KERMA IN MAMMOGRAPHIC EXAMS

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ABSTRACT

The aim of this work was to evaluate the distribution of entrance surface air kerma (ESAK) in five-mammography facilities located in RJ (A-E). The E Clinic was chosen to evaluate breast thickness and composition influence in the ESAK values. The criteria for image quality were considered as well as the Average Glandular Dose (DG). Data related to 1140 patients were carried out reaching a total of 4520 mammograms images. A medium ESAK value was obtained for breast thickness of 45mm equal to 5.58mGy in A Clinic; in B Clinic equal to 10.07mGy; in C Clinic equal to 13.89mGy and in D Clinic equal to 7.21mGy. Comparing the results found with the value of reference (equal to 10mGy), C Clinic presented a higher ESAK value in 38.9% for the recommended limit for a thickness of 45mm. In D G it can be seen that for the same compressed breast thickness of 50mm, the DG value varied from 0.20 to 3.60m Gy, reaching as medium value equal to 1.50mGy for all Clinics studied. In image quality evaluation, D Clinic was the only one which presented a very low acceptability of quality criteria and inadequacies in relation to microcalcification and mass. To evaluate the breast thickness and composition influence, E Clinic (794 radiographic images) was selected. Through the results it was possible to verify that the entrance surface air kerma estimated for phantom-methods were low in all breast thicknesses and composition in comparison with the patient-methods.

1. INTRODUCTION

According to the National Institute of Cancer [1], the screening for mammography is recommended for women with ages between 50 and 69 years, with the maximum of two years between the examinations. The effectiveness of this examination depends on the production of radiographs of the highest quality [2]. In accordance with international recommendations, the optimisation of the procedures is essential to get an image with the information required for the diagnostic and with the minimum adequate radiation dose. So, the proposal of this work was to evaluate the entrance surface air kerma (ESAK) in a sample of patients of five-mammography facilities located in Rio de Janeiro, taking into consideration the criteria of the image. The result was compared with the reference level established for Decree 453 [3].
2. MATERIALS AND METHODS

In the evaluation of the entrance surface air kerma (ESAK), 1140 patients were randomly selected with a total of 4520 mammograms images (A - E). The E Clinic was selected to evaluate breast thickness and composition influence in the ESAK values. The radiographic data recorded for each examination were: the identification number and the age of patient, the compressed breast thickness and breast composition, the type of view projection [craniocaudal (CC) and mediolateral oblique (MLO)], and radiographic techniques (kVp, mAs, target/filter combination and mode of exposure). The technical parameters and the breast thickness were indicated by the mammography. The classification of the breast in relation to its composition was carried out by the radiologists of each Clinic in: glandular (100% glandular), moderately glandular (> 50% adipose tissue), heterogeneity glandular (< 50% adipose tissue) and adipose (100 % adipose).

2.1 Image Quality Evaluation

Over the clinical aspects for the image evaluation in each Clinic, 10 patients with compressed breast thicknesses between 50 mm and 60 mm were selected. The image quality evaluation [4] was carried out by the radiologists of each Clinic in both view projections (CC and MLO). The A and E Clinics haven’t taken part in this stage because there weren’t available radiologist who could evaluate the images. In the evaluation over the physical aspects, the breast simulator of the American College of Radiology (ACR) [5] was used. The method consisted of counting the number of objects of tests visualized in each group.

2.2 Evaluation of the dose in sample of patients

2.2.1 Determination of the entrance surface air kerma (ESAK) in patients

The values of ESAK were estimated from the radiation output rate (mGy/mAs) of the mammography. The ionization chamber Radcal model 9015 connected to the electrometer of 6 cm$^3$ was used. In this way it was possible to estimate the ESAK value for all the sample of patients, using the equation as follows:

$$K_e = \frac{Yc_P d_{ref}}{d} B = a U^b P_{it} \left( \frac{d_{ref}}{d} \right)^2 B$$

(1)

where $Y$ is the radiation output rate (mGy/mAs); $U$ is the tension applied to the tube (kVp) and $a U^b$ is the function which approach to the radiation output rate, $Y$; $d_{ref}$ is the distance where the radiation output rate was determined; $d$ is the focus-skin distance; $P_{it}$ is the tube loading (mAs) chosen during the exposition of each patient; and $B$ is the backscatter factor. The adopted value for $B$ was 1.09 [4].
2.2.2 Evaluation of Average Glandular Dose ($D_G$) in the patients

The Average Glandular Dose ($D_G$) was calculated from the values of kerma in air for each patient, using the equation:

$$D_G = g_{PB} s K_i = g_{PB} s Y \left( \frac{d_{ref}}{d} \right)^2$$  \hspace{1cm} (2)

where $K_i$ is air kerma incident (INAK) for each patient, which gets from the radiation output rate, measured with the same value of tension applied to the tube and after corrected by the distance: $K_i = Y(d_{ref}/d)^2$; $g_{PB}$ is the conversion coefficient to be used to calculate average glandular dose, which depends of the half-value layer (HVL). Value of $g_{PB}$ are obtained through Monte Carlo simulations for the standard breast measured by Dance [6]; and $s$ is a factor that depends on target/filter combination. It is used Mo/Mo combination; the value of $s$ is the unit.

2.2.3 Evaluation of the influence of the thickness and the composition of the breast in the values of ESAK

Due to the different thicknesses and compositions of the breast, an evaluation was carried out to know how these differences may influence in the value of the ESAK. For this, a sample of 200 patients were randomly selected (E Clinic). For a posterior comparison of the ESAK values obtained with the sample of patients, it was used a phantom of breast with different thicknesses.

The ESAK values in patients were estimated from the radiation output rate (mGy/mAs) of the mammography, using the same methodology in topic 2.2.1. To determine the ESAK value in the phantom, it was used the phantom of breast of Victoreen, model 18-222 with different thicknesses (10 - 70 mm) and different compositions (70% glandular/30% adipose, 50 % glandular/50 %adipose and 30 % glandular/70 % adipose). The readings of air kerma in the phantom were taken using the ionization chamber of the Radcal model 9015 connected to 6cm³ located inside of the phantom in the position of examinations of the breast. To reproduce under the same conditions of examinations for a view projections cranio-caudal, the exposure was carried out using the compression plate and automatic exposure control (AEC) system.

3. RESULTS AND DISCUSSIONS

3.1 Image Quality Evaluation

In the image evaluation over the clinical aspects, it was observed in MLO view (Figure 3.1) in the B Clinic that criteria 4 and 9 (one related to the positioning and other related the
exposure) have not presented a 100% of acceptability. The non-attendances of these criteria indicate that the detection of breast disease cannot be assured. The Clinic C presented acceptability of 100% in all the quality criteria. In relation to D Clinic, criteria 2, 3, 4 and 6 were attended in only 10% of the images. This arise a problem of breast positioning and it does not allow to assure the detection of breast disease in the mammary tissue, the skin and the fat. The criteria 1, 7 and 5 have also presented a low an acceptability, which represents a problem in breast positioning.

In CC view (Figure 3.2), in C Clinic, a criteria 1 (visualization of the pectoral muscle) only presented a lower acceptability, 60%, while in the other clinics it was not attended in any studied images. Although it does not imply in the loss of diagnostic information and to depend on the type of patient breast and the effectiveness of the technique (or technologist). The presence of the pectoral muscle in the image represents the certainty of that all the area of the breast is contained in the x-ray. This criteria evaluates the positioning, that in this in case, indicates that the breast is not placed correctly and does not present mammary symmetry. In D Clinic, it was possible to observe a low tax of acceptability in criteria 3, 4 and 7, being visualized in only 20% of the examinations. The not attended of these criteria indicates problems of breast positioning, that can affect the detection of breast disease.

In the image evaluation over physical aspects, it was possible to verify that only in D Clinic is not in accordance with the requirements established for Decree 453 [3] and the ACR [5]. The results are presented in Table 3.1.

<table>
<thead>
<tr>
<th>Objects of tests</th>
<th>A Clinic</th>
<th>B Clinic</th>
<th>C Clinic</th>
<th>D Clinic</th>
<th>E Clinic</th>
</tr>
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<td>5</td>
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<tr>
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<td>0.69</td>
<td>0.56</td>
<td><strong>0.33</strong></td>
<td>0.66</td>
</tr>
</tbody>
</table>

Figure 3.1. Frequency of acceptability of each criteria of image quality for B, C and D Clinics, in MLO view.

Figure 3.2. Frequency of acceptability of each criteria of image quality for B, C and D Clinics, in CC view.

Table 3.1 Results of the visualization of objects of tests for the A, B, C, D and E Clinics
3.2 Evaluation of the entrance surface air kerma (ESAK) in patients

3.2.1 Distribution of the ESAK for the B, C and D Clinics for different compressed breast thicknesses

It was obtained a medium ESAK value for breast thickness of 45 mm equal to 5.58 mGy in A Clinic; in B Clinic equal to 10.07 mGy; in C Clinic equal to 13.89 mGy and in D Clinic equal to 7.21 mGy. Comparing the results found with the value of reference (equal to 10 mGy), C Clinic presented a superior ESAK value in 38.9% for the limit recommended for a thickness of 45 mm.

3.2.2 Distribution of the ESAK for different breast compositions

The distribution of the medium ESAK value for different breast compositions is presented in Figure 3.3. The breast thickness selected for this study was of 50 mm. It can be observed in the A Clinic, the medium ESAK value for a glandular breast was 9.69 mGy; in the B Clinic, the value was 14.30 mGy; and in C Clinic, the value was 19.0 mGy, evidencing that the patients have received higher doses in relation to the other two Clinics. It is important to point that Clinic C was presented in adequacy with the questions of image quality under physical aspect and also presented a high acceptability in the evaluation of the quality criteria. In D Clinic, only two breast compositions was observed, glandular and adipose, where the ESAK values was found to be equal to 11.06 mGy e 9.80 mGy, respectively.

![Figure 3.3. Distribution of the medium ESAK for different breast compositions and compressed breast thickness of 50mm.](image)

3.2.3 Distribution of the $D_G$ in the B, C and D Clinics for different compressed breast thicknesses

The values of Average Glandular Dose ($D_G$) estimate for the Clinic (A – D) were compared with the reference value of 3.0 mGy [7]. It can be observed that for a compressed breast
thickness of 50 mm, the value of the D$_G$ varied approximately of 0.20 mGy to 3.60 mGy, with medium value equal to 1.50 mGy, being in accordance with acceptable limits [7].

3.2.4 Evaluation of the influence of the thickness and the composition of the breast in the values of ESAK

In the results it can be verified that the entrance surface air kerma estimated for phantom-methods were low in all breast thicknesses and composition in comparison with the patient-methods.

4. CONCLUSION

It can be concluded that the Clinic where the patients had received higher doses, have presented adequacy with the questions of image quality. On the other hand, the Clinic, where ESAK values was found to lower, the evaluation of the image quality under the physical aspects was found to be inadequate. These results show the necessity of developing Optimization Programs for all the practical of mammography.

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REFERENCES