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Original Article

Sonomammograhy versus MRI diffusion in evaluation of suspicious breast lesions

Radiology

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ABSTRACT

Background: Breast cancer is the most frequent cancer in women and the second leading cause of death among them. Breast lesions were first categorized as benign or cancerous.

Objective: was to highlight the role of noninvasive diagnostic breast modalities including mammography, ultrasound, conventional MRI and MRI diffusion imaging in detection and characterization of suspicious breast lesions.

Methodology: It was a hospital based cross sectional study done on total number of 50 female patients presented by breast lump or nipple discharge, some of them were referred from surgical department and others from out-patient clinic to the radiology department at Met Ghamr oncology center, after receiving clearance from the institute's ethical council, the study was carried out for two years, from June 2019 to August 2021. Before being included in the trial, all patients provided informed permission. They were subjected for imaging by digital mammography, ultrasonography and MRI mammography.

Results: The study revealed that in the evaluation and description of worrisome breast lesions, MRI mammography plays a leading role over digital mammography and ultrasonography.

Conclusion: MRI mammography outperformed digital mammography and ultrasonography regarding of sensitivity, specificity, and diagnostic performance.

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Key words: Digital mammography (DM), Ultrasonography, MRI mammography, speculated mass, restricted diffusion

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INTRODUCTION

Breast cancer (BC) is the most frequent female malignancy, reaching 22.9 percent of all female malignancies globally and 37.7 percent in Egypt [1]. Screening mammography for all women starting over at 40 years old is likely to maximize the number of lives saved [2].Mammography is exceptionally sensitive in identifying micro calcifications; mammography's sensitivity in diagnosing the disease and early cancer associated to micro calcifications was 80.5 percent, but its specificity was only 61.5 percent [3]. Ultrasound is used to evaluate breast abnormalities found by screening mammography. Ultrasonography is also advised as an additional tool in women who have had mammography screening, as well as in women with thick breasts who do not satisfy the requirements for MRI as a screening modality [4]. Breast imaging may be made more sensitive by combining it with magnetic resonance imaging (MRI), which is particularly useful when the status of a breast lesion is uncertain [5]. In some cases, (MRI) may be extremely beneficial. Patients at high risk, particularly those with thick breast tissue, fall into this category. Dense breast tissue in young women might produce ambiguous signals of malignancy on mammography, making it difficult to determine the exact degree of the disease [6]. Kinetic enhancement analysis, in addition to physical parameters of the lesion such as form, edges, and internal architecture, can be utilized to differentiate among benign and malignant lesions. Diffusion-weighted imaging (DWI), on the other hand, gives valuable qualitative and quantitative data concerning structural tissue changes at the cell level, which benefits distinguish between among and malignant lesions [7]. The visual contrast obtained by (DWI) is owing to differences in water molecule mobility between tissues, which is reliant on tissue cellularity and the presence of intact cell membranes [8]. The apparent diffusion coefficient (ADC), which is a quantitative metric that is directly proportional to the water diffusion coefficient, may be determined using the (DWI) procedure [9]. The aim of this study was to highlight the role of noninvasive diagnostic breast modalities including mammography, ultrasound, conventional MRI and MRI diffusion imaging in detection and characterization of suspicious breast lesions.

PATIENTS AND METHODS

Study design

This hospital based cross sectional study was performed on 50 female patients with suspicious breast lesions. They were referred from surgical department and from out-patient clinic to radio-diagnosis and imaging department at Met Ghamr oncology center from June 2019 to August 2021. All patients were subjected to brief history taking including personal history (age and family history), and presenting complain (breast lump, nipple discharge, skin changes).The study was approved by Al-Azhar University's ethics board.

Inclusion criteria

Female patients with ages ranged from 24-80 years with family history or history of previous lesion, palpable new lesions, asymmetry between the two breasts or skin changes were included into the study.

Exclusion criteria

Patients who were unwilling to complete the study and any female incompatible with MRI.

Methodology

After giving written informed consents, the following procedures were performed to all studied patients: complete history taking, full clinical examination, measuring tumor markers, digital mammography, breast ultrasonography and MRI mammography.

1. **Mammography:** was done for detection of micro calcification, architectural distortion and asymmetry in breast density.
2. **Ultrasonography:** all cases were done for detection of benign and malignant criteria and classification of the breast lesions as in (BIRADS) classification.
3. **Magnetic Resonance Mammography:** a dedicated double breast coil. Patients were placed in the prone position. The MR protocol applied in this study is:
   - Axial T1W and T2WIs.
   - Axial T2 fat suppressed, STIR (Short Tau Inversion Recovery).
   - Diffusion weighted imaging: In the case of ADC value assessment, ADC values of the lesion were determined by manually creating regions of interest (ROIs) within the selected lesions on ADC maps; we utilized an ADC ROI of 25 mm^2.
   - Dynamic post-contrast MRI: for quantitative measurements of signal intensity changes.

The lesions were evaluated as follow: Site of the lesion (upper outer, upper inner, lower outer or lower inner quadrants, retroareolar or axillary), regular or irregular outlines, the borders were described as circumscribed, non-circumscribed, the lesions were classified as size, shape, multiplicity, calcifications, architectural distortion. Skin thickening and nipple retraction were also reported, lymph node abnormalities were reported.

Statistical analysis

The data was gathered and entered into Excel sheet. Then it was statistically analyzed using SPSS version 21. Results were expressed as frequencies (50 cases) and percentages. Grading changes between benign and malignant lesions and comparison between categorical data were performed using Chi-square or Fisher's exact test. Standard diagnostic including sensitivity, specificity, PPV and NPV were calculated. Fisher Exact test (FE) is a statistical test used to determine if the proportions of categories in two group variables significantly differ from each other. Monte Carlo Exact test *MC) allows to estimate exact significance without relying on the assumptions required for the asymptotic method.

RESULTS

This study included 50 female patients. Digital mammography, ultrasonography and magnetic resonance mammography were performed. Patients were either had different breast complaints. The mean age of the studied patients was 46 ±11 years and ranged between 24 to 80 years old. 16 patients (32.0%) underwent previous surgery (lumpectomy in 13 cases and mastectomy in 3 cases), Among the 50 studied patients; 75 lesions were detected, out of them 63 lesion were proven to be malignant and 12 lesions were proven to be non-malignant. About one-quarter showed lymph node spread (28.0%).Based on BIRADS classification, mammography showed 78.9% sensitivity, 33.3% specificity, 78.9% PPV, and 33.3% NPV. Ultrasonography showed 94.7% sensitivity, 25% specificity, 76.4% PPV, and 64.8% NPV. MRI showed 97.4% sensitivity, 91.7% specificity, 97.4% PPV, and 91.7% NPV (table 1).

Thirty-four lesions (45.3%) showed the same BIRAD classification on both sonomammography and MRI mammography. 29 lesions (38.7%) showed higher BIRADS classification on MRI mammography than that of sonomammography. In contrast, 12 lesions (16.0%) showed lower BIRADS classification on MRI mammography than that of sonomammography (table 2 and 3).

In our study 65 lesions (86.7 %) showed restricted diffusion, only 63 were proved to be malignant by histopathology, while the other two lesions were proved to be adenoma and a hemorrhagic cyst. Out of the 75 lesions, 10 lesions (13.3 %) showed no diffusion restriction and all proved to be non-malignant (table 4).

ROC analysis was performed for ADC in diagnosing malignant lesions. It showed an excellent AUC of 0.923 with a 95% confidence interval ranged from 0.779 to 1. The best cut-off point was ≤ 1.024, at which sensitivity, specificity, PPV, and NPV were 100%, 91.7%, 97.4%, and 100%, respectively (table 5 and figure 1).Speculated mass, distortion and suspicious calcification showed a sensitivity of (44.4%, 39.7%, 93.7%), specificity of (100%, 25%, 50%), PPV of (100%, 73.5%, 80.6%) and NPV of (25.5%,7.3%,78.2%) respectively (table 6).

Table (1): Diagnostic performance of mammography, ultrasonography, and MRI mammography, based on BIRAD

Item	Sensitivity	Specificity	PPV	NPV	Accuracy
Mammography	78.9%	33.3%	78.9%	33.3%	68%
Ultrasonography	94.7%	25%	76.4%	64.8%	78%
MRI mammography	97.4%	91.7%	97.4%	91.7%	96.2%

BIRADS: breast imaging reposting and data system

Table (2): Grading changes between benign and malignant lesions

Grading	Lesions		Total (n=75)
	Malignant (n=63)	Benign (n=12)	
	n (%)	n (%)	n (%)
Same	34 (54.0)	0 (0.0)	34 (45.3)
Downgrade	0 (0.0)	12 (100.0)	12 (16.0)
Upgrade	29 (46.0)	0 (0.00)	29 (38.7)
MC(= 75.000			

*: Significant p value (p < 0.05).

Table (3): BIRADS upgrade and downgrade change details compared to final histopathology diagnosis

	No. of lesions	BIRADS by Sonomammograhy		BIRADS by MRI mammography		Histopathology	n (%)
Downgrade	**12**	**BIRADS**	**no. (%)**	**BIRADS**	**no. (%)**	Fat necrosis Hemorrhagic Granulation tissue Sclerosed fibrosis Adenoma	4 (33.4%) 2 (16.6%) 3 (25 %) 1 (8.4 %) 2 (16.6%)
		BIRADS IVa BIRADS IVb	8 (66.6%) 4 (33.4%)	BIRADS II BIRADS III	2 (16.6%) 10 (83.4%)		
Upgrade	**29**	**BIRADS**	**n (%)**	**BIRADS**	**n (%)**	IDC IDC + DCIS Adenocarcinoma Atypical lymphoid proliferation	23 (79.3%) 2 (6.9%) 3 (10.3%) 1 (3.5 %)
		BIRADS IVb BIRADS IVc	11 (38%) 18 (62%)	BIRADS IVc BIRADS V	9 (31%) 20 (69%)		
		MC = 84.872 p 0.001*		MC = 76.352 p 0.001*		MC = 95.969 p 0.001*	

BIRADS: breast imaging reposting and data system, IDC: invasive ductal carcinoma, DCIS: ductal carcinoma in situ, *: Significant p value (p < 0.05).

Table (4): MRI diffusion between benign and malignant lesions

MRI	Lesions		Total (n=75)
	Malignant (n=63)	Benign (n=12)	
	n (%)	n (%)	n (%)
Restricted	63 (100.0)	2 (16.7)	65 (86.7)
Facilitated	0 (0.0)	10 (83.3	(10) (13.3)
FE = 60.577			

*: Significant p value (p < 0.05)

Table(5): ROC analysis of ADC in diagnosing malignant lesions

ROC characteristics	
AUC (95%CI)	0.923(0.779-1)
Best cut-off	≤ 1.024
Sensitivity	98.4%
Specificity	91.7%
PPV	97.4%
NPV	91.3%
p-value	0.001*

ADC: Apparent Diffusion Coefficient, AUC: area under curve, PPV: positive predictive value, NPV: negative predictive value, *: Significant p value (p < 0.05).

Solid consistency, architectural distortion, hypo-echogenicity, non-parallel orientation and internal vascularity showed a sensitivity of (81%, 12.7%, 93.7%, 90.5%, 39.7%), specificity of (75%, 66.7%, 41.7%, 50%, 75%), PPV of (94.4%, 66.7%, 89.4%, 90.5%, 89.3%) and NPV of (42.9%, 12.7%, 55.6%, 50%, 19.1%) respectively (table 7).Low T1, T2, high STIR and restricted diffusion showed a sensitivity of (88.9%, 84.1%, 79.4%, 100%), specificity of (75%, 83.3%, 58.3%, 83.3%), PPV of (94.4%, 96.4%, 90.9%, 96.9%) and NPV of (56.3%, 50%, 35%, 100%) (table 8).

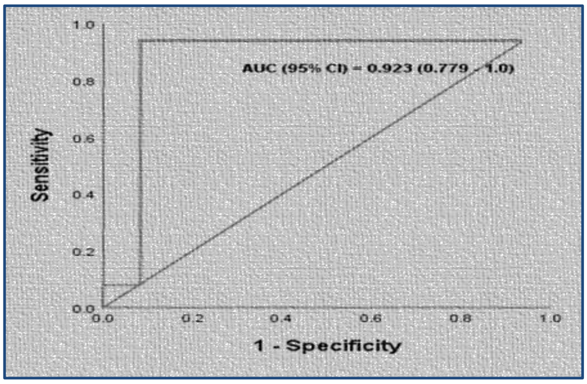

Figure (1): ROC analysis of ADC in diagnosing malignant lesions

Table (6) Diagnostic performance of mammography in detecting malignant lesions:

Types of malignant lesions	Sensitivity	Specificity	PPV	NPV
Speculated mass	44.4%	100.0%	100.0%	25.5%
Distortion	39.7%	25.0%	73.5%	7.3%
Suspicious calcification	93.7%	50%	80.6%	78.2%

PPV: positive predictive value, NPV: negative predictive value

Table (7): Diagnostic performance of sonography in detecting malignant lesions

Types of malignant lesions	Diagnostic accuracy				p value
	Sensitivity	Specificity	PPV	NPV	
Solid lesion	81.0%	75.0%	94.4%	42.9%	0.001*
Architectural distortion	12.7%	66.7%	66.7%	12.7%	0.074
Hypo-echogenicity	93.7%	41.7%	89.4%	55.6%	0.001*
Non-parallel orientation	90.5%	50.0%	90.5%	50.0%	0.001*
Internal vascularity	39.7%	75.0%	89.3%	19.1%	0.335

PPV: positive predictive value, NPV: negative predictive value, *: Significant p value ($p < 0.05$).

Table (8): Diagnostic performance of MRI in detecting malignant lesions

MRI	Diagnostic accuracy				p value
	Sensitivity	Specificity	PPV	NPV	
Low T1	88.9%	75.0%	94.4%	56.3%	0.001*
Low T2	84.1%	83.3%	96.4%	50.0%	0.001*
High STIR	79.4%	58.3%	90.9%	35.0%	0.007*
Restricted Diffusion	100.0%	83.3%	96.9%	100.0%	0.001*

PPV: positive predictive value, NPV: negative predictive value, STIR: short-T1 inversion recovery, *: Significant p value ($p < 0.05$).

Case 1

38 year old female patient, presented with left breast lump, histopathology reveals mucinous carcinoma + DCIS.

Figure (2a) Ultrasound of the left breast shows ill-defined hypo echoic speculated mass with significant internal vascularity. **Figure (2b)** Digital mammography shows ill-defined high dense speculated mass lesion with suspicious grouped micro calcifications in left retro areolar region.

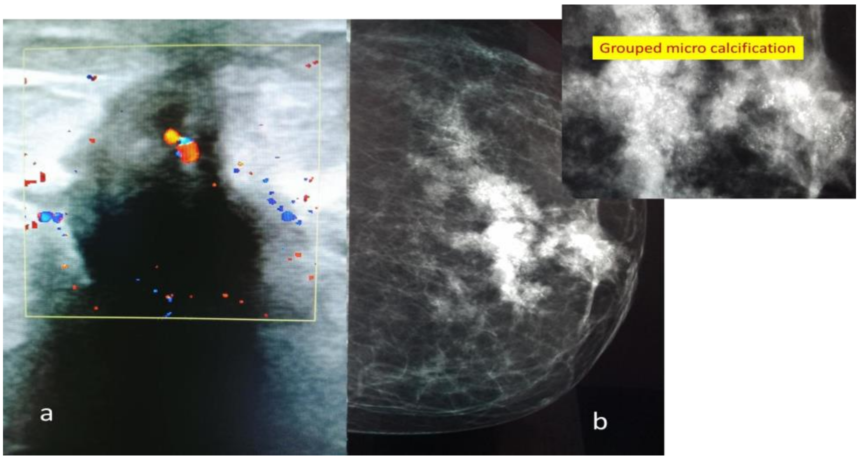

Figure (2): Case 1: (a) ultrasound of the left breast shows ill-defined hypo echoic speculated mass with significant internal vascularity, **(b)** mammography of the left breast shows ill-defined high dense speculated mass lesion with suspicious grouped micro calcifications in left retro areolar region.

Figure (3) MRI study of the left breast shows retro areolar mass of low signal intensity on T1 and intermediate signal on T2 weighted images, high signal intensity on STIR, DWI shows high signal intensity and intermediate signal intensity on ADC map with ADC value of 1.38 x10 -3 mm2 /S. MR subtraction sequence shows suspicious heterogeneously enhancing left retro areolar lesion.

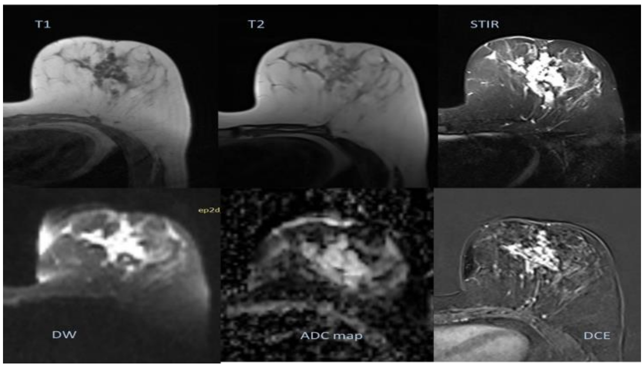

Figure (3): Case 1: MRI of the left breast shows retro areolar mass of low signal intensity on T1 and intermediate signal on T2 weighted images, high signal intensity on STIR, DWI shows high signal intensity and intermediate signal intensity on ADC map with ADC value of 1.38 x10 -3 mm2 /S. MR subtraction sequence shows suspicious heterogeneously enhancing left retro areolar lesion.

Case 2

40 years old female with right breast mass, histopathology revealed invasive ductal carcinoma with mucinous carcinoma component. **Figure (4)** Digital mammography shows heterogeneous breast density with right side ill-defined high dense lobulated mass and no micro calcification.

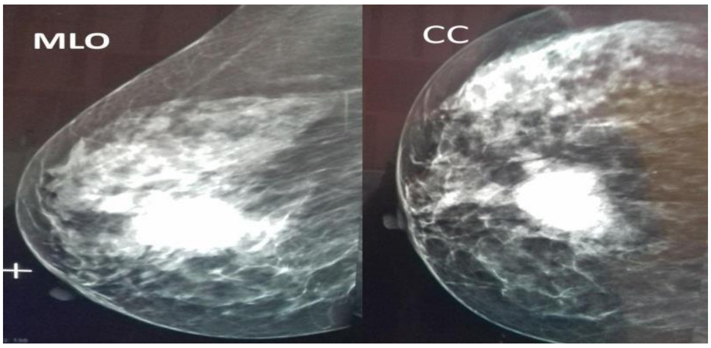

Figure (4): Case 2: mammography of the right breast including craniocaudal (CC) and mediolateral oblique (MLO) views, shows heterogeneous breast density with right side ill-defined high dense lobulated mass and no micro calcification. **Figure (5)** Ultrasound shows underlying hypo echoic lobulated mass with evidence of internal vascularity, seen opposite 12 o'clock, measuring about 4.5x4 cm.

Figure (5):case 2: Ultrasound of the right breast shows underlying hypo echoic lobulated mass with evidence of internal vascularity, seen opposite 12 o'clock, measuring about 4.5x4 cm.

Figure (6) MRI study of the right breast shows large mass seen opposite 12 o'clock of intermediate signal intensity on T1 and T2 weighted images, high signal intensity on STIR, DWI shows high signal intensity and low signal intensity on ADC map with ADC value of 1.196 mm2 /S. MR subtraction sequence shows early heterogeneous enhancement.

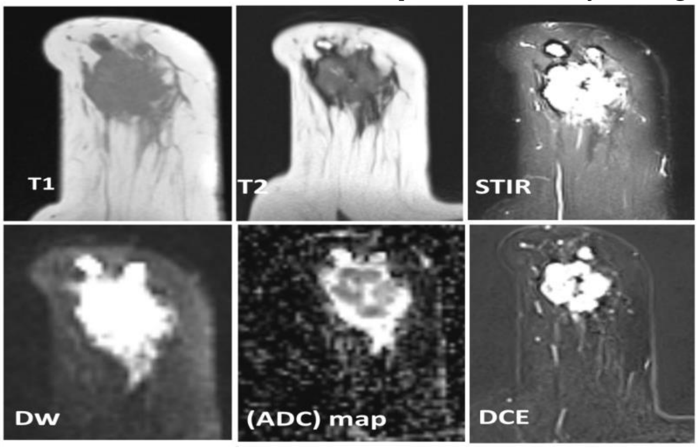

Figure (6): case 2: MRI of the right breast shows large mass seen opposite 12 o'clock of intermediate signal intensity on T1 and T2 weighted images, high signal intensity on STIR, DWI shows high signal intensity and low signal intensity on ADC map with ADC value of 1.196 mm2 /S. MR subtraction sequence shows early heterogeneous enhancement.

DISCUSSION

This study was carried out on 50 patients who have family history of breast cancer, or undergo self or clinical examination with suspicion of breast lesion; were subjected to mammography, ultrasonography and MRI mammography.

In our study the sensitivity and specificity of micro calcifications in detecting breast cancer were 93.7% and 50% respectively. According to Carney et al. [10] Mammography is extremely sensitive in detecting microcalcifications, the sensitivity of mammography in detection of cancer and early cancer related to microcalcifications was 80.5%, and specificity was only 61.5%.

In our study ultrasonography finding of speculated masses was found to be the feature with the most potential in differentiating malignant lesions from benign with sensitivity 44.4% and specificity 100.0%. As Al-Khawari et al., and Tozaki and Igarashi[11,12] showed in their studies that most malignant lesions had diffuse and irregular shape while benign lesions had round or oval shape.

One of MR mammography indications, is the differential diagnosis between cancer recurrence and surgical scar, In our study MRI showed 97.4% sensitivity, 91.7% specificity, 97.4% PPV, and 91.7% NPV. In agreement, Saif El-nasr et al.[13] reported that DCE-MRI showed 100% sensitivity, 93.9% specificity, 93.1% 'PPV', 100% 'NPV' and 96.7% accuracy in differentiating postoperative changes and related treatment changes from true recurrence.

In the present study 65 lesions showed restricted diffusion, only 63 were proved to be malignant by histopathology, while the other two lesions were proved to be adenoma and a hemorrhagic cyst. Our results match with study of Fiki et al. [14]who stated that most benign lesions show facilitated diffusion with some few exceptions as seen in the intraductal papillomas due to their high cellularity and granulomatous abscesses due to their condensed thick proteinaceous contents.

The mean ADC value was 0.972 mm^2/s. ROC analysis was performed for ADC in diagnosing malignant lesions. It showed an excellent AUC of 0.923 with a 95% confidence interval ranged from 0.779 to 1. The best cut-off point was ≤ 1.024, at which sensitivity, specificity, PPV, and NPV were 98.4%, 91.7%, 97.4%, and 91.3%, respectively. These findings agree with Hetta [15], who discovered that the optimum ADC cut-off value for distinguishing among benign and malignant lesions was 1.2 mm2/s (P <0.001), with sensitivity, specificity, PPV, NPV, and accuracy of 85, 93.33, 94.4, 82.4, and 90.3 percent, respectively.

The first exception in our study is fat necrosis and scar fibrosis which showed low ADC value (0.51 ± 0.08 × 10−3 mm2/s) and (0.557× 10−3 mm2/s) respectively mimicking recurrence and this in agreement with Gonzales [16] study which reported that fat necrosis and scar tissue can show lower ADC values. This finding mirrored that of Mansour and Behairy [17], who found that the mean ADC value of benign lesions was statistically greater than that of malignant lesions, with two exceptions: fat necrosis and fibrosis. Each has a low value (fibrosis was = 0.77 ± 0.2 × 10−3 mm2/s, and fat necrosis was = 0.56 ± 0.1 × 10−3 mm2/s).

Mucinous carcinoma of the breast, which had a substantially higher ADC than other malignant breast tumors in our sample, was the second exception (ADC = 1.38 ± 0.1 × 10−3 mm2/s).This is consistent with Hatakenaka [18], who found an inverse relationship between cellularity and ADC in lesions of several organs, especially breast cancers, implying that the mucinous carcinoma of the breast's usually low cellularity contributes to its high ADC.

CONCLUSION

MRI can be a very valuable tool in detecting undiscovered lesion by the usual mammography and ultrasonography, considering that non-enhanced MRI methods such as STIR and DWI, as well as ADC, are valuable tools for identifying and characterization of benign and malignant breast lesions.

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الملخص العربي

دور التصوير الشعاعي والموجات فوق الصوتية والتصوير بالرنين المغناطيسي المعزز بمعامل الانتشار في تقييم آفات الثدي المشبوهة

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ملخص البحث

الخلفية :سرطان الثدي هو الورم الأكثر شيوعاً في السيدات وثانى سبب رئيسي للوفاة بينهن ،حيث يتم تصنيف آفات الثدي لأول مرة على أنها حميدة أو خبيثة .

الهدف:هو معرفة دور التصوير الشعاعى والموجات فوق الصوتية والتصوير بالرنين المغناطيسي المعزز بمعامل الانتشار في تقييم آفات الثدي عند النساء.

الطرق: تم إجراء هذه الدراسة على ٥٠سيدة حيث خضعن للتصوير الشعاعي للثدي والموجات فوق الصوتية والتصوير بالرنين المغناطيسي.

النتائج: أظهرت نتائجنا ان التصوير بالرنين المغناطيسي له دور مسبق في تقييم وتوصيف آفات الثدي المشبوهة على التصوير الشعاعي للثدي والتصوير بالموجات فوق الصوتية.

الاستنتاجات: تصوير الثدي بالرنين المغناطيسي أظهر حساسية وخصوصية أعلى من التصوير الشعاعي والموجات فوق الصوتية في الكشف عن افات الثدي وتوصيفها.

الكلمات المفتاحية: التصوير الشعاعي للثدي، الموجات فوق الصوتية، الرنين المغناطيسي للثدي، الأورام المتشعبة، محدودية الانتشار.

الباحث الرئيسي:

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