MAMMOGRAPHY IN SERBIA: IMAGE QUALITY AND RADIATION DOSE

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Abstract. *The purpose of this study is to investigate the radiation dose and technical image quality in mammography in Serbia after two years of implementation of the breast screening programme. A total of 186 mammography units, including Full-Field Digital Mammography (FFDM), Computed Radiography (CR) and Screen-Film Mammography (SFM) units were used in the patient dose and image quality assessment. Patient dose, in terms of Mean Glandular Dose (MGD), was assessed for the standard breast, while image quality was evaluated in terms of spatial resolution, threshold contrast visibility and Contrast to Noise Ratio (CNR) for CR and FFDM units. The mean MGD assessed was (1.8±0.94) mGy, (1.3±0.51) and (1.7±0.64) for CR, FFDM and SFM, respectively. Spatial resolution was better than 12 lp/mm only for 3/186 (1.6%) units. In 34/186 (18%) units, spatial resolution was less than 5 lp/mm. Threshold contrast visibility was better than 1.2 in 41/186 (22%). Mean CNR for CR and FFDM units was 5.2 ±2.2. Following the initial implementation at the beginning of the population-based breast cancer screening campaign, it is essential to establish an effective system of regular and periodic Quality Control (QC) tests and to ensure that high-quality mammograms with minimal possible radiation dose to population are included in the screening.*

Key words: *Mammography, image quality, radiation dose*

1. INTRODUCTION

Breast cancer is a major cause of mortality among female population in Serbia [1]. It is presumed that the introduction of a screening programme will reduce mortality. Quality Control (QC) in mammography is an essential element of the successful breast cancer screening campaign as it provides a basis for standardization of the image quality and radiation dose in mammography [2-4].

Mammography is a significantly useful non-invasive imaging technique for the early detection of breast cancer and for the detection and diagnosis of cancer at any stage of the disease. However, this requires adequate image quality and a reasonably low radiation dose as basic postulates of good quality in mammography. Quality Assurance (QA) in mammography has received increasing attention as an essential element of a successful clinical mammography and breast cancer screening programme [1,5,6]. QA requires multidisciplinary approach, continuous education, evaluation, effectiveness and detriment minimization. In Serbia, the use of ionizing radiation in medicine is regulated by national legislation [2]. The legal framework covers, to a certain extent, the area of QA in medicine, including clinical mammography and mammography screening. In addition to legal documents, there is a lack of national guidelines for Quality Control (QC), whereas the operating staff commonly does not have sufficient knowledge about equipment and their responsibility in optimizing daily practice.

Performance of mammography centers is evaluated by licensed external technical services annually. These activities frequently do not include internal QC that should encompass more frequent tests performed by local staff.

The purpose of this study is to investigate the radiation dose and technical image quality in mammography in Serbia after two years of implementation of the breast screening programme.

2. MATERIALS AND METHODS

This work consisted of two phases. In the first phase, QC protocols containing a list of parameters, methodology, frequency of tests and reference values for Screen-Film (SF), Computed Radiography (CR) and Full-Field Digital Mammography (FFDM) units were developed. The second phase focused on the initial implementation of these protocols. The paper presents the results of the tests of the selected parameters, with a special emphasis on the patient dose and image quality descriptors.

Detailed recommendations for the implementation of the QA programme in mammography are given in the "European Guide lines for Quality Assurance in Breast Cancer Screening and Diagnosis" [2]. Initially, QC protocols containing a list of parameters, methodology, frequency of tests and reference values for Screen-Film, Computed Radiography and Full-Field Digital Mammography) units were developed and subsequently implemented. In Serbia, daily and weekly

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tests should be performed by local staff, however the full implementation of this requirement is still lacking. Six-monthly and annual tests are be performed by medical physicists, which is done on regularly basis.

During the period from 2013-2015, QC protocols were applied to the total of 186 mammography units – namely, 18 Full Field Digital Mammography (FFDM) units, 82 Computed Radiography (CR) units and 86 Screen-Film Mammography (SFM) units.

Test object TOR MAS (Leeds test objects, Leeds, UK), containing structures for the assessment of low and high contrast resolutions, as well as those for the visualization of small details such as micro-calcifications and low contrast sensitivity, was used in this survey [4]. Sensitometry and densitometry tests were performed with a calibrated sensitometer and a densitometer (X-Rite, Germany) in order to assess the gross optical density of the exposed film. For the assessment of the parameters of the x-ray tube and generator a multimeter Barracuda (RTI Electronics, Mölndal, Sweden) with a calibrated solid-state detector was used. Additional tools for QC test implementation, such as PMMA plates, spacers, Al filters and other tools, were also used.

This work presents the results of the tests of the selected parameters of the patient dose and image quality. The patient dose in terms of Mean Glandular Dose (MGD) was assessed for the standard breast represented by 45 mm PMMA phantom (CC projection), while the image quality in terms of spatial resolution and threshold contrast visibility was assessed using TOR MAS test object.

A standard phantom of 45mm PMMA was exposed for determination of the MGD at clinical settings and with compression paddle present. Incident air kerma was obtained by multiplying the tube output (mGy/mAs) in the reference point and the actual tube loading (mAs), and corrected for the actual breast thickness [2,8]. The reference point is a point 45 mm above the breast support, 60 mm from the chest wall side and laterally centered [2]. The MGD was estimated as a product of incident air kerma and conversion factors for dose assessment with PMMA phantoms [2]. The g- and c- conversion factors used are given as a function of the breast thickness and the Half-Value Layer (HVL) of the x-ray beam, while s-factors account for the various target-filter combinations [2,8]. The g- and c- conversion factors are available both for breasts and the standard breast simulated by PMMA plates

In addition, for CR and FFDM units, the contrast to noise Ratio (CNR) was assessed using a PMMA homogenous phantom and 0.2 mm aluminum details [2].

3. RESULTS

The assessed MGD was (1.8±0.94) mGy, (1.3±0.51) and (1.7±0.64) for CR, FFDM and SFM, respectively. Radiation dose in majority of units was in line with the reference level of 2.5 mGy for a standard breast [2]. The assessed values of MGD are presented in Figure 1.

The spatial resolution was higher than 12 lp/mm only for 3/186 (1.6%) units. In 34/186 (18%) units, spatial resolution was less than 5 lp/mm. The results of the high contrast (spatial) resolution assessment are presented in Figure 2.
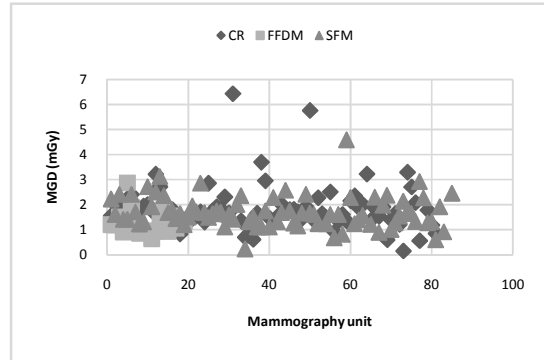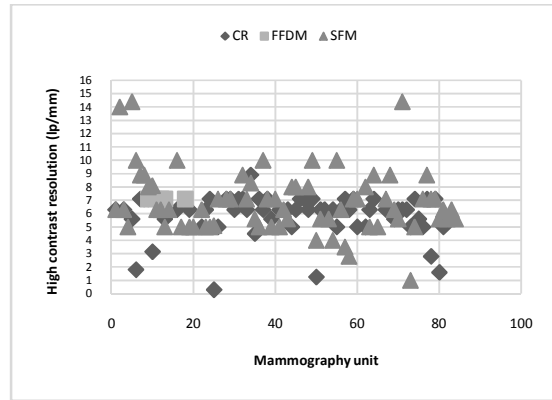

Figure 1. Mean glandular dose (MGD)

Figure 2. High contrast (spatial) resolution

Threshold contrast visibility was better than 1.2 % [4] in 41/186 (22%), and better than 1.5 % [2] in 95/186 (51%), as presented in Figure 3.

Mean CNR for CR and FFDM units was 5.2 ±2.2 and the assessed values for all CR and FFDM units are presented in Figure 4. Gross optical density related to imaging of 45 mm PMMA phantom is presented in Figure 5.

The relevant parameters of the x-ray tube and generator, as accuracy and reproducibility of the x-ray tube voltage, half-value layer, alignment of the x-ray filed, and radiation output) were within the reference values [2].

4. DISCUSSION

Image quality and dose are the most important indicators of mammography practice and important components of a quality control programme. A quantitative assessment of dose is well-defined and straightforward, as there are well-developed dosimetry protocols [2, 8]. Although it is difficult to establish a correlation between clinical and physical image quality [1,5], the results of the image quality assessment using

test objects presented here were of importance for the comparison of different mammography units, different technologies and for the establishment of minimal standards in mammography. There was no significant correlation between image quality and MGD as presented in Figure 6.

The presented results are the first efforts to implement a comprehensive QC in mammography, in particular in CR and FFDM units. Contrary to the implementation of tests in SFM and FFDM (groups of parameters related to detector and x-ray tube and generator), there were difficulties related to the inabilities of workstations in CR mammography units to extract the basic statistics of a selected region of interest, such as the mean pixel value and standard deviation. Also, there were problems with the import of DICOM QC test images for monitor and printer QC test. Such problems highlighted a need to carefully analyze the technical specification of the purchased equipment and establish a close cooperation with manufacturers. Insufficient image quality was noted in most of the units.
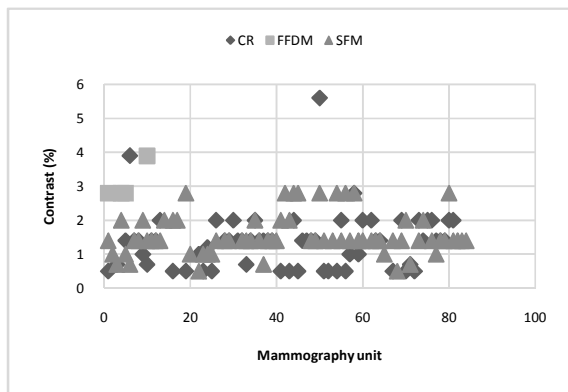

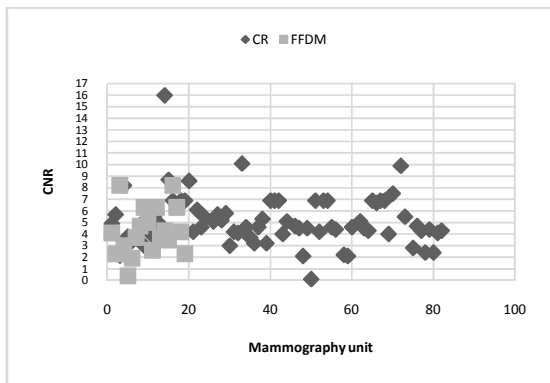Figure 3. Low contrast sensitivity

Figure 4. Contrast to noise ratio (CNR) for CR and FFDM mammography units

The transition from analogue to digital equipment is occurring very fast all over the world. This first experience based on a number of countries in the area of digital mammography was very important [6,9].
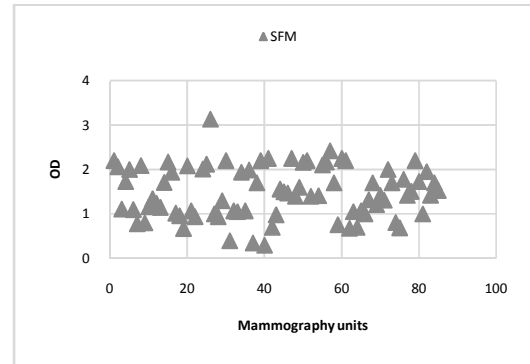

Figure 5. Gross optical density for screen-film mammography

The results demonstrated that the doses for the standard beast were satisfactory and in most cases within the reference levels of 2.5 mGy [2], when analyzed without taking into account the image quality. In particular, the presented results related to CR systems reflecting the necessity to establish procedures for optimisation that require the participation of a medical physicist, radiographers, radiologists and field engineers of both x-ray mammography equipment and CR system used as image receptors [10-12]. The physical measures expressing spatial resolution and signal-to-noise ratio are consistent with the published finding that sites employing CR systems had lower image quality [13]. Guidelines for appropriate settings of the automatic exposure control for CR and FFDM systems are developed, but it seems that these are not well appreciated by maintenance engineers.
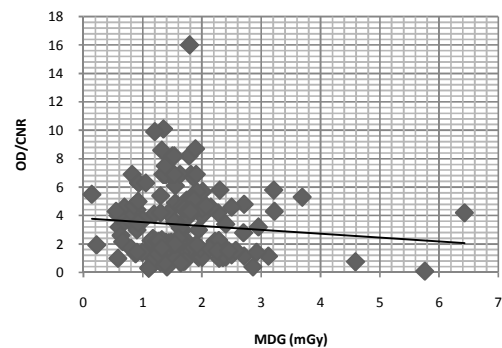

Figure 6. Image quality indices as CNR and optical density versus mean glandular dose for a standard breast

In addition, major problems are associated with the lack of central data analysis, lack of clear differentiation between units used for clinical and screening mammography, deficiencies in the image receptor and mammography unit operation (automatic exposure control, compression), lack of in-hospital QC and inadequate implementation and follow-up of the corrective actions.

5. Conclusions

After the initial implementation at the beginning of the population-based breast cancer screening campaign, it is essential to establish an effective system of regular and periodic QC tests and to ensure high quality mammograms with minimal possible radiation dose to the population included in the screening.

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