The Value of Shear Wave Sono Elastography in Characterization of Breast Lesions in Correlation with Histopathology

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ABSTRACT

Background: Elastography is an imaging tool that works in conjunction with conventional B-mode ultrasound to provide additional information on the stiffness of the tissues and improve the diagnosis of breast cancer. It can also reduce the number of true cut biopsies for suspicious breast lesions.
Objective: This study aims to assess whether adding shear wave elastography (SWE) to B-mode US is a useful adjunct for better characterization of suspicious breast lesions and lowering the number of unnecessary breast biopsies.
Patients and method: This is considered a prospective study of seventy-three ladies complaining of suspicious breast lesions categorized as BIRAD III and more between December 2020 and January. 2022.SWE was used to assess the breast lesions' elastography measures and compare them with histopathology results.
Results: SWE gives excellent discriminative ability with an area under the curve (UAC) of 0.862; the Sensitivity was 100%, and the specificity was 77.5%.
Conclusion: Shear wave elastography (SWE) is a noninvasive tool that can differentiate benign and malignant lesions. Most false positive results were granulomatous mastitis; lesions with thick inspissated secretions also show high elastography values.

Keywords: Cancer, Breast, Elastography, Shear Wave Elastography.

قيمة الموجات فوق الصوتية باستخدام الموجات القصية في توصيف آفات الثدي وعلاقتها بالتشريح المرضي

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الخلاصة

الخلفية : تصوير المرونة هو أداة تصوير تعمل جنبًا إلى جنب مع الموجات فوق الصوتية ذات الوضع لتوفير معلومات إضافية عن تصلب الأنسجة وتحسين تشخيص سرطان الثدي ، يمكن أن يقلل من عدد الخزعات الحقيقية لآفة الثدي المشبوهة.
الهدف : الهدف من هذه الدراسة هو تقييم ما إذا كانت إضافة موجات القص الى الموجات فوق الصوتية هي أداة مساعدة مفيدة لتوصيف أفضل لآفات الثدي المشبوهة وخفض عدد خزعات الثدي غير الضرورية.
المرضى والطريقة : تعتبر هذه دراسة استطلاعية لـ ثلاث وسبعون سيدة يشتكين من آفات ثدي مشبوهة مصنفة على انها ذات عامل خطورة من المستوى الثالث واكثر وتم استخدام موجات القص مع الموجات فوق الصوتية لتقييم قياسات مرونة افات الثدي ومقارنتها بنتائج النسيج المرضي.
النتائج : يبدو أن التصوير المرن لموجة القص يعطي قدرة تمييزية جيدة إلى ممتازة بمساحة تحت المنحني تبلغ ٠.٨٦٢، وكانت الحساسية ١٠٠% والنوعية ٧٧.٥%.
الاستنتاجات : تصوير المرونة بموجة القص هو اداة غير جراحية تظهر قدرة ممتازة في التمييز بين الافات الحميدة والخبيثة. وكانت معظم النتائج الإيجابية الكاذبة هي التهاب الثدي الحبيبي، كما أظهرت الآفات ذات الإفرازات السميكة قيم مرونة عالية.

الكلمات المفتاحية : سرطان، الثدي، تصوير المرونة للثدي، تصوير المرونة بموجات القص.

INTRODUCTION

The prevalence of breast cancer is markedly increasing, thus emphasizing the importance of breast cancer detection[1]. Breast cancer has become the most frequent of all malignancies, accounting for more than 1.6 % of all cancer deaths in women globally[2]. Breast cancer mortality has dropped in recent years as a result of the development of new techniques in breast imaging, as well as screening programs and better levels of health awareness[3]. The breast is made up of a variety of tissues, including fibrous, glandular, and fatty components; the fatty tissues yield the breast its velvety consistency[4] on palpation, malignant breast masses are well-known to be harder than benign breast masses[5]; this concept has been applied to the development of imaging approach for determining the link between various structures and their inherent tissue elasticity[6], Elastography is an imaging tool that works in conjunction with B-mode ultrasound to provide additional information on the stiffness of the tissues and improve diagnosis of breast cancer[7]. Real-time Elastography is a new noninvasive technology that examines the stiffness of the tissues by using Ultrasound[8]; it admixes the information given by B-mode ultrasound and stiffness of the tissues similar to clinical palpation so that it can be referred to as .twenty first century of palpation[9].

Nowadays, Strain elastography and, more recently, SWE are the most extensively utilized elastographic techniques. Strain elastography examines tissue deformation caused by manual compression and codes the data on a color scale based on tissue displacement. In the form of an elastogram, strain images illustrate the relative stiffness of the lesions in comparison to the surrounding tissues. Malignant masses appear dark on strain images and have high contrast with background breast tissues. In contrast, benign masses appear light on strain images and have lower contrast with background breast tissues.[10,11] This modality's biggest flaw is that it does not clarify the quantitative assessment of the lesion stiffness[12.] SWE is a modern quantitative elastography technique. Unlike traditional elastographic technologies, SWE is based on a combination of ultrasonic beam-induced radiation force on the tissues and ultrafast image sequence, which can capture the propagation of ensuing shear save in real-time[13]. SWE introduces key innovations to Elastography, the most superior one is being quantitative; it has an advanced spatial resolution, provides a real-time elasticity map, and is also reproducible with negligible inter-observer variability .[14]

Elastography improves the characterization of benign and malignant breast masses when combined with B-mode ultrasound[15]. Because of the difficulty of characterizing the masses in BIRAD classifications III and IV, elastography is particularly a valuable adjunct; by minimizing the number of false positives, it may be able to reduce the number of unnecessary biopsies in such masses[16] Elasticity assessment was included in the more recent edition of the BI-RAD system as a proof that this technique helps characterize lesions[17.]

AIM OF THE STUDY

This study aims to assess whether the addition of SWE to B-mode US is useful adjunct for better characterization of suspicious breast lesions and lowering the number of unnecessary breast biopsies.

PATIENTS AND METHODS

This is considered a prospective study of seventy-three ladies complaining of suspicious breast lesions categorized as BIRAD III, and this study was done at a Breast center in Irbil city of Iraq; a specialist radiologist and junior radiologist examined ladies between December 2020 and January 2022

The data were collected from the ladies regarding their age, first menarche, menopause, marital status, lactation history, breast density, family history of breast and ovarian cancer, and smoking history.

After consent was obtained from all patients, a clinical breast examination followed by B- y mode and SWE ultrasound were applied, and then a histopathological test was done.

The Procedure:

The ultrasound examination uses the SIEMENS diagnostic ultrasound system "Acuson S 2000 machine using an 8 MHZ linear-array transducer. B-mode and SWE ultrasound The patient was lying in the supine position and asked to put her hands behind the head proper exposure of the breasts and axillae was obtained, then a systematic examination of the breasts was done in a clockwise direction from the periphery to the nipple; any lesion detected was examined for size, homogeneity, shape, margin, acoustic shadowing, and enhancement Shear wave Sono elastography (index diagnostic test) After that, the SWE option is activated by taking at least two regions of interest (ROI) in the lesion and comparing them with the surrounding tissues at the same depth. Qualitative and quantitative parameters were obtained and compared independently.

Histopathological tests (reference standard test) under ultrasound control, five cc of 2% lidocaine was injected, four passes with a G 14 biopsy needle to the mass; the needle is seen inside the lesion with no immediate complication. The specimen is added to formalin and sent to the laboratory unit.

Statistical Analysis

We classify the lesions into benign and malignant lesions according to histopathology; the different cutoff elastography values were assessed using the receiver operator characteristic curve (ROC) according to some systematic reviews, the optimal cutoff value is between 36 and 80 KPa for Each cutoff value, including the sensitivity, specificity, positive and negative predictive values, was calculated.

RESULTS

BREAST LESIONS AND PARTICIPANT

66 women complaining of breast lesions were identified. An Ultrasound-guided breast biopsy (reference standard test) for the suspicious lesions with(BIRAD III, IV, and V) was done with Elastography (an index test) extending from December 2020 to January 2022; the mean age was around 41y with a minimum of 17 years and a maximum of 71 years, table (1) shows age characteristics. Benign tumors were 40 (54.8%), of which 14 (35%) were fibroadenomas, while malignant tumors were 26(35.6%), of which 19(73%) were invasive ductal carcinoma. Table 2 shows types of tumors by histopathology; intermediate results were 7 (9.696), which were not present included in the statistical parameters.

Out of all 40 benign lesions, as mentioned, 14 (35%) were fibroadenomas, the rest were fibroadenomas (n= 7), granulomatous mastitis (n=6), fat necrosis (n= 3) with the remaining constituting (n=3)., While in 26 malignant lesions, as mentioned, the invasive ductal carcinoma 19 (73%), which was the primary type of malignant lesions followed by invasive lobular carcinoma 3(11.5%), table (2) shows types of tumors by histopathology.

Table 1: Age Characteristics

AGE	FREQUENCY	PERCENT	VALID PERCENT	CUMULATIVE PERCENT
Valid less than 20	2	2.7	2.7	2.7
20-29	10	13.7	13.7	16.4
30-39	24	32.9	32.9	49.3
40-49	18	24.7	24.7	74.0
50-59	11	15.1	15.1	89.0
60-69	4	5.5	5.5	94.5
More than 70	4	5.5	5.5	100.0
Total	73	100.0	100.0	

Table 2: Types Of Tumors By Histopathology.

Benign	No	%	Intermediate	NO	%	Malignant	No	%
Fibroadenoma	14	19.2	Fibroadenosis with atypia	3	4.1	Invasive ductal carcinoma	19	26
Fibroadenosis	7	9.6	Atypia	1	1.4	Invasive lobular carcinoma	3	4.1
Fat necrosis	3	4.1	Ductal hyperplasia	3	4.1	DCIS	2	2.7
Granulomatous mastitis	6	8.2				Papillary carcinoma	1	1.4
Plasma cell mastitis	1	1.4				Leukemia	1	1.4
Papilloma	2	2.7						
Total	40	54.8			7,9.6		26	35.6

Shear wave elastography diagnostic performance

Shear wave elastography seems to give sound to excellent discriminative ability with an area under the curve (UAC) of 0.862 Table (5) when 66 out of 73 lesions were included in the study (as seven lesions show intermediate results by histopathology and need definitive diagnosis by excisional biopsy), results of the ROC are shown in fig 1 and table 6.

Table (3) illustrates elastography statistics; the mean tissue stiffness for benign =51.8 Kpa (SD 34.6), and for malignant lesions, the mean tissue stiffness was 118.7 KPa(SD 12.8).

Table (4) shows elastography range-up to 59 KPa; no malignant lesion was detected, while malignant lesions constitute 84.2% (n=16/19) when the Elastography measures more than 120 Kpa.

Table (3) Elastography Statistics

		Elastovar benign	Elastovar.malignant	Elastovar. intermediate
N	Valid	40	26	7
	missing	33	47	66
Mean		51. 8625	118.7400	57.8571
Median		36.0000	126.0000	56.0000
Std. Deviation		34.64471	12.86316	20.09294
Range		106.50	49.00	60.00
Minimum		19.50	77.00	30.00
Maximum		126.00	126.00	90.00

Table (4) Elastography "range" Histocat Crosstabulation

Histocat			benign	intermediate	Malignant	total
Elasto. Range	less than 30	Count	18	1	0	19
		% within the Elasto range	94.4%	5.6%	0.0%	100.0%
	30-59	Count	11	3	0	14
		% within the Elasto range	78.6%	21.4%	0.0%	100.0%
	60-89	Count	3	2	2	7
		% within the Elasto range	42.9%	28.6%	28.6%	100.0%
	90-119	Count	5	1	8	14
		% within the Elasto range	35.7%	7.1%	57.1%	100.00%
	More than 120	Count	3	0	16	19
		% within the Elasto range	15.8%	0.0%	84.2%	100.0%
Total		Count	40	7	26	73
		% within the Elasto range	54.2%	9.7%	36.1%	100.0%

Table (5) demonstrates the area under the curve for the means of Elastography. It reveals that the estimated area is 0.862 with very high significance, and the 95% confidence interval (CI) ranges from 0.769 to 0.955.

Table (5): The Area Under The Curve For The Means Of Elastography

Area	Std.Error	P- value	Asymptotic 95% confidence Interval	
			Lower Bound	Upper Bound
0.862	0.047	0.0001	0.769	0.955

Figure (1) illustrates the ROC curve of mean values of Elastography. It shows different cutoff values, which show the Sensitivity and specificity for discriminating between benign and malignant tumors among the sample (n=66).AUC=0.869 ,.Table (6) shows the different cutoff points for the means of Elastography. It depicts that the Sensitivity for cutoff points from 35.75 to 62.25 is 100 %, while specificity increases with the higher cutoff points till the cut–off point of 62.25, at which the specificity is 77.5%. At a cutoff point of 70.0, the specificity reaches 85.0%, while the Sensitivity drops to 38.5%

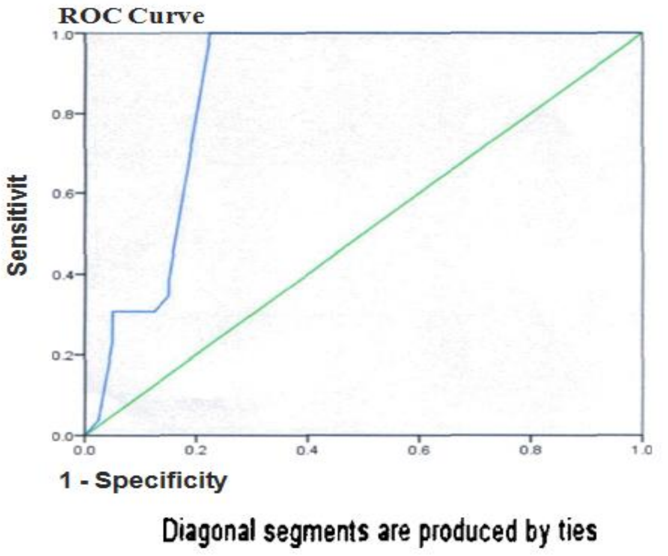

Figure (1): ROC curve of mean values of Elastography.

Table (6): The Different Cutoff Points For The Means Elastography.

Cutoff points	Sensitivity %	Specificity	PPV%	NPV%
35.75	100.00%	50.0%	66.7%	100.00%
37.00	100.00%	52.5%	67.8%	100.00%
48.25	100.00%	62.5%	72.7%	100.00%
52.50	100.00%	65.0%	74.5%	100.00%
54.50	100.00%	67.5%	75.5%	100.00%
57.25	100.00%	70.0%	76.9%	100.00%
60.00	100.00%	72.5%	78.4%	100.00%
61.00	100.00%	75.0%	80.0%	100.00%
62.25	100.00%	77.5%	81.6%	100.00%
70.00	38.5%	85.0%	71.9%	58.0%
81.00	34.6%	85.0%	69.8%	56.5%

Figure (2,3) displays two examples of benign and malignant lesions that are correctly identified by SW elastography, while Figure(4) shows a benign lesion (granulomatous. mastitis) incorrectly identified as a hard lesion by SWE (limitation of the study). Using the 62.25 KPa cutoff value, the false positive results were 22.5, which can be explained by six histopathologically proven granulomatous mastitis lesions that yield high elasticity readings (hard Elastography).

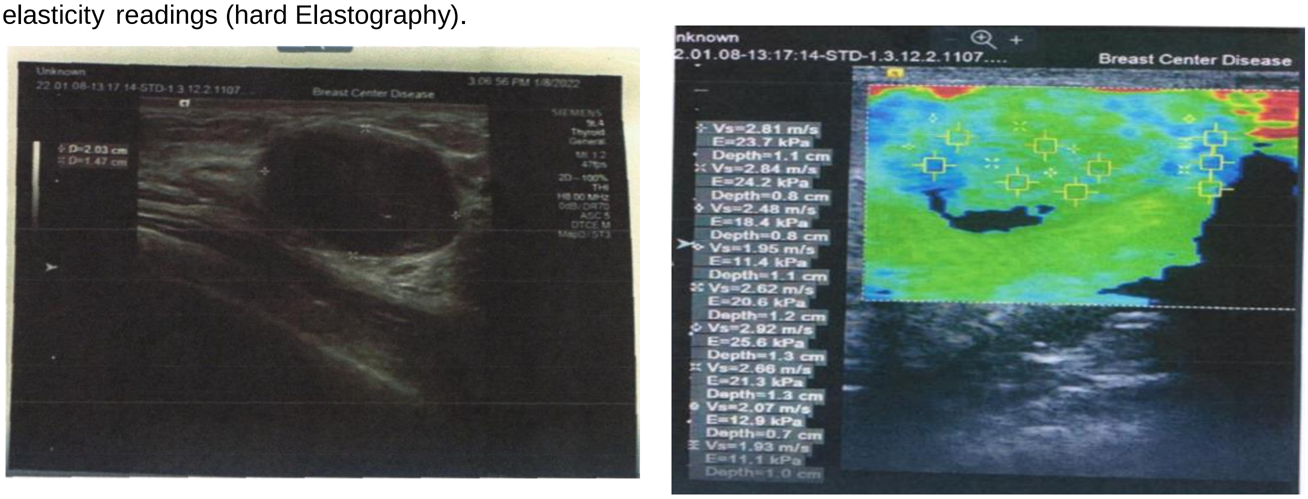

Fig .2 shows 35 -year-old patient. The Ultrasound revealed solid, hypoechoic, regular mass margins and parallel orientation at 10 o'clock in the right breast. Elasticity is not more than 25 Kpa, and histopathology reveals fibroadenoma.

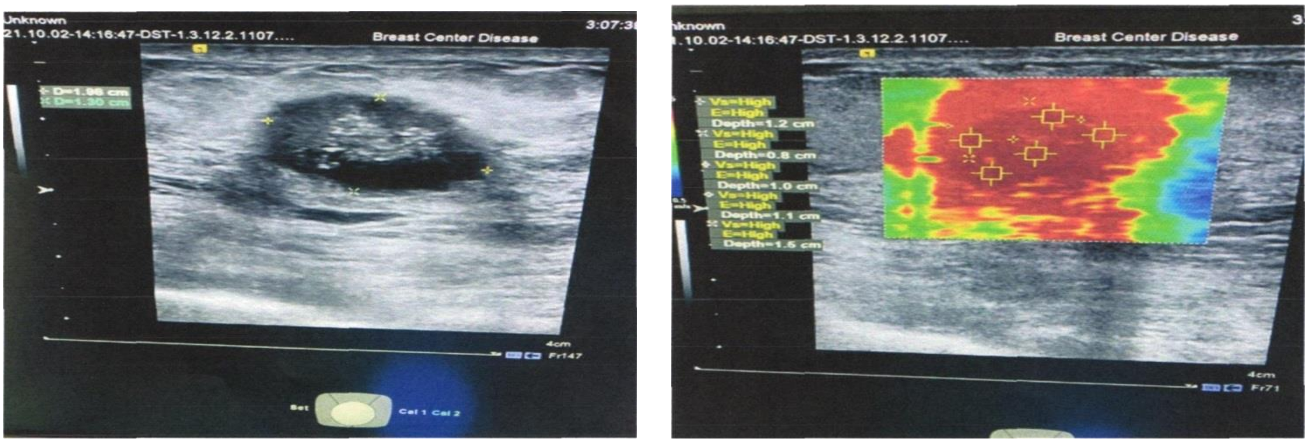

Fig .3 shows a 71- year-old patient. Ultrasound revealed a solid, hypoechoic, irregular mass margins and parallel orientation at the 8 o'clock position of the right breast. Elasticity more than 125 KPa" histopathology reveals invasive ductal carcinoma.

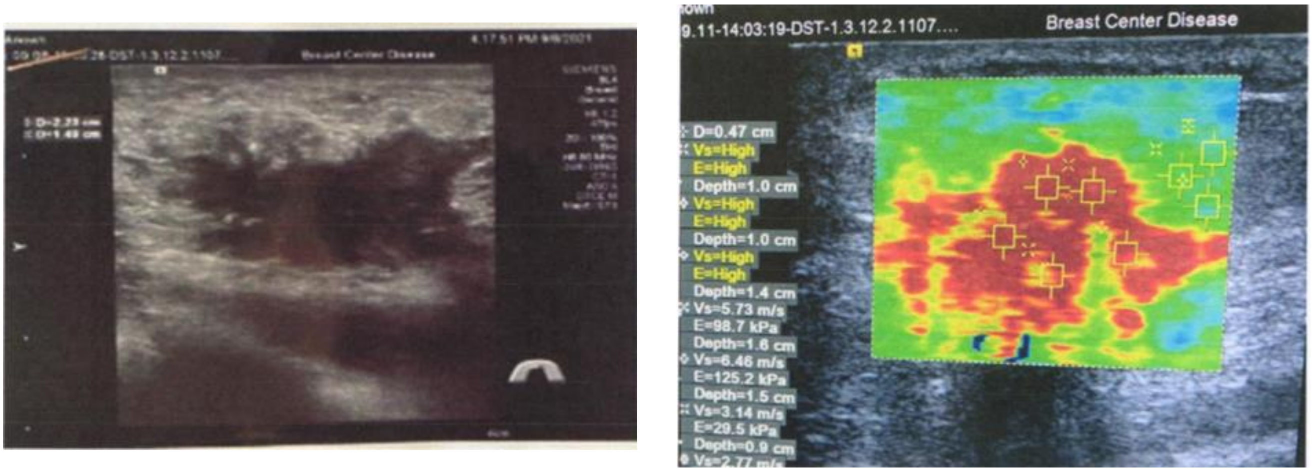

Fig .4 shows 24 -year-old patient. Ultrasound revealed a solid, hypoechoic, irregular mass margins and parallel orientation at the 5 o'clock position of the right breast. Elasticity more than 1 25 KPa" histopathology reveals granulomatous mastitis.

DISCUSSION

For the assessment of breast lesions by qualitative and quantitative SWE, with B mode US finding taken into account, a statistically significant difference was found between measurements of Elastography for the benign and malignant lesions: the mean tissue stiffness for malignant lesions was 118.7 KPa (SD 12.8) while for benign lesions was 51.8 KPa (SD 34.6) (P< 0.0001), these outcomes are consistent with previous study by Lee SH, Chang JM, Kim WH et al at 2014 [18] where Malignant masses showed higher quantitative elasticity values (maximum elasticity 119.0 kPa (SD 52.2) than benign masses (41.4 kPa (SD 32.1).

Using a 62.25 KPa cutoff value, Elastography revealed an overall sensitivity of 100% to detect malignant lesions in comparison to Pesce and Marina in 2020 [19,] where the Sensitivity was 87 % and also higher than Liu B, ZhengY, and Huang G as the Sensitivity was 88.6 % [20]

The specificity was 77.5 %, slightly inferior to the previously mentioned studies[19,20] , 82.3% and 86.6%, respectively.

The false positive rate was 22.5 (could be due to high elastography measures of granulomatous mastitis(n=6), which was comparable to Kim[21] and Yoon[22] studies with 11% and 36.6 % respectively.

The false negative rate was zero compared to Kim [21] , 22%, and Yoon [22] which was 20.6.

A cutoff value different from the previously mentioned studies was used; this could be explained by the various software and equipment used and the other number of measurements.

The study limitations were a lower size of the sample and retrospective design based on our results, which is shown to be concordant with other studies that are mentioned previously. SWE had revealed an adequate diagnostic performance and can be regarded as a valuable supporting technique for discriminating malignant and benign lesions especially when taking in to account it is noninvasiveness,.reliability and reproducibility, low cost and relatively easy to perform.

CONCLUSION

Shear wave elastography (SWE) is a noninvasive tool that can differentiate benign and malignant lesions depending on the Shear Wave criteria for better characterization of suspicious breasts. Most false positive results were granulomatous mastitis, and the thickened inspissated secretions' lesions also showed high elastography values.

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