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Exploratory survey of image quality on CR digital mammography imaging systems in Mexico

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HIGHLIGHTS

- Radiation dose in CR digital mammography (CRDM) systems was determined.
- Image quality related with dose in CR digital mammography (CRDM) systems was analysed.
- Image processing artefacts were observed and correlated with dose.
- Measured entrance dose by TL phosphors could be good parameter for radiation protection optimization in patient.

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ABSTRACT

The purpose of this study was to assess the current status of image quality and dose in computed radiographic digital mammography (CRDM) systems. Studies included CRDM systems of various models and manufacturers which dose and image quality comparisons were performed. Due to the recent rise in the use of digital radiographic systems in Mexico, CRDM systems are rapidly replacing conventional film-screen systems without any regard to quality control or image quality standards. Study was conducted in 65 mammography facilities which use CRDM systems in the Mexico City and surrounding States. The systems were tested as used clinically. This means that the dose and beam qualities were selected using the automatic beam selection and photo-timed features. All systems surveyed generate laser film hardcopies for the radiologist to read on a scope or mammographic high luminance light box. It was found that 51 of CRDM systems presented a variety of image artefacts and non-uniformities arising from inadequate acquisition and processing, as well as from the laser printer itself. Undisciplined alteration of image processing settings by the technologist was found to be a serious prevalent problem in 42 facilities. Only four of them showed an image QC program which is periodically monitored by a medical physicist. The Average Glandular Dose (AGD) in the surveyed systems was estimated to have a mean value of 2.4 mGy. To improve image quality in mammography and make more efficient screening mammographic in early detection of breast cancer is required new legislation.

1. Introduction

The current morbidity and mortality of breast cancer in Mexico constitutes a public health problem as it has become the number one cause of death among Mexican women, only recently surpassing uterine cancer as such. In fact, data from the Mexican National Institute of Geography and Statistics (NIGS) show that in 2007 breast cancer became the leading cause of death for the female adult population with a 13.8% mortality rate (INEGI, 2007).

The screening mammography has proven to be a reliable radiological study for early detection of breast cancer in asymptomatic women. Mammography systems are designed with this purpose: the high efficacy of early diagnostic of breast cancer solely based in a radiographic image of all breast tissues. Therefore, such an image must perform well in terms of five fundamental image quality indicators: high tissue contrast, high spatial resolution, low image noise, adequate average optical density and low radiation dose per view (Gaona, 2002).

It is an accepted fact that sectors of adult female populations who do not have regular screening mammograms statistically show a lower survival rate when developing breast cancer than those who have periodic mammograms. A similarly serious problem

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arises when mammograms are performed improperly or inadequately and thus result in images of poor quality, as women whom met feel safer because they have regular mammograms may find out that a cancer was undetected because of the poor and inadequate quality of such studies. Due to the recent rise in the use of digital radiographic systems in Mexico, computed radiographic digital mammography (CRDM) systems are rapidly replacing conventional film-screen systems without any regard to quality control or image quality. The only reference to an image quality standard in digital mammography can be found in the Official Mexican Regulation NOM-041-SSA2-2011 Section 21D, which indicates that mammography facilities should "carry out tests for quality control compliance with frequencies and tolerances established by the manufacturer of the equipment" (SSA, 2011). As a consequence only a handful of CRDM facilities have an established image quality control program because manufacturers do not provide them with neither test procedures nor compliance standards; or simply because the tests do not exist given the age and vintage of the CRDM systems. There are no mandatory quality control programs or medical audit programs for digital mammographic modalities. In fact, it is likely that none of the CRDM systems underwent any optimization or fine-tuning process. Lack of knowledge and training on QC procedures among the technologists, or the lacks of a designated QC technologist also impact the performance of the systems. In general CRDM systems do not perform as well as state-of-the-art film-screen-based mammography systems in terms of acceptable detection and determination of the shape of small details in a mammographic image. Indeed, if the CR system is not optimized and setup, it may be possible for some very small microcalcifications not to be detectable, thus significantly affecting the quality of the diagnosis.

The CRDM facilities surveyed print the processed images on laser film (hardcopy) for the radiologist to read on a scope or mammographic high luminance light box exactly in the same way that is done in the film-screen case, it is important to note that printing must be done on a printer dedicated to mammography. The purpose of this study was to assess the current status of image quality and dose in CR digital mammography (CRDM) systems. In the survey included CRDM systems of various models and manufactures for the purpose of performance comparison, dose and image quality.

2. Materials and methods

The survey was conducted in 65 mammography facilities which use CRDM systems in Mexico City and surrounding States (either private clinics or public part of the health system). No distinctions were made regarding manufacture and model of the systems. The studied was carried out in four different mammography systems which their ages range between one and five years old, using conventional CR technique. Image quality was assessed imaging the MQSA phantom and according to the American College of Radiology (ACR) Mammography Quality Control Manual (Hendrick et al., 1999). Entrance exposures were measured using a Radcal Accu-Gold Dosimeter using standard technique factors as those for a right cranio-caudal (CC) mammographic view. These exposure values, along with the corresponding kV and half-value layers (HVL) values were used to determine the Average Glandular Dose (AGD) using the appropriate ACR tables (Hendrick et al., 1999). The Mexican regulations NOM-229-SSA1-2002 and NOM-041-SSA2-2011 establish that the AGD per view shall not exceed 3.0 mGy (SSA, 2006, 2011). All systems in the survey possess automatic exposure controls (AEC), with nominal focal spot sizes of 0.3 mm and nominal HVLs at 30 kV of 0.34–0.38 mm Al.

The systems were tested as used clinically. This means that the dose and beam qualities selected were chosen using the system automatic beam selection and photo-timed features. Three images were obtained on the same day for each CRDM system and these were evaluated by two radiologists and medical physicist on hardcopy using the local laser film printer. Image quality was assessed by the total score of resolved phantom objects detected, according to the ACR guidelines by viewing the film in a light box with a luminance above 3000 nits and each image classified into one of two groups, depending on whether it meets the minimum score or does not. The minimum number (score) of objects resolved must be 4 fibres, 3 speck groups and 3 masses, for a total of 10 resolved objects (Food and Drug Administration (FDA), 2002; Gaona, 2006; Hendrick et al., 1999).

3. Results and discussion

The study found that 51 (78.5%) of phantom images from the CRDM systems presented a variety of image artefacts and non-uniformities arising from poor acquisition and processing, as well as from defective printing (Table 1). These results point to a lack of QC procedures and programs at these facilities. This is quite a severe problem, as some of the artefacts can be mistaken as breast lesions or can disturb and affect the reading of the images. In order to avoid misinterpretation, recognizing artefacts and understanding their physical technical background is of great importance in digital breast imaging (Van Ongeval et al., 2008). Table 1 shows the overall results of the survey of 65 CRDM systems. A significant number of artefacts and non-uniformities were observed in the images of the 17 older CRDM systems surveyed. The photoluminescent plates and photomultiplier tube utilized with these systems had been in use for up to 2 years with significant variations in sensitivity across the plates. It appears that sensitivity had declined slowly with exposure and the mean glandular dose was increased >3 mGy per view. In addition to this, some images present artefacts and non-uniformities due to prolonged use of the plates and photomultiplier tube, which are damaged and worn-off over time; such artefacts will affect image quality especially measurements using test objects (Ian et al., 2009; Van Ongeval et al., 2008). Manufacturers recommend regular replacement of

Table 1
General results of CRDM facilities surveyed.

Evaluated concepts	Number of CRDM systems
Images presenting artefacts and non-uniformities	51 (78.5%)
Facilities using laser printers dedicated to mammography	50 (76.9%)
Facilities using laser film dedicated to mammography	44 (67.7%)
Routine, undisciplined alteration of processing algorithms by technologist	42 (64.6%)
Quality image meets the minimum score of resolved objects (10) standards in the ACR phantom, not accounting for artefacts	27 (41.5%)
Meet standards of the Mexican regulations of the NOM-041-SSA2-2011	4 (6.2%)
Average glandular dose (AGD)≤3 mGy per view	48 (73.8%)