Diagnostic Performance of The Strain and Shear-Wave Ultrasound Elastography for The Differentiation of Benign and Malignant Breast Lesions

Ashraf Mohammed El-Aggan[a]*, Alaa Abd El-Hamid Saad[a], Amel Abd El-Tawab Hashish[b], Atef Hammad Teama[a]

[a]Radiodiagnosis Department, Faculty of Medicine, Tanta University, Tanta, Egypt
[b]General Surgery Department, Faculty of Medicine, Tanta University, Tanta, Egypt

Abstract

Background: Breast cancer represents the predominant cancer type among females in developed as well as developing nations. Guidelines recommend breast cancers screening utilizing both mammography as well as ultrasonography (US).

Objectives: This work was aimed at assessing the diagnostic accuracy of elastography performed with strain elastography (SE) as well as shear wave elastography (SWE) while differentiating between benign as well as malignant breast lesions.

Patients and Methods: Our retrospective study was involved 100 female cases presented with breast masses. All participants underwent a conventional B-mode US exam then assessed based on the BIRADS categories. Additionally, a real time free hand US elastography was carried out during the same session then images were analyzed utilizing the Tsukuba elasticity score as well as the strain ratio method.

Results: Out of 100 patients, 44 (44%) patients showed benign, and 56 (56%) patients showed malignant breast lesions. PPV 96.2% for strain ratio, 92.6% for elastoscoring and 88.9% for ultrasound. NPV was 87.5% for strain ratio, 86.9% for elasto scoring and 82.6% for ultrasound. Strain ratio and elasto scoring had the same sensitivity, 89.3% while ultrasound proved to be less sensitivity 85.7%. Strain ratio had the highest specificity 95.5%, followed by elasto scoring was 90.9% and the least ultrasound was 86.4%. The strain ratio was the highest at 92% followed by elasto scoring (90%). The least was ultrasound (86%).

Conclusion: Elastography represents a simple approach that possesses superior diagnostic performance. It could be simply utilized along with B-mode ultrasonography during the same session, thus enhances its specificity. It has shown efficacy in reducing needless biopsies, particularly in BIRADS III as well as IVa lesions' evaluation.

Keywords: Ultrasound, Strain Elastography; Shear Wave Elastography; Breast Masses; Magnetic Resonance Imaging.

***Correspondence**: ashrafelagan@yahoo.com

DOI: 10.21608/SVUIJM.2024.287236.1860

Received: 2 May, 2024.

Revised: 10 May, 2024.

Accepted: 27 May, 2024.

Published: 28 May, 2024

Cite this article as: Ashraf Mohammed El-Aggan, Alaa Abd El-Hamid Saad, Amel Abd El-Tawab Hashish, Atef Hammad Teama.(2024). Diagnostic Performance of The Strain and Shear-Wave Ultrasound Elastography for The Differentiation of Benign and Malignant Breast Lesions. *SVU-International Journal of Medical Sciences*. Vol.7, Issue 1, pp: 1079-1093.

Introduction

Breast cancer represents the predominant cancer type among women globally and remains a primary ethology of cancer-related mortality in females. Its prevalence has been progressively rising in both developing as well as developed nations **(Lin et al., 2019)**. The rising occurrence along with death rates in low- and middle-income nations may be attributed to factors, involving longer life expectancy, urbanization, lifestyle changes, as well as diagnosis delay. A prompt identification is crucial for enhancing the prognosis and survival of breast cancer **(Kanagaraju et al., 2021)**.

Recent imaging modalities available for breast cancers' screening involve mammography, ultrasonography, as well as magnetic resonance imaging (MRI). Though mammography is the standard modality utilized currently, it exhibits a reduced sensitivity in breast tissues with a high density, in smaller lesions, as well as the young **(Zhao et al., 2015)**. Breast ultrasonography represents a frequently utilized approach for assessing as well as characterizing breast lesions, since it shows high sensitivity **(Balkenende et al., 2022)**.

As a non-invasive, inexpensive, as well as reproducible approach, Ultrasound (US) was proven to show many benefits while differentiating between breast lesions. Hence, it has emerged as the first-line imaging among the young (particularly for those younger than fort). Additionally, it represents a complementary modality to mammography among older women having breast tissues with high densities **(Guo et al., 2018)**.

Recently developed US and elastography methods have been investigated as an alternative approach to assess tissues' stiffness, thus enhancing the US examinations' specificity while identifying local breast masses **(Cosgrove et al., 2017)**.

Strain elastography (SE) as well as shear wave elastography (SWE) represent the two primary modalities utilized for breast imaging. SE is a technique that combines qualitative and semi-quantitative methods. It involves applying compression on the body utilizing an external source, namely a transducer. It remains stationary and positioned perpendicular to the body surface **(Shahzad et al., 2022)**. As regards the SE, it is not possible to determine the absolute value due to the unknown magnitude of compressive force applied. Instead, the lesion deformation may be expressed in respect to a reference tissue (such as fat tissue in the breast) then visualized utilizing color or gray scale **(Guiban et al., 2023b)**.

The stiffness scale encompasses a spectrum of color values, that vary from red to blue, with green representing an intermediate stiffness. Red corresponds to soft tissue, while blue indicates stiff parts, and green falls in between. For a semi-quantitative along with a qualitative assessment utilizing color map, the strain ratio (SR) could be determined through comparing the deformability ratio between tumors as well as the breast fat **(Cosgrove et al., 2013)**. SWE represents a quantitative approach that utilizes the force of acoustic radiation to produce shear waves inside tissues. It offers precise quantitative data (expressed in kPa or m/s) represented as a color map, showing the lesions' characteristics as well as the surrounding tissues in real time **(Guiban et al., 2023b)**.

Several research assessing the potential SWE as well as SE role, have addressed that breast brings many advantages while differentiating between benign from malignant tumors.

Additionally, it could considerably decrease the need for biopsies through enhancing the breast US accuracy **(Grajo and Barr, 2014, Barr and Zhang, 2015, Cosgrove et al., 2017)**.

This work was aimed at assessing the diagnostic accuracy of elastography performed with SE as well as SWE while differentiating between benign as well as malignant breast lesions.

Patients and methods

Our retrospective study involved 100 female cases presented with breast mass. The study was done from April 2023 to the end of November 2023, after approval from the Ethical Committee, Tanta university hospital (approval code:36264PR607/3/24). All participants were asked to fill in an informed consent.

We excluded cases having histopathological proved malignant breast mass and patient received chemotherapy or radiotherapy.

All participants went through a comprehensive medical history, physical examinations, histopathologic diagnoses and conventional B-mode ultrasound to all cases and 50 patients were examined by conventional mammography.

Mammography

Mammography was done for Fifty cases, comprising standard craniocaudally as well as medio lateral oblique views of the breasts and wherever warranted spot or global magnification images over the region of interest. If needed, further magnification and compression images were acquired. The radiography technologists conducted all exams under close supervision.

Breast ultrasound

Breast ultrasound was conducted utilizing Toshiba Aplio 500 ultrasound systems, equipped with a 7.5 MHz superficial liner small parts transducer. The process was carried out with awareness of the patients' clinical as well as mammographic results.

Patient Position: Scanning of the inner medial breast was conducted when patients were supine. To examine the outer lateral breast, they were positioned in a contra-lateral oblique posture. A pillow was placed underneath their shoulders with their arms raised.

Technique: Survey systematic scanning was carried out in sagittal as well as transverse planes with additional scans in other planes as needed. The long axis of the mass lesions was determined within longitudinal as well as transverse planes, thus yielding 3 diameters. Pathological lymph nodes were assessed in both axillae. Lymph nodes that were bigger than 1 cm, matted, or showed lack of fatty hilum, thickened cortex, or uneven node contour were classified as pathologic.

Images were assigned to one of five categories to the BIRADS criteria for ultrasound:

Category 1 indicates normal findings. **Category 2:** corresponds to benign ones. **Category 3:** indicates a probably benign finding. **Category 4 corresponds to** a suspicious malignant case. **Category 5** denotes highly suggestive of malignancy. Cases diagnosed with a breast lesion underwent elastography assessment. The examination was conducted with the patient lying supine with arms behind the head. The ultrasound probe was positioned on the breast to conduct a thorough radial as well as ductal examinations. The B-mode US images were shown with elastography strain images to ensure maximum attention as well as accuracy.

An elastographic examination was conducted with the same patients' positions for conventional US exam (B-mode). Additionally, the transducer was inserted perpendicular to the region of interest (ROI). Prior to evaluation, the target lesion underwent repeated compression to verify the absence of any lateral shifts. Following the initiation of elastography, consistent manual compression was exerted on the target area, at a right angle to the pectoral muscle, till tissue resistance was identified. When encountering resistance, the application of manual pressure stopped so enabling the breast parenchyma to decompress spontaneously. The research area included the region extending from the subcutaneous tissue to the pectoral muscle, including the mass margins up to a distance of 0.5 cm. Each pixel within elasticity image was allocated one of 256 specific colors, based on the stain magnitude.

The scale spanned from red, indicating components with the greatest strain (exhibiting the softest components), to blue, indicating components with no strain (exhibiting the firmest components). While green represents the mean strain level within ROI. Images were superimposed over the B mode images. The obtained images were evaluated in real-time utilizing "cine memory", enabling the retrospective assessment of the mass's behavior during compression as well as following decompression.

Regarding the qualitative (color coded) sono elastographic images' assessment, lesion categorization was carried out according to a 5-point scoring technique, namely Tsukuba scoring system introduced by Itoh et al. **(Itoh et al., 2006)** **Score 1** denoted that the entire lesion exhibited an even strain, being evenly stained in green. **Score 2** denoted that most of the lesion exhibited strain, some regions developed no strain (the lesion exhibited a mosaic pattern of green as well as blue). **Score 3** denoted that only the lesion's periphery exhibited strains, (the peripheral region was green, while the centre exhibited blue). **Score 4** denoted that the whole lesion had no strains (the whole lesion exhibited blue, however adjacent areas was not involved. **Score 5** denoted that both the whole lesion as well as the adjacent area developed no strains (the whole lesion as well as its surrounding area deemed to be blue).

Regarding the semi quantitative sono elastographic images' assessment, the lesions' strain indices were measured. For each case, a normally appearing breast area located at the same lesion level was identified as an internal reference (channel 1). Additionally, the ROI encompassing the lesion was chosen as (channel 2). This allowed for a better identification of stiffness variation between the lesion as well as adjacent normal areas. The strain ratio was automatically calculated as the ratio between the strain measured via channel 1 and the strain measured via channel 2.

Statistical analysis

Data went through a statistical analysis utilizing SPSS v26 (IBM Inc., Chicago, IL, USA). Quantitative variables were displayed as mean as well as SD. Qualitative variables were displayed as frequency as well as percentage (%). P values below 0.05 were deened to show statistically significance.

Results

Out of 100 cases, 44 (44%) patients showed benign, and 56 (56%) patients showed malignant breast lesions. The most affected group was the 4th decade group (>30- 40 years) which included 26 patients (26%) (20 cases with benign lesions, 6 cases with malignant lesions), followed by 6th decade group (> 50 -60 years) which included 22 patients (22 %) (18 subjects having malignant tumors, 4 subjects having benign tumors). One hundred patients were presented clinically with lump in 76 patients (76%), with lump and mastalgia in 20 patients (20%) and with nipple discharge in 4 patients (4%). Breast lump was the predominent complaint. Out of 100 cases, 50 patients had performed mammography and classified according to their breast density, (**Table 1).**

Table 1.Distribution of studied participants based on age, symptoms and ACR pattern (n = 100)

Variables	Benign	Malignant	Percentage (%)
Age (years)	33.7±10.4	51.1±14.5	43.1±15.5
10-20	2	-	2%
>20-30	14	6	20%
>30-40	20	6	26%
>40-50	4	10	14%
>50-60	4	18	22%

>60-70	-	14	14%
>70-80	-	-	0%
>80-90	-	2	2%
Symptoms			
Lump	76		76%
Lump and mastalgia	20		20%
Nipple discharge	4		4%
ACR pattern			
Fatty (ACR pattern I/II)	18		36%
Fibro-glandular dense	16		32%
Heterogeneous dense	4		8%
Dense (ACR pattern III/IV)	12		24%

Data are displayed as mean ± SD or frequency (%).

Pathological specimens of the 100 patients included in our study were taken by fine needle aspiration biopsy, true cut biopsy and excisional biopsy. (56/100) (56%) had confirmed histo-pathologically to be malignant breast lesions and (44/100) patients (44%) had confirmed histo-pathologically to be benign breast lesions. According to BIRADS classification, the cases were divided in to two group shown in table 2: group I included (BIRADS I, II, III) i.e. considered benign breast lesion and group II included (BIRADS IV, V) i.e. considered malignant breast lesions (**Table. 2).**

Table 2. Classification of study participants based on Histopathology and the U/S BIRADS (n=100)

Variables	N (%)
Benign breast lesions	44 (44%)
Fibro adenoma	30 (68.3%)
Simple cyst	2 (4.5%)
Complicated cyst	2 (4.5%)
Mammary dysplasia	2 (4.5%)
Lipoma	4 (9.1%)
Granulomatous mastitis	2 (4.5%)
Tubular adenoma	2 (4.5%)
Malignant breast lesions	56 (56%)
IDC	36 (64.3%)
ILC	8 (14.3%)
Ductal carcinoma in situ	4 (7.1%)
Medullary carcinoma	8 (14.3%)
BIRADS	
U/S BIRADS (1-3) (benign)	46 (46%)
U/S BIRADS (4-5) (malignant)	54 (54%)

Data are presented as frequency (%). IDC: Infiltrating ductal carcinoma, ILC: Infiltrating lobular carcinoma. BIRADS: Breast Imaging Reporting and Data System.

According to mammographic examination, all cases presented with dense opacities in their mammogram, which ill-defined was predominant finding (20/50) (40%), and these lesions were malignant as well as lesions with microcalcifications, speculated and irregular shape, in controversy well defined (8/50) (16%), oval, or rounded shaped lesions with regular outlines were benign. In our study we found that (96/100) cases (96 %) were solid and (4/50) cases (4%) were cystic. In our study most of the solid lesions were hypoechoic

(88/96) (91.7%), heterogeneous in texture (56/96) (58.3%) and only four of them showed halo zone surrounding the lesions and four showed calcifications within. The four cystic lesions were found to be simple cysts and complicated cysts. Most of the cases are associated with suspicious looking lymph nodes (60/100) (60%), and the (40/100) (40%) showed reactive enlarged lymph nodes. **(Table.3).**

Table 3.Mammographic and ultrasound finding of all participants (n=50)

Variables		N (%)
Mammographic Findings		
Shape (50 masses)	**Rounded**	10 (20%)
	Oval	14 (28%)
	Lobular	6 (12%)
	Irregular	20 (40%)
Margins (50 masses)	**Well - defined**	8 (16%)
	Micro -lobulated	10 (20%)
	Ill-defined	20 (40%)
	Speculated	12 (24%).
Calcifications (14 masses)	**Macro calcifications**	10 (20%)
	Micro calcification	4 (8%)
Ultrasound findings		
A) Solid		96 (96%)
Texture	**Homogenous**	40 (41.7%)
	Heterogenous	56 (58.3%)
Echogenicity	**Hypoechoic**	88 (91.7%)
	Hyperechoic	8 (8.3%)
Halo-zone		4 (4.2%)
Calcifications		4 (4.2%)
B) Cystic lesions		4 (4%)
Simple cyst		2 (50%)
Complicated cyst		2 (50%)
Associated pathological enlarged lymph nodes	**Reactive**	40 (40%)
	Suspicious	60 (60%)

Data are presented as frequency (%).

Most of the benign lesions (36/44) (81.8%) were oval shaped and parallel to the skin, (28/44) (63.6%) showed circumscribed margins, (36/44) (81.8%) had abrupt interface, (36/44) (81.8%) hypoechoic in echogenicity and (8/44) (9.1%) had acoustic shadowing. Most of the malignant lesions (44/56) (78.6%) were irregular in shape, (54/56) (96.4%) not parallel to skin, (38/56) (67.9%) showed speculated margins, all the malignant lesions were hypoechoic and with indistinct boundaries, out of them 30 cases had posterior shadowing. (**Table.4)**

Table 4. Ultrasound finding in benign and malignant cases

Variables		N (%)
Benign cases (n=44)		
Shape	**Rounded**	8 (18.2%)
	Oval	36 (81.8%)
Orientation	**Parallel to skin**	36 (81.8%)
	Not Parallel to skin	8 (18.2%)
Margin	**Circumscribed**	28 (63.6%)
	Macro-lobulated	16 (36.4%)
Lesion boundary	**Abrupt interface**	36 (81.8%)

	Anechoic halo	4 (9.1%)
Echo pattern	Hyperechoic	6 (13.6%)
	Hypoechoic	36 (81.8%)
	isoechoic	2 (4.5%)
Acoustic shadowing		4 (9.1%)
Malignant cases (n=56)		
Shape	Rounded	12 (21.4%)
	Irregular	44 (78.6%)
Orientation	Parallel to skin	2 (3.6%)
	Not Parallel to skin	54 (96.4%)
Margin	Angular	6 (10.7%)
	Micro-lobulated	12 (21.4%)
	Speculated	36 (67.9%)
Lesion boundary	Echogenic halo	0 (0%)
	Indistinct	56 (100%)
Echo pattern	Hyperechoic	0 (0%)
	Hypoechoic	56 (100%)
Posterior shadowing		30 (53.6%)

Data are presented as frequency (%).

Distribution of studied cases according to sonographic evaluation showed in (**Table. 5**). The most common in elasto scoring of our cases was score 4 (30 cases) followed by score 2 (26 subjects), score 1 was (12 subjects), score 3 (8 subjects) while score 5 was (24 cases). (**Table. 6**).

Table 5.Distribution of studied cases according to sonographic evaluation (n=100)

BIRADs	Group I (Benign)	Group II (Malignant)
II	6 (13.64%)	0 (0%)
III	32 (72.73%)	8 (14.3%)
IV	6 (13.64%)	22 (39.3%)
V	0 (0%)	26 (46.4%)

Data are presented as frequency (%). BIRADS: Breast Imaging Reporting and Data System.

Table 6. Distribution of participants based on elastoscoring

Score	Group I (Benign)	Group II (Malignant)	P
1	12(27.2%)	0 (0%)	<0.001*
2	24 (54.5%)	2 (0%)	
3	4 (9.1%)	4 (7.1%)	
4	4 (9.1%)	26 (46.4%)	
5	0 (0%)	24 (42.9%)	

Data are presented as frequency (%).

Recorded True positive cases were 50 by both elastoscoring and strain ratio and 48 by conventional ultrasound. Falsely detected positive lesions that were histologically proved benign were account for strain ratio, elastoscoring and ultrasound were 2, 4 and 6 respectively, detailed above. Falsely detected negative lesions that were histologically proven to be malignant were account for strain ratio, elastoscoring and ultrasound were 6, 6, and 8 also detailed before. PPV was calculated 96.2% for strain ratio, 92.6% for elastoscoring and 88.9% for ultrasound. NPV was calculated 87.5% for strain ratio, 86.9% for elasto scoring and 82.6% for ultrasound strain ratio and elasto scoring had same sensitivity, accounted as 89.3% while ultrasound proved to be less sensitivity 85.7%. Strain ratio had the highest specificity 95.5%, followed by elasto scoring was 90.9% and the least ultrasound was 86.4%. Accuracy was calculated, the strain ratio was the highest 92% followed by elasto scoring (90%). The least was ultrasound (86%). (**Table 7)**

Table 7. Comparison between the BIRADS, elasticity score and strain ratio of the studied cases

Result	Strain ratio	Elastoscoring	BIRADS
True positive	50	50	48
False positive	2	4	6
False negative	6	6	8
True negative	42	40	38
Sensitivity	89.3%	89.37%	85.75%
Specificity	95.5%	90.9%	86.4%
Positive predictive value	96.2%	92.6%	88.9%
Negative predictive value	87.5%	86.9%	82.6%
Accuracy	92%	90%	86%

Data are presented as percentage. BIRADS: Breast Imaging Reporting and Data System.

Case 1

A 50-years-old female patient complaining of right hard painless mobile breast lump. (**Fig. 1)**

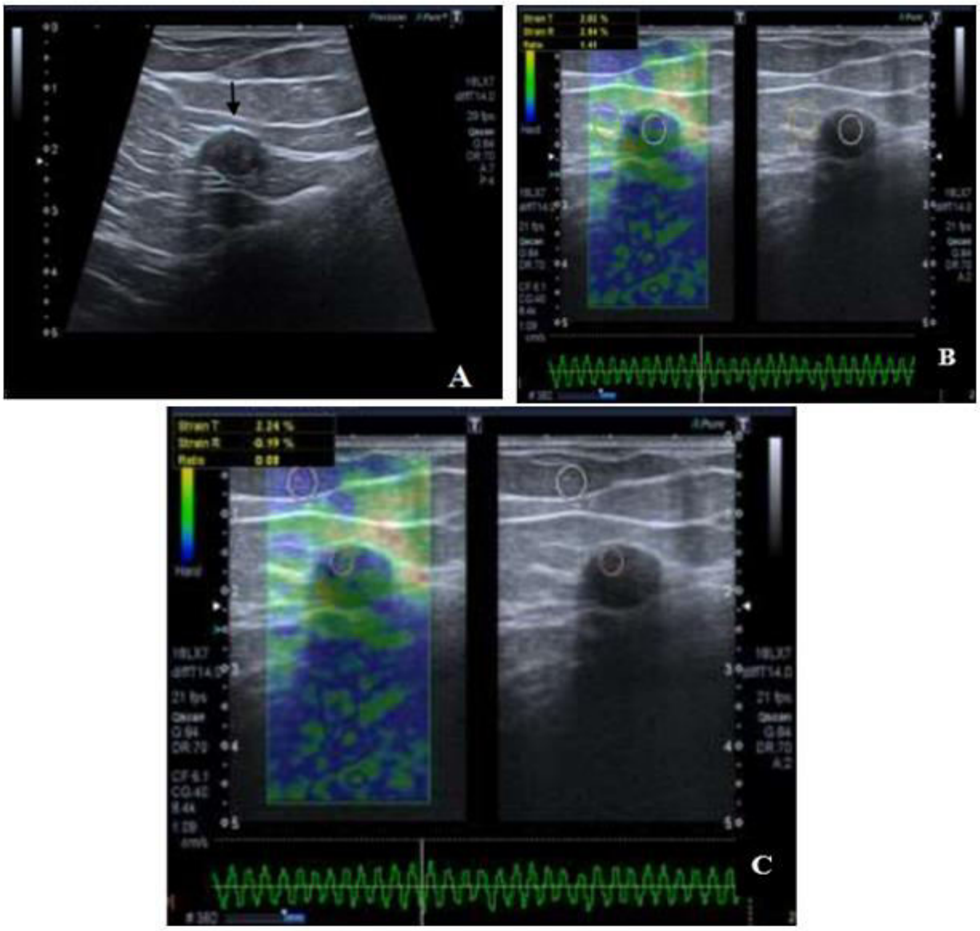

Fig. 1.A 50-years-old female case with right breast fibroadenoma. A) B mode U/S of right breast revealed a well-defined oval hypoechoic, solid mass measuring about 13 x 7.9 mm seen at 1 o'clock exhibiting U/S appearance of (BIRADS III). B, C) Elastography of this lesion showed central greenish discoloration & small marginal bluish discoloration exhibiting ES appearance of scoring 2. Strain ratio of 1.41 & confirmed histopathologically to be fibroadenoma

Case 2

Female patient aged 32 years old presented clinically by right breast tenderness and palpable upper outer quadrant lump. (**Fig. 2**)

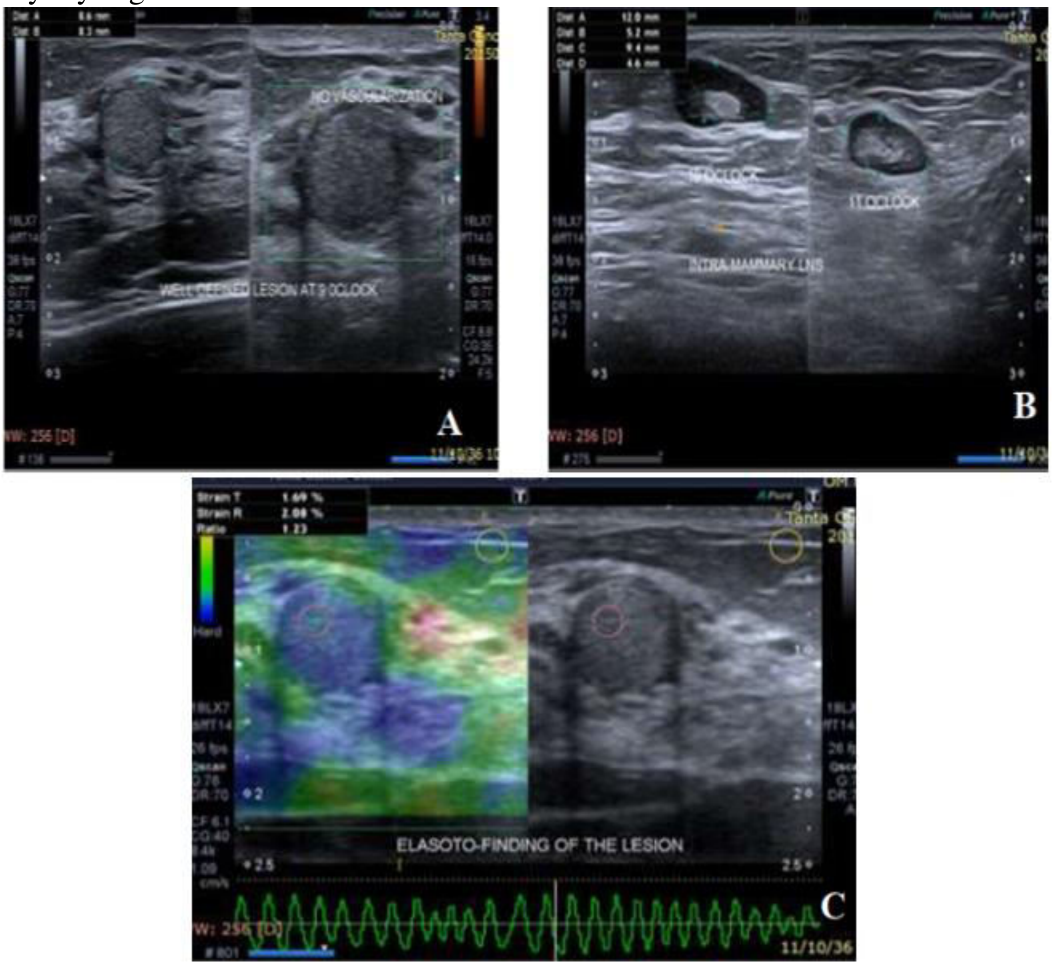

Figure 2: A 32-years-old female case with right breast moderate mammary dysplasia, infected fibrocystic dysplasia with suppuration. (A) B mode U/S of right breast revealed a well-defined, hyperechoic, rounded lesion measuring about 8.6 x 8.3 mm seen at 9'oclock exhibiting U/S appearance of (BIRADS III), associated with enlarged ipsilateral axillary lymph nodes some of them showed increased cortical thickening (4.6mm) and preserved fatty hilum (benign looking) (B). (C) Elastography of this lesion showed bluish discoloration of the lesion and greenish discoloration of the surrounding tissue exhibiting ES appearance of scoring 4. Strain ratio of 1.23 & confirmed histopathologically to be moderate mammary dysplasia, infected fibrocystic dysplasia with suppuration and no evidence of malignant

Case 3

Female patient aged 30 years old presented clinically by palpable lump and nipple discharge from right breast. (**Fig. 3)**

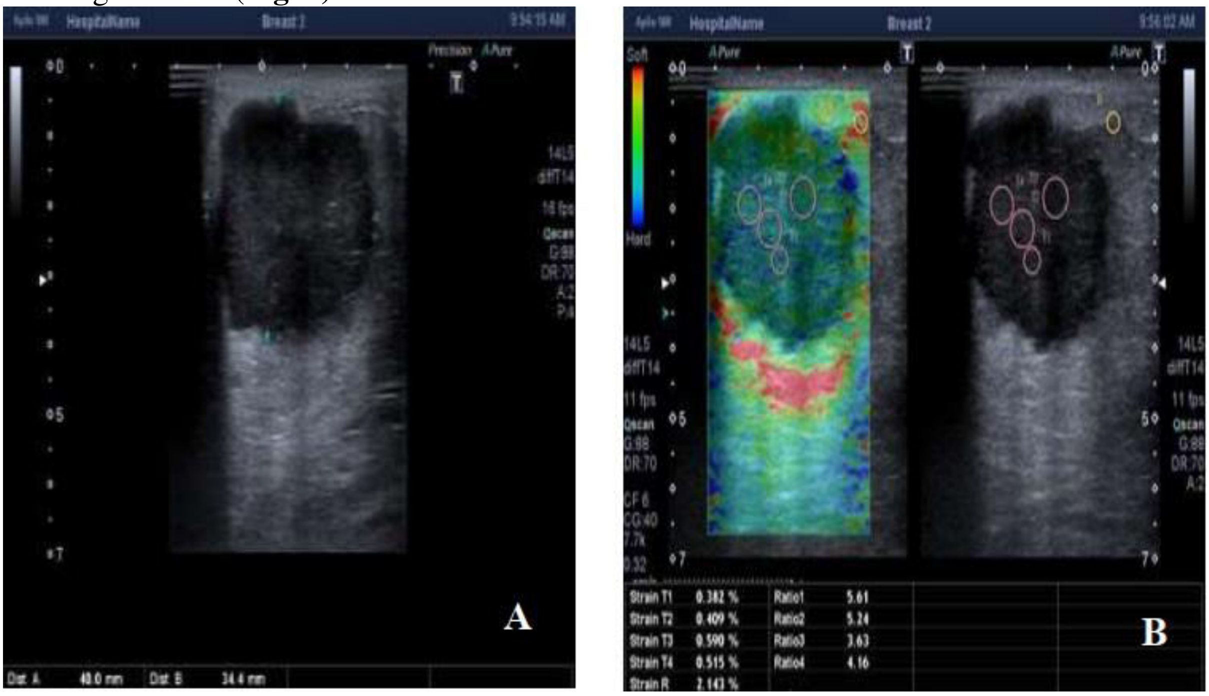

Fig.3. A 30-years-old female case with right invasive ductal carcinoma. (A) B mode U/S of right breast revealed a well-defined rounded, hypoechoic, lobulated solid mass measuring about 40 x 34 mm seen at 12 o'clock exhibiting U/S appearance of (BIRADS V). (B) Elastography of this lesion mosaic greenish and bluish discoloration exhibiting ES appearance of scoring 3. Strain ratio of 5.61& confirmed histopathologically to be Invasive ductal carcinoma

Case 4

Female patient aged 28 years old presented clinically by right hard painless breast lump.

Fig.4

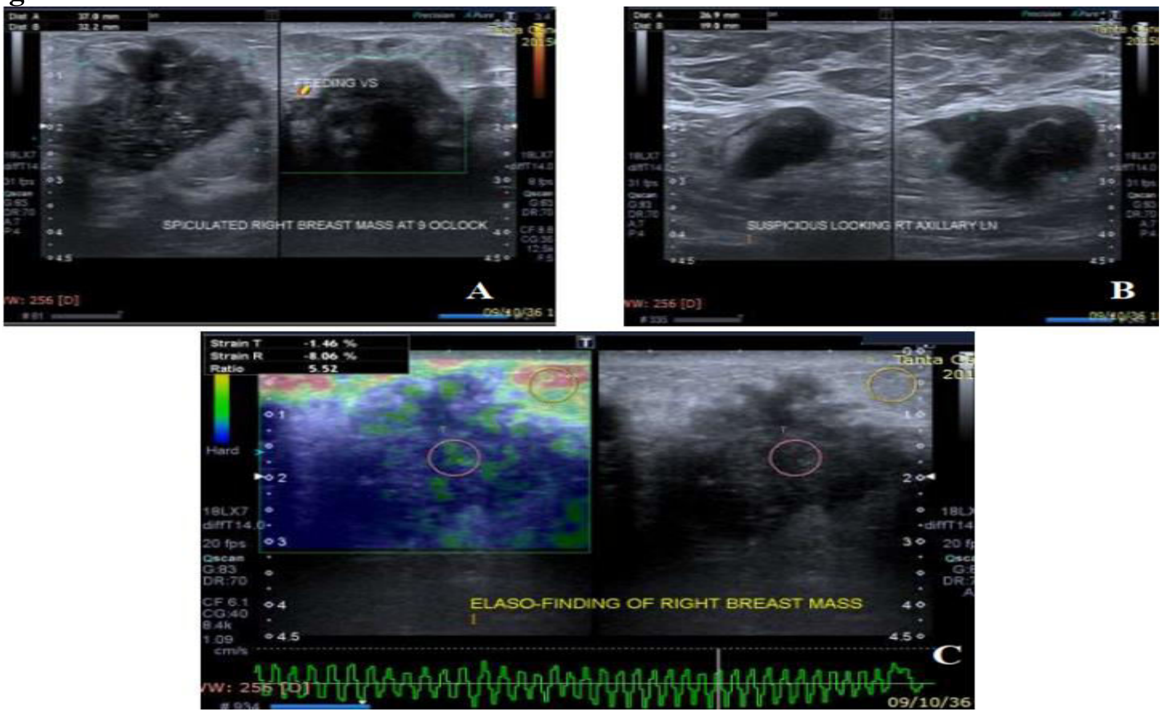

Fig. 4.A 28-years-old female case with right invasive lobular carcinoma. (A) B mode U/S of right breast revealed ill-defined hypoechoic, speculated solid mass measuring about 37 x 32 mm seen at 9 o'clock exhibiting U/S appearance of (BIRADS V) associated with ipsilateral enlarged lymph node with loss of fatty hilum exhibiting malignant criterion measuring about 26 x 19 mm (B). (C) Elastography of the lesion showed bluish discoloration with irregular margin also bluish discoloration in the surrounding tissue exhibiting ES appearance of scoring 5. Strain ratio of 5.52 and confirmed histopathologically of this breast mass was invasive lobular carcinoma

Discussion

In recent years, there has been a renewed emphasis on evaluating elastography imaging for breast imaging. The primary drawbacks of static elastography were the incapacity to provide a quantitative evaluation as well as notable interobserver variability **(Farooq et al., 2019)**. The primary SWE benefit in comparison to traditional elastography is in its superior reproducible results as well as objectivity. This is achieved by enabling the tissue to move, with no need for external compression via a transducer **(Mutala et al., 2022)**. Several shears wave electrographic parameters could be utilized while assessing breast lesions associated with elasticity values, involving, minimum (EMin), mean (EMean), along with maximum (EMax). EMin, EMean, as well as EMax correspond to the lesions' stiffness while ERatio corresponds to the relative stiffness of the lesion to fat tissue, possessing a coherent elasticity value of three kPa **(Pillai et al., 2022)**. Several research have adressed that both SWE as well as SE could be beneficial while characterizinh breast lesions, possessing higher sensitivity as well as specificity since malignant tumors often exhibits a significantly stiffness as opposed to benign ones **(2017, Guiban et al., 2023a, Li et al., 2024)**.

Our research addressed a conventional U/S sensitivity of 85.7 %, with specificity indicating 86.4%, while the total accuracy reached 86 %. The PPV, as well as NPV exhibited 88.9%, and 82.6 %.

Our findings went through a comparison with a prior research by Itoh et al. **(Itoh et al., 2006)** addressing a greater sensitivity (96.2%) along with a reduced specificity (62.7%) while accuracy reached (78.4%) as opposed to ours. Additionally, the study by Shon et al. (150) addressed greater sensitivity (98.2%) along with a more reduced specificity (44.1%).

Based on our research, we regarded elastographic scoring of 1,2,3 as benign while those of 4, 5 as malignant. The mean elasticity score exhibited a significantly greater value within malignant lesions (indicating four) as opposed to benign ones (indicating two). Our findings supported Itoh et al **(Itoh et al., 2006)** addressing a mean elasticity scoring for benign tumors of two while malignant ones exhibited four. Nevertheless, the research by Tan et al **(Tan et al., 2008)** addressed a mean elastoscoring for benign of two while malignant ones exhibited five.

According to our research, the elastography scoring sensitivity exhibited 89.3%, while specificity indicated 90.9%, PPV as well as NPV exhibited 92.6% and 86.96% respectively, with a total accuracy reaching 90%.

Additionally, some research has addressed the elastography diagnostic impact while differentiating between breast nodules. Several authors also addressed, SE could be utilized as a supplementary method to the BI-RADS classification, thus improving the US performance **(Chiorean et al., 2008, Tan et al., 2008)**.

Our findings supported Chamming et al. **(Chamming's et al., 2019)** addressing that the AUC, sensitivity, specificity, NPV, PPV, as well as accuracy for SWE while diagnosing malignancies exhibited 89%, 69%, 100%, 80%, 100%, and 86%, respectively, and while identifying invasive components reached 0.93, 75%, 100%, 75%, 100%, and 85%.

Our findings were quite similar to Itoh et al.'s research **(Itoh et al., 2006)** addressing that the best cutoff point ranges from three to four elasticity scores, indicating sensitivity (86.5%), specificity (89.8%), as well as accuracy (88.3%). Additionally, Elsaid. N & Mohamed G **(Elsaid and Mohamed, 2012)** addressed a sensitivity reaching (84%) specificity (84%). Moreover, we addressed similar findings to those of by Schaefer et al **(Schaefer et al., 2011)** addressing greater sensitivity (96.9%), a reduced specificity (76.0%) while accuracy reached 82.9%. Scaperrotta et al **(Scaperrotta et al., 2008)** assessed the sono elastography diagnostic performance while distinguishing between benign as well as malignant non-palpable breast tumors, they addressed that the U/S overall performance exhibited lower values as opposed to SE, the latter showed sensitivity as well as specificity of 80% and 80.9% respectively, while the US showed 87.5% and 85.71%.

In our study revealed sensitivity of elastography according to strain ratio was 89.3% and specify was 95.5%, NPV was 87.5%, and PPV was 96.2%, the total accuracy reached 92%. Our findings supported Zhi et al. **(Zhi et al., 2010)** addressing, when a cutoff point (3.05) was developed, SR modality exhibited 92.4% sensitivity, 91.1% specificity, as well as 91.4% accuracy. Farrokh et al. **(Farrokh et al., 2011)** addressed 94.4% sensitivity while specificity reached 87.3% possessing a cutoff more than 2.9. Within a prospective study utilizing the strain ratio (FLR). Sadigh **(Sadigh et al., 2012)**addressed an overall sensitivity reaching 88% while specificity (83%) when utilizing strain ratio. Another research utilizing B-mode, strain pattern (elasticity score) as well as strain ratio, Alhabshi et al. **(Alhabshi et al., 2013)** addressed that SR exhibited more benefits while characterizing lesions, possessing a cut-off value (5.6) for SR. Thomas and his colleges (156) addressed Sensitivity as well as specificity of 96% and 56% for B-mode scanning, 81% and 89% for elastography, while 90% and 89% for SRs. A SR cutoff value reaching 2.45 significantly distinguished between malignant as well as benign tumors. Kumm and Szabunio **(Kumm and Szabunio, 2010)** addressed a sensitivity of 76% for ES while 79% as regards SR. Specificity reached 81% for ES while 76% as regards SR.

While performing a comparison between conventional sonography (BIRADS category) as well as elastography (Tsukuba scoring system), most research addressed better specificity for elastography while conventional sonography possessed greater sensitivity, except a prior research by Cho et al **(Cho et al., 2008)** addressing degrees of sensitivity reaching 82%, while ered specificity exhibited reduced values reaching 84% for sonographic elastography as opposed to conventional sonography (89%).

As for us, we agree with most studies that elastography has better specificity values but disagree with that conventional sonography has better sensitivity values; Our study results show that sonographic elastography sensitivity (89.3%) and conventional sonography have sensitivity (85.7%) While elastography showed better specificity values (90.9%) compared to conventional sonography specificity value (86.4%). Leong et al. **(Leong et al., 2010)** concluded that ultrasound breast elastography exhibited more specificity as well as accuracy as opposed to conventional US. Additionally, when elastography is employed along with US, this could enhance the US specificity as well as accuracy, thus substantially decreasing false positive outcomes.

Limitations: A modest sample size. The study was in a single center. Further investigations are advised to be conducted on axillary lymph nodes to assess the elastography effectiveness while distinguishing reactive from malignant pathologically enlarged axillary lymphadenopathy. Also, other studies may be needed to depict the elastographic role in diagnosing mammographically diagnosed indeterminate micro calcifications.

Conclusion

Elastography performed with SE as well as SWE represents a simple approach that possesses superior diagnostic performance. It could be simply utilized along with B-mode ultrasonography during the same session, thus enhances its specificity. It has shown efficacy in reducing needless biopsies, particularly in BIRADS III as well as IVa lesions' evaluation.

Acknowledgments: Nil
Financial support and sponsorship: Nil
Conflict of Interest: Nil

References

- **Alhabshi SM, Rahmat K, Abdul Halim N, Aziz S, Radhika S, Gan GC, et al. (2013)**. Semi-quantitative and qualitative assessment of breast ultrasound elastography in differentiating between malignant and benign lesions. Ultrasound Med Biol, 39(4): 568-578.
- **Balkenende L, Teuwen J, Mann RM. (2022)**. Application of Deep Learning in Breast Cancer Imaging. Seminars in Nuclear Medicine, 52(5): 584-596.
- **Barr RG, Zhang Z. (2015)**. Shear-wave elastography of the breast: value of a quality measure and comparison with strain elastography. Radiology, 275(1): 45-53.
- **Chamming's F, Mesurolle B, Antonescu R, Aldis A, Kao E, Thériault M, et al. (2019)**. Value of shear wave elastography for the differentiation of benign and malignant microcalcifications of the breast. American Journal of Roentgenology, 213(2): W85-W92.
- **Chiorean A, Duma MM, Dudea SM, Iancu A, Dumitriu D, Roman R, et al. (2008)**. Real-time ultrasound

elastography of the breast: state of the art. Medical ultrasonography, 10(2): 73-82.

- **Cho N, Moon WK, Park JS, Cha JH, Jang M, Seong MH. (2008)**. Nonpalpable breast masses: evaluation by US elastography. Korean J Radiol, 9(2): 111-118.
- **Cosgrove D, Barr R, Bojunga J, Cantisani V, Chammas MC, Dighe M, et al. (2017)**. WFUMB guidelines and recommendations on the clinical use of ultrasound elastography: part 4. Thyroid. Ultrasound in medicine & biology, 43(1): 4-26.
- **Cosgrove D, Piscaglia F, Bamber J, Bojunga J, Correas J-M, Gilja Oa, et al. (2013)**. EFSUMB guidelines and recommendations on the clinical use of ultrasound elastography. Part 2: Clinical applications. Ultraschall in der Medizin-European Journal of Ultrasound, 34(03): 238-253.
- **Elsaid N, Mohamed H. (2012)**. Sonoelastography versus dynamic magnetic resonance imaging in evaluating BI-RADS III and IV breast masses. The Egyptian Journal of Radiology and Nuclear Medicine, 43293–300.
- **Farooq F, Mubarak S, Shaukat S, Khan N, Jafar K, Mahmood T, et al. (2019)**. Value of Elastography in Differentiating Benign from Malignant Breast Lesions Keeping Histopathology as Gold Standard. Cureus, 11(10): e5861.
- **Farrokh A, Wojcinski S, Degenhardt F. (2011)**. [Diagnostic value of strain ratio measurement in the differentiation of malignant and benign breast lesions]. Ultraschall Med, 32(4): 400-405.
- **Grajo JR, Barr RG. (2014)**. Strain elastography for prediction of breast cancer tumor grades. Journal of Ultrasound in Medicine, 33(1): 129-134.
- **Guiban O, Rubini A, Vallone G, Caiazzo C, Di Serafino M, Pediconi F, et al. (2023a)**. Can New Ultrasound Imaging Techniques Improve Breast Lesion Characterization? Prospective Comparison between Ultrasound BI-RADS and Semi-Automatic Software "SmartBreast", Strain Elastography, and Shear Wave Elastography. Applied Sciences, 13(11): 6764.
- **Guiban O, Rubini A, Vallone G, Caiazzo C, Di Serafino M, Pediconi F, et al. (2023b)**. Can New Ultrasound Imaging Techniques Improve Breast Lesion Characterization? Prospective Comparison between Ultrasound BI-RADS and Semi-Automatic Software “SmartBreast”, Strain Elastography, and Shear Wave Elastography. Applied Sciences, 13(11): 6764.
- **Guo R, Lu G, Qin B, Fei B. (2018)**. Ultrasound Imaging Technologies for Breast Cancer Detection and Management: A Review. Ultrasound Med Biol, 44(1): 37-70.
- **Gynecologists. ACoOa. (2017)**. Practice Bulletin No. 179 Summary: Breast Cancer Risk Assessment and Screening in Average-Risk Women. Obstetrics & Gynecology, 130(1): 241-243.
- **Itoh A, Ueno E, Tohno E, Kamma H, Takahashi H, Shiina T, et al. (2006)**. Breast disease: clinical application of US elastography for diagnosis. Radiology, 239(2): 341-350.
- **Kanagaraju V, Dhivya B, Devanand B, Maheswaran V. (2021)**. Utility of Ultrasound Strain Elastography to Differentiate Benign from Malignant Lesions of the Breast. J Med Ultrasound, 29(2): 89-93.
- **Kumm T, Szabunio M. (2010)**. Elastography for the Characterization of Breast Lesions: Initial Clinical Experience. Cancer control : journal of the Moffitt Cancer Center, 17156-161.
- **Leong LC, Sim LS, Lee YS, Ng FC, Wan CM, Fook-Chong SM, et al. (2010)**. A prospective study to compare the diagnostic performance of

breast elastography versus conventional breast ultrasound. Clin Radiol, 65(11): 887-894.

- **Li W, Zheng Y, Liu H, Tai Z, Zhu H, Li Z, et al. (2024)**. Multimodal ultrasound imaging for diagnostic differentiation of sclerosing adenosis from invasive ductal carcinoma. Quant Imaging Med Surg, 14(1): 877-887.
- **Lin L, Yan L, Liu Y, Yuan F, Li H, Ni J. (2019)**. Incidence and death in 29 cancer groups in 2017 and trend analysis from 1990 to 2017 from the Global Burden of Disease Study. J Hematol Oncol, 12(1): 96.
- **Mutala TM, Mwango GN, Aywak A, Cioni D, Neri E. (2022)**. Determining the elastography strain ratio cut off value for differentiating benign from malignant breast lesions: systematic review and meta-analysis. Cancer Imaging, 22(1): 12.
- **Pillai A, Voruganti T, Barr R, Langdon J. (2022)**. Diagnostic Accuracy of Shear-Wave Elastography for Breast Lesion Characterization in Women: A Systematic Review and Meta-Analysis. Journal of the American College of Radiology, 19(5): 625-634.e620.
- **Sadigh G, Carlos RC, Neal CH, Dwamena BA. (2012)**. Accuracy of quantitative ultrasound elastography for differentiation of malignant and benign breast abnormalities: a meta-analysis. Breast Cancer Res Treat, 134(3): 923-931.
- **Scaperrotta G, Ferranti C, Costa C, Mariani L, Marchesini M, Suman L, et al. (2008)**. Role of sonoelastography in non-palpable breast lesions. Eur Radiol, 18(11): 2381-2389.
- **Schaefer FK, Heer I, Schaefer PJ, Mundhenke C, Osterholz S, Order BM, et al. (2011)**. Breast ultrasound elastography--results of 193 breast lesions in a prospective study with histopathologic correlation. Eur J Radiol, 77(3): 450-456.
- **Shahzad R, Fatima I, Anjum T, Shahid A. (2022)**. Diagnostic value of strain elastography and shear wave elastography in differentiating benign and malignant breast lesions. Ann Saudi Med, 42(5): 319-326.
- **Tan SM, Teh HS, Mancer JF, Poh WT. (2008)**. Improving B mode ultrasound evaluation of breast lesions with real-time ultrasound elastography--a clinical approach. Breast, 17(3): 252-257.
- **Zhao H, Zou L, Geng X, Zheng S. (2015)**. Limitations of mammography in the diagnosis of breast diseases compared with ultrasonography: a single-center retrospective analysis of 274 cases. Eur J Med Res, 20(1): 49.
- **Zhi H, Xiao X-Y, Yang H-Y, Ou B, Wen Y-L, Luo B-M. (2010)**. Ultrasonic elastography in breast cancer diagnosis: strain ratio vs 5-point scale. Academic radiology, 17(10): 1227-1233.