

Original article

Evaluating the Role of Breast Ultrasound and Mammography in Early Detection of Breast Cancer at the National Cancer Institute in Misurata, Libya

Mona Gerriow¹, Mohamed Ben Taher^{2,3*}, Shaima Bensasi⁴, Esra Obeid³, Eman Ghabag⁴, Mohamed Almajdub²

¹Department of Medical Physics, Faculty of Science, Libyan Academy – Misurata Branch, Misurata, Libya

²Department of Radiology, Faculty of Medical Technology, Misrata University, Misurata, Libya

³Department of Radiology, National Cancer Institute of Misurata, Misurata, Libya

⁴Department of Radiology, Faculty of Medicine, Misrata University, Misurata, Libya

Corresponding email. mohamed.bentaher@academy.edu.ly

Abstract

Breast cancer is one of the biggest health dilemmas worldwide and remains a leading cause of death among women, particularly when diagnosed at advanced stages. Consequently, early and accurate detection is a cornerstone in improving survival rates and ensuring the effectiveness of therapeutic interventions. Mammography is globally recognized as the primary screening tool for the early detection of breast cancer due to its ability to identify subtle tissue changes. However, its diagnostic accuracy is significantly compromised in women with dense breast tissue, which reduces sensitivity and increases the likelihood of missed lesions. In such contexts, ultrasound emerges as an essential complementary modality that enhances the overall diagnostic performance. This study aimed to compare the diagnostic accuracy of ultrasound and mammography in detecting abnormal breast masses in Misurata, Libya. A retrospective cross-sectional study of 100 women with an average age of 50 years (range: 15–95) who underwent both ultrasound and mammography in 2024. Mammography served as a provisional reference standard because histopathological confirmation was not available for all cases. ROC curves and Chi-square, Cochran, and Mantel-Haenszel tests with the significance level set at 0.05 ($\alpha=0.05$) were used to assess diagnostic performance. Ultrasound showed excellent diagnostic accuracy with AUC = 0.916 (Right breast) and 0.960 (Left breast). Sensitivity was 90.9% (Right breast) and 100% (Left breast), while specificity was 92.3% and 92%, respectively. No significant differences were found between ultrasound and mammography ($p > 0.05$). Ultrasound demonstrates high diagnostic accuracy comparable to mammography, particularly in dense breasts. In resource-limited settings, the combined use of ultrasound and mammography is recommended to optimize detection.

Keywords: Breast Cancer, Diagnostic Accuracy, Mammography, Ultrasound, Breast Density.

Introduction

Cancer is one of the most serious global health challenges, which might lead to mortality rates and impose a substantial economic burden on healthcare systems worldwide. Breast cancer is the most common malignancy that can affect in woman's life. Breast cancer arises from the uncontrolled proliferation of breast tissue cells, leading to the formation of tumors or lesions. While many of these lesions are benign, their presence elevates the likelihood of developing breast cancer, thereby representing a persistent threat to women's health and quality of life [1,2]. According to Boder et al. (2011), a study of 234 breast cancer patients in Libya (2002–2006) stated that the incidence rate was 18.9 cases per 100,000 women. The mean age at diagnosis was 46 years, and most patients were discovered at late stages of the disease [3].

The knowledge of self-examination and breast cancer awareness will be important to detect and reduce breast cancer mortality. Furthermore, according to a study by Ben Taher et al. (2024) conducted in Misurata, breast cancer awareness among Libyan women remains remarkably low. The results showed that only 14.8% of participants performed regular monthly breast self-examinations, while the vast majority (85%) never or rarely performed this examination. The study also showed that 92% of women had very poor knowledge about mammography, reflecting a clear gap in awareness of the importance of early screening. The researchers concluded that this lack of knowledge and practice represents a major barrier to early diagnosis, emphasizing the urgent need for awareness and educational programs to promote early screening among women in Libya [4].

Mammography is considered the ideal method for discovering breast cancer, due to its efficiency in accurately showing lesions and calcifications. However, mammography is inaccurate in diagnosing women with high-density breasts, which reduces the device's sensitivity in these cases [2]. To compensate for these limitations, ultrasound has been presented as a valuable complementary diagnostic method. Ultrasound imaging is a non-ionizing form of radiation, relatively inexpensive, and widely available. Ultrasound offers real-time imaging capability, enabling the assessment of breast lesions with greater clarity in dense breast tissue. Several studies indicate that the combination of mammography and ultrasound increases diagnostic sensitivity, improves overall accuracy, and minimizes diagnostic uncertainty. This combination of these methods has been shown to reduce the

number of false-negative results, thereby ensuring that more cases are identified at earlier and more treatable stages [5,6]. The global diversity in genetic predisposition, environmental exposures, and healthcare resources makes it clear that a consistent diagnostic strategy cannot be universally applied to identify breast tumors. International health organizations and professional societies have stated the importance of tailoring screening protocols to the specific needs of each community. Designing diagnostic programs that account for differences in breast tissue density, resource availability, and healthcare infrastructure is vital for improving outcomes.

In the Libyan community, and especially in Misurata, there is a pressing need to evaluate the effectiveness of current protocols and adapt them to local realities. This procedure is critical not only for improving survival rates but also for optimizing the limited healthcare resources available [2][7][8]. The meta-analysis research, which included 26 studies from both middle - and low-income countries, found that handheld ultrasound demonstrated sensitivity and specificity of 80.1% and 88.4%, respectively. On the other hand, when in Low- and Middle-Income Countries data was analyzed, ultrasound achieves a diagnostic sensitivity of 89.2% and specificity of 99.1%, supporting its role as an effective detection tool in low-resource settings where mammography is limited [6]. This study aimed to evaluate the quality and reliability of breast cancer detection by using Ultrasound and Mammography.

Methods

Sample Description

The initial sample for this retrospective study comprised 158 cases, collected from patient files and imaging reports at the National Cancer Institute in Misurata during 2024. Following a thorough review, 58 cases were excluded due to the use of only a single imaging modality—either mammography or ultrasound—which rendered them unsuitable for comparative analysis. Specifically, 35 cases had been assessed by Observer 2 using ultrasound only, 18 cases by Observer 1 using ultrasound only, and 5 cases by Observer 1 using mammography only. The final study sample therefore, included 100 cases with complete data, in which both imaging modalities—mammography and ultrasound—were available, along with diagnostic assessments from the observers. These cases were distributed among the three observers as follows: Observer 1 evaluated 72 cases (72%), Observer 2 evaluated 16 cases (16%), and Observer 3 evaluated 12 cases (12%).

Participants ranged in age from 15 to 95 years. All underwent digital mammography (Siemens Mammomat Inspiration) and ultrasound imaging (GE LOGIQ P9, 7.5–12 MHz). Mammography was used as the reference standard. Statistical analyses included the Chi-square test, Cochran's Q test, Mantel-Haenszel test, and ROC curve analysis, conducted using SPSS version 21. A significance level of $p \leq 0.05$ was applied. Ethical approval was obtained from both the attending physicians and the administration of the National Cancer Institute in Misurata.

Statistical analysis

Descriptive statistics were used to summaries and display respondent's demographics, and comparison diagnostic between Ultrasound and Mammography were made by chi-squared test to find out whether a difference between categorical variables is due to change or a relationship between them and ROC curve analysis using the Statistical Package for the Social Sciences (SPSS), version (21) Significance was set at $p \leq 0.05$.

Results

To assess the diagnostic accuracy of ultrasound in comparison with mammography, Receiver Operating Characteristic (ROC) analysis was conducted. The results demonstrated excellent performance of ultrasound across both breast sides. For the right breast ($n = 100$; disease prevalence = 22%), the ROC analysis yielded an Area Under the Curve (AUC) of 0.916, indicating very high diagnostic accuracy. The 95% Confidence Interval (CI) ranged from 0.844 to 0.962, with a statistically significant result ($p < 0.0001$). The Youden index was 0.832 at the optimal criterion (> 0), corresponding to a sensitivity of 90.91% and specificity of 92.31%. For the left breast ($n = 98$; disease prevalence = 23.5%), the AUC was even higher at 0.960, reflecting excellent accuracy. The 95% CI ranged from 0.900 to 0.989, also statistically significant ($p < 0.0001$). The Youden index reached 0.920 at criterion > 0 , with sensitivity of 100% and specificity of 92%. These findings, illustrated in Figures 1 and 2, confirm the robustness of ultrasound as a diagnostic tool, particularly when evaluated against mammography as the reference standard.

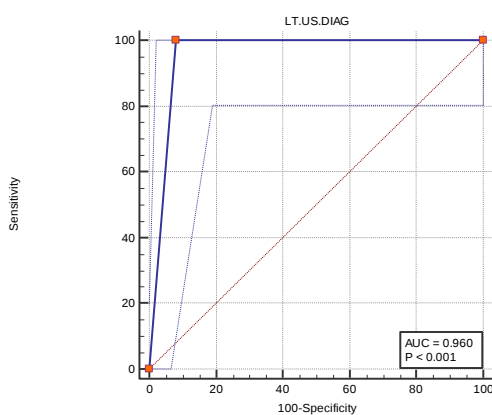


Figure 1: ROC curve for left breast (AUC = 0.960)

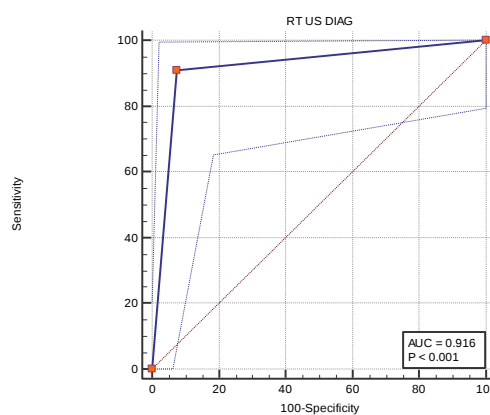


Figure 2: ROC curve for right breast (AUC = 0.916)

The characteristics of the study sample in terms of density are shown in Table 1.

Table 1. The characteristics of the study sample (density).

Variable	Code	Levels	Frequency	Percent
Density	1	A	16	16.0
	2	B	43	43.0
	3	C	23	23.0
	4	D	13	13.0
Total			100	100.0%

To determine the extent to which density affects the performance of the ultrasound device, the sample was divided according to density, and the sensitivity and specificity of the ultrasound were calculated. The findings are shown in (Tables 2 and 3), Ultrasound has proven highly effective in both aspects, especially in the left breast (AUC≈0.96) and with densities B and C, with sensitivity often 100% and specificity 89–100%. This supports its use as a powerful complementary tool, especially with dense breasts.

Table 2: Ultrasound vs Mammography to detect the different tissue density of the right breast

Density	NO	Prevalence (%)	AUC	Youden Index	Sensitivity (%)	Specificity (%)	Conclusion
A	16	37.5	0.817	0.633	83.33	80.00	Good performance and clinically useful
B	43	23.3	0.950	0.900	90.00	100.00	Excellent accuracy; near-complete exclusion of false positives
C	23	17.4	0.921	0.842	100.00	84.21	Excellent sensitivity; slight reduction in specificity

Table 3: Ultrasound vs Mammography to detect the different tissue density of the left breast.

Density	NO	Prevalence (%)	AUC	Youden Index	Sensitivity (%)	Specificity (%)	Conclusion
A	16	25.0	0.958	0.917	100.00	91.67	Near-perfect performance
B	41	26.8	0.950	0.900	100.00	90.00	Very high accuracy; good balance
C	23	17.4	0.947	0.895	100.00	89.47	Complete sensitivity with high specificity

To evaluate the agreement between Ultrasound and Mammography, this study was conducted. Statistical tests (Chi-square, Mantel-Haenszel, and Cochran's Q) showed no significant differences between ultrasound and mammography results ($p > 0.05$). This study indicates a high level of agreement between the two modalities, confirming their comparable diagnostic value as demonstrated in Tables 4&6.

Table 4. Crosstab of the Chi-square test comparing Mammogram and Ultrasound (Left breast)

Method	Left breast						Total	Chi-Square	P-Value
	Normal	Benign	Likely benign	Likely malignant	Malignant	Missing			

Mammography	39	16	18	12	11	4	100	1.464	0.962
Ultrasound	33	17	17	17	12	4	100		
Total	72	33	35	29	23	8	200		

Table 5. Crosstab of the Chi-squared test comparing mammogram and ultrasound (Right breast)

Right breast								Chi-Square	P-value
Method RT	Missing	Normal	Benign	Mostly benign	Mostly malignant	Malignant	Total		
Mammography	4	46	11	17	6	16	100	9.003	0.109
Ultrasound	4	37	16	18	13	12	100		
Total	8	83	27	35	19	28	200		

Table 6. Tests of Conditional Independence

Tests of Conditional Independence	Chi-Squared	Different	P-value
Cochran's Left	0.000	1	1.000
Mantel-Haenszel Left	0.000	1	1.000
Cochran's Right	0.439	1	0.508
Mantel-Haenszel Right	0.245	1	0.620

Discussion

In recent years, Ultrasound has provided images of high quality, and it has become more desirable. Various studies conclude that using US as screening may detect suspicious breast tumors missed by mammography. Moreover, it can provide a higher discovery rate and high-level sensitivity for breast cancer [9][10]. A greater number of patients in the study done in Nigeria underwent mammography on account of several breast-related complaints, rather than routine screening for breast cancer. Therefore, there is a need for increased awareness of screening mammography among women in resource-constrained settings [11]. This study aimed to compare the diagnostic accuracy of mammography and ultrasound in detecting abnormal breast masses at the National Cancer Institute in Misurata. Mammography, when interpreted using the BI-RADS system, can serve as a reliable provisional reference standard in resource-limited settings such as Misurata, particularly in the absence of biopsy for all cases. This finding is consistent with the [12][13]. Moreover, ROC-curve analyses in this study demonstrated excellent accuracy of ultrasound (AUC ~0.91–0.96), confirming its strong diagnostic value. Comparable improvements in cancer detection when adding ultrasound to mammography, particularly in dense breasts, are consistent with the systematic review by Sood et al., which confirmed the high diagnostic accuracy of ultrasound and its complementary role to mammography, particularly in dense breasts [13].

Regarding breast density, previous studies have consistently shown that mammographic sensitivity decreases as density increases, while ultrasound maintains its diagnostic efficiency (Wang et al, Boyd, M.D.SC. Devoli-Desha, et al). This study supports these observations: ultrasound maintained high sensitivity (up to 100%) and strong specificity across density levels. This reinforces international recommendations that ultrasound should be incorporated as an adjunct, especially in young women and patients with dense breast tissue [8][14][15]. The results of the current study demonstrated that ultrasound achieved a sensitivity of 90.9% in the right breast and 100% in the left breast, with a corresponding specificity of 92.3% and 92%, respectively. These results are highly comparable to those reported by Ohuchi et al. in Japan, where sensitivity reached 91.1% and specificity 87.7%. Similarly, our results align with the study of Kelly et al. (2010) in the United States, which reported a sensitivity of 81% and a higher specificity of 98.7% for combined mammography/Automated Whole-Breast Ultrasound (AWBU). The outcomes are also consistent with Choi et al. (2021) from South Korea, who reported a sensitivity of 83.3% and specificity of 90.7%. On the other hand, studies such as Brem et al. (2015), Wilczek et al. (2016) emphasized increased cancer detection rates with adjunct ultrasound, although precise sensitivity and specificity values were not always available. Taken together, these comparisons indicate that the present study corroborates the global evidence supporting ultrasound as a reliable diagnostic tool alongside mammography, particularly in resource-limited settings [16–21]. This study was analyzed per-lesion, which demonstrated high agreement between ultrasound and mammography. Whereas the referenced meta-analysis, which contains Comprehensive searches conducted in PubMed, Scopus, and Embase from 2008 to 2021, showed that an ultrasound was more accurate at the lesion level [22].

The findings of this study are particularly important in the Libyan context, where breast cancer is the most common malignancy among women, with low awareness of early screening and limited healthcare resources [4]. Demonstrating the effectiveness of ultrasound alongside mammography provides a practical approach to improving early detection, especially in women with dense breast tissue. This study. Therefore, helps fill a local knowledge gap and offers applicable solutions in resource-limited settings.

Limitations

This study has several limitations that should be acknowledged. One major limitation of this study is the absence of histopathological confirmation for all detected lesions. While mammography was used as a provisional reference standard, this approach is less robust compared to biopsy, which is universally regarded as the diagnostic gold standard for breast cancer. Relying on mammography alone may introduce misclassification bias, as certain lesions could be falsely categorized, thereby affecting the accuracy estimates of ultrasound. Consequently, the diagnostic performance reported in this study should be interpreted with caution. Future research should incorporate histopathological verification of findings to provide stronger and more definitive evidence of diagnostic accuracy. Breast density was assessed by a single radiologist, which could introduce observer bias, even though international guidelines were followed to minimize subjectivity. The study was conducted on a relatively small sample size from a single institution, which may limit the generalizability of the findings. Ultrasound is inherently operator-dependent, and slight variations in technique may affect detection rates despite efforts to standardize protocols. The number of cases with extremely dense breasts (category D) was very small, which prevented us from conducting a reliable statistical analysis for this subgroup.

Conclusion

This study concluded that an Ultrasound is highly accurate in detecting abnormal breast masses and is comparable to mammography. Combined use of both modalities is recommended, particularly in dense breasts and in low-resource environments. Future studies should include biopsy confirmation to strengthen diagnostic reliability.

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