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Relationship Between Entrance Surface Skin Exposure for Iraqi Women with Compressed Breast Thickness in Mammography

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Abstract

Background: The evaluation of compressed breast thickness has been conducted based on the results of mammography examinations. While it is well-established that breast compression influences breast tissue, its effect on the axillary (armpit) region remains unclear. Increased compression of breast tissue in women can lead to a reduction in breast tissue thickness.

Objective: To determine the correlation between entrance surface skin exposure with compressed breast thickness and compare the mean of entrance surface skin exposure results from mammography in Iraq with other studies.

Patients and Methods: A study was conducted at Al-Alwiya Teaching hospital from December 2023 to January 2024 and involved 100 Iraqi women. The study used a mammography (model GE healthcare) to determine compressed breast thickness and skin exposure for craniocaudal and mediolateral oblique projections.

Results: The mammography findings revealed a statistically significant correlation between entrance surface skin exposure (ESE) and compression breast thickness (CBT) in Iraqi women. Specifically, it was observed that increased CBT was associated with higher ESE values.

Conclusion: The study demonstrates that breast compression thickness and radiation exposure were notably higher in the mediolateral oblique (MLO) view compared to the craniocaudal (CC) view. A significant positive correlation was observed between compression breast thickness and radiation dose. These findings underscore the importance of region-specific guidelines and standards in mammography practices to ensure optimal patient care and safety.

Keywords: Axillary region, Breast parenchyma, Entrance surface skin exposure, Mammography, Compressed breast thickness.

Introduction

The female breast is a complex anatomical structure primarily composed of glandular, fibrous, and adipose tissues (1). The glandular component is organized into lobules and ducts, which are crucial for milk production and transport during lactation. The fibrous stroma provides essential structural

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support. Adipose tissue surrounds these elements and significantly influences the breast's overall size and shape. In addition, the breast contains an intricate network of blood vessels, lymphatic channels, and nerves, which collectively contribute to its physiological functions and immunological defense (2,3,4). There are several reasons for applying firm (but not painful) compression to the breast during the mammographic examination (5). Compression causes breast tissues to be spread out, minimizing superposition from different planes and thereby improving the conspicuity of structures.

This effect may be accentuated by the fact that different tissues (fatty, fibrous, glandular, and cancerous) exhibit varying elasticity (6,7,8), resulting in the tissues being spread out to different extents and potentially making a cancer more visible. As in other areas of radiography, scattered radiation reduces contrast in mammograms. The use of compression decreases the ratio of scattered to directly transmitted radiation reaching the image receptor (9).

The effect of breast thickness on scatter is quantified. Compression also decreases the distance from any plane within the breast to the image receptor, thereby reducing geometric unsharpness. The compressed breast provides lower overall attenuation to the incident X-ray beam, allowing the radiation dose to be reduced. The compressed breast also provides more uniform attenuation over the image. This reduces the exposure range that must be recorded by the imaging system, and in screen-film mammography, allows a film with a higher gradient to be employed. Finally, compression provides a clamping action, which reduces

anatomical motion during the exposure, thereby reducing this source of image un-sharpness, it is essential that the breast (10-12) be compressed as uniformly as possible and that the edge of the compression plate at the chest wall be straight and aligned with both the focal spot and image receptor to maximize the amount of breast tissue (13, 14) that is included in the image. The mechanical properties of the breast are non-linear; after a certain reduction in thickness, application of additional pressure provides little benefit in terms of improved image quality and only contributes to patient discomfort. Specialized mechanisms have been introduced by several manufacturers to try to achieve better compression while minimizing the risk of overcompression (15,17,18).

This research seeks to estimate and compare the ESE from mammography procedures in Iraq with those reported in other studies. Additionally, it aims to explore the relationship between ESE and breast compression thickness.

Patients and Methods

Study design: The study involved 100 Iraqi women, aged between 30 and 60 years, who were referred to Al-Alwiya Teaching Hospital between December 2023 and January 2024. ESE and compressed breast thickness (CBT) measurements for craniocaudal (CC) and mediolateral oblique (MLO) views from mammography were recorded for both breasts. Various anode-filter pairings were considered, including Mo/Mo, Mo/Rh, and Rh/Rh.

Exclusion Criteria:

1. Patients with a history of radiation therapy.

2. Patients exhibiting symptoms of mastitis or breast abscess.

3. Patients with any inflammatory condition that may increase skin thickness beyond normal limits, potentially resulting in a higher radiation dose.

Data analysis: Analysis of the data was carried out using the Statistical Package for the Social Sciences, version 24 (SPSS-24). Data were presented in simple measures of mean, standard deviation, and range. The significance of the difference between different means (quantitative data) was tested using Student's t-test for the difference between two independent means or the Paired T-Test for a difference between paired

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observations (or two dependent means).

The scattering distribution curve was used for correlation analysis. Statistical significance was considered whenever the p-value was equal or less than 0.05.

Results

Age distribution: The age distribution of our data, collected from 100 Iraqi women, is shown in Figure 1.

The study groups were divided into smaller groups according to their ages, and the results showed that the percentage of the age range of patients of 30-39 years was 18.0%, it was 38.0% of patients within 40-49 years, and 44.0% for patients within the age range of 50 to 59 years old.

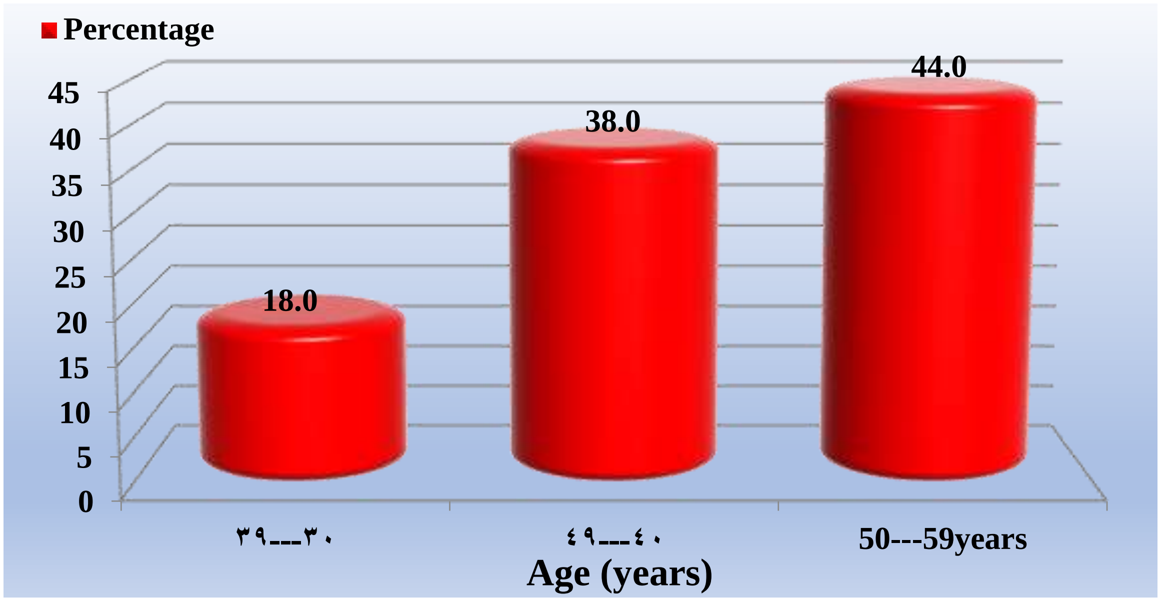

Figure 1. Age distribution of Iraqi women used in the current study at Al-Alwiya hospital.

These measurements are provided separately for the right breast, left breast, and combined for both breasts. Additionally, the range of values for each category is included.

Breast Thickness: For the cranio-caudal (CC) projection, the average compressed breast thickness for the right breast is 50.62 mm with a standard deviation of 9.62. The range of values for this measurement extends from 30.0 mm to 77.0 mm. Similarly, for the left breast, the mean thickness is 50.35 mm with a standard deviation of 9.38, and the range was from 30.0 mm to 75.0 mm. When both breasts are considered together, the average thickness was slightly higher at 50.90 mm, with a standard deviation of 9.89 and a range of 30.0 mm to 77.0 mm. In the mediolateral oblique (MLO) projection, the compressed breast thickness is generally more significant than in the CC projection. The mean thickness for the right breast is 61.12 mm, with a standard deviation of 12.57, and the range spans from 33.0 mm to 89.0 mm. For the left breast, the average thickness is 60.28 mm, with a standard deviation of 12.86, and the range is identical at 33.0 mm to 89.0 mm. When both breasts are analyzed together, the mean compressed thickness increases slightly to 61.97 mm, with a standard deviation of 12.27 and a range of 37.0 mm to 89.0 mm these shown at Table 1.

ORIGINAL RESEARCH
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Table 1. The mean and standard deviation of compression breast thickness.

Physical parameters of mammography	Mean ±SD (Range) For right breasts	Mean ±SD (Range) For left breasts	Mean ±SD (Range) For both breasts
Compression breast thickness for CC (mm)	50.62±9.62 (30.0-77.0)	50.35±9.38 (30.0-75.0)	50.90±9.89 (30.0-77.0)
Compression breast thickness for MLO (mm)	61.12±12.57 (33.0-89.0)	60.28±12.86 (33.0-89.0)	61.97±12.27 (37.0-89.0)

Entrance Surface Exposure: Based on Table 2 and Figure 2 which show the craniocaudal (CC) projection, the entrance surface exposure for the right breast has a mean value of 12.91 mGy, with a standard deviation of 3.19. The exposure values range from 7.0 mGy to 21.99 mGy. Similarly, for the left breast, the mean exposure was 12.91 mGy, with a standard deviation of 3.10, and the range is from 7.0 mGy to 21.21 mGy. When the data for both breasts are combined, the mean remains consistent at 12.91 mGy, with a slightly lower standard deviation of 3.10, and the range spans from 7.02 mGy to 21.99 mGy in mediolateral oblique (MLO) projection, the entrance surface exposure is slightly higher compared to the CC projection. For the right breast, the mean exposure is 15.38 mGy, with a standard deviation of 4.73, and the range is from 6.22 mGy to 37.09 mGy. While in the left breast, the mean exposure was 15.31 mGy, with a standard deviation of 4.88, and the range was from 7.41 mGy to 37.09 mGy. When both breasts are analyzed together, the mean exposure was 15.45 mGy, with a standard deviation of 4.61, and the range spans from 6.22 mGy to 31.25 mGy.

Table 2. Comparison of Entrance Surface Exposure (mGy) in Mammography.

Radiation factors	Mean ±SD (Rang) For right breasts	Mean ±SD (Range) For left breasts	Mean ±SD (Range) For both breasts
Entrance surface exposure of CC (mGy)	12.91±3.19 (7.0-21.99)	12.91±3.10 (7.0-21.21)	12.91±3.30 (7.02-21.99)
Entrance surface exposure of MLO (mGy)	15.38±4.73 (6.22-37.09)	15.31±4.88 (7.41-37.09)	15.45±4.61 (6.22-31.25)

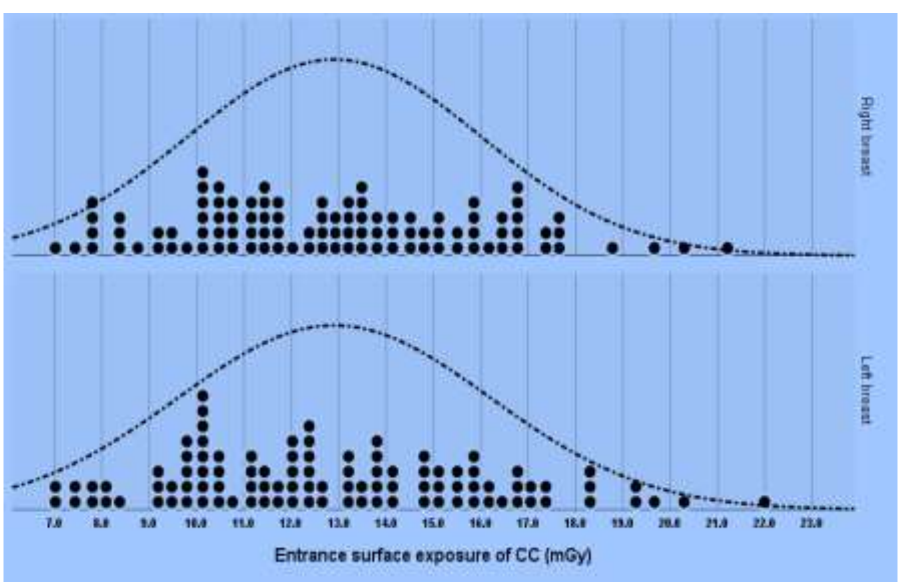

Figure 2. Analysis of radiation dose in CC and MLO mammography projection for left and right breast.

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Breast Thickness and Radiation Doses: Table 3 provides an analysis of the correlation between compressed breast thickness (CBT) and radiation doses during mammography for the cranio-caudal (CC) and mediolateral oblique (MLO) projections. The relationship is assessed using the Pearson correlation coefficient (R) and the corresponding p-values (P), which indicate the statistical significance of the results**.**

Correlation Coefficient: For the CC projection, the correlation coefficient ® between entrance surface exposure (ESE) and breast compression thickness was 0.401. This value signifies a moderate positive correlation, meaning that as breast thickness increases, the radiation dose required for the CC projection also increases. The associated p-value for this correlation is 0.0001, which was considered highly significant. This strong statistical significance underscores the reliability of the relationship between CBT and radiation dose in this projection.

In the case of the MLO projection, the correlation coefficient between ESE and CBT is slightly lower at 0.337, which also indicates a moderate positive correlation. Similar to the CC projection, this relationship implies that thicker breast tissue requires a higher radiation dose for adequate imaging. The p-value for this correlation is also 0.0001, demonstrating a high level of statistical significance. Despite being slightly weaker than the CC projection, the correlation remains important for understanding the factors influencing radiation dose during mammography.

When looking at the overall correlation between CBT and ESE in the MLO projection, the relationship becomes stronger, with a correlation coefficient of 0.654. This indicates a strong positive correlation, suggesting that breast thickness has an even greater impact on radiation dose in the MLO projection. The p-value remains at 0.0001 which confirms the high statistical significance of this correlation.

Table 3. Correlation between compressed breast tissue and radiation doses. (*Correlation is significant at the 0.05 level, **Correlation is highly significant at the 0.01 level).

Radiation doses		CBT For CC	CBT For MLO
ESE For CC	R	0.401**	0.337**
	P	0.0001	0.0001
ESE For MLO	R	0.305**	0.654**
	P	0.0001	0.0001

Discussion

Our study shows that the majority of women visiting Al-Alwiya Hospital are aged 50–59 years (44%), followed by those aged 40–49 years (38%), with the lowest percentage in the 30–39 years group (18%). This suggests that older women seek medical care more frequently, likely due to age-related health issues or routine check-ups (19). The current study reveals that breast compression thickness is slightly higher in the MLO view compared to the CC view. Measurements are consistent between right and left breasts, with ranges of 30–77 mm (CC) and 33–89 mm (MLO). This ensures reliable imaging for both views. MLO view has been reported to have a higher radiation exposure than the CC view, with consistent values between right and left breasts. Mean ESE ranges from 12.91 mGy (CC) to 15.38 mGy (MLO). The study results revealed a positive correlation between radiation doses (ESE) and mammography techniques (CBT) in both CC and MLO positions, with a highly significant statistical level of 0.01. In the CC position, the correlation coefficient ® was 0.401, indicating a moderate positive correlation. This can be explained by the fact that increased breast tissue density or thickness in this position requires higher radiation doses to achieve diagnostic image quality. In the MLO position, the correlation coefficient was 0.337, reflecting a mild to moderate positive correlation. This is because the MLO position captures more glandular tissue (20, 21), resulting in higher radiation exposure; however, the correlation is lower than in the CC position due to differences in imaging angles and tissue distribution**.**

The highest correlation was observed between radiation doses and the MLO position, with an R value of 0.654. This can be attributed to the broader tissue area covered in this position, requiring higher radiation doses for effective penetration. These findings are attributed to several factors, including the differences in tissue density, breast thickness, and imaging angles. Additionally, the quality and calibration of imaging devices directly influence the radiation required dose. A comparison of the Entrance Surface Exposure (ESE) values in mammography between this study and a Sudanese study revealed significantly lower ESE values in this study across all views (RCC, RMLO, LCC, LMLO) compared to the Sudanese study (18). This difference could be attributed to advancements in mammography technology (10), stricter radiation safety protocols, and differences in patient characteristics. The lower ESE enhances patient safety by minimizing radiation exposure while maintaining diagnostic quality. However, this result does not align with the study conducted by Myug-Su Ko et al in 2013, where the mean of ESE was 5.98 ± 1.22, which is significantly lower than our findings. This discrepancy could be explained by the fact that the device used in their study has a higher level of safety compared to the one used in our study.

Conclusions

The study found that most patients involved here were within the age range of 50–59 years. Breast compression thickness and radiation exposure were higher in the MLO view, with a positive correlation between thickness and dose. The ESE values were significantly lower, which indicates that the mammography device used in this study is very advanced.

Recommendations

It is recommended to increase the number of patients to obtain accurate results and incorporate additional studies to compare the Entrance Skin Exposure (ESE) of mammography devices in other countries with those in Iraq, thereby ensuring greater accuracy and reliability of the results.

Source of funding: No source of funding.

Ethical considerations: The study received ethical approval from the University of Baghdad, College of Medicine, in partnership with the Ministry of Health (specifically, the outpatient Al-Alwiya Teaching Hospital), number 495 on 2/4/2024.

Conflict of interest: None.

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العلاقة بين تعرض سطح الجلد للإشعاع لدى النساء العراقيات وسُمك الثدي المضغوط في التصوير الشعاعي للثدي

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الملخص

الخلفية: يجرى تقييم سُمك الثدي المضغوط (**CBT**) بشكل أساسي من خلال فحوصات الماموغرافي. وعلى الرغم من التأكيد العلمي على أن الضغط على الثدي يؤثر بشكل ملحوظ على خصائص أنسجة الثدي، إلا أن التأثير المحدد لهذا الضغط على منطقة الإبط لا يزال غير واضح. إذ قد يؤدي زيادة الضغط إلى تقليل سُمك أنسجة الثدي، مما يؤثر بدوره على جودة التصوير ومعايير التعرض للإشعاع.

الأهداف: تهدف هذه الدراسة إلى تحديد العلاقة بين التعرض السطحي للجلد (**ESE**) وسُمك الثدي المضغوط (**CBT**) لدى النساء العراقيات، بالإضافة إلى مقارنة المتوسط الحسابي لقيم التعرض السطحي للجلد الناتجة عن فحوصات التصوير الشعاعي للثدي في العراق بقيم وردت في الدراسات الأخرى.

المرضى والطرق: أُجريت دراسة مقطعية في مستشفى التعليمي "العلوية" خلال الفترة من ديسمبر ٢٠٢٣ إلى يناير ٢٠٢٤، وشارك فيها ١٠٠ امرأة عراقية. تم إجراء فحوصات الماموغرافي باستخدام جهاز من طراز GE Healthcare، مع استخدام كل من الإسقاطات الأمامية-الخلفية (CC) والجانبية المائلة (MLO) لتقييم سُمك الثدي المضغوط والتعرض السطحي للجلد.

النتائج: أظهرت النتائج وجود علاقة إيجابية ذات دلالة إحصائية بين التعرض السطحي للجلد (ESE) وسُمك الثدي المضغوط (CBT). وبشكل محدد، لوحظ أن زيادة سُمك الثدي المضغوط كانت مرتبطة بارتفاع قيم التعرض السطحي للجلد. علاوة على ذلك، كان متوسط قيم التعرض السطحي للجلد المسجلة في هذه الدراسة أقل بكثير مقارنةً بالمتوسط الحسابي للقيم المُبلغ عنها في دراسات مماثلة أُجريت في السودان.

الاستنتاج: تُظهر الدراسة أن سُمك الثدي المضغوط والتعرض للإشعاع يكونان أعلى بشكل ملحوظ في الإسقاط الجانبي المائل (MLO) مقارنةً بالإسقاط الأمامي-الخلفي (CC). كما تم رصد علاقة إيجابية قوية بين سُمك الثدي المضغوط وجرعة الإشعاع. بالإضافة إلى ذلك، كانت قيم التعرض السطحي للجلد في هذه الدراسة أقل بكثير من تلك التي وُجدت في الدراسات المماثلة في السودان. وتؤكد هذه النتائج على ضرورة اعتماد إرشادات ومعايير إقليمية خاصة في ممارسات الماموغرافي لضمان توفير الرعاية المثلى للمرضى وسلامتهم.

الكلمات المفتاحية: منطقة الإبط، نسيج الثدي، التعرض السطحي للجلد (**ESE**)، التصوير الشعاعي للثدي، سُمك الثدي المضغوط.

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