PATIENT DOSE EVALUATION IN DIGITAL BREAST TOMOSYNTHESIS*

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Breast cancer (BC), a most common women malignancy, is often screened by mammography (MG) and ultrasound exams. Patients, for whom MG study does not give a clear answer or is impossible to interpret, are often further diagnosed by additional modalities. MRI is currently regarded as the most sensitive BC detection technique. On the other hand, it is limited by higher costs and lower availability and it provides higher rates of false positive cases. Relatively new method applied in breast neoplasms detection is digital tomosynthesis (Digital Breast Tomosynthesis — DBT, 3D imaging), introduced in 2011. The aim of this study was to compare doses given to the patients during conventional digital mammography with doses obtained from digital breast tomosynthesis. The comparison of average glandular dose (AGD) values for both options are discussed in the paper, respectively. Data from 219 patients have been collected and analyzed in tomosynthesis mode. AGD for tomosynthesis was 30–60% higher depending on breast thickness, comparing with 2D examination (*i.e.* 1.36 *vs.* 1.75 mGy for 63–72 mm compressed breast thickness). The diagnostic benefits of 3D imaging compensate for the risk associated with increasing the glandular dose in patients, especially in groups where the breast thickness after compression does not exceed 63 mm.

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1. Introduction

Breast cancer (BC), a most common women malignancy, is often screened by mammography and ultrasound exams. Mammography provides early micro-calcification recognition that is important for further cancer diagnosis. The imaging method-of-choice in the case of BC is an X-ray mammography (MG), also with the use of high-resolution digital modality. However, a planar MG has some limitations in terms of its sensitivity [1], especially in patients with dense and treated breasts. Moreover, MG contributes to the overall radiation burden of patients, and it is known that the risk for breast cancer is correlated with an exposure on ionizing radiation due to medical imaging. Patients, for whom MG study does not give a clear answer or is impossible to interpret, are often further diagnosed by contrast-enhanced spectral mammography (CESM) [2, 3] and breast magnetic resonance imaging (MRI). MRI is currently regarded as the most sensitive BC detection technique. On the other hand, it is limited by higher costs and lower availability and it provides higher rates of false positive cases. Relatively new method applied in breast neoplasms detection is digital tomosynthesis, introduced in 2011. A classical planar (2D) mammography image characterized by a superposition of all breast structures projected onto the detector plane, making difficult to recognize suspected areas. Tomosynthesis is a modality in which a series of breast exposures [1] are performed at different angles (usually 9). Acquired images are subsequently used to reconstruct thin (1 mm) slices, which eliminates the problem of overlapping breast structures. This makes it easier to detect potentially suspicious changes, which can additionally be supported by specialist software such as CAD (Computer Aided Diagnosis). On the basis of European studies, tomosynthesis improves cancer detection rate. In the U.S. studies, reduction in recall rate can be observed [4].

2. Materials and methods

Images and dosimetry data were used from digital tomosynthesis mode of GE SenoBright at the Department of Radiology and Imaging Diagnostics — Centre of Oncology in Kraków. Permission No. OIL/KBL/17/2018 from Bioethical Committee at the Regional Medical Commission in Kraków was given for this project. So far, data from 219 patients have been collected and retrospectively analyzed in a total of 357 CC/MLO projections in tomosynthesis mode. Additionally, 70 of the patients had also classic 2D examination used as a reference in term of dose. The first stage of the work was to compare the average glandular dose (AGD) indicated by the system (based on imaging direct radiography (DR) panel measurement) with the value determined from direct measurements using the RaySafe semiconductor detector for the three reference PMMA plate thicknesses: 20 mm, 45 mm and 70 mm.

In order to estimate AGD based on Entrance Surface Air Kerma (ESAK) measurements, at the surface of the PMMA phantom, special coefficients were used to compensate differences in breast structure in accordance with the European guidelines for quality assurance in breast cancer screening [5]. Verification measurements of automatically provided ESAK and AGD were performed according to the formula

$$\mathrm{AGD} = \mathrm{ESAK} \times g \times s\,, \tag{1}$$

where g — glandularity conversion coefficients, s — spectral correction factor.

3. Results

After confirming the reliability of ESAK and AGD calculating by the system (4–8% difference between calculated and measured values), a comparative analysis of the patient's data subjected to mammography screening in tomosynthesis conditions was started. Patients were divided into groups depending on the thickness of the breast. AGD values in digital tomosynthesis for CC and MLO projection are compared with standard digital mammography and presented below. The collected data are in accordance with the one-tailed Student's t-distribution. For AGD comparison for tomosynthesis and 2D planar mammography, statistical t-test was used. Comparing the AGD for tomosynthesis *vs.* 2D imaging for CC projection: calculated t-value is 2.956 which determines p-value to be equal 0.009. For MLO projection: t-value is 2.031, p-value is 0.035. The difference between two distributions of AGD is significant at the defined significance level: 0.05 for CC and MLO projections. Comparing AGD values for 3D imaging between CC and MLO projections, the differences are not statistically significant ($t = 0.521$, $p = 0.308$) for 0.05 significance level.

4. Discussion and conclusions

Average Glandular Dose was calculated among the patients subjected to the analysis. The largest group were patients whose breast thickness after compression was 53–62 mm. They constituted over 27% of all patients. Irrespective of the projection and mammography (2D-planar, CESM, 3D — tomosynthesis), the average glandular dose increases with the breast thickness increase from 0.89 mGy for breast patients below 32 mm (in 2D mode) [6] to 7.71 mGy for female patients breasts after compression above 70 mm (CESM). It was observed that the increase in home appliances along with breast thickness after compression is much faster in patients undergoing tomosynthesis (9 exposures) than in standard 2D mammography (1 exposure). On the basis of data presented in Figs. 1 and 2, increase of AGD for 3D mode *vs.* 2D mode can be observed: from 18% (30–42 mm of compressed breast thickness, CC projection) up to 50% for thick breast (> 73 mm, MLO projection). Average glandular dose of the 2D study accounted for at least 64% of the dose received by the patient during tomosynthesis. This is a relatively small increase in household appliances compared to traditional planar techniques. Digital breast tomosynthesis dose (DDBT) estimates for a standard breast thickness (Teerstra *et al.*: DDBT: 1.74 mGy Michell *et al.*: DDBT: 1.66–1.90 mGy) performed according to the American College of Radiology technical standard [7] are similar to our results (Figs. 1 and 2, 43–52 mm of compressed breast thickness). Gennaro *et al.* concluded that average increase of AGD in digital breast tomosynthesis compared do 2D mammography is 38% [8], which is similar to our results: 36%. Østerås *et al.* reported 24% of increase for AGD for tomosynthesis [9]. On the basis of European studies, tomosynthesis improves cancer detection rate. In the U.S. studies, reduction in recall rate can be observed [4]. The diagnostic benefits of 3D imaging compensate for the risk associated with increasing the glandular dose in patients [10], especially in groups where the breast thickness after compression does not exceed 63 mm.

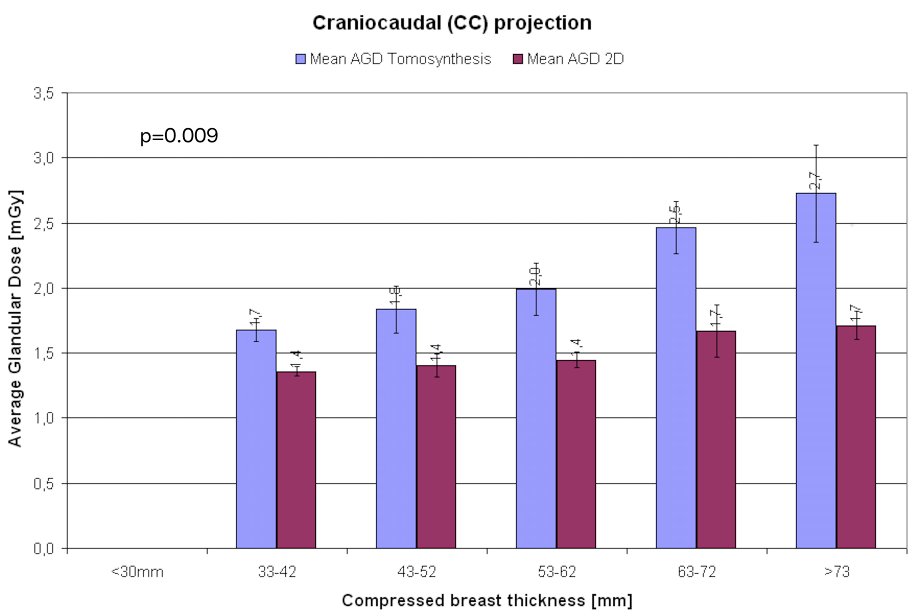

Fig. 1. Tomosynthesis *vs.* 2D examination — AGD for Craniocaudal projection.

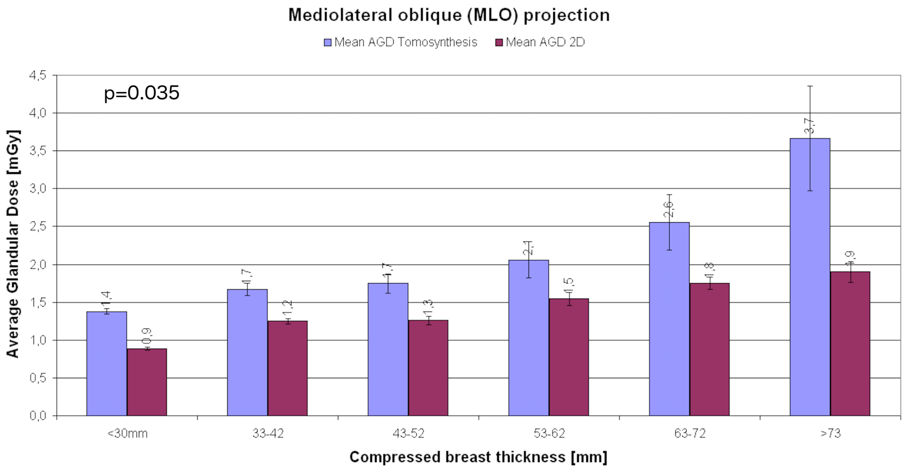

Fig. 2. Tomosynthesis *vs.* 2D examination — AGD for Mediolateral oblique projection.

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