IMAGE QUALITY IN SCREENING MAMMOGRAPHY IN CROATIA

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INTRODUCTION

Mortality reduction through screening mammography (SMG) is possible only with examination of high image quality (IQ) [1], which should be performed with acceptable patient breast radiation dose (BRD). Besides film processing control, equipment assessment with breast phantom and dosimetry [2], periodical external mammographic IQ assessment (MIQA) is needed, including image labelling (L), breast positioning (BP), exposure (EX) and artefacts (AR) assessment [3]. The nationwide breast cancer screening program (NBSP) has been introduced in Croatia in 2006 [4], and the MIQA is initiated as the first step in establishing quality assurance/quality control (QA/QC) framework in breast imaging in Croatia. The current study was aimed: (1) to provide objective evidence about the technical MIQ in NBSP in Croatia, (2) to compare MIQ between different types of mammographic units (MUs), (3) to identify the common deficiencies, and (4) to propose corrective activities.

MATERIAL AND METHODS

Mammograms (MGs) for IQA were collected from a total of 84 MUs which participate in NBSP, which represents 70 % of all MUs nationwide: Twenty (20) in general and county hospitals (GH), 8 in university hospitals (UH), 25 in private clinics (PR), and 31 in primary healthcare centres (MC). A total of $84 \times 5 = 420$ MG examinations were reviewed. Each MU was requested to submit "what they consider to be their five best representative MGs, each one performed in one of five consecutive workdays". MIQA was done using viewbox dedicated for MG (Ultraviol, NGP 31m, Zgierz, Poland), with luminance of 5500 cd/m^2 [5], by two reviewers (radiologist and radiology technologist (RT)). IQ evaluation system (IQES) was developed specifically for Croatian NBSP, and compiled two standardised

clinical IQES available [5,6] considering also experience of other authors [3,7-9]. Image attributes were grouped in four categories: L, BP, EX and AR. In the L category the adequacy of identification (ID) of patient (PT), exam and MU were evaluated: PT name, additional PT identifier, date of exam, laterality and view, MU name, RT ID and cassette / screen ID, and radiographic technique. Each item was allocated 1 point if present as required. In the EX category following attributes were evaluated: optical density (OD), overall contrast, visibility of blood vessels and fibrous strands through dense glandular tissue (GT), visibility of GT through pectoral muscle (PM), visibility of skin structures along PM on mlo-view and visibility of skin outline. Each feature was scored with 1 point if appropriate. The score was diminished by 1 point if GT transparency was nonuniform, OD differed on > 1 film or motion blurr was present. In the BP category were PM presentation, breast tissue coverage, image symmetry and nipple presentation evaluated. Two reference lines, posterior nipple line (PNL) and nipple line (NL) were used in evaluation of PM [5,10-13], and scored as follows [5,10-14]: PM up to 1 cm above PNL with 1 point**,** down to PNL with 2 points, and down to NL with 3 points. PM width was assessed at superior film aspect. "A negative point" was applied if: PM width < 5 cm [8], retroglandular fat not seen, GT reaches posterior film aspect or compression of anterior GT was suboptimal. PM presentation on mlo-view was assessed according to [7]: convex anterior contour (type I) was scored with 1 point, while other types (II, III and IV) yielded no points. PM visibility on cc-view, inframammary angle on mlo-view, all medial breast tissue and all lateral GT visibility on cc-view, absence of skinfolds, presentation of nipples in profile [6] and absence of asymetry and cutoff were each scored with 1 point. In the last category ARs were scored as follows: complete absence of ARs with 2 points, scarce easily recognizable ARs which does not obscure anatomy or simulate lesion with 1 point, and many ARs which might simulate lesion or obscure anatomy with 0 points [9].

The total IQ score was returned as the sum from the four categories: 7 + 6 + 10 + 2 = 26. Prior to objective IQA, a "subjective quality grade" (SQG) was attributed to each sample as a subjective rating of the overall quality and diagnostic value of the examination, on 5-point ordinal scale (1 – unacceptable, 2 – barely acceptable, 3 – acceptable, 4 – good, 5 – excellent). The results were presented as percentages of MUs that fulfil the defined criteria in each category. Mean and median of the scores in each category for each type of MU, and mean of total score for all MUs were

returned. Statistical significance of the differences of percentages and means were checked by Mann-Whitney U-test. Correlations between total IQ score with scores of each category were calculated. Mean values of SQGs for each MU type and correlations with total IQ score were returned. The Spearman test was used for the correlation analysis.

RESULTS

Mean age of MG machines was 7.76 years (range 2 – 21), with no difference between four MU types (7.42; 8.47; 8.04; 7.47 for GH, UH, PR and MC, respectively, $p > 0.05$).

Best L practice was seen in UH and the worst in PR. PT name was inadequately labeled in 17 % GH, and 5 % UH. Birthyear was absent in 55 % of PR and MC, and 43 % GH. Exam date lacks in 25 % of GH and PR. Laterality and view-marks were inadequate in 26 % of non-academic MUs. RT ID was present in 38 % of UH, but rarely in PR. Radiographic technique was rarely evident in all MU. Facility name lacks in 50 % PR and only in 2 % UH.

Best BP was seen in UH, and the worst in GH, with insufficient PM appearance in 40 % cases from UH to 60 – 70 % from other MUs. Nipple was not in profile in 20 % UH and up to 40 % GH and PR. Skinfolds were seen in 25 % UH and 35 % GH and PR. Inframammary angle was seen in 50 % UH and 30 % MC, medial breast aspect in 25 % UH and 15 % PR, and lateral in 45 % UH and up to 25 % of others. PM on cc-view was seen in only 15 % UH and < 5 % others.

EX was satisfactory in 93 % GH, 95 % MC and PR and all UH and contrast in 71 % PR, 78 % GH and MC and 86 % UH. Dense GT was well penetrated in a half of all samples, and PM in 80 % samples. Skin appearance was adequate in 90 % of UH and 80 % of other MUs.

No critical AR were seen in 78 % GH, 81 % MC, 87 % PR and 92 % UH, while in 25 % samples from UH and PR no ARs were seen at all.

Mean total IQ scores were 12.8, 16.1, 13.0 and 13.7 for GH, UH, PR and MC, respectively. Total IQ score (mean ± SD) for all MUs was 13.5 ± 3.2. Mean SQG was 2.5, 2.8, 2.7 and 2.6 for GH, UH, PR and MC, respectively.

Significantly better ($p < 0.05$) L practices were seen in UH than in PR and in MC than in PR. Significantly better ($p < 0.05$) EX and contrast were seen in UH than in PR. Significantly better ($p < 0.01$) BP was seen in UH than in all other MUs. Significantly fewer ($p < 0.05$) ARs were seen in samples from UH than from GH. Significantly higher ($p < 0.05$) total IQ

score was found in UH than in all other MUs. SQG differences did not reach statistical significance.

The total IQ score correlated significantly with quality of ID ($r = 0.69$), the quality of EX ($r = 0.64$) and the most strongly with quality of BP ($r = 0.78$), while the correlation with AR was weak ($r = 0.35$). Significant correlations between objective total IQ score and SQG ($p = 0.71 – 0.83$) were found.

This very first study of MIQ in Croatia corroborated our intuitive impression of inadequate IQ, staff training and equipment in many MUs nationwide. As MIQ strongly influences BC detection rate [15-17], suboptimal QA/QC always carries a risk to compromise the success of NBSP.

Film L should be complete, legible and permanent with any information unequivocally comprehensive [18]. In many PR the name was cut off or printed poorly, while in those lacking ID cameras was handwritten and hardly legible. Lack of birth year arise the risk to confuse the women with identical or similar names. Patient current age given in years (*e.g.* 50), or the birth year truncated (1950 to '50) can lead to confusion. Laterality and view marks were not adequate in a quarter of non-academic MUs. Non-standard abbreviations "ml" or "lat" used for mlo-view, suggesting 90 ° lateral view which has not been used in SMG for years [14,19-21]. The mlo-angle enables RT to choose optimal obliquity in future exams, considering variations of PM orientation in different women [21] and helps radiologist to perceive 3D relationship in the breast; this information was however not given in any patient. The deficiencies in L considerably contributed to lower IQ observed in PR, and could be easily corrected with better training, organization and working discipline.

Along with BP and compression, film OD and contrast strongly influence small BC detection rate [15,16,22]. As only few MUs in Croatia regularly perform daily QC, OD is usually lower than recommended [23]. However, analysed on low-luminance view-boxes [24], such MGs may seem acceptable for radiologists unaware of specific requirements of MIQ. The best OD in UH may be due to properly selected and matched film/screens and good processors with fresh chemistry due to considerable daily throughput. Hospital radiologists are stricter in their MIQ demands, keeping RTs more alert and open for continuous education than in smaller MUs. OD would be even better if MG dedicated processors were available. Comparable to previous results [24] film contrast was suboptimal in many PR, because of objective (low gradient receptors), and subjective reasons.

Low film rejection rate in PR is due to absence of instantaneous radiologist-to-RT feedback about MIQ. Many RTs are unaware of importance of compression for sharpness, contrast and BRD reduction, especially in PTs with dense breasts. Poor BP skill and lack of cooperation and confidence between PT and RT may result in painful exam [25], which compromises compression. Deficiencies of EX and contrast should be corrected through introducing QA/QC also in small capacity MUs, applying stricter standards for equipment maintenance and additional RT training.

The adequacy of BP strongly determines the amount of glandular tissue (GT) imaged on MG, which influence the sensitivity of the method [16]. The presentation of pectoralis muscle (PM) is the main criterion of mlo-image quality. PM could be visualized down to the posterior-nipple line (PNL) in 50 % [3–7,13,26,27], and within 1 cm from PNL in over 80 % of women [3,27]. Convex PM anterior outline, wider PM at the top than at the bottom of the image and visualization of inframmamary angle are recommended [5]. Only in a half of mlo-images in our material PM was properly visualized, often seen only marginally in axilla, indicating poor RT's expertise. Rarely seen convex anterior PM border reflects that PM was not relaxed and shifted medially during compression [21]. Although depictable on cc-view in certain percentage of women [3,7,14,21], PM was rarely seen on cc-view in our study. Medial skin reflection was too often sacrificed in an attempt to cover properly lateral GT. Although PT body habitus and the lack of large image holders may be responsible for this deficiency, many RTs are not aware of that posteromedial part of the breast is an inherent "blind area" of mlo-view, hence imperatively must be seen on cc-view [6]. The consistent efforts to mobilize the lateral GT under compression plate often lacked. As described by other authors [28], BP deficiencies were considerably responsible for overall MIQ impairment, especially in PR and MC. These BP failures can be overcome by additional RTs' training and prompting to refer to relevant professional texts [3,7].

The majority of ARs were typical and easily recognizable, hence not critical for diagnosis. ARs which imitate microcalcifications or lesions were less frequent, as reported earlier [24] and urgent corrective actions were requested by phone in such cases. Low frequency of AR in UH reflects better care of screens/cassettes, available in many sets and more frequently renewed. In small-patient volume MUs ARs occur more frequently as RTs lack specific training for QA/QC in MG. The use of processors dedicated for MG only, better education of the staff and regular QA/QC in all MUs are necessary.

Our material reflects the circumstances in different types of MUs from wide geographical diversity. It is known that MUs with higher patient volume has lower IQ failure rates [29]. We found better MIQ in UH than in GH, due to better BP and less ARs. The difference is even more significant in comparison of UH with all non-academic MUs. Because of the best MIQ, substantial participation of UHs is desirable in NBSP, while MUs with unacceptable IQ should be disengaged if unable to correct the deficiencies.

CONCLUSIONS

Deficiencies in SMG, especially in ID and BP reflect different level of competency of radiological staff in Croatia. Differences in MIQ in various MU types are determined by their organization, equipment, education, working habits and motivation. More efforts are needed to train both RTs and radiologists to implement and maintain QA/QC in their institutions.

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