COMPARATIVE EVALUATION OF AVERAGE GLANDULAR DOSE AND IMAGE OF DIGITAL MAMMOGRAPHY AND FILM MAMMOGRAPHY IN MINAS GERAIS, BRAZIL

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ABSTRACT

Breast cancer is the most common cancer among women, and early detection is critical to its diagnosis and treatment. Mammography is the best method for breast-cancer screening and is capable of reducing mortality rates To date, the most effective method for early detection of breast cancer has been x-ray mammography for which the screen/film (SF) technique has been the gold standard. Digital mammography has been proposed as a substitute for film mammography given the benefits inherent to digital technology. The purpose of our study was to compare the technical performance of digital mammographic and screen-film mammography. A PMMA phantom with objects to simulate breast structures. For the screen/film (SF) technique the results showed that 54% mammography units did not achieve the minimum acceptable performance as far the image quality. Besides, 67% services showed inadequate performance in their processing systems, which had significant influence on the image quality. At the mean glandular dose only 44% of digital systems evaluated were compliant in all thicknesses of PMMA. The average glandular dose AGD was 90 % higher than in screen/film systems.

1. I. INTRODUCTION

According to data from National Cancer Institute - INCA, breast cancer is the second most common type of cancer in the world, is more common among women, accounting for 22% of new cases each year. In Brazil mortality rates from breast cancer remain high and that 57,120 new cases were estimated for the year 2014. In 2030, the global burden will be 21.4 million new cancer cases and 13.2 million of cancer deaths as a result of growth and an aging population, and the reduction in infant mortality and deaths from infectious diseases in developing countries The same publication has estimated for the state of Minas Gerais, the incidence of 5,210 new cases with 49 new cases per 100,000 women, breast cancer is the highest incident cancer among brazilian women. For over a decade it has been the leading cause of death from cancer among brazilian women [INCA, 2014].

Mammography is an essential tool for diagnosis and early detection of this disease. In order to be effective, the mammography must be of good quality. Because of the risks of ionizing radiation, techniques that minimize dose and optimize image quality are essential, to ensure

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that all women are submitted to mammography procedures of high quality for the detection of breast cancer. A mammography cannot be considered of good quality if it is not able to register with definition and contrast details of the normal and abnormal breast structures. Equipment performance, radiographic techniques, including breast positioning and compression, and film processing have direct impact on image quality in mammography.

Computed radiography (CR) is a process comparatively similar to the conventional screen-film system. The film is replaced by a plate (IP) made up of photostimulable phosphorus (PSP) which is introduced into a cassette of similar characteristics than the one used with the film. Digital mammography, which was developed in part to address some of the limitations of film mammography, separates image acquisition and display, allowing the optimization of both. Image processing of digital data allows the degree of contrast in the image to be manipulated, so that contrast can be increased in the dense areas of the breast with the lowest contrast [PISANO et.al. 2005; NG, K.H. et. al, 2006].

The average glandular dose (AGD) related to the tissues which are believed to be the most sensitive to radiation-induced carcinogenesis. Guidance for film/screen mammography provides a remedial level of mean glandular dose for 45 mm thickness of polymethylmethacrylate (PMMA) of 2.5 mGy. This is equivalent to 53 mm of compressed breast tissue with a glandularity of 29% in the central region [EC, 2006].

To aid in the optimization process the NHSBSP [NHSBSP, 2009] and [EUREF, 2005; SEFM, 2012] guidelines for the commissioning and routine testing of full field digital mammography systems also provide remedial values of mean glandular dose for equivalent breast thicknesses of 20 to 90 mm as well as levels of acceptable and achievable image quality. The objective of this study was to investigate the quality status of all the mammography facilities in the state of Minas Gerais, Brazil, for quality assurance in mammography screening in a national programmer for breast cancer as well as to compare the technical performance of digital mammographic and screen-film mammography.

2. MATERIALS AND METHODS

The data presented in this paper were Image quality and some technical parameters (anode-filter combination, film-screen combination, compression force, automatic exposure control, etc.) of x-ray equipment mammography in Minas Gerais, Brazil were studied in 2009–2013 by performing quality tests on the mammography equipment installed in Belo Horizonte, Minas Gerais, during inspections of the State Program of Quality Control in Mammography – PECQMamo [Nogueira et. al. , 2013]. The mammographic image quality on the analog system is scored from 0 to 5, according to the number of structures seen in the image of the simulator (microcalcifications, fibers and tumor masses) and the performance evaluation of optical density and background index image contrast. Considered high-quality images with only the score of 5 (Fig. 1).

The digital image quality was obtained through a radiographic image from a phantom CDMAM model 3.4 (Fig. 2), which is a contrast and detail simulator. This device is made up of an aluminum base plate having gold discs in various thickness and diameters. This aluminum base is covered with a thin plate of Plexiglas (PMMA) and in the exposure conditions of 28 kV and target/filter combination of Mo/Mo, the thickness of the aluminum plus the Plexiglas cover produce an attenuation of the x-ray beam equivalent to 10 mm of PMMA. The simulator is complemented by four 10mm-thick PMMA plates each.

Using 4 PMMA plates close to the x-ray tube output, being each 1 cm thick , measurement of the incident air kerma, K_i was measured with solid state detector - Unfors 8202031 - H Xi R/F & MAM detector platinum – serial number 181096 and base 8201023 - c Xi base unit platinum plus W/mAs serial number 190046, for a set voltage of 28 kV, combination target/filter in Mo/Mo and loads of 4,8,16,25,32,45,63,100 and 140mAs. The contrast noise ratio CNR was calculated through the exposure of PMMA plates whose thickness varied from 2 to 7 cm using the automatic exposure control (AEC).

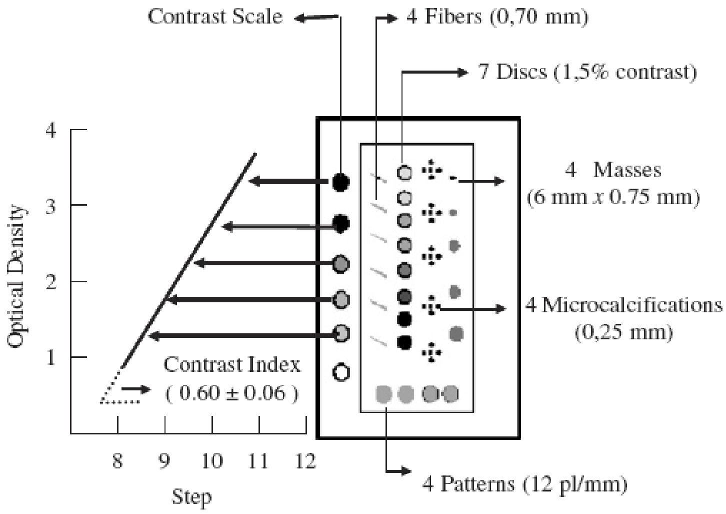

Figura 1. Details of the physical breast phantom used in PECQMamo/CDTN Mammography Program [Oliveira, 2007]

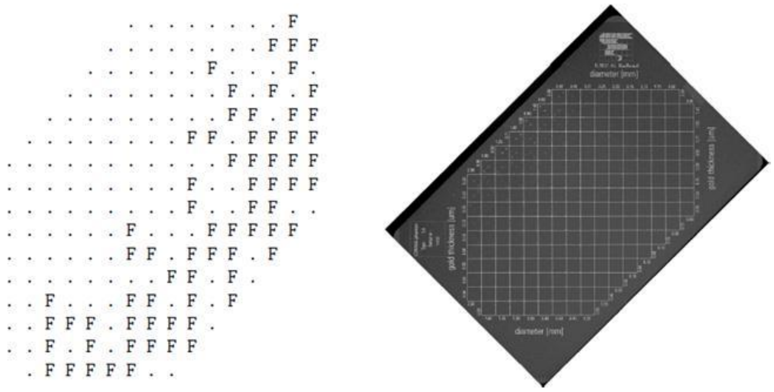

Figura 1. CDMAM Phantom Image - manufactured by Artnis Medical Systems [Artinis,2015]

The assessment of the signal noise ratio SNR was calculated through the images obtained in the different areas of the PMMA plate in the CNR test. The results of the mean pixel value (VPMs) and the ROI 1, were used to calculate the SNR for each area of the PMMA using Equation 1.

$$SNR = VPM/DP \qquad (1)$$

Where DP is standard deviation.

The Kerma air surface entrance (ke) to the screen-film mammography was measured with LiF100 TL dosimeters and phantom images were obtained with automatic exposure technique and fixed 28kV.The phantom used (Phantom Mama-Fig.1) is made of 5.0 cm thickness of polymetilmetacrylate (PMMA) and 0.5 cm thickness of wax containg structures simulating tumoral masses, microcalcifications, fibers and low contrast discs

The visualization of 5 simulated structures (masses, mi-crocalcifications, fibers, discs and patterns), the mean opti-cal density and the contrast index allowed to classify the phantom image quality in a 7-point scale. The optimal performance level to the phantom image quality was a score of 7 points and minimum accepted level was 6 points.

The average glandular dose was determined from the incident air kerma (without backscatter) using tabulated conversion coefficients for different compressed breast thickness and beam quality [SEFM, 2012] according to the equation:

$$DGM = c_{DG,Ki}.s.Y.P_{It}\left(\frac{d_{ref}}{d}\right)^2 \qquad (2)$$

Where:
$C_{DG,Ki}$ = conversion coefficient of K_i for MGD [DANCE, R. D, 2006].
s = correction factor, factor which depends on the anode/filter combination; *Y* = performance at 1.0 meter from the focal point in mGy/mAs; P_{It} = load in mAs; d_{ref} = reference distance of1.0 m); *d* = focus-simulator distance

3. RESULTS AND DISCUSSION

Image quality and some technical parameters of x-ray equipment mammography in Minas Gerais, Brazil were studied in 2009–2013. According to the results for overall phantom image quality we found that conformity was greater to digital mammography (Fig 3) for different phantoms. Further, digital mammography offers other advantages over film mammography – namely, easier access to images and computer-assisted diagnosis; improved means of transmission, retrieval, and storage of images.

There is a relationship between the final quality and performance of the image processing system. Among the services that had an adequate system of film processing, we found 33% with good quality images and 67% produced images with poor quality (Fig. 4).

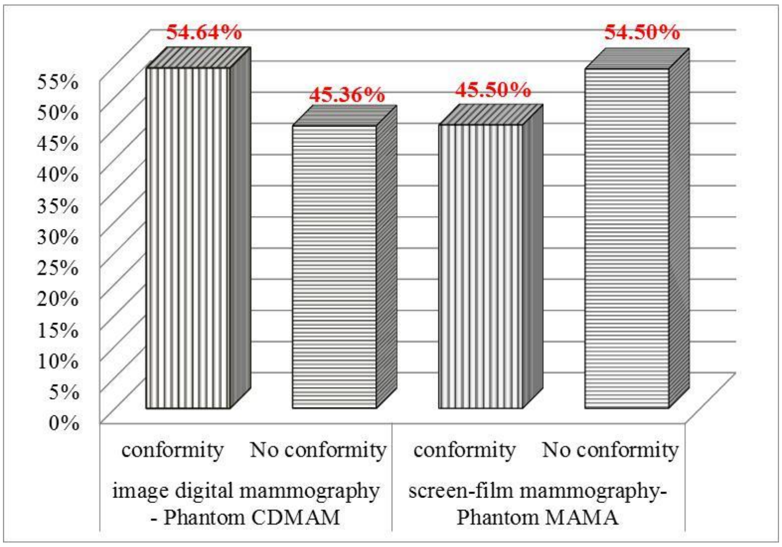

Figura 3. Results in the assessment of conformity of the image achieved by digital and creen film mammography for different image phantom.

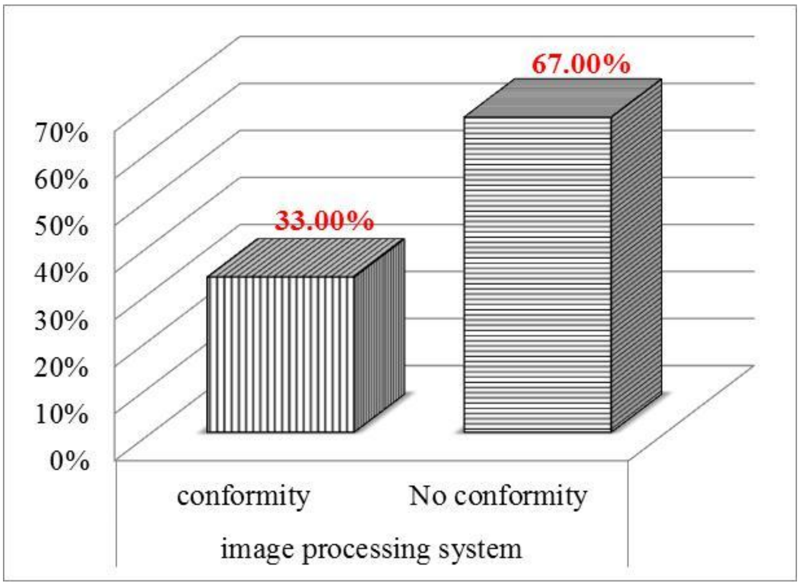

Figura 4. Results obtained in the evaluation of systems for processing.

The signal noise ratio - SNR is an important parameter for the quality of the digital system, the SNR assesses the ability to produce useful signal for forming the image through the x-ray photons that reach the detector. Serves as indication of presence of additional noise beyond the quantum noise sources. In this study 62.89% of assessed mammography equipment conform with respect to signal to noise ratio, 37.11% were considered to be no conformity (Fig. 5).

The Figure 6 shows results for AGD by digital versus screen-film mammography. Measurements of the average glandular dose were made for different thicknesses of PMMA (20 to 70 mm) to simulate the AGDs which, breasts of different thicknesses are subject to receive a mammography examination using computed radiography system. It was found that only 63.92% of the assessed services obtained AGD within the recommended maximum.

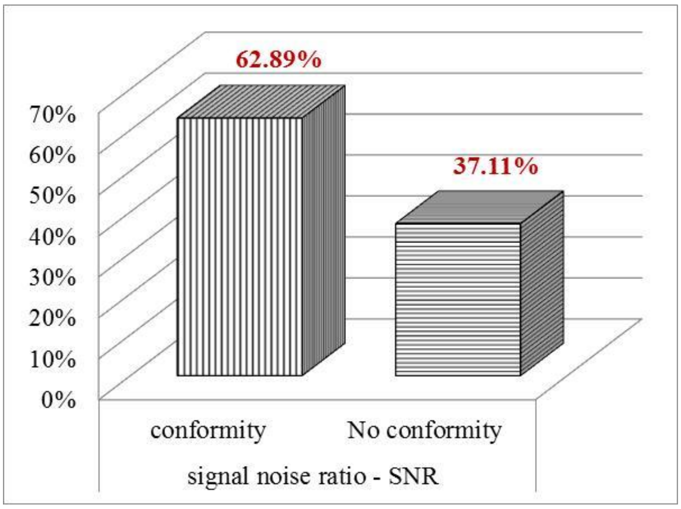

Figura 5. SNR evaluation result.

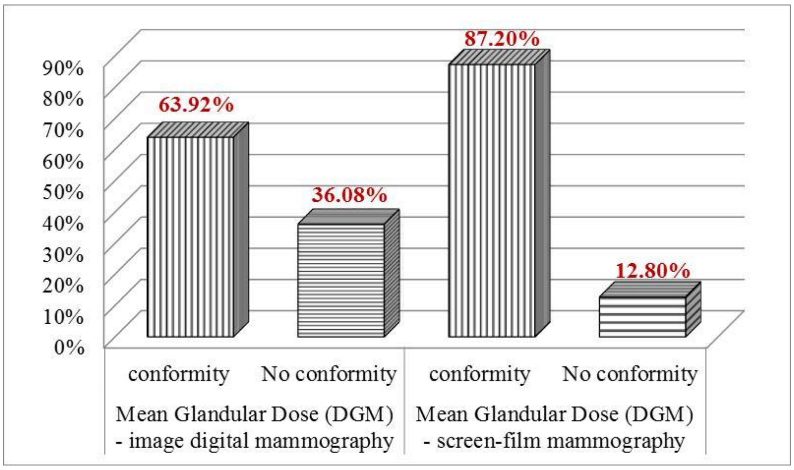

Figura 6. Results of the evaluation of AGD by digital versus screen-film.

Guidance for film/screen mammography provides a remedial level of mean glandular dose for 45 mm thickness of polymethylmethacrylate (PMMA) of 2.5 mGy. This is equivalent to 53 mm of compressed breast tissue with a glandularity of 29% in the central region. To aid in the optimization process the NHSBSP [NHSBSP, 2009] and SEFM [SEFM, 2012] guidelines for the commissioning and routine testing of full field digital mammography systems also provide remedial values of mean glandular dose for equivalent breast thicknesses of 20 to 90 mm as well as levels of acceptable and achievable image quality.

The Fig. 7 shows results for AGD by digital versus screen-film for the same set of sites. For the eleven screen-film sites, AGD from a single view was 1.67 mGy for screen-film mammography exposures and 2.63 for digital, 92% lower for screen-film than for digital mammography, using computed radiography (CR).

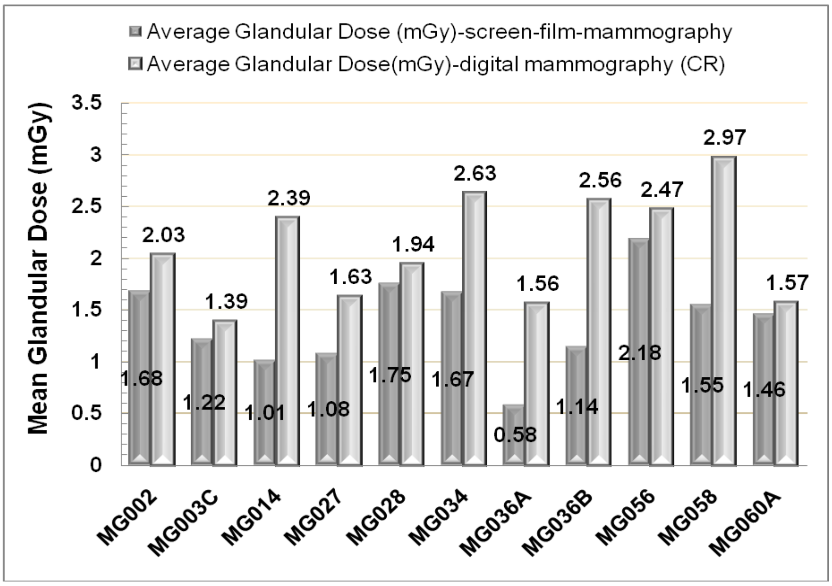

Figura 7. Graph shows comparison of AGD from screen-film mammography by digital for different sites.

Based on the findings, a relation can be drawn between the quality of image and the doses applied in the mammography establishments using computed systems mammography. Figure 8 shows that some services are applying doses below the reference levels; even so they cannot produce good quality images – as indicated by “x”. Only 2 institutions (18%) achieved doses within the reference levels recommended and produced good quality images.

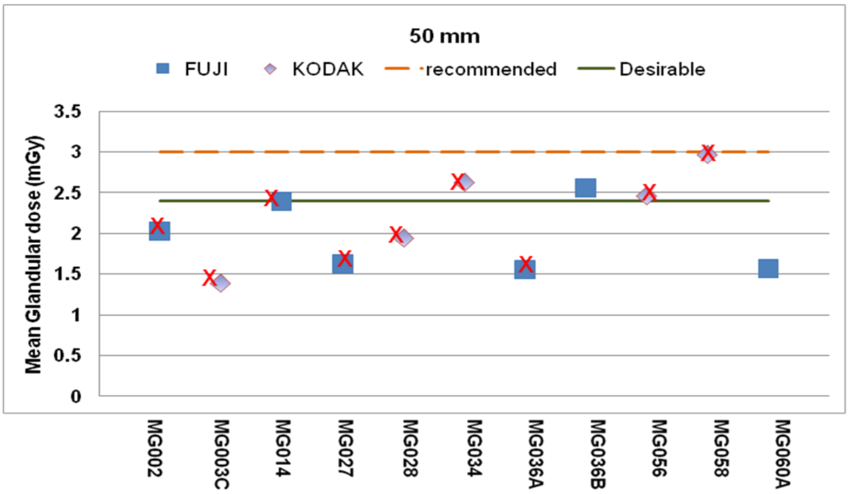

Figura 8. Achieved doses within the reference levels recommended.

4. CONCLUSIONES

Our results show large differences between screen-film and digital mammography (CR). The conformity of image quality were greater to digital mammography systems, also there were an increase in mean average glandular dose more than 90%. The results for tests of image quality indicated that the main sources for optimum image quality are related to deficiencies in processing and signal noise ratio - SNR. We may conclude that action is needed to improve the image quality and decrease the dose to the early detection of the breast cancer.

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5. REFERENCES

Artinis, 2015. http://www.artinis.com/product/cdmam34_analyser. Accessed on February 06, 2015.

EUREF. European Protocol for the Quality Control of the Physical and Technical Aspects of Mammography Screening, European, 2005.

EUROPEAN COMMISSION. European guidelines for quality assurance in breast cancer screening and diagnosis. (Luxembourg: CEC) Fourth Edition (2006).

INCA, 2014. INSTITUTO NACIONAL DE CÂNCER (Brasil). Estimativa 2014. Incidência de câncer no Brasil. Rio de Janeiro: INCA; 2014.

NG, K.H.; JAMAL, N.; DEWERD, L. Global quality control perspective for the physical on technical aspects of screen-film mammography-image quality and radiation dose. Radiation Protection Dosimetry, 2006; 121(4): 445-451.

NHSBSP, 2009. National Health Service Breast Screening Programmes. (2009). Commissioning and Routine Testing of Full Field Digital Mammography Systems. NHSBSP Equipment Report 0604. (London, UK).

Nogueira M. S, et al. Quality assessment and radiological protection requirements in digital mammography and monitoring of mammography services in Minas Gerais. GERAIS: SuS/MG Journal of Public Health. Vol 1, Number 1, Jul/Dec 2013. ISSN 2318-2598 (available on http://revistageraissaude.esp.mg.gov.br/ last access 9 December 2014).

OLIVEIRA M., NOGUEIRAA M.S; GUEDESA E.; ANDRADEB M.C.; PEIXOTO J.E.; JOANAB G.S., CASTRO J.G. Nuclear Instruments and Methods in Physics Research , v 580, p 574–577, 2007.

Pisano ED, Yaffe MJ. Digital mammography. Radiology 2005; 234:353-61.
SEFM, 2012. SOCIEDAD ESPAÑOLA DE FISICA MEDICA. Protocolo Español de Control de Calidad en Radiodiagnóstico. Madri: SEFM, 2012.