Abstract

Objective: This work aims to define patient doses and factors which influence them for all critical groups of patients in routine mammography. Methods: A level of risks and benefits of screening mammography is under constant scrutiny. The size which best describes the amount of risk for glandular tissue caused by application of radiation in mammography is called mean glandular dose. One hundred and five patients from 40 to 78 years of age were included in this study from the Department of Radiology of the University Clinical Center Tuzla. Clinical data were collected from 400 mammograms taken from 105 women from routine mammographic screening. The exposure conditions of each mammogram were recorded. The mean glandular dose was calculated based on measuring ESAK, half value layer, kVp, mAs, breast thickness and clinical spectrum. Results: Mean MGD for women between 40 and 49 was 1.22 ± 0.47 mGy, for the group between 50 and 64 mean MGD was 1.24 ± 0.45 mGy and 1.23 ± 0.40 mGy for the group between 65 and 78. According to the correlation analysis, there was significant statistical significance between the MGD and a CBT (r = 0.709, p < 0.01). Conclusion: Values of MGD doses ranged within acceptable limits and were somewhat higher due to the extremely high value of compressed breast thickness.

Key words: risk, breast cancer, patient doses, routine mammography.
Introduction

Contemporary radiology is based on prevention of all types of diseases which it examines by its early detection. Mammography is used for prevention and detection of breast cancer as the most reliable radiological diagnostic method. The breast cancer is the most frequently diagnosed type of cancer and it is the leading cause of death among all cancers among women [1]. A sudden growth of its percentage representation in the total number of cancers diagnosed with women positioned it as the leading health problem both in developed and in less developed economies of the world [1–3]. Every year several thousands of new cases of this cancer are diagnosed among women in Bosnia and Herzegovina [4,5]. Due to a very good topographic position and a high degree of mobility of the breast it is possible to diagnose most cancers in their early phase [6,7] with mammography [8,9]. Classical and digital mammography are the most frequently applied in breast cancer detection, in spite of conflicting opinions about their advantages and disadvantages [10–12]. Successfulness of cancer detection greatly depends on quality of clinical screenings, which is ensured through procedures for ensuring quality control (QA), and it causes inability to timely detect and classify a breast cancer and other anomalies detected in a breast. Poor screening quality results in unnecessary exposure to applied radiation doses. Therefore, high-quality mammography represents a key for a long-term control and good results in the breast cancer treatment. In order to achieve conditions necessary for a high-quality mammography each of its procedures has to be justified and optimized [13]. Most studies and researches regarding mammography tend to define risks and benefits [14–17] caused by application of radiation in mammography. The size which best describes risks for glandular tissue caused by application of radiation in mammography is called mean glandular dose (MGD). MGD doses are defined for two critical age groups of patients: 40–49 and 50–64 years of age. It is also necessary to define MGD doses for other patients involved in mammographic diagnostics [5].

Material and methods

One conducted experimental measuring of measurable parameters during routine mammographic diagnostics at the Radiology Clinic at the University Clinical Center Tuzla. All routine examinations during the mammography were performed on a specialized apparatus for breast diagnostics – Siemens Mammomat 3000 Nova (Mo/Mo). This device is connected to a system which performs automatic storing of mammographic screenings with basic information about a patient and used parameters. During data collection one measured values of anode voltage, reproducibility of a dose and half-value layer (HVL) without a return radiation and compression board, with different kVp settings, according to recommendations of the European Protocol [32] which define frequency and methodology of measuring. Accuracy of measuring of compressed breast thickness was also done by the recommendations of the mentioned protocol. All tests regarding quality control and dosimetry were...
performed with Barracuda instrument. In classic mammography (film-screen), Mo/Mo dominates as one of the most frequently applied meta/filter combinations [18] and many mammographic systems have it as the only meta/system combination. The study involved 105 patients from 40 to 78 years of age who satisfy the criteria for involvement into the study. Beside physical, one collected all other available technical, medical and diagnostic parameters.

The following parameters were recorded during diagnostic examinations:

a) Patient’s age,

b) Applied clinical spectrum (meta/filter combination),

c) CBT (compressed breast thickness) and projection type (CC, MLO) for every breast,

d) exposition factors: charge I·t (mAs) and voltage (kVp),

e) size of applied film (18 x 24 or 24 x 32),

f) number of previous mammographic examinations undergone by every patient,

g) possible ultrasound control examinations.

Collected parameters were used for calculation of air kerma strength, filter half-value, conversion factors and doses applied to patients during the routine diagnostic mammography.

MGD was calculated for every mammogram on the basis of conversion factors defined by Dance et al. [31] and calculated ESAK (entrance surface air kerma measured freely in the air without return radiation) with the following relation:

\[ \text{MGD} = K \cdot G \cdot I \cdot C \cdot s \]

ESAK for each individual exposition was calculated from applied charge mAs (I·t) and exit data for an applied roentgen set in μGy mAs\(^{-1}\) used in the field of exposure. Dance et al. calculated conversion factors for different clinical spectra (meta/filter combination), HVL, compressed breast thickness and breast glandularity.

\( \text{G}, \text{I}, \text{C} \) are conversion factors which include characteristics of roentgen spectrum and breast composition, i.e. various percentage of adipose and glandular tissue. Factor s includes correction for applied clinical spectrum and all screenings were made with the application of the same clinical spectrum Mo/Mo.

In the most cases of diagnostic examinations one made two screenings for both projections, mediolateral (MLO) and craniocaudal projection (CC) of the left and the right breast. A total number of diagnostic screenings for the complete examination was 4 and for a control examination of one breast it was 2. The results of the research were processed in the software package SPSS 20.0. and shown through a standard deviation. Pearson’s coefficient was applied to define a statistical significance between compressed breast thickness and an applied dose. The accepted statistical significance will be at the level \( p < 0.05 \).
Results and discussion

An average age of all patients covered by the research was 54.32 ± 8.45 years. The youngest patient covered by the research was 40 and the oldest one was 78 (the range is 38 years). A standard mammography is done for two age groups of patients: patients from 40 to 49 years of age and those from 50 to 64 years of age. 84.76% of all patients belonged to one of the previously mentioned age groups of patients. During the research there were 16 patients from 65 to 78 years of age who had to undergo a mammography after a breast ultrasound examination and certain doubts. This is an usual procedure in the algorithm of a breast diagnostic procedure where the ultrasound examination is the first choice for all patients. Due to the newly arisen situation we formed a non-characteristic, third age group. Finally, the patients were grouped by age into three groups: patients from 40 to 49, patients from 50 to 64 and patients from 65 to 78 years of age [5].

The greatest number of patients included into the research was from the age group from 50 to 64 years of age – 59 patients (56.19%). There were 30 patients (28.57%) from the age group from 40 to 49 years of age and the smallest number of patients came from the age group from 65 to 78 years of age – 16 patients (15.24%). Average age of patients from the age group from 40 to 49 years of age was 44.38 ± 2.62 years while it was 55.97 ± 4.04 years for the patients from the age group from 50 to 64. Average age for the third group of patients from 65 to 78 years of age was 68.63 ± 3.85 years.

Table 1. Complete table illustration of performed mammographic screenings, compressed breast thickness and doses applied to patients per age groups

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Number of patients</th>
<th>Number of screenings</th>
<th>CBT ± SD (mm)</th>
<th>MGD±SD (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40–49</td>
<td>30</td>
<td>116</td>
<td>52.65 ± 11.19</td>
<td>1.22 ± 0.47</td>
</tr>
<tr>
<td>50–64</td>
<td>59</td>
<td>230</td>
<td>53.80 ± 12.67</td>
<td>1.24 ± 0.45</td>
</tr>
<tr>
<td>65–78</td>
<td>16</td>
<td>54</td>
<td>53.52 ± 13.58</td>
<td>1.23 ± 0.40</td>
</tr>
</tbody>
</table>

*CBT – compressed breast thickness
*MGD – mean glandular dose

During this research the applied voltage ranged from 26 kVp to 33 kVp. The most frequently applied voltages were 28 kVp (32.75%), 30 kVp (48.75%) and 32 kVp (13.75%) while the least frequently applied voltages were 26 kVp (3%), 27 kVp (1.5%) and 33 kVp (0.25%) and 31 kVp was not applied at all.

The need to apply very high voltages of 30 kVp and 32 kVp was caused by very high values of compressed breast thickness, which was 53.43 ± 12.37 mm for all patients from the research. Distribution of compressed breast thickness in mammography was symmetrical to patients’ age and it ranged from 20 to 89 mm. The error in defining compressed breast thickness was within ± 1 mm. There was a good
correlation between patients’ age group and compressed breast thickness. A similar symmetry was noted in other works [7, 16, 19, 20]. It is known that compressed breast thickness value shows a certain tendency to grow with patients younger than 60 and a tendency to decline with older patients [21], which proved to be true with our researched sample. Mean value of compressed breast thickness for the mediolateral projection was greater than with the craniocaudal projection. This piece of information is very important for understanding of results and explanation of obtained mean glandular doses for breasts.

The same clinical spectrum Mo/Mo was applied during a routine mammography. One made 400 diagnostic screenings (Table 1) for an examination of 105 patients from 40 to 78 years of age. 380 diagnostic screenings were used for a complete mammographic examination of 95 patients and 20 screenings for a control examination of one breast with 10 patients. For a complete mammographic examination one made two screenings for CC and MLO projection respectively. In this way both breasts were completely diagnostically processed, which provided conditions to define all possible anomalies by comparison of the screenings.

Applied MGD doses ranged within the scope of permitted values and prescribed protocols. The smallest values of MGD doses for one mammographic screening were recorded with the third age group 1.23 mGy. MGD doses in the age group from 40 to 49 are for about 2% less in regard to the group from 50 to 64 years of age. This result is the product of the fact that value of compressed breast thickness in the age group from 50 to 64 is on average 2.14% higher in regard to the age group from 40 to 49. MGD dose for the complete mammographic examination of the younger age group (40–49 years of age) was 4.84 mGy, while it was 4.96 mGy with the older age group (50–64 years of age). Values of MGD doses ranged within permitted limits and they were somewhat higher due to extremely high value of compressed breast thickness.

There is a set of studies and published works [16,19,22–24] which treated the problem of MGD doses during a routine mammography. Values of MGD doses match pretty well with results of studies about the Bosnian population [7] and results obtained in studies regarding MGD doses, applied in screen film mammography, for values of compressed breast thickness higher than 50 mm [5,16,19,20].

In comparison with other studies, the obtained dose is within the limit of doses from a study conducted in Sweden [25] which covered a sample of 1,350 patients and a study from Australia which involved 490 patients [26]. A study conducted in Iran which involved 246 patients [27] showed that an MGD dose obtained for a complete mammographic examination in that country is much higher than in Bosnia and Herzegovina and that this the most probably is, as the author of the work states himself, a consequence of poor and insufficient care about quality control. The mentioned studies did not use conversion factors according to Dance while this study did. In Australia they were defined according to Wu, in Sweden according to Rosenstein, in Malesia according to Wu and in Iran according to Sobol. Values of the MGD dose for a complete mammographic examination in Bosnia and Herzegovina
are somewhat higher in regard to results obtained in Malesia with a sample of 300 patients [28] and in regard to the most complete study [29] conducted in the Great Britain which included 8,745 patients. Over 70% of all mammographic diagnostic examinations was done with doses less than 3.5 mGy. According to a correlation analysis there was a significant significance between MGD and CBT (r = 0.709, p < 0.01) [19,30]. MGD doses applied during the routine mammography ranged from 0.449 mGy for the thinnest compressed breast thickness to over 1 mGy for greater compressed breast thickness in the sample.

Conclusion

Values of MGD doses varied within allowed limits and were something higher due to extremely high values of compressed breast thickness.

References


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PROCJENA RIZIKA OD JONIZIRAJUĆEG ZRAČENJA KOD MAMOGRAFIJE

Apstrakt

Cilj: Ovaj rad ima za cilj određivanje pacijentnih doza i faktora koji utiču na njih za sve kritične grupe pacijenata tokom rutinske mamografije. Materijal i metode: Stepeni rizika i koristi od upotrebe mamografije je pod stalnim ispitivanjem. Veličina koja najbolje opisuje rizik za glandularno tkivo uzrokovano primjenom zračenja u mamografiji naziva se srednja glandularna doza. U studiju je uključeno 105 pacijentica starosne dobi od 40 do 78 godina s Klinike za radiologiju Univerzitetsko-kliničkog centra Tuzla. Klinički podaci su prikupljeni za 400 mamograma načinjenih u svrhu rutinske mamografije 105 pacijentica. Zabilježeni su svi ekspozicioni faktori. Srednja glandularna doza (MGD) je izračunata na osnovu jačine kerme u zraku, kVp, HVL-a, kompresovane debljine dojke, kliničkog spektra i konverzionalnih faktora. Rezultati: Srednja glandularna doza iznosila je 1,22 ± 0,47 mGy za starosnu skupinu 40–49 godina, 1,24 ± 0,45 mGy za starosnu skupinu 50–64 godine i 1,23 ± 0,40 mGy za starosnu skupinu 65–78 godina. Prema korelacionoj analizi postojala je značajna signifikantanost između MGD-a i CBT-a (r = 0,709, p < 0,01). Zaključak: Vrijednosti pacijentnih doza su se kretale u dozvoljenim granicama i bile su nešto više zbog izuzetno visoke vrijednosti kompresovane debljine dojke.

Ključne riječi: rizik, karcinom dojke, pacijentna doza, rutinska mamografija.