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Research Article

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HOW DOES A WOMAN'S REPRODUCTIVE AND BREAST-FEEDING HISTORY, WEIGHT, HEIGHT, BODY MASS INDEX, BREAST SIZE AND BREAST DENSITY AFFECT THE RADIATION DOSE SHE TAKES DURING MAMMOGRAPHY?

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Abstract

Objectives: Mammography is the screening test for breast carcinoma. The radiation dose received during this imaging has always been a point of consideration. The aim of this study is to search the relation of radiation dose received during mammographic imaging and the patient's age, menarche age, menopause age, childbirth history, total time of breastfeeding, height, weight, body mass index, mammographic breast density pattern and breast size.

Materials and Methods: Patients applying for mammography imaging were questioned about their menarche age, menopause status and age and their weight, height, and breast upper and inferior mammary fold sizes were measured. Their mammographic breast density and radiation doses were recorded. Statistical analysis was made with ANOVA and Pearson correlation.

Results: Breast size, weight, body mass index are found to be related to the radiation dose received during mammography. Age, number of given births, weight, body mass index and breast size have an effect on the mammographic breast density, which is a factor in both developing and diagnosing breast carcinoma.

Conclusion: Breast density on mammography can show differences according to the patient's reproductive history and body stature. Radiation dose taken during a mammography is found to be affected by body mass index and breast size. Breast tissue with increased adipose tissue is suitable for mammographic imaging in the aspect of radiation exposure.

Keywords: Breast density, mammographic density, radiation, weight, height, menarche, menopause, breast.

Introduction

Breast cancer is the most common malignancy and the leading cause of death from malignancy among women.[1] It affects 1.5 million women each year, and in 2015, 570,000 women lost their lives because of this cancer. It is 15% of all women's cancer deaths. Due to its high incidence and mortality rates, it is tried to be diagnosed early with screening programs all around the world.[1] On the other hand, it has various morbidity effects on the survivor, mostly about the upper limb. Edema and decreased range of motion are the main morbidities after the treatment of breast cancer.[2]

Mammography is the screening tool for breast cancer. The World Health Organization (WHO) declared the principles of effective breast screening in 1968, and the WHO screening guidelines mentions five key points, each of which applies to breast cancer and mammography: Breast cancer, being screened is serious and prevalent, the test-mammography is sensitive and specific, the test is well tolerated, the test is inexpensive, and the test changes therapy or outcome.[3]

The radiation dose received during mammography imaging has always been a point of consideration.[4] Radiation doses received at this procedure change from person to person; even changes from year to year in the same woman.[5]

X-ray is electromagnetic radiation energy that can cause ionization at the tissue.[6]

In order to produce x-ray suitable for soft tissue composition, breast mammography devices eradiate low kilovoltage x-rays.

The interaction of the x-ray with the tissue is affected by the composition of the tissue.[7]

The breast is composed of fibroglandular tissue and adipose tissue. Fibroglandular tissue is affected by hormonal changes both during menstrual cycles and during the lifetime. Adipose tissue can change with the weight of the woman. Also, personal and familial properties have an effect on the composition of the breast tissue.

The relation of dens breast structure and breast cancer development risk has been studied for a long time.[4, 8-11] The aim of the study is to find the effects of patient's age; hormonal history as menarche age, menopause age, menopause status; reproductive history as the number of births, total time of breastfeeding; body stature as weight, height, body mass index, and breast size and mammographic breast density on radiation dose received during mammography. Also, the effects of these variables on breast density are searched.

Materials and Methods

Patients and Image collection

After the approval of the institutional ethical review board, all patients applied to our conventional mammography (Giotto IMS, Bologna; Italy) unit in June 2015 (179 women) formed the study group. Informed consent was obtained from all participants.

Patients were questioned for their age, menarche age, menopause status and age, number of births, total time of breastfeeding as a summation of breastfeeding periods of all children. The menopause situation and age were questioned and noted. Menopause ages were also grouped in 5 years intervals

Their weight and height were measured. Breast size was found with the measurements of the breast's maximum size over areola (breast upper size) and the chest size from the infra-mammary fold (breast lower size). The cup size was calculated by subtracting inferior mammary fold measurement from maximum breast size.

Each patient had two mammograms (RCC: right craniocaudal, LCC: left craniocaudal, RMLO: right mediolateral oblique, LMLO: left mediolateral oblique) for each breast.

Image evaluation

Breast density was codded according to the BIRADS (Breast Imaging Reporting and Data Systems) density categories as; Type A (less than 25% of the mammogram is fibroglandular tissue), Type B (25-50% of the film is fibroglandular tissue), Type C (50-75% fibroglandular tissue), Type D (dense breast-more than 75% is fibroglandular tissue).[12]

The radiation doses during each of these films, average radiation doses, and total radiation doses were recorded. For the patients with unilateral mammography, total doses were calculated with twice the unilateral doses for correction.

Statistical Analysis

NCSS (Number Cruncher Statistical System) 2007&PASS (Power Analysis and Sample Size) 2008 Statistical Software (Utah, USA) were used for all statistical analysis, including descriptive statistics. The normal distribution was searched with histograms. The parametric values were analyzed with the ANOVA test, and correlation analysis was made with Pearson correlation. The significance was accepted at %95 confidence interval. Weight's contribution to breast size's relation with radiation dose is searched with a multiple linear regression test.

Results

There were 179 patients between 19 and 77 years old with a mean of 51.57 years.

The age of the patients and menarche age, menopause age, reproductive years, breast upper size, breast fold size, breast cup size, height, weight, body mass index, number of births, total breastfeeding duration (in months) and radiation doses of each projection images are summarized at Table 1.

Table 1. The descriptive statistics of the variables

	Minimum	Maximum	Mean	Std. Deviation
Age	19	77	51.57	8.35
Menarche age	11	21	13.52	1.55
Menopause age	24	58	46.33	5.12
Reproductive years	12	47	33.22	5.48
Breast upper size	77	133	99.26	10.93
Breast fold size	65	118	89.05	9.14
Breast cup size	-3	23	10.20	4.32
Height	145	173	159.56	6.11
Weight	41	116	74.64	13.49
Body mass index	18	48.3	29.41	5.41
Birth	0	10	2.50	1.50
Breast feeding (in months)	0	144	30.6	29.2
RCC dose	0.30	0.90	0.43	0.09
RMLO dose	0.30	1.10	0.39	0.10
LCC dose	0.30	0.90	0.43	0.08
LMLO dose	0.30	1.10	0.39	0.10
Average dose	0.30	1.00	0.41	0.08
Total dose	1.20	4.00	1.66	0.34

RCC: Right craniocaudal graph, RMLO: Right mediolateral oblique graph, LCC: Left mediolateral oblique graph, LMLO: Left mediolateral oblique graph.

Age of the woman, her upper and lower breast sizes and cup size, her weight, body mass index and her fertility are found to be correlated with her breast density type in the analysis of One-way ANOVA (Table 2).

The total radiation dose was found to be related to breast upper size, breast fold(lower) size, weight, and BMI (Table 3).

Table 2. Breast density types according to patients' age, reproductive properties and body stature in the analysis of One-way ANOVA.

Breast density type	P
Age	0.002
Menarche age	0.463
Reproductive period	0.229
Menopause age	0.151
Breast upper size	<0.001
Breast lower size	<0.001
Cup size	0.023
Height	0.138
Weight	0.001
Body mass index	<0.001
Birth	<0.001
Breast feeding period	0.318

In order to search the effect of the weight on breast size and eventually in the radiation dose, a multiple-linear regression test was performed. It is seen that BMI was the factor affecting mainly the dose (R:0.4 $p<0.001$ for BMI and $p=0.512$ for breast cup size), not the breast size.

Radiation dose and breast density type relation are demonstrated in Table 4. It is seen that both total and average breast doses and mediolateral oblique projection doses are affected by breast density, but craniocaudal projection radiation doses were not significantly affected by breast density.

Older age, being in menopause, having larger breasts, increased weight and BMI, being more parous have a negative relation with breast density (Figure 1a, 1b and 2a, 2b).

Only body mass index and weight, and- with their effect- breast upper and lower sizes had a negative relation with the total and average radiation doses taken during mammography as well as lower breast density (Figure 1a, 1b and 2a, 2b).

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Table 3. Results of Pearson Correlations of variables with total radiation dose. ** points significance.
BMI- Body Mass Index

		Total dose
Age	Correlation	-0.063
	P	0.402
Menarche age	Correlation	0.010
	P	0.895
Reproductive period	Correlation	0.107
	P	0.306
Menopause age	Correlation	0.177
	P	0.082
Breast upper size	Correlation	-0.300**
	P	<0.001
Breast fold	Correlation	-0.332**
	P	<0.001
Cup size	Correlation	-0.056
	P	0.460
Height	Correlation	0.043
	P	0.571
Weight	Correlation	-0.407**
	P	<0.001
BMI	Correlation	-0.401**
	P	<0.001
Birth number	Correlation	-0.048
	P	0.527
Breast feeding	Correlation	-0.023
	P	0.762

** points significance. BMI: Body Mass Index

Table 4. Breast density and radiation doses of 4 projections of mammography, average and total doses.

	RCC	RMLO	LCC	LMLO	AVARAGE DOSE	TOTAL DOSE
P	0.482	0.003	0.200	0.001	0.020	0.035

RCC: Right craniocaudal graph, RMLO: Right mediolateral oblique graph, LCC: Left mediolateral oblique graph, LMLO: Left mediolateral oblique graph. One-way ANOVA test was used.

Discussion

As a cancer screening tool, the radiation dose of mammography has always been a matter of interest for both radiologists and clinicians. As the technology develops in the path of mammography with a better resolution by using lower radiation doses, the subjective factors depending on the patient still remain as a factor in the dose absorbed.[13]

Mean glandular dose is the main measure for quantifying mammographic radiation dose absorbed. But in this equation, half-value layer of aluminum, milliampere second values, breast thickness and patient's age are also included in the equation to obtain the mean glandular radiation dose.[14] Since this equation includes breast thickness as a multiplier, and our study also aims to search the effect of breast size in radiation, the row radiation dose value was used for each mammography.

This study revealed a negative correlation between weight and BMI and the total radiation dose. As the weight increased, the total dose and breast density decreased consecutively. If the breast is composed of more adipose tissue, an X-ray can penetrate it more easily, and the required radiation dose will be lower.[15]

Upper and lower breast sizes (transverse measurement of the chest passing from the nipple and inframammary fold levels) were related to the radiation dose in contrast to cup size. But all three of these measurements were in relation to breast density. In order to search the effect of the weight on breast size and eventually in the radiation dose, a multiple-linear regression test was performed. It's seen that BMI was the factor affecting mainly the dose (R:0.4 $P<0.001$ for BMI and $p=0.512$ for breast cup size), not the breast size. This is an important finding because if we would use only the breast size passing over the nipple, we could find a relation between breast size and radiation dose. But cup size did not show this relationship, and in addition, even the upper breast size passing through the nipple did not confirm a relationship with radiation dose with multiple regression study. Only one measurement of a breast is not trusty in assessing a relationship between breast size and radiation dose.

It is understood that; despite both breast size, BMI and weight have a relation with the total radiation dose; the BMI is the factor that has also affected the breast size and eventually in the radiation dose (Figure 1 and 2). Height revealed a relationship with neither breast density nor radiation dose. So, the main factor in BMI and radiation dose interaction is due to weight.

Although we were expecting a decrease in the radiation dose with increased fertility, we could not see that relation, but breast density was seen to be affected(decreased) from the birth number. Having more children resulted in more lipomatous breast tissue and decreased breast density. Similarly, Nakajima et al. also show that having children was related to having less mammographic breast densities.[16] In our study17/179 patients were nulliparous. Lifetime breastfeeding period in months had a non-significant tendency of negative relation with breast density ($p=0.063$) and did not lead to a decreased radiation.

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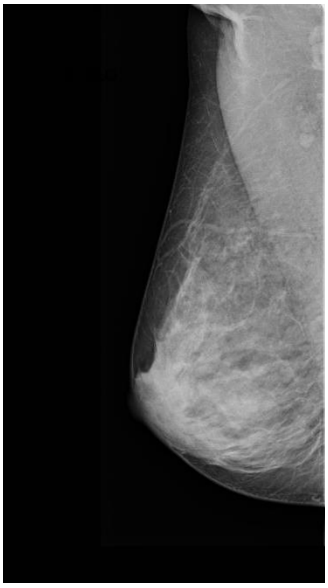

Figure 1a. Right mediolateral oblique mammogram of a 51 years old female. [BIRADS category D, dens breast. She has one child. Her BMI is 22.6. Total radiation dose is 2.8 mGy. Her upper breast size is 86, lower breast size is 79 cm (cup size 7cm)]

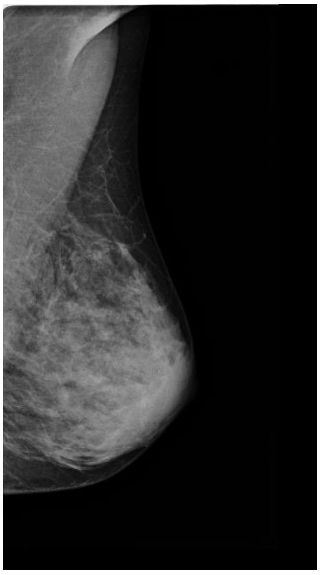

Figure 1b. Left mediolateral oblique mammogram of a 51 years old female. [BIRADS category D, dens breast. She has one child. Her BMI is 22.6. Total radiation dose is 2.8 mGy. Her upper breast size is 86, lower breast size is 79 cm (cup size 7cm)]

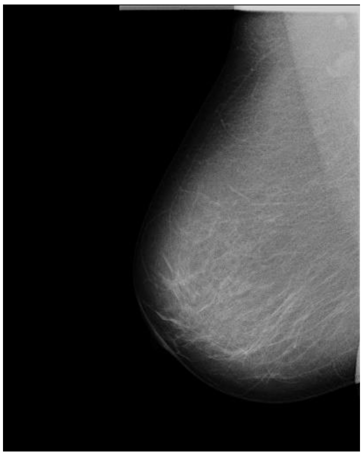

Figure 2a. Right mediolateral oblique mammogram of a 46 years old woman with 3 children, who has breast measurements of 108 and 98 cm (cup size10) with a BMI of 35.9. She has BIRADS type A breast pattern. Her total radiation dose was 1.2 mGy.

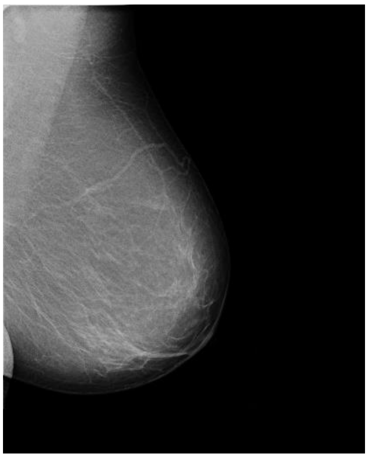

Figure2b. Left mediolateral oblique mammogram of a 46 years old woman with 3 children, who has breast measurements of 108 and 98 cm (cup size10) with a BMI of 35.9. She has BIRADS type A breast pattern. Her total radiation dose was 1.2 mGy.

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There was not a relation between being in menopause and the radiation dose. But it was related to the mammographic breast density. Post-menopausal women had lower breast density as it is expected that they are losing the effect of sex hormones on fibroglandular tissue.

Age of menarche or menopause, total reproductive years did not reveal a correlation with radiation dose. These factors have been related to breast carcinoma.[4,17] Alexeeff et al. showed a negative relation between the menarche age and breast density, pointing out late menarche as a factor for dense breast pattern in their very large numbered patient study with digital breast density measurement application.[4] In our study, menarche age was not found as a factor influencing the breast density either but the breast density evaluation techniques were different between these two studies. In our study, the BIRADS mammographic visual categorization is used.

Older age, being in menopause, larger cup size and higher number of births given were only related to lower mammographic breast density. Higher breast density is a known risk for breast carcinoma and a reason for lower sensitivity in mammographic screening. Younger, premenopausal patients with small breast sizes and fewer children will form the dense breast group, which will be the difficult ones to diagnose and have increased risk due to density.

Mammographic breast density showed a correlation with the radiation dose (Table 4). It was prominent on MLO projections. It can be a result that, on MLO projections, imaged volume is larger since the axillary tail is also included in the evaluation.[18] Another property of MLO projections is the compression is less than the CC projections, and evaluated breast thickness is more.[18] On the contrary, on CC image compression is stronger, and as a result, glandular tissue is more dispersed and less dense, resulting in less radiation.[19]

Breast density as a risk factor for breast cancer seems to be a problem for breast health in another aspect.[20] Women with dense breasts are recently accepted as a group of people that should be informed about their increased risk.[20] And due to this increased risk, a more serious screening should be issued for this group of people. But it is seen that this group is also having higher amounts of radiation during screening mammography, which will result in a dilemma.

The main limitation of this study is the scarcity of the patient number. Also, the breast density was not obtained with computerized mammographic programs.[21]

In conclusion, women in older age, in menopause, having larger breasts, with increased weight and BMI and women who are more parous had lower density breasts. It is concluded that lower body mass index, as well as the higher mammographic breast density pattern, is the main factor affecting the increased radiation during mammography.[9-10] Despite obesity being a risk factor for breast cancer, it is seen that slim body feature results in more radiation intake during mammography. Similarly, dens breast, as a known risk factor of breast cancer, also appears to be a risk factor for increased radiation dose during screening mammography in this study. But still, studies with larger patient numbers are required. Evaluation of each patient should be planned according to patient-based medicine properties.

Ethical Considerations: The ethical approval of the institutional ethical review board (AYBU No: 26379996/103) was obtained for this study. Informed consent was obtained from all participants.

Conflict of Interest: The authors declare no conflict of interest.

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