Al-Azhar International Medical Journal

Volume 5 | Issue 4 Article 47

4-30-2024

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How to Cite This Article

Aun, Abdel Aziz Kamal; El deeb, Ahmed Mohammed; and Al-manhal, Basim Rikan Buhaibeh (2024) "The Diagnostic Efficacy of Shear Wave Ultrasound Versus Magnetic Resonance Imaging In Differentiating Solid Breast Masses," *Al-Azhar International Medical Journal*: Vol. 5: Iss. 4, Article 47.
DOI: https://doi.org/10.58675/2682-339X.2391

ORIGINAL ARTICLE

The Diagnostic Efficacy of Shear Wave Ultrasound Versus Magnetic Resonance Imaging In Differentiating Solid Breast Masses

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Abstract

Background: ***Carcinoma of the breast is among the most common forms of cancer observed in females across the globe. Breast cancer individuals' 5-year survival rates, as well as their quality of life, have both increased alongside the development of more refined imaging diagnostic tools in recent years.***

Aim and objectives: ***evaluation of shear wave elastography for identifying solid breast masses relative to magnetic resonance imaging for specificity, reliability & sensitivity.***

Patient and methods: ***This cross-sectional trial was performed on 103 cases with solid lesions in their breasts, which were examined in the Department for Early Breast cancer detection in AL-Yrmouk teaching hospital and maternity teaching hospital by ultrasound with shear wave elastography (SWE) and MRI from July 2020 to June 2023.***

Results: ***The diagnostic value of MRI in differentiating breast solid masses was described by the sensitivity of 91.6%, specificity of 84.4%, in addition, the accurateness of 89.3%. The negative predictive value (NPV) & positive predictive value (PPV) were 92.9% and 81.8%. The area under the curve was 75.5%, while the diagnostic value of shear wave in distinguishing breast solid masses was described by a specificity of 78.1%, sensitivity of 85.9%, & accuracy of 83.5%. The PPV was 89.7%, and NPV was 71.4%. As area under the curve was 82%.***

Conclusion: ***When it comes to the detection and evaluation of breast cancer, magnetic resonance imaging (MRI) is superior to SWE due to its higher specificity (91.6%), as well as its accuracy (85%).***

Keywords: Shear Wave Ultrasound; Magnetic Resonance Imaging; Solid Breast Masses

1. Introduction

Breast cancer is the type of cancer that is identified in most people, and It was the primary factor that led to death due to cancer in the year 2020. Breast cancer is one of the most frequent malignant diseases that can be found in female populations around the world. Both the number of people who die from cancer and the number of those who are diagnosed with the disease are rising at an alarming rate around the world. It is anticipated that there will be 19 million new instances of breast cancer, along with roughly 10 million deaths from cancer worldwide, in the year 2020. It is also estimated that the mortality rate from breast cancer will reach approximately 11 million by the year 2030.[1]

Together with developments in imaging diagnostic technologies for breast illnesses over the past few years, early identification & remedying have contributed significantly to an increase in both the 5-year survival rate as well as the quality of life for those who have been diagnosed with breast cancer.[2]

Accepted 14 April 2024.
Available online 30 April 2024

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https://doi.org/10.58675/2682-339X.2391

As a result, the prognosis improves with treatment administered at an earlier stage of the disease thanks to early and sensitive diagnostic procedures. Individuals diagnosed with breast cancer who receive prompt and effective treatment have been shown to have a 10-year survival rate of as much as eighty percent, according to recent scientific research.[3]

Breast imaging with B-mode ultrasound (or just ultrasound) is simple, accessible, and non-invasive. However, the technique cannot evaluate stiffness, as it uses real-time scanning to detect breast lesions as well as assess their morphologic properties like echogenicity, shape & solid or cystic nature. [4]

Sonography's shear-wave elastography technique measures the attenuation of a shear wave supplied perpendicular to the tissue to determine its stiffness.[5]

This research aimed to compare magnetic resonance imaging with shear wave elastography to diagnose solid breast masses of varying kinds.

2. Patients and methods

This cross-sectional trial was done on 103 persons with solid lesions in their breasts who were examined in the Department for Early Breast Cancer Detection in AL-Yrmuok Teaching Hospital and Maternity Teaching Hospital by ultrasound with shear wave elastography and MRI from July 2020 to June 2023.

Inclusion criteria: Individuals with a recent breast mass diagnosis & the breast lesions included were either solid or mixed (partially cystic- partially solid) nodules, whether or not calcification is present.

Exclusion criteria: Patients with cystic nodules

All participants were assessed for medical history, demographic criteria (Name, age, sex, and residence), patient demographics, breast tumor histology, along with breast biopsy results & imaging by Ultrasound Elastography (UE) examination (using General Electric (GE) Logic P7 with a linear probe of 7.5–12 MHz frequency and Veno G 65 US device) and Conventional B-mode ultrasonography (Two-dimensional ultrasound scanning was done on the persons' breasts to detect the location, number as well as the size of the lumps. The lesion location then undergoes real-time UE investigation).

Shear wave elastography technique: No transducer pressure was used to acquire the shear wave elastography. The target lesion and enough healthy breast tissue around it were factored into the region of interest (ROI) box. Once an optimal shear wave elastography image has been obtained, the procedure is "frozen" for a few seconds to stabilize the shear wave image.6 The usual color scale (from 0 to 180 kPa) from blue to red was used to investigate lesion severity qualitatively. For each color map, we assessed maximum color, homogeneity, occurrence of a maximum hardness area located inside or surrounding the lesion & the existence of an intralesional echo. For clarity, we suggested categorizing qualitative lesions into five distinct classes.7

MRI examination: Each individual was scanned in the prone situation using a 1.5 Tesla Magnetom Aera (Siemens Medical Solutions, Erlangen, Germany) magnetic resonance imaging scanner with a breast surface coil. Scanning was performed on both breasts, as well as the prothoracoids and axillae. Axial T1-weighted, T2-weighted, Dynamic T1, and Short-Time Inversion Recovery were all incorporated into the breast MRI protocol to help reduce the appearance of fat.

Histopathological diagnosis: Samples were taken by expert pathologists using either fine needle aspiration cytology (FNAC), surgical excision, core biopsy, or radical surgery.

Ethical consideration: The ethics committee at Al-Azhar University's School of Medicine gave their blessing. The privacy of patients' information was protected. Before any operations or biopsies were performed, individuals gave their informed consent.

Statistical analysis: SPSS (Statistical Package for the Social Sciences) version 26 was used to conduct statistical analyses on the acquired data. The Shapiro-Wilk test was used to check if the data followed a normal distribution. The qualitative information was displayed as frequencies & percentages. Quantitative data was expressed as mean and standard deviation. To determine the accuracy with which mortality predictions can be used, the ROC (receiver operating characteristic) curve analysis was developed. An AUC of 1 indicates perfect death/survival discrimination by the predictor. AUC = 0.5 suggests no discernible variation in the distribution of predictor values between the two groups. Statistical significance is indicated when the P value is under 0.05; otherwise, it is considered nonexistent.

3. Results

Table 1. Basic characteristics of the cases

VARIABLE		N= 103
AGE (YEARS)	Mean ± SD	48.1± 9.3
	Median (Range)	47 (33, 78)

Table 1 showed that the mean age was 48.1± 9.3 years ranging from 33 to 78 years with median 47 years.

Table 2. Shear wave ultrasound results among the participants.

VARIABLE		N (%)
COLOR MAP	Blue	25 (24.3)
	Green	8 (7.8)
	Red	21 (20.4)
	Orange	43 (41.7)
	Black	6 (5.8)
E_{MAX} (KPA)	mean± SD	106.7± 56.9
SW SCORE	mean± SD	3.5± 1.2

Table 2 showed blue color appeared among 24.3%, green color appeared among 7.8%, Red among 20.4%, orange among 41.7%, and black among 5.8%. The mean Emax was 106.7± 56.9 kPa, & the mean score was 3.5± 1.2.

Table 3. MRI, SW and clinical pathology of the participants.

VARIABLE		N (%)
MRI	Benign	25 (24.3)
	Malignant	78 (75.7)
SW	Benign	35 (34)
	Malignant	68 (66)
CLINICAL PATHOLOGY	Benign	32 (31.1)
	Malignant	71 (68.9)

Table 3 showed that by MRI, there were 75.7% malignant and 24.3% benign. By shear wave, 34% were benign and 66% were malignant. While by clinical pathology, 31.1% were benign lesions and 68.9% were malignant lesions.

Table 4. Clinical pathology data of the participants.

BENIGN	N	MALIGNANT	N
MASTITIS	4 (3.9)	Ductal carcinoma in situ	15 (14.6)
FIBROADENOMA	6 (5.8)	Infiltrating ductal carcinoma	32 (31.1)
FIBRO ADENOSIS	7 (6.8)	Infiltrating lobular carcinoma	9 (8.7)
FIBROCYSTIC	3 (2.9)	Infiltrating nodular carcinoma	3 (2.9)
HAMARTOMA	3 (2.9)	Infiltrating tubular carcinoma	3 (2.9)
ADENOSIS	3 (2.9)	Metastasis	3 (2.9)
FAT NECROSIS	3 (2.9)	MUC	3 (2.9)
PAPILLOMA	3 (2.9)	Papillary carcinoma	3 (2.2)
TOTAL	32	Total	71

Table 4 showed that the most common benign lesions were fibro adenosis (6.8%), fibroadenoma (5.8%) and mastitis (3.9%). While the most common malignant lesions were ductal carcinoma in situ (14.6%), infiltrating ductal carcinoma (31.1%), & infiltrating lobular carcinoma (8.7%).

Table 5. Diagnostic value of MRI in differentiating solid breast mass with clinical pathology as a gold standard.

VARIABLE	MRI
AUC	75.5%
SENSITIVITY	91.6%
SPECIFICITY	84.4%
PPV	92.9%
NPV	81.8%
ACCURACY	89.3%
TP	65
TN	27
FP	5
FN	6
P VALUE	<0.001*

Table 5 showed that the diagnostic value of magnetic resonance imaging in differentiating breast solid masses was described by sensitivity of 91.6%, specificity of 84.4% in addition to accuracy of 89.3%. The PPV was 92.9% and NPV was 81.8%. As area under the curve was 75.5%.

VARIABLE	SW
AUC	82%
SENSITIVITY	85.9%
SPECIFICITY	78.1%
PPV	89.7%
NPV	71.4%
ACCURACY	83.5%
TP	61
TN	25
FP	7
FN	10
P VALUE	<0.001*

Table 6: Diagnostic value of SW in differentiating solid breast mass with clinical pathology as a gold standard.

Table 6 showed that the diagnostic value of shear wave in differentiating breast solid masses was described by sensitivity of 85.9%, specificity of 78.1% & accuracy of 83.5%. The PPV was 89.7% in addition to NPV was 71.4%. As area under the curve was 82%.

Case presentation

45 year- old women with breast lump and nipple retraction

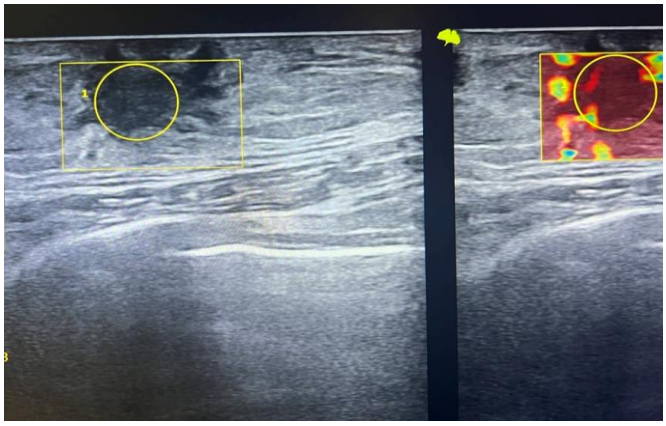

Figure 1. B. mode ultrasound and SWE case

Evidence of (3x2 cm) speculated margins mass on B. mode ultrasound with central dark red color with perilesional orange-red color as hard area by SWE as qualitative pattern, on quantitative SWE show high value as E- max 180kpa.lesion would have been categorized BI-RAD 5 on B. mode and

score 5 on SWE.

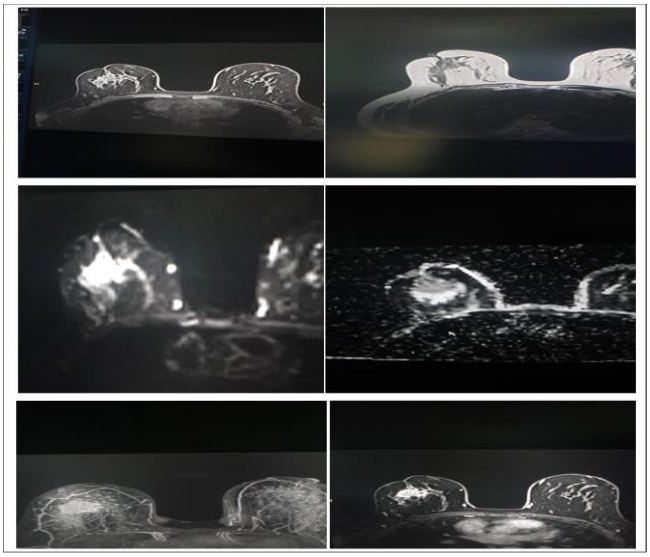

Figure 2. MRI of breast

Pulse sequences:

Pre-contrast: axial T1, T2, STIR and DWIs, Post contrast: axial and subtraction WIs

Report: right breast UOQ irregular shape, speculated mass lesion displaying low T1 and intermediate T2 signals showing intense heterogeneous post contrast enhancement measuring about 3.5x3 cm in its maximum dimensions, the mass lesion is seen extending anteriorly invading the nipple with subsequent nipple retraction. Normal skin thickness and contour, nonspecific axillary lymphadenopathy

Opinion: right locally advanced cancer (BIRADS 5).

Histopathology specimen by u/s guided core biopsy revealed: Invasive tubular carcinoma grade 1

4. Discussion

In this study, we enrolled 103 women with solid breast lesions. Their mean age was 48.1years,

By clinical pathology, 31.1% of lesions were benign, and 68.9% were malignant. The main benign lesions were; Fibroadenosis (6.8 %(and Fibroadenoma (5.8%). The main malignant lesions include infiltrating ductal carcinoma (IDC) (31.1%) & Ductal carcinoma in situ (DCIS) (14.6%)

Gweon et al. enrolled 133 breast lesions in 119 consecutive females with a mean age of (45.3 years); of the 133 lesions, pathological diagnosis showed that 36 (27.1 %) were malignant, besides 97 (72.9 %) were benign. Primary malignant lesions included invasive ductal carcinoma in twenty-four cases & ductal carcinoma in situ in 6 instances; primary benign lesions included fibrocystic variation thirty cases), fibroadenoma (twenty cases) & fibroadenomatous hyperplasia (14 cases).[6]

In the current study, by magnetic resonance imaging, 75.7% of lesions were diagnosed as malignant & 24.3% were diagnosed as benign. However, by Shear wave, compared to MRI, more cases were diagnosed as benign, 34%, in addition to lower cases, 66% were malignant.

By ROC analysis, we found the diagnostic value of magnetic resonance imaging in differentiating breast solid masses was described by a sensitivity of 91.6%, specificity of 68.9%, and accuracy of 85%. The PPV was 81.8%, and the negative predictive value was 76.9%. The area under the curve was 75.5%.

Variable results reported in the literature, as Shafqat et al. testified better specificity, sensitivity, and negative & positive predictive values of kinetic MRI for finding breast lesions were 85%, 94%, 82%, and 90%, respectively. The overall accuracy of magnetic resonance imaging of the breast was 90%.[7]

Our results were at odds with those of Hetta, who demonstrated that a DCE-MRI test has a sensitivity of eighty percent and a specificity of 73.33 percent. [8]

A real-time color overlay box displays the shear wave elastography images, with various colors denoting the shear wave speed (in meters per second, m/sec) or the degree of tissue stiffness (Young modulus; in kilopascals, kPa) in each pixel. You can evaluate the masses' rigidity in two ways: qualitatively, with a color map, or quantitatively, with a measurement.[9]

For qualitative examination of SWE, benign lesions tend to be homogeneously soft (blue), whereas malignant lesions have a heterogeneous complex (red) appearance.[10]

Overall, the shear wave elastography was 85.9% sensitive, 7.81% specific, & 8.35% accurate. There was an NPV of 71.4 percent & a PPV of 89.7%. An 82% AUC was observed.

In contrast, the sensitivity of SW was estimated to be 91.3 percent, while its specificity was found to be 80.6%, its PPV was found to be 91.3%, its NPV was found to be 80.6%, & its accuracy was found to be 88%.[9]

Feldmann et al. demonstrated that sensitivity was 89%, specificity was 60%, PPV was 65%, and negative predictive value was 87% for SW when applied to 83 breast masses, of which 38 were malignant, and 45 were benign.[11]

In the current research, the quantitative SWE parameter utilized to determine Kpa was E max. In particular, the research done by Suvannarerg et al. observed that maximum elasticity offered the best diagnostic performance, making it the most discriminative quantitative shear wave elastography characteristic.[9]

This conclusion was consistent with the findings of Lee et al., who discovered that maximum elasticity is the diagnostic parameter providing the highest AUC and the best overall performance. Maximum elasticity is considered to be the most

discriminative metric for the simple reason that the region of interest typically contains the mass with the highest stiffness. This is true regardless of the size of the ROI.[12]

SWE demonstrated a minor sensitivity (85.9% vs. 91.6%) as well as accuracy (83.5%. vs. 85%) than MRI when it came to discriminating breast masses in our research; however, shear wave elastography had higher specificity (78.1% vs 68.9%) than MRI did. We concluded by comparing SWE and MRI approaches in this area.

According to the findings of the research conducted by Farghadani et al., the sensitivity of shear wave elastography & MRI were equally high at 94.59%. However, the specificity of shear wave elastography was much higher than that of MRI at 93.02%, and its accuracy was significantly higher at 93.75% compared to 70%. Other diagnostic values of SWE were also considerably superior to those of MRI. Even though they employed different parameters than we did in our investigation, shear wave elastography had a higher diagnostic concordance with histological results than MRI (considering that we used different parameters).[13]

5. *Conclusion*

In conclusion, both qualitative & quantitative metrics utilizing SWE showed an excellent ability to discriminate benign and malignant breast lesions, with a sensitivity of 85.9%, a specificity of 78.1%, and an accuracy of 83.5%. These results are presented in the table below. Despite this, MRI is still the preferred method for the diagnosis and evaluation of breast cancer, as it has a higher specificity of 91.6% as well as an accuracy of 85% than shear wave elastography.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

Funding

No Funds : Yes

Conflicts of interest

There are no conflicts of interest.

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