Evaluation of the quality of mammographic screening examinations performed in the Mazovian Province in 2007–2009

Ewa Fabiszewska, Iwona Grabska, Katarzyna Jankowska, Witold Skrzyński, Wioletta Ślusarczyk-Kacprzyk

Department of Medical Physics, Oncology Center — Institute in Warsaw, Warsaw, Poland

Author’s address: Iwona Grabska, Department of Medical Physics, Oncology Center — Institute in Warsaw, Roentgena 5 Str., 02-781 Warsaw, Poland, e-mail: i.grabska@zfm.coi.pl

Summary

Background: There is a significant risk of radiation-induced carcinogenesis associated with x-ray mammography. Therefore, the dose received by a woman during mammography should be as low as possible, with an optimal quality of the image. The purpose of this study was to assess changes in the quality of mammographic examinations within three consecutive years of the screening program in the Mazovian Province.

Material/Methods: The material for this study consisted of protocols from 114 mammography facilities, developed by physicists from the Mazovian Coordinating Centre in 2007–2009. According to the method published by Dance, individual doses (data from 2007 and 2008) and the value of the absorbed dose in a routine exposure of a standard PMMA phantom with a thickness of 4.5 cm were calculated. Moreover, optical densities of the phantom image (data from the years 2007 to 2009) were measured.

Results: The weighted average value of the calculated individual doses in 2008 was lower by 15%, as compared to the value from 2007. Reduction of individual doses is also reflected in the reduced phantom dose in routine exposures performed in consecutive years. In 2007, 2008, and 2009, the phantom dose in routine exposures did not exceed 2.5 mGy in 54%, 70% and 75% mammography facilities (respectively) and the optical density ranged from 1.3 to 1.8.

Conclusions: Results from consecutive years showed an evident tendency for decreasing radiation risk, with increasing image quality.

Key words: mammography • individual dose • phantom dose • screening examinations

Background

Among the registered cases of malignancy in women from Poland, in 2003, there were almost 19.9% cases of breast cancers [1]. This number increased to 21.5% in 2006 [2]. Due to the constantly rising number of registered cases of breast cancer, and thus the increasing number of mammographic examinations, it has become very important to assess women’s exposure to X-rays. It is especially significant for mammographic screening conducted once in every two years in the population of healthy women, aged from 50 to 69 years. Due to the fact that the glandular tissue of breasts is very sensitive to ionising radiation, the probability of breast cancer induction rises with increasing doses of radiation. Therefore, the dose received by women during mammography should be as low as possible, with an optimal image quality.

In 2007, 294 centres in Poland participating in the “National Breast Cancer Early Detection Program” were subjected to inspection for the first time. The range of the inspection was same for every province [3]. They were carried out by physicists from so called WOKs (Wojewódzkie Ośrodki Koordynujące, in English: Regional Coordination Centres), i.e. centres selected through competition by the Ministry of Health, and remaining under the authority of COK (Centralny Ośrodek Koordynujący, in English: Central Coordination Centre) with its seat in Oncology Center in Warsaw.

In the years 2007–2008, i.a. in the Mazovian Province, all centres involved in the screening programs were subjected to inspection (48 and 46 facilities, respectively). In 2009 in the Mazovian Province, only 20 centres were inspected. These were mainly the facilities new in the program and those which received an ‘unsatisfactory’ rating during inspections in 2008.

The inspections in 2007-2008 determined i.a.: the dose absorbed during a routine exposure by the PMMA phantom with a thickness of 4.5 cm (called ‘phantom dose’ in further text). The PMMA phantom with a thickness of 4.5 cm, called a ‘standard phantom’ in further text is believed to be an equivalent of a standard breast [4]. A routine exposure is an exposure carried out in clinical settings of the mammography units. Optical density was also evaluated at the reference point of the image of the above mentioned phantom. Additionally, in the years 2007-2008, the values of individual doses received by women during mammographic examinations were established according to the method published by Dance [5].
The aim of this report was to evaluate individual doses, find the phantom dose for a routine exposure, and optical density of the phantom image for that exposure, at mammography facilities in the Mazovian Province, participating in the "National Breast Cancer Early Detection Program" in the years 2007–2009. Fulfilling this aim allowed for an evaluation of changes in the quality of mammography within the three consecutive years of program implementation.

Material and Methods

The material used for the purposes of this report included post-inspection protocols from 114 mammography facilities, developed by physicists from the Mazovian WOK in the years 2007–2009. They concerned facilities equipped with screen-film mammographs (cassettes with screens made of rare earth elements) with automatic film processors.

The evaluation of women’s exposure to X-rays was carried out in two stages. The first stage consisted of establishing individual doses for 50 women at each of 94 facilities inspected in the years 2007 and 2008. The material included data from a total of 18800 exposures (i.e. 200 exposures per each facility). At every facility, the data from every exposure were collected and included: the value of high voltage, mAs, material of the anode, type of additional filter, and breast thickness after compression. Moreover, the physicists carried out measurements allowing for the determination of the half-thickness layer for every set value of high voltage and combination of anode/filter at particular facilities. On the basis of these data, individual doses were established according to the Dance’s method [5].

The accuracy of this method is limited to the central part of the breast, placed over the ionisation chamber of the system for automatic exposure control.

The second stage consisted in determining the phantom dose at 114 facilities inspected in the years 2007–2009. These values were established with the use of the Dance’s method [5], with the following composition assumed: 50% of glandular tissue and 50% of adipose tissue. Next, the study aimed to find out in what percentage of the inspected mammography facilities, the established phantom dose did not exceed the acceptable level (i.e. 2.5 mGy) and the achievable level (i.e. 2.0 mGy).

On the basis of the standard phantom image obtained as a result of exposure in clinical settings at each of 114 facilities, optical density was measured at the reference point, which is 6 cm from the edge of the film, on the thoracic side, and centrally between the left and right edge of the film. Optical density value was held for appropriate when ranging from 1.3 to 1.8 (i.e. within the ranges regulated in a regulations of the Ministry of Health [6]). The obtained data allowed for evaluation of the percentage of mammography facilities in which, in particular years, the phantom dose did not exceed 2.0 mGy and the optical density was appropriate, and in which the phantom dose did not exceed 2.5 mGy and the optical density was appropriate.

To perform measurements, the following equipment was used, fulfilling the requirements of the European Commission [4]:

- multimeter Piranha (type 305) by RTI Electronics AB;
- densitometer Normscan by Pehamed;
- PMMA phantoms with the basis of 160×240 mm in size: two with a thickness of 2.0 cm each, and one with a thickness of 0.5 cm;
- Aluminium filters by Gammex, with a purity of Al ≥99.9%.

The assumed measurement uncertainty for individual and phantom doses was 14% [7].

Results

Figure 1 shows the distribution of individual doses received by women examined in the years 2007 and 2008 at 48 and 46 mammography facilities, respectively. The brighter colour stands for individual doses obtained in 2007, while the darker one for those in 2008.

Table 1 includes the minimum and maximum values of the phantom dose at mammography facilities in 2007–2009. It also contains the percentage of inspected facilities at which the acceptable and achievable level of the phantom dose was not exceeded.
Table 1. Phantom doses and percentage of mammography facilities where the phantom doses did not exceed acceptable and achievable level in mammography facilities in 2007–2009.

<table>
<thead>
<tr>
<th>Year</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum value of the phantom dose</td>
<td>1.19</td>
<td>1.07</td>
<td>1.00</td>
</tr>
<tr>
<td>Maximum value of the phantom dose</td>
<td>4.14</td>
<td>3.96</td>
<td>3.65</td>
</tr>
<tr>
<td>Percentage of mammography facilities where the phantom dose did not exceed the acceptable level</td>
<td>73%</td>
<td>90%</td>
<td>93%</td>
</tr>
<tr>
<td>Percentage of mammography facilities where the phantom dose did not exceed achievable level</td>
<td>46%</td>
<td>72%</td>
<td>80%</td>
</tr>
</tbody>
</table>

Table 2. Optical densities of standard phantom images in mammography facilities in 2007–2009 and percentage of mammography facilities where the optical density ranged from 1.3 to 1.8, was lower than 1.3, or higher than 1.8.

<table>
<thead>
<tr>
<th>Year</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal optical density of a standard phantom image</td>
<td>0.96</td>
<td>0.55</td>
<td>1.33</td>
</tr>
<tr>
<td>Maximal optical density of a standard phantom image</td>
<td>2.77</td>
<td>2.13</td>
<td>2.07</td>
</tr>
<tr>
<td>The percentage of inspected facilities in which the optical density of the standard phantom image ranged from 1.3 to 1.8</td>
<td>75%</td>
<td>76%</td>
<td>80%</td>
</tr>
<tr>
<td>The percentage of inspected facilities in which the optical density of the standard phantom image was lower than 1.3</td>
<td>21%</td>
<td>13%</td>
<td>0%</td>
</tr>
<tr>
<td>The percentage of inspected facilities in which the optical density of the standard phantom image was higher than 1.8</td>
<td>4%</td>
<td>11%</td>
<td>20%</td>
</tr>
</tbody>
</table>

Table 3. Percentage of mammography facilities where phantom doses did not exceed the acceptable and achievable level, and the required optical density of the standard phantom image was obtained, in 2007–2009.

<table>
<thead>
<tr>
<th>Year</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of mammography facilities where the phantom dose did not exceed the acceptable level, and the required optical density of the standard phantom image ranged from 1.3 to 1.8</td>
<td>54%</td>
<td>70%</td>
<td>75%</td>
</tr>
<tr>
<td>Percentage of mammography facilities where the phantom dose did not exceed the achievable level, and the required optical density of the standard phantom image ranged from 1.3 to 1.8</td>
<td>31%</td>
<td>48%</td>
<td>70%</td>
</tr>
</tbody>
</table>

Table 2 includes the minimum and maximum values of optical density of the standard phantom image at mammography facilities in 2007–2009. It also contains the percentage of inspected facilities at which the optical density ranged from 1.3 to 1.8 (appropriate), was lower than 1.3, or higher than 1.8.

Table 3 shows the percentage of inspected facilities at which the phantom dose did not exceed the acceptable and achievable level, with optical density fulfilling the condition of acceptance at mammography facilities in the years 2007–2009.

Discussion

Individual doses for all women examined at 48 facilities of the Mazovian Province in 2007 ranged from 0.20 mGy to 10.63 mGy, and in 2008 from 0.17 mGy to 9.14 mGy (Figure 1). The weighted mean of these doses in the year 2008 was 1.97 mGy and was lower by 15%, as compared to 2007. Reduction of individual doses was confirmed by phantom dose decrease in the years 2007-2009. As it follows from Table 1, the difference between the maximum and the minimum value of the phantom dose was 2.95 mGy in 2007, 2.86 mGy in 2008, and 2.65 mGy in 2009. The highest percentage of inspected facilities in which the phantom dose did not exceed the acceptable level (93%) and the achievable level (80%) was found in 2009. These values were higher by 8% and 3%, respectively, as compared to the results from 2008, and by 34% and 20% as compared to 2007.

The analysis of optical density of standard phantom images (Table 2) showed that the condition of ‘appropriate optical density’ at the reference point was met by 75% of facilities in 2007, 76% of facilities in 2008, and 80% of facilities in 2009. Optical density of less than 1.3 was found in 21% of facilities in 2007, No such a case was registered in 2009. Optical density of over 1.8 was found in 4% of facilities in 2007, in 11% in 2008, and in 20% in 2009.
Both conditions (phantom dose not exceeding 2.5 mGy and optical density of the standard phantom image within the range of 1.3–1.8) were, according to the Table 3, met by 54% of facilities in 2007, 70% in 2008, and 75% in 2009. A more stringent criterion (i.e. phantom dose not exceeding 2.0 mGy with the same optical density range) was met by 31%, 48% and 70% of facilities in 2007, 2008, 2009, respectively.

Conclusions

On the basis of the obtained results for individual doses we may conclude that their values were lower in 2008, as compared to 2007. This can be confirmed by a decrease in phantom doses within the following years. Therefore, it may be suspected that individual doses would be lower in 2009 than in 2008.

References: