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Dose Indicators for Full-Field Mammography and Digital Breast Tomosynthesis at CHC Rijeka

Vrijednosti doznih indikatora za postupke standardne mamografije i digitalne tomosinteze u KBC-u Rijeka

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Abstract. ***Aim***: The aim of the study is to determine typical values of dose indicators for standard mammography and digital breast tomosynthesis at the Department of Diagnostic and Interventional Radiology at the Clinical Hospital Center Rijeka, to assess whether the determined typical values of the dose indicators for standard mammography procedures are in accordance with the national diagnostic reference values and whether the determined typical values of the dose indicators for digital breast tomosynthesis are in accordance with the data published in current international publications. This is one of the first studies in the Republic of Croatia with the aim of determining typical values of dose indicators for digital breast tomosynthesis procedures. ***Participants and methods***: Data from a total of 135 women who had undergone planar mammography and 285 women who had undergone digital breast tomosynthesis were analyzed. Median values of average glandular dose for standard mammography and tomosynthesis were calculated for a compressed breast thickness of 5-6 cm. ***Results***: The median values of the average glandular dose for standard mammography at a compressed breast thickness of 5-6 cm at Clinical Hospital Center Rijeka are 1.51 mGy per projection, while for digital breast tomosynthesis, they are 1.99 mGy per projection. It was found that the values of the typical dose indicator for standard mammography procedures determined at the Clinical Hospital Center Rijeka are lower than the national diagnostic reference values. The determined values of the typical dose indicator for digital breast tomosynthesis are consistent with the values published in recent international publications. ***Conclusions***: The results of this study have shown that the values of the average glandular dose for planar mammography and digital breast tomosynthesis at the Clinical Hospital Center Rijeka are in accordance with national and international recommendations.

Keywords: diagnostic reference levels; health care; mammography; quality assurance

Sažetak. ***Cilj***: Cilj rada je odrediti tipične vrijednosti doznih indikatora za postupke standardne mamografije i digitalne tomosinteze dojke na Kliničkom zavodu za dijagnostičku i intervencijsku radiologiju Kliničkog bolničkog centra Rijeka, utvrditi jesu li dobivene tipične vrijednosti doznih indikatora za standardne mamografske postupke u skladu s nacionalnim dijagnostičkim referentim razinama u Republici Hrvatskoj te utvrditi jesu li dobivene tipične vrijednosti doznih indikatora za digitalnu tomosintezu dojke u skladu s podatcima objavljenim u recentnim međunarodnim publikacijama. Rad predstavlja jedno od prvih istraživanja u Republici Hrvatskoj čiji je cilj odrediti tipične vrijednosti doznih indikatora za postupke digitalne tomosinteze dojke. ***Ispitanici i metode:*** Analizirani su podatci 135 žena koje su podvrgnute standardnoj mamografiji te 285 žena kod kojih je učinjena digitalna tomosinteza dojke. Medijani vrijednosti srednje glandularne doze za standardnu mamografiju i digitalnu tomosintezu dojke izračunati su za debljinu komprimirane dojke od 5 do 6 cm. ***Rezultati***: Medijan srednje glandularne doze za standardnu mamografiju po jednoj projekciji u Kliničkom bolničkom centru Rijeka iznosi 1,51 mGy za debljinu komprimirane dojke od 5 do 6 cm, dok za digitalnu tomosintezu iznosi 1,99 mGy. Utvrđeno je da su dobivene tipične vrijednosti doznih indikatora u Kliničkom bolničkom centru Rijeka za standardne mamografske postupke manje

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od nacionalnih dijagnostičkih referentnih razina. Dobivene tipične vrijednosti doznih indikatora za digitalnu tomosintezu dojke sukladne su vrijednostima objavljenim u recentnim međunarodnim publikacijama. ***Zaključci***: Rezultati istraživanja pokazuju da su vrijednosti srednje glandularne doze za standardnu mamografiju i digitalnu tomosintezu dojke u Kliničkom bolničkom centru Rijeka u skladu s nacionalnim i međunarodnim preporukama.

Ključne riječi: dijagnostičke referentne razine; mamografija; osiguranje kvalitete u zdravstvenoj njezi

Periodic monitoring of the absorbed dose delivered to the patient during diagnostic procedures and determining typical values of dose indicators for the most common examinations is an important step in the optimization process.

INTRODUCTION

Breast cancer is the most common malignancy in women in Croatia[1]. Despite technological advances in other diagnostic imaging techniques, mammography remains the "gold standard" for the detection of breast cancer in the general population[2]. It is a medical imaging procedure performed with a mammography machine that uses low-energy X-rays to produce detailed images of the internal structures of the breast. In standard mammography, imaging is performed in two projections: craniocaudal (CC) and mediolateral oblique (MLO) (Figure 1). Digital breast tomosynthesis is a sophisticated imaging modality that uses low-energy X-rays and computer reconstruction algorithms to create a three-dimensional image of the breast. In digital breast tomosynthesis, the X-ray tube moves in an arc around the compressed breast and images it from several different angles. The computer reconstructs the digital data into a set of three-dimensional image data, significantly reducing the likelihood of image overlap that can obscure specific pathology or make it difficult to distinguish between an overlap of normal breast tissue and pathologic processes[3]. Like standard mammography, overall imaging time must be optimized to avoid degradation of mammography quality due to patient movement[4].

Quality assurance in radiology includes all planned and systematic activities that enable high-quality diagnostic imaging information to be obtained to answer clinical questions. The absorbed dose delivered to the patient should be optimized to enable the generation of image data of sufficient quality[5]. In the Republic of Croatia, the obligation to establish a quality assurance program for the use of ionizing radiation and its implementation is regulated by the Act on Radiological and Nuclear Safety[6], and the content of the quality assurance program is prescribed by the Regulation on the Conditions and Radiation Protection Measures for Performing Activities With Ionizing Radiation Sources[7]. The quality assurance system in radiology includes compliance

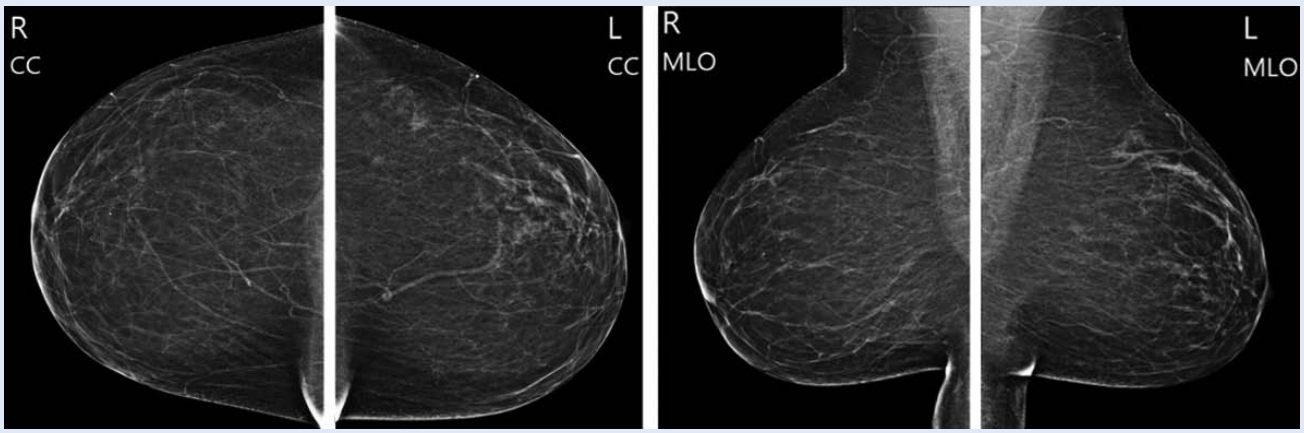

Figure 1. Craniocaudal projection of the right (R-cc) and left (L-cc) breast, oblique mediolateral projection of the right (R-mlo) and left (L-mlo) breast. Source: Archive of the Clinical Department of Diagnostic and Interventional Radiology, Clinical Hospital Center Rijeka (retrieved on 4.9.2023.)

with a few requirements for imaging equipment and ancillary systems[7–10] that relate to the optimization of their physical parameters and, consequently, to the imaging procedures themselves. Regular monitoring of the absorbed dose delivered to the patient during diagnostic procedures and the determination of typical values of dose indicators for the most common examinations is an important step in the optimization process. The Regulation on Conditions for Application of Ionizing Radiation Sources for the Purpose of Medical and Non-medical Irradiation[8] prescribes the use of Diagnostic Reference Levels (DRLs) for optimization purposes. DRLs are values of dose indicators in imaging that indicate whether, under routine conditions, the absorbed dose delivered to patients during an imaging procedure using ionizing radiation corresponds to the recommended values[11]. National DRLs are defined for the most common X-ray procedures as the third quartile of the mean values of the prescribed dose indicators for a group of standard patients[11]. According to the Regulation[8], each facility performing diagnostic and interventional radiological procedures is required to establish typical dose indicator values for diagnostic procedures for a standard patient and these must be reviewed annually. Typical values within the facility are determined as the median for certain dose indicators in accordance with the recommendations of the International Commission on Radiological Protection[11] and the International Atomic Energy Agency[12]. The values determined are compared with the national DRLs[6] and if deviations from the national values are found, measures should be taken to further optimize the individual imaging procedure.

For mammographic procedures, the dose indicator for which typical values are determined is the average glandular dose (AGD). To determine the AGD, data on breast thickness, glandular tissue content, half-value layer thickness and entrance surface air kerma (ESAK) are required. With modern mammography devices, it is not necessary to calculate the AGD values, as the device's control system enables this data to be displayed. Verification of the accuracy of the displayed AGD values on such mammography devices is the responsibility of medical physicists who perform AGD verification as part of regular quality control at least once a year[7]. In the Republic of Croatia, the diagnostic reference value of AGD per projection in standard mammography procedures is defined for a compressed breast thickness of 5.5 cm ± 0.5 cm and is set at 3 mGy[8]. The national diagnostic reference level for digital breast tomosynthesis in the Republic of Croatia has not yet been defined. The main objective of this study is to review the typical values of AGD on the Hologic Selenia Dimensions mammography unit (Hologic, Bedford, Mass) used in the Clinical Department of Diagnostic and Interventional Radiology (CDDIR), Clinical Hospital Center (CHC) Rijeka. In addition to typical values for standard mammography procedures, AGD values for digital breast tomosynthesis are analyzed and compared with data from recent international publications[13–15].

PARTICIPANTS AND METHODS

Data were collected retrospectively for female patients who underwent mammography at CDDIR, CHC Rijeka, between February 1, 2023 and April 1, 2023. Exclusion criteria included mammograms performed as part of the national screening program, previous breast surgery or biopsies, breast implants and male patients. Data were collected and analysed using the DOSE dose monitoring system (Qaelum NV, Leuven, Belgium) used at CDDIR CHC Rijeka. The system collects only parameters related to the procedures, without the patients' personal data, thus ensuring complete anonymity of the participants. The retrospective data collection included the following parameters: Voltage (kV), charge (mAs), compressed breast thickness and AGD. Typical AGD values were determined for standard mammography procedures and digital breast tomosynthesis using the Hologic Selenia Dimensions device. The device is included in the quality assurance program, as are all devices that generate or use ionizing radiation at CHC Rijeka. The typical AGD value on this device was calculated as the median[11, 12].

Statistics

The statistical analysis of the data was performed with the program Statistica 14.0.0.15 (TIBCO

Software Inc.). The Kolmogorov-Smirnov test was used to test the data for normal distribution. The t-test for independent samples was used to determine whether there was a significant difference between the values of the dose indicators for standard mammography and digital breast tomosynthesis at CHC Rijeka, at a significance level of 5%.

RESULTS

From February 1, 2023 to April 1, 2023, a total of 1891 patients underwent a mammography procedure. A total of 1471 participants were excluded from the study, and the analysis focused on a total of 135 women who underwent standard mammography and 285 women who underwent digital breast tomosynthesis. The age range of patients who underwent standard mammography was between 37 and 86 years, with a median age of 59, while the age range of participants who underwent digital breast tomosynthesis was between 36 and 85 years, with a median age of 58. Exposure parameter analysis and AGD estimation were performed only for a compressed breast thickness of 5.5 cm ± 0.5 cm. The Kolmogorov-Smirnov test shows that the exposure parameters – kV and mAs – do not follow the normal distribution and the median values with range for standard mammography and digital breast tomosynthesis are shown in Table 1.

Table 1. Values of kV and mAs for standard mammography and digital breast tomosynthesis for a compressed breast thickness of 5.5 cm ± 0.5 cm.

	kV median (range)	mAs median (range)
Standard mammography	29 (28 – 31)	136 (110 – 180)
Digital breast tomosynthesis	31 (31 – 32)	60 (57 – 72)

The median or typical value of AGD for standard mammography at CHC Rijeka is 1.51 mGy per projection, while for digital breast tomosynthesis it is 1.99 mGy. Table 2 shows the median AGD for standard mammography and digital breast tomosynthesis per projection, together with the national diagnostic reference level (DRL) and results from other publications. Since Bowman et al[15] reported the mean AGD rather than the median, the mean value of AGD for digital breast tomosynthesis at CHC Rijeka was also calculated for comparison.

The Kolmogorov-Smirnov test showed that the AGD values for standard mammography and digital breast tomosynthesis correspond to the normal distribution. The result of a t-test for independent samples showed a statistically significant difference between AGD for standard mammography and tomosynthesis ($p < 0.001$) (Figure 2).

DISCUSSION

The values of the dose indicators for standard mammography procedures on the Hologic Selenia Dimensions unit at CCDIR, CHC Rijeka are below the national diagnostic reference level. Since the DRLs for digital breast tomosynthesis have not yet been established in the Republic of Croatia, the AGD data from this study were compared with AGD values from recent international publications[13–15] (Table 2). The obtained AGD values for digital breast tomosynthesis at CHC Rijeka are comparable to the values reported in the studies by Bouwman et al[15] and Osteras et al[14], and they are lower than the values reported by Asbeutah et al[13]. The possible reason for the discrepancy between the AGD values at CHC Rijeka and those of Asbeutah et al[13] could be due to dif-

Table 2. Mean and median values of the AGD for standard mammography and digital breast tomosynthesis at Clinical Hospital Center (CHC) Rijeka, Croatian national diagnostic reference level (DRL) for AGD and AGD results from other publications.

	CHC Rijeka AGD / mGy median (IQR)	CHC Rijeka AGD / mGy mean ± SD	National DRL AGD / mGy Q3	Asbeutah et al[13] AGD / mGy median (IQR)	Osteras et al[14] AGD / mGy median (IQR)	Bouwman et al[15] AGD / mGy mean ± SD
Standard mammography	1.51 (0.33)	1.52 ± 0.30	3	-	-	-
Digital breast tomosynthesis	1.99 (0.19)	1.96 ± 0.17	-	3 (1.2)	2.06 (0.29)	2.28 ± 0.25

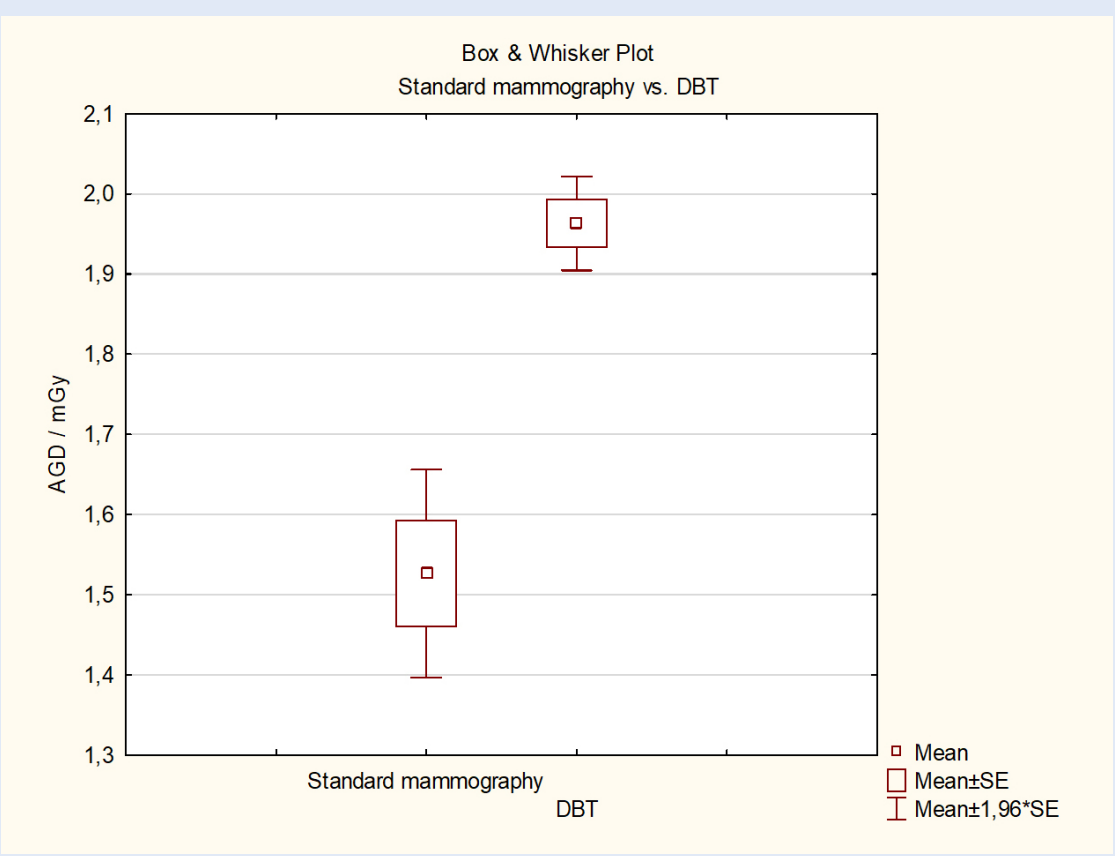

Figure 2. Box and whisker plot of average glandular dose (AGD) for standard mammography and digital breast tomosynthesis (DBT) at Clinical Hospital Center (CHC) Rijeka for compressed breast thicknesses of 5.5 ± 0.5 cm.

ferences in mammography equipment. The device for which the AGD values were calculated in Asbeutah et al[13] has a different detector configuration, uses a different combination of filters and has different slice thicknesses and slice spacing than the device in CHC Rijeka.

The AGD values for tomosynthesis of the breast are higher than the AGD values for standard mammography, which is consistent with previous studies using the same device[16]. However, the AGD values for digital breast tomosynthesis are lower than the national diagnostic reference level for standard mammography (3 mGy). The reason for the higher AGD values for digital breast tomosynthesis is that a series of low-dose images (up to 15) are used for each projection as the X-ray tube moves around the breast. The reconstruction algorithm then produces a three-dimensional image of the breast, as opposed to standard mammography, which uses only one image for a single projection. With standard mammography, the overlap of tissue can make it difficult to detect certain lesions, and sometimes the overlap of tissue can be misinterpreted as a lesion, leading to false-positive findings. Compared to standard mammography, digital breast tomosynthesis has a significantly higher sensitivity, specificity and accuracy in the diagnosis of indeterminate lesions[17]. Examples from clinical practice show that radiologists are less likely to perform a BI-RADS 0 classification (BI-RADS – Breast Imaging-Reporting and Data System) on images obtained with digital breast tomosynthesis, indicating indeterminate findings that require additional investigations[18, 19]. The slightly higher absorbed dose delivered to patients is justified by the improvement in diagnostic image quality with digital breast tomosynthesis.

CONCLUSIONS

Periodic monitoring of the dose indicators used to calculate the absorbed dose delivered to the patient is an integral part of the quality assur-

ance program and is mandatory for all diagnostic procedures based on the use of ionizing radiation, both in diagnostic and interventional radiology[20] and in nuclear medicine[21, 22]. DRLs are not mandatory values for radiological procedures, but should be used as guidelines. If a facility does not have values that correspond to the national reference values, the cause must be determined and the procedure further optimized if necessary. Since breast tissue is sensitive to radiation, monitoring dose indicators for standard mammography and digital breast tomosynthesis is extremely important. Additionally, performing regular quality checks helps identify potential issues and highlight deficiencies in imaging equipment, the proper functioning of which is crucial for obtaining high-quality images and making accurate diagnoses.

The results indicate that breast imaging procedures at CHC Rijeka are well optimised, following international recommendations.

The results of this study show that the values of dose indicators for standard mammography procedures at CHC Rijeka do not exceed the national diagnostic reference levels established for standard mammography. The values for digital breast tomosynthesis are comparable with data from recent international publications. This indicates that the breast imaging procedures at CHC Rijeka are well optimized according to international recommendations.

Conflicts of Interest: Authors declare no conflicts of interest.

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