PERFORMANCE OF MAMMOGRAPHY EQUIPMENT IN THE MACEDONIAN BREAST SCREENING CAMPAIGN 2008/2009

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Breast screening campaign in Macedonia started in the end of 2007 and 19 national mammography departments were included. Contrary to the European Guidelines for Quality Assurance in Mammography Screening, the quality assurance activities were not implemented before the start of the campaign, except at the University Clinic of Radiology, Skopje. The quality control tests were performed for the very first time at 13 mammography units under a licence-obtaining procedure. One of the machines was suspended from clinical and screening practice due to heavy malfunction of the generator, X-ray tube and automatic exposure control (AEC) system. Only 3 of the 13 mammography machines met the criteria for tube voltage (kV) accuracy. Two of the seven AEC systems were calibrated in the optimal optical density (OD) range (OD >1.4). AEC settings corresponded to the recommendations at eight units, while nine units met basic overall image quality criteria. Mean glandular dose (MGD) was higher than the recommended level of 2.5 mGy in four departments. Mean gradient of the film $G_{0.25–2.0}$ was below 2.8 at four units. Only two light boxes had a luminance of $>1700 \text{ cd m}^{-2}$ and six rooms had an ambient light level of $<50 \text{ lx}$. The findings of this work clearly suggest that the performance of the mammography equipment involved in the campaign in almost 50 % do not supply basic quality criteria for a breast screening programme.

INTRODUCTION

In order to promote early breast cancer diagnosis in Macedonia, the Ministry of Health started the breast screening campaign in the end of 2007. Contrary to the European Guidelines for Quality Assurance in Mammography Screening, the QA activities were not implemented before the start of the campaign, except at the University Clinic of Radiology, Skopje. No additional training for the staff involved in the campaign was provided, also. A total of 22 587 patients were screened in 2008 and nearly 35 000 in 2009.

The campaign was conducted at 19 national mammography units of the national health departments. The quality control (QC) tests were performed at 14 units for the very first time, during the licence-obtaining procedure. One machine was suspended immediately after the QC procedures, unfortunately after being more than a year involved in the campaign. Following suggestions of the authors of this work, the Ministry of Health organised clinical image assessment at three units. Any type of QA procedures have not been performed yet at four mammography units.

MATERIALS AND METHODS

The type of mammography machines involved in the campaign were SIEMENS (B, C3, 300, Balance, 3000 NOVA), Plan MED (Sophie), HOLOGIC (Affinity), GE (Senograph, AlfaRT), PHILIPS (Mammo Diagnostic) and ITALRAY (Mammograph). All 19 machines were analogue systems with different film/screen combinations.

QC measurements were performed with the Barracuda X-ray analyzer (RTI Electronics), polymethyl methacrylate (PMMA) plates, RMI image quality phantom of the American College of Radiology and a film processing set (PTW). The European guidelines for quality assurance in breast cancer screening and diagnosis were applied (1). The AEC mode was changed from manual to semi-automatic at five units. Due to non-optimal calibration, the AEC mode was changed from automatic to semi-automatic at one unit (2). The new values of the optical density (OD) were adjusted whenever it was possible (3) and the phantom image quality and MGD were assessed for those corrected OD values.

RESULTS

The results from the measurements of the most critical parameters are presented in this paper. At those units where the tube voltage inaccuracy was higher than the tolerance limits, half-value layer (HVL) was determined with higher error than typical (on graph marked with a star). As a consequence, the MGD for the same units was determined with an error higher than typical.

Generator performance

Tube voltage accuracy

Four mammography machines met tube voltage (kV) accuracy criteria at 28 kV, representing 27 % of the tested facilities (Figure 1).
Maximum tube voltage error in the clinically useful range

Only three machines met criteria for tube voltage accuracy in the clinically useful range of 25–32 kVp (Figure 2).

X-ray tube and beam quality

Specific radiation output and HVL

Specific radiation output of 1677 μGy mA s⁻¹ at tube voltage >40 kV was determined for one machine (Figure 3) and assessment of the MGD value was not possible. This machine was suspended...
from practice and measurements of some AEC parameters were not performed.

The same machine, with considerably high tube voltage and radiation output, did not meet HVL criteria (Figure 4).

AEC performance

OD for 4.5-cm PMMA phantom

AEC systems could not achieve OD > 1.3 applying 28 kVp at five units (Figure 5).
AEC short-term reproducibility, object thickness and tube voltage compensation

AEC short-term reproducibility was in allowable tolerance at 10 machines (Figure 6). AEC object thickness compensation was below the limit at eight mammography machines (Figure 7).

AEC tube voltage compensation below the limit was found at 10 machines (Figure 8).

Film processing
Sensitometry gradient

Developer temperature was changed from 28°C to 33°C and after that light sensitometry performed at two units.

Four units did not supply the minimum recommended value for mean gradient of the film $G_{0.25 - 2.00}$ (Figure 9).

Image quality
Phantom image quality, high-contrast resolution and low-contrast detectability

Two units did not meet the basic image criteria (Figure 10). Resolution $<10 \text{ lp mm}^{-1}$ was found at one unit (Figure 11) and four units did not meet low-contrast detectability criteria (Figure 12).

MGD

MGD was $>2.5 \text{ mGy}$ at three units. MGD was higher at units 2 and 12 due to the use of non-optimal film/screen combination. Non-optimal calibration of AEC in automatic mode was found additionally at unit 15 (Figure 13).

Viewing conditions
Light box luminance and ambient light level

None of light boxes met the minimum European luminance criteria of 3000 cd m$^{-2}$. The average luminance of light boxes was 1341 cd m$^{-2}$ (Figure 14).

Average ambient light level measured under optimal conditions was 79 lx (Figure 15). Clinical image analyses were performed at almost daylight level at 50–60 % of the units.

CONCLUSION

Despite exposure parameters optimisation and OD adjustments were made, the performance of the tested mammography equipment, involved in the campaign, did not supply basic quality criteria for breast screening programme at almost 50 % of the units. Only two units had dedicated film processors for mammography, which was a factor affecting the image quality. Only four units were equipped with large Bucky that compromised the examinations of larger breasts.

Clinical image quality assessment, done in the three departments, revealed no proper positioning, the use of medio-lateral view projection instead of mediolateral-oblique view, lower OD values, etc.

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REFERENCES