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Sensitometric analyses of screen-film systems for mammography exams in Brazil

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HIGHLIGHTS

- Achievement quality control of mammographic films.
- Establishment of a methodology for verifying the quality control of mammographic films.
- Determination of sensitometric parameters of mammographic films utlizados in Brazil.

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ABSTRACT

A determination of the sensitometric parameters of screen-film systems to evaluate their qualities was performed. The quality control of the automatic film processor was carried out to ensure a high level of efficiency. Based on ISO 9236-3, the following potentials were applied on the X-ray tubes: 25 kV, 28 kV, 30 kV and 35 kV. Four different mammography films from different manufacturers with and without screens were tested for curve shape, speed and average gradient. The results indicated that film 1 exhibited better contrast, film 3 demonstrated the highest energy dependence, and film 4 presented the largest base + fog density. None of the four mammographic films tested achieved satisfactory results in all parameters analyzed. Improvements in the manufacturing process for these films must be completed to avoid losses in the image quality.

1. Introduction

The image quality of a mammogram is the main goal services that use radiological films. To obtain an image useful for diagnosis, the radiological equipment must be controlled to ensure that its operating conditions are in ac Prod. Type: FTPcordance with the manufacturer's recommendations.

Therefore, quality assurance programs (QAP), which refer to the performance of X-ray equipment, processors and screen-film combinations, are important and should be efficient. The application of a QAP can reduce radiation exposure to the patient, decrease costs, and result in a significant improvement in service (Magalhães, 2001). Relevant factors, such as lowest dose and image quality, are dependent on other parameters, such as screen-film speed, contrast and image processing.

The sensitometric parameters assessed in this study are as follows: characteristic curve, average gradient, speed and base + fog of the film-screen system used in mammography exams. The tests were conducted, in part, as recommended by the International Organization for Standardization (ISO 9236-3 1999). The verification of the conditions for the automatic film processing was also performed to ensure that no commitments in the evaluation of the sensitometric parameters occurred. Studies indicate that the percentage of films that are rejected in radiological services represent 13% of the films analyzed, due to the improper processing of these images (Magalhães et al., 2002).

2. Materials and methods

The following equipment were used to carry out the work: X-ray tube (Philips, model PW 2185/00), ionization chamber (Radcal, 10 × 5–6 m model), electrometer (Keithley, 6517A model), aluminum plates (purity of 99.9% and variables thickness from

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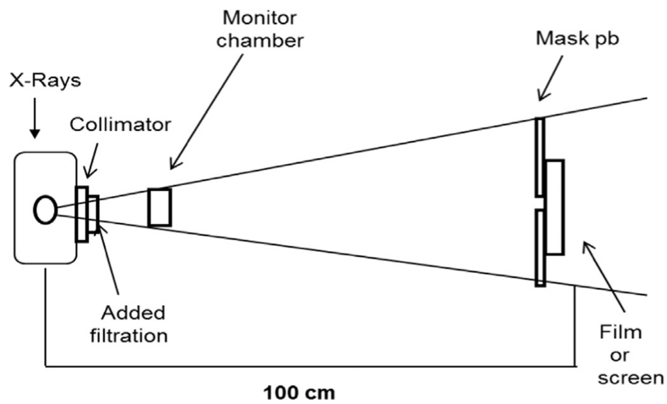

Fig. 1. Experimental arrangement used by LCR to obtain the characteristic curves.

0.1 mm to 2.0 mm, GoodFellow), intensifying screens (IBF R300MM), measuring tape, mammography films from different manufacturers, developer and fixer solutions (Kodak), stopwatch (accuracy of ±0.1 s, MJ-1822-Moure Jar), digital thermometer (Digi-Sense Scanning Thermometer), pH meter (accuracy 0.1 pH, model PH-107), thiosulfate retention kit, Kodak Hypo clearing agent, densitometer (Densix, model 603, PTW), sensitometer (Sensix model 4071 PTW), automatic film processing instrument (Mamoray Classic, model 1754, AGFA).

Four different mammography films (assigned numbers 1, 2, 3 and 4) from different manufacturers were tested and evaluated. The experimental setup to obtain the characteristic curves and the sensitometric parameters is illustrated in Fig. 1. The optical densities were obtained by positioning a fixed collimator and additional filter in relation to the focal point of the tube. Afterwards, the ionization chamber was set, as well the film or the film with cassette, at a fixed distance of 100 cm from the focal point. At that distance, scattering does not significantly influence the results because the ISO (ISO 9236-3, 1999) allows for a tolerance of up to 3 m to carry out the measurements. With the goal of limiting the exposed area of the mammography film was used a diaphragm of lead with a circular opening of 10 mm in diameter. For exposure without screen, the films were placed inside black plastic bag and sealed, to prevent light inside it. After the film was positioned, using a height-adjustable support. Between the film and the X-ray tube was placed lead plate that has been aligned with the window of the tube using a laser. In addition, two sheets, one of 1.8 mm thick Al and another of 0.03 mm thick Mo were fixed the on filter wheel. After the correct positioning and alignment were achieved, irradiation was carried out for the selected times. The films were exposed 14–23 times at 25 kV, 28 kV, 30 kV and 35 kV to obtain the characteristic curves; the results were plotted on a logarithmic scale to compare the optical densities obtained. The optical densities ranged from 0.25 to 4.1.

To obtain the kinetic energy released per unit mass (kerma) corresponding to each optical density, the ionization chamber was placed in the same location previously occupied by the films during the exposures (i.e., 100 cm distance between the film and the focal point). Next, irradiations were performed using the linear relationship between the kerma and exposure time, and only the set exposure was varied to modulate the intensity of the beam. From the optical densities and their respective kermas, the characteristic curves were obtained [log(kerma) × DO]. Fig. 2 shows the experimental arrangement used for obtaining the kerma values. To calculate the average gradient and the sensitivity of the film tested, Eqs. (1) and (2) were used.

$$\bar{G} = \frac{D_2 - D_1}{\log_{10}K_2 - \log_{10}K_1} \quad (1)$$

$$S = \frac{K_0}{K_S} \quad (2)$$

where D_1 and D_2 are density values between 2.0 and 0.25, respectively. K_1 and K_2 are the corresponding values sobtained from the sensitometric kerma curve. $K_0 = 10^{-3}$ Gy and K_0 is the kerma with an optical density closest to 1.

3. Results

Image processing can generate serious problems in important parameters such as gradient and sensitivity. Thus, the control of automatic processing was performed to monitor and analyze important processing features. Fig. 3 shows that the temperature of the developer remained within acceptable limits during the processing (i.e., with variation less than 0.3 °C), as recommended by its manufacturer (Magalhães et al., 2002). The pH of the developer and fixer solutions were within the recommended limits, as shown in Figs. 4 and 5, respectively. This result indicates that the chemical solutions were within the expiration date and prepared correctly.

Figs. 6 and 7 show the variation in the processing time and the level of fog in the darkroom, respectively. The processing time remained below the threshold of 3% of the time determined by the processor's manufacturer. The level of fog in the darkroom presented a variation in the optical density above 0.05 only for 4 min

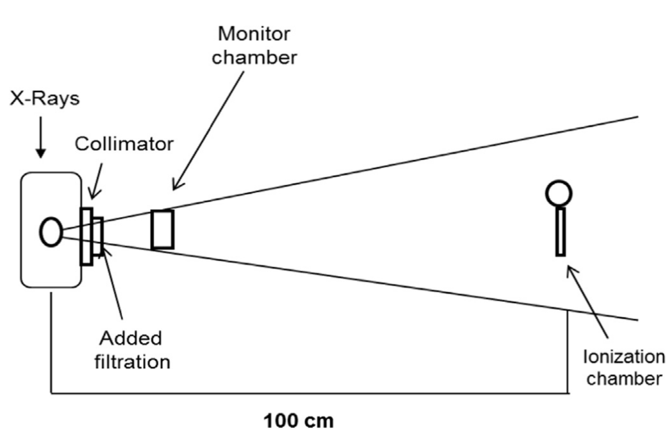

Fig. 2. LCR experimental setup to obtain air kerma.

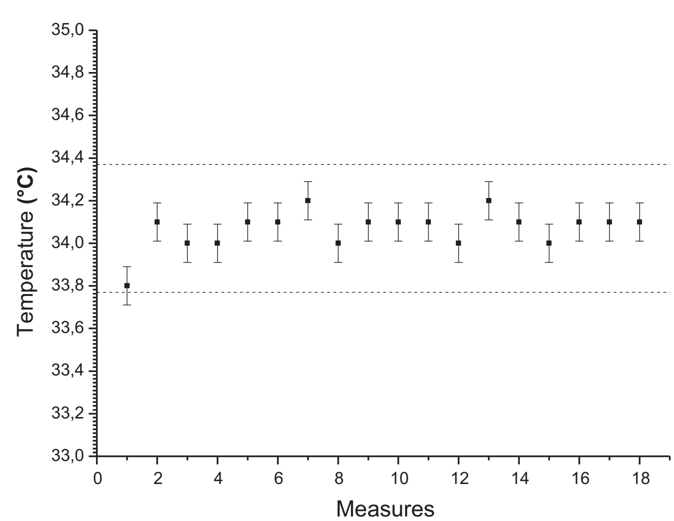

Fig. 3. Variation in the developer temperature of the processor.