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Research Article

The Role of Ultrasound Elastography in Evaluation of Breast Masses

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Abstract

Introduction: Elastography is a non-invasive medical imaging technique that detects tumors based on their stiffness (elasticity). Strain images display the relative stiffness of lesions compared with the stiffness of surrounding tissue as cancerous tumors tend to be many times stiffer than the normal tissue, which ''gives'' under compression.

Purpose: To prospectively evaluate the sensitivity and specificity of the real-time sonoelastography as compared with B-mode US for distinguishing between benign and malignant breast lesions

Methods: The study was conducted on 20 patients with 36 lesions, each patient was subjected to complete history taking, thorough Clinical examination. Then all patient had conventional US and elastography while only 17 patients did mammography.

Results: Among the 20 patients, sensitivity and specificity of the elastography test in breast lesions according to the elastography score were 80% and 80.95% respectively, while sensitivity and specificity of conventional B mode US were 80% and 76% respectively. yet the combined B mode US and US elastography showed sensitivity and specificity of 86.6% and 90.4% respectively.

Conclusion: Elastography is not used independently but in the same session of ultrasound taking about five minutes more than the conventional ultrasound examination as an additional role for conventional ultrasound examination in an attempt to increase and improve the accuracy of diagnostic efficiency assessed by the BIRADs scoring system and not as a separate examination.

Keywords: Sonoelastography (SE); Breast Cancer; Ultrasound; Strain Ratio (SR)

Introduction

Breast is made up of glandular, fatty, and fibrous tissues. There is a layer of fatty tissue that surrounds the breast glands and runs throughout the entire breast giving breast its soft consistency. Solid breast lesions may be benign or malignant. Fibroadenoma is the common benign breast lesion, while invasive ductal carcinoma is the most common malignancy [1].

Breast cancer is the leading cause of deaths in women in industrialised countries and its incidence continues to escalate. Therefore early detection to improve breast cancer outcomes remains the cornerstone of breast cancer control [2].

A recent decline in cancer mortality is now observed due to improvement in the imaging technologies in addition to a higher degree of health awareness and educational programs [2].

There are three imaging techniques that are available to radiologists to detect breast lesions. Mammography is the reference technique, while sonography and MRI are considered to be complementary imaging methods. B-mode sonography is an indispensable complementary examination for the investigation of breast masses, whether they are palpable or not [1].

One of the new technique of ultrasound is sonoelastography. Ultrasound elastography is a new imaging mode that display tissue

softness or hardness in real time as a colour map that translucently overlays the conventional B-mode image. This technique significantly improves the differentiation between benign and malignant tissues [3].

Generally, breast cancer tissue is harder than the adjacent normal breast tissue. This property serves as the basis for some examinations, such as palpation, that are currently being used in the clinical assessment of breast abnormalities, as well as for elastography. It is the difference in tissue stiffness which contributes in the differentiation between benign and malignant lesions [4,5].

Sonoelastography (SE), looking at the mechanical properties of tissues (relative stiffness) as opposed to conventional ultrasound, which looks at the backscatter of transmitted ultrasound waves through tissues [1].

Sonoelastography is based on the comparison of signals acquired before and after tissue displacement. Several sonoelastographic techniques have been devised, including compression strain imaging, and real-time shear velocity. Among these techniques, compression sonoelastography currently has the most prominent role in breast imaging [6].

The technique of ultrasound elastography is based on the principle that the soft parts of tissue deform more easily than harder parts of tissue under compression, thus allowing an objective determination of tissue consistency [7].

US strain imaging (also known as elastography) may aid in the differentiation of benign from malignant solid breast masses. This technique exploits the theory that benign and malignant breast lesions have inherent differences in firmness. Strain images display the relative stiffness of lesions compared with the stiffness of surrounding tissue. Stiffer areas deform less easily than do their surroundings and are depicted as dark on strain images, whereas softer areas deform more easily than do their surroundings and are depicted as light [8,9].

Malignant masses typically appear dark and have high contrast with background breast tissue during deformation. Benign masses typically appear lighter and have lower contrast with background breast tissue during deformation. In addition; malignant lesions tend to be larger on US strain images than on corresponding B-mode US images, perhaps because of the desmoplastic reaction commonly associated with malignancy. The changes in contrast with deformation can only be appreciated in a sequence of images. The appearance of masses on strain images and lesion size discrepancies between B-mode and strain images may be promising tools for distinguishing benign from malignant lesions [8,9].

The interpretation criteria in elastography consist of the qualitative parameter elasticity score (ES) and the quantitative parameter strain ratio (SR) [10,11].

The process begins with conventional gray-scale ultrasound imaging of the target lesion. Slight manual pressure is then applied in a direction perpendicular to the skin [12-14].

Differences in the echo reflection from selected lesion tissue and background tissue during compressed and noncompressed intervals are quantified and then used to produce an elastogram. Current image processing allows for the production of a color elastogram that can be used to further categorize the stiffness or strain of the target tissue [13].

Areas of high strain, indicating easily compressed tissue such as adipose tissue, generate a red pixel on the ultrasound-viewing screen [13].

Areas of high strain, demonstrated by tissues that tend to compress to the same degree as fibroglandular or benign tissue, generate green pixels, while areas of lower strain, indicating hard or malignant tissue, generate blue pixels [13].

A color map is then generated and is superimposed over the gray-scale ultrasound images. A grading scale used to categorize lesions based on the color signature generated by evaluation of target lesions has been proposed by Itoh., *et al*. [13] (figure 1).

- Category 1 lesions demonstrate a uniform pattern of high strain, marked by an evenly distributed green color throughout the lesion.
- Category 2 lesions show a heterogeneous but mostly green color signature, indicating a predominantly high strain pattern of the lesion.
- Category 3 lesions show a pattern of high peripheral strain with central low strain pattern, and they produce a small central blue area that is surrounded by a green peripheral color.

- Category 4 lesions produce a low strain pattern and a uniformly blue color signature confined to the visible margin of the lesion.
- Category 5 lesions show a similar blue signature that extends beyond the lesion into the adjacent tissues [13].

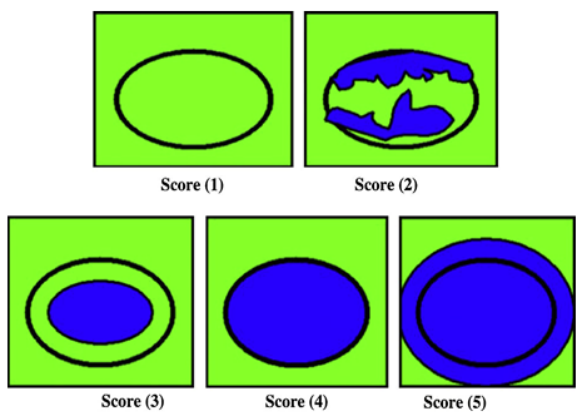


Figure 1: Elasticity scores [13].

On subsequent analysis, lesions that are designated category 0, 1, or 2 are considered to have a higher likelihood of benign result. Category 3 lesions are indeterminate, while lesions graded as category 4 or 5 are more likely to be malignant [1,13].

Calculation of the SR value is based on determining the average strain measured in a lesion and comparing it to the average strain of a similar area of fatty tissue in the adjacent breast tissue. Using proprietary software, the average strain of the lesion is determined by selecting a region of interest (ROI) encompassing the lesion [15].

The ROI for the lesion is expressed as ST – ave LESION. A corresponding ROI of adjacent adipose tissue is then selected and is expressed as ST – ave FAT. The ratio of these two measurements is calculated according to the formula Ratio = ST – ave FAT/ST – ave LESION The ratio value increases as a function of the relative stiffness of the target lesion. As the SR increases, the likelihood of invasive breast cancer increases [15].

Strain imaging may help to offset subjective factors in the scoring of color images, and it may show an advantage in the evaluation of lesions in dense or small breasts [15].

Aim of the work

The aim of this work was to evaluate the diagnostic utility of sono-elastograpy in differntiating different breast masses (benign or malignant).

Material and Methods

The study was conducted on 20 patients with 36 lesions, each patient was subjected to complete history taking, thorough Clinical examination. Then they did:

- **Mammography:** 17 patients from 20 patients did mammogram however 3 patients did not do mammogram as they were young (less than 30 years), Mammograms were obtained using a dedicated X-ray unit having 0.5 target focal spot in a molybdenum anode. Two views were obtained for each breast, the craniocaudal and the mediolateral oblique views.
- **US technique:** All patients were subjected to breast US using 7.5 MHz linear probe. The transducers were directly applied to the skin surface to examine the inner quadrants of the breasts, and the supine oblique position, to evaluate the outer quadrants. Scanning was performed in the radial and antiradial planes in relation to the nipple, and/or sagittal and transverse planes were used, where it begins in the upper inner quadrant of the breast and proceeds slowly to the outer quadrant to obtain sagittal images. The transducer is then moved lower on the breast and the scanning action is repeated until the whole breast has been examined. The comment on the US included description of the breast parenchymal pattern, skin thickening and evaluating ducts for duct ectasia, intraductal soft tissue lesions, or inspissated secretions. Evaluation of any focal lesion for site, size, shape, echogenicity, borders, posterior acoustic phenomena (shadowing, enhancement or none), architectural distortion or tissue edema, vascularity of the lesion on Doppler US, effect of compression on the lesion, whether it is flattened, compressed or not and if the lesion is mobile or fixed under the probe.
- **Elastographic method:** After B-mode US detection of the lesion of interest, the patient remains in the same supine position. Then the dual elastographic program starts, with the US monitor showing in real time the B-mode US image of the lesion on the right side and the same image with color-coded elasticity features superimposed on the left side and motion images are obtained by applying a light constant pressure with the probe in contact with the skin perpendicular to the chest wall. In order to obtain correct elastographic images, attention must be paid to the

definition of the ROI, which has to be sufficiently wide to include enough breast tissue surrounding the lesion so that data about the average strain of the tissue inside the region are available.

The ROI usually must extend from the subcutaneous fat at the top to the anterior profile of the pectoral muscle at the bottom, with lateral borders set more than 5 mm from the lesion's boundary.

The elasticity image was displayed with 256 color mapping for each pixel according to the degree of strain within the region of interest, by using a scale from red (greatest strain, softest component), to green (average strain, intermediate component), to blue (no strain, hardest component). Strain imaging allowed analysis of the strain ratio values that were also calculated. The examination took approximately 10–15 min.

The results were confirmed by further biopsy (7 cases did FNAC, 7 cases did core needle biopsy, 1 case did discharge cytology), follow up in 6 cases and MRI mammography in 1 case.

Results

This study included 20 patients with palpable breast lumps. Their ages ranged from 24 years to 67 years with a mean age of 46 years (table 1).

Age (years)	No.	%
20 - <30	3	15.0
30 - <40	5	25.0
40 - <50	2	10.0
≥50	10	50.0
Min. – Max.	24.0 – 67.0	
Mean ± SD.	45.90 ± 13.38	
Median	48.0	

Table 1: Distribution of the studied cases according to age (n=20).

All patients were evaluated by gray scale ultrasound and sonoelastography examination, 20 cases had multiple lesions with a net result of 36 lesions being evaluated.

Considering the diagnosis in 20 cases, there were 36 breast lesions subdivided into 21 benign and 15 malignant lesions according to histopathology, MRI and follow up.

According to the BIRADS classification, 16 breast lesions (44.2%) were BIRADS 2, 8 lesions (22.2%) were BIRADS 3, 2 lesions (13.3%) were BIRADS 4, 8 lesions (53.3%) were BIRADS 5 and 2 lesions (13.3%) were BIRADS 6.

BIRADS	Total (n = 36)		Benign lesion (n = 21)		Malignant lesion (n = 15)		c^2	^{MC}p
	No.	%	No.	%	No.	%		
0	0	0.0	0	0.0	0	0.0	32.502*	<0.001*
1	0	0.0	0	0.0	0	0.0		
2	16	44.2	16	76.1	0	0.0		
3	8	22.2	5	23.8	3	20		
4	2	5.5	0	0.0	2	13.3		
5	8	22.2	0	0.0	8	53.3		
6	2	5.5	0	0.0	2	13.3		

Table 2: The relation between the BIRADS of the studied lesions and the diagnosis is summarized.

χ^2: Chi square test

MC: Monte Carlo test

*: Statistically significant at $p \leq 0.05$

Ultrasound elastography of breast lesions: Elastoraphy was performed on 20 cases with a total number of 36 lesions being classified according to modified Ueno and Ito elasticity score system.

Benign lesions took elastography score 1, 2, 3 and 4. 4 lesions (19%) had elastography score 1, 11 lesions (52.4%) had elastography score 2, 2 lesions (9.5%) had elastography score 3 and 4 lesions (19%) had elastography 4.

However malignant breast lesions took elastography score 3, 4 and 5. 3 lesions (20%) had elstography score 3, 9 lesions (60%) had elstography score 4 and 3 lesions (20%) had elastography score 5 (Table 3).

Elastography score	Total (n = 36)		Benign lesion (n = 21)		Malignant lesion (n = 15)		c^2	^{MC}p
	No.	%	No.	%	No.	%		
1	4	11.1	4	19.0	0	0.0	19.964*	<0.001*
2	11	30.6	11	52.4	0	0.0		
3	5	13.9	2	9.5	3	20.0		
4	13	36.1	4	19.0	9	60.0		
5	3	8.3	0	0.0	3	20.0		

Table 3: Relation between the elastography score and the diagnosis of breast lesions.

χ^2: Chi square test

MC: Monte Carlo test

*: Statistically significant at $p \leq 0.05$

None of the malignant lesions had score 1or 2, while none of the benign lesions had score 5.

As regards the relation between BIRADS classification and elastography score (Table 4)

- Lesions with BIRDAS 2 had elastography score 1,2, 3 and 4. 3 lesions (8.3%) had elastogrphy score 1, 3 lesions (8.3%) had score 2, 9 (25%) lesions had score 3 and 1 lesions (2.7%) had score 4
- Lesions with BIRADS3 had score 1,2,3 and 4. 1 lesion (2.7%) had score 1, 1 lesions (2.7%) had score 2, 2 lesions (5.5%) had score 3 and 4 (11.1%) had score 4.
- Lesions with BIRADS 4 had score 4. 2 lesion (5.5%) had score 4.
- Lesions with BIRADS 5 had score 4 and 5, 7 lesions (19.4%) had score 4 and 1 lesion (2.7%) had score 5.
- Lesions with BIRADS 6 had score 3. 2 lesions (5.5%) had score 3 as this lesions were malignant on chemotherapy.

Sensitivity and specificity of the elastography test in breast lesions according to the elastography score: benign lesions according to the elastography score should have score 1, 2 and 3 and malignant lesions should take score 4 and 5.

In our study 4 lesions out of 21 benign lesions took score 4 and 3 lesions out of 15 malignant lesions had score 3. So sensitivity of the elastography test was 80%, while specificity was 80.95% with PPV 75% and NPV 85% and accuracy 80.56% (Table 5).

Birads	Elastography score	Number of the lesion (n = 36)	
		No.	%
2	1	3	8.3
	2	3	8.3
	3	9	25
	4	1	2.7
3	1	1	2.7
	2	1	2.7
	3	2	5.5
	4	4	11.1
4	1	0	0.0
	2	0	0.0
	3	0	0.0
	4	2	5.5
	5	0	0.0
5	1	0	0.0
	2	0	0.0
	3	0	0.0
	4	7	19.4
	5	1	2.7
6	1	0	0.0
	2	0	0.0
	3	2	5.5
	4	0	0.0
	5	0	0.0

Table 4: Classification of the lesions according to the BIRADS and elastography score.

Elastography score	Benign lesion (n = 21)	Malignant lesion (n = 15)	Sensitivity %	Specificity %	PPV %	NPV %	Accuracy %
1 + 2 + 3	17	3	80.0	80.95	75.0	85.0	80.56
4 + 5	4	12					

Table 5: Relation between the elastography score and pathological diagnosis.

Sensitivity and specificity of the elastography test in breast lesions according to the elastography score were 80%, 80.95% respectively, while sensitivity and specificity of conventional B mode US were 80%, 76% respectively and combined B mode US and US elastography showed higher sensitivity and specificity as they were 86.6%, 90.4% respectively (Table 6).

Imaging modality	Sensitivity%	Specificity%	PPV%	NPV%
B mode US	80	76	70	84
US Elastography	80.0	80.95	75.0	85.0
Combined B mode US and US elastography	86.6	90.4	86	90.4

Table 6: Sensitivity, specificity, and predictive values of the B-mode and real time elastography (RTE).

Relation between strain ratio and the diagnosis of breast lesions

All benign lesions had strain ratio with Min. – Max (0.20-8), Mean ± SD (1.64 ± 1.62), and Median (1.30) while all malignant lesions had strain ratio with Min. – Max(2-81), Mean ± SD (22.56 ± 26.2) and Median (15) (Table 7).

Strain ratio	Total (n = 36)	Benign lesion (n = 21)	Malignant lesion (n = 15)	Z	p
Min. – Max.	0.20 – 81.0	0.20 – 8.0	2.0 – 81.0	4.679*	<0.001*
Mean ± SD.	10.36 ± 19.6	1.64 ± 1.62	22.56 ± 26.2		
Median	2.0	1.30	15.0		

Table 7: Comparison between the benign and malignant lesions according to strain ratio.

Z: Z for Mann Whitney test

In this study we included 20 patients with 36 breast lesions confirmed on US. There were 21 benign and 15 malignant lesions. Fibro adenoma, cyst and fibrocystic changes were the most common benign lesions while infiltrative ductal carcinoma was the most common malignant lesions (Table 8).

Fibroadenomas appeared smooth oval or rounded in shape with well-defined margins, homogenous echotexure, isoechoic with bilateral acoustic shadowing, wider than taller and either softer than or had the same elasticity as adjacent glandular tissue with score 1,2 or 3 (Figure 2). Fibro adenomas sometimes (4 lesions from 12 lesion in our study) have elastographic size or stiffness features that are more typical of malignancy as in calcified fibroadenoma with elasticity score 3 or 4 (Figure 3).

Pathological diagnosis	Number of lesions 36
Fibro adenoma	**12**
Simple cyst	**2**
Fibrocystic disease	**2**
Duct dilatation	**5**
Invasive ductal carcinoma	**7**
Ductal carcinoma in situ	**2**
Anaplastic carcinoma	**5**
Fibrocystic disease with atypia	**1**

Table 8: Final diagnosis of all breast lesions.

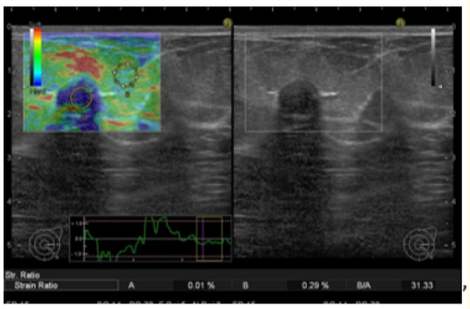


Figure 2: 25 years female with multiple bilateral palpable breast lumps. (a) Conventional US showed well defined iso to hypoechoic focal lesion (b) on elastography: the score was 2(the lesion showed a heterogeneous but mostly green color signature) and strain ratio 0.6. The diagnosis was confirmed by follow up after 6 months to be multiple fibroadenomas.

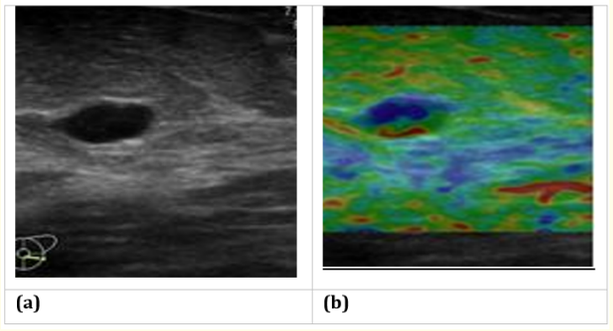


Figure 3: 37years female with left palpable breast lump. Conventional US and sono-elastography showed well defined hypoechoic focal lesion with coarse calcification and elastography score 4 (the lesion was uniformly blue color signature confined to the visible margin of the lesion) and strain ration 30. The diagnosis was confirmed by follow up after 6 months to be calcified fibroadenoma.

Breast cysts appeared as anechoic round or oval well-circumscribed lesions with an imperceptible posterior wall and had an elasticity score of 1 with a characteristic three-layered appearance: blue-green-red (BGR), blue being the superficial color and red the deep one, even in large dimension lesions (figure 4).

Fibrocystic nodules had elasticity similar to that of the surrounding parenchyma.

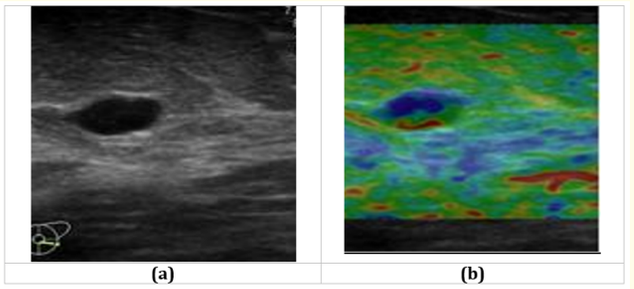


Figure 4: 24 years female with palpable right breast lump. (a) Conventional US showed well defined simple cyst. (b) On elastography BGR pattern (blue, green and red pattern). Confirmed by follow up after 6 months to be simple cyst.

Malignant breast lesions showed irregular shape,ill defined, speculated with heterogeneous echotexture, distorted architexure, central shadowing, taller than wider, microcalcifications, elastography score 4 or 5 and strain ratio above 3. They appeared larger on the elastography image because of better visualization of the surrounding desmoplastic reaction (Figures 5-7).

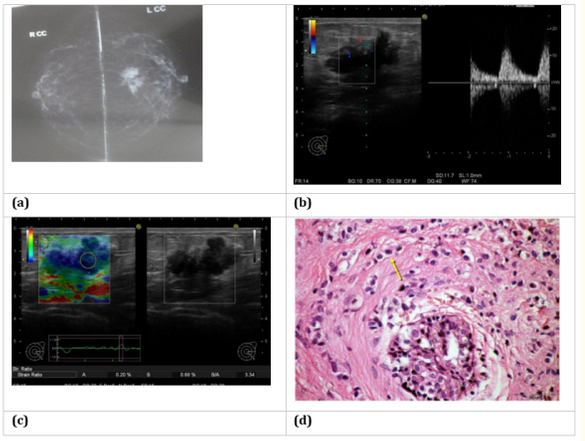
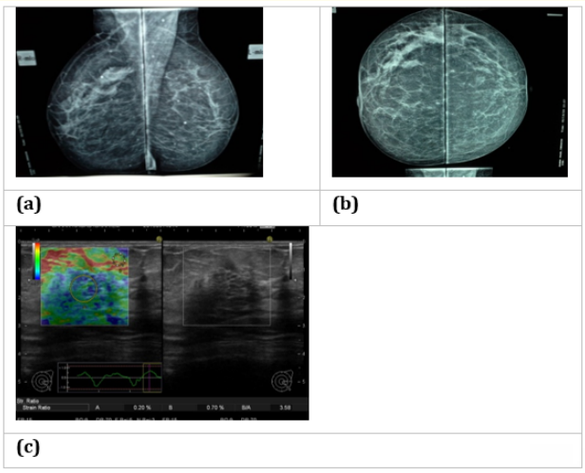
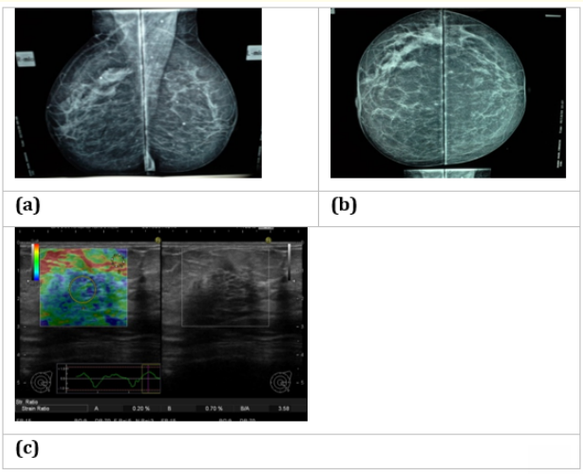


Figure 5: 55 years female with palpable left breast lump. (a) Mammogram (CC view) showed dense opacity with irregular outlines in the inner quadrant from the left breast. (b) conventional US showed hypoechoic lesion with irregular borders, posterior acoustic shadowing with detected vascularity on color Doppler. (c) elastography of the lesion showed score 4 (the lesion was uniformly blue color signature confined to the visible margin of the lesion) and strain ration 3.3 (d) FNAC of the mass revealed infiltrating ductal carcinoma with small hyperchromatic cells around proliferating ducts.



(a) (b) (c)

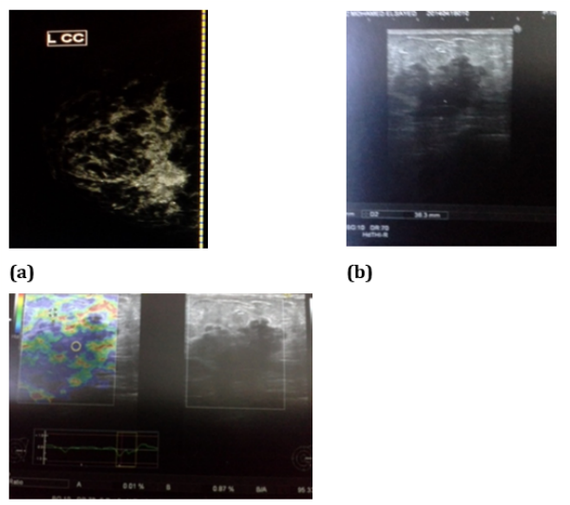
Figure 6: 35 years female with palpable right breast lump (a) Mammogram (MLO view) showed focal asymmetry in the upper quadrant in the right breast. (b) Mammogram (CC view) showed focal asymmetry in the upper quadrant. (c) US and elastography, showed aggregated dense glandular tissue with score 4 (the lesion was uniformly blue color signature confined to the visible margin of the lesion) and strain ratio 3.5. the final diagnosis was confirmed by core needle biopsy as ductal carcinoma in situ.



(a) (b) (c)

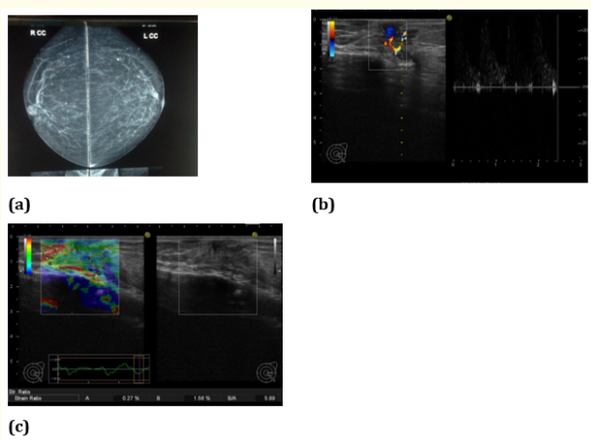
Figure 6: 35 years female with palpable right breast lump (a) Mammogram (MLO view) showed focal asymmetry in the upper quadrant in the right breast. (b) Mammogram (CC view) showed focal asymmetry in the upper quadrant. (c) US and elastography, showed aggregated dense glandular tissue with score 4 (the lesion was uniformly blue color signature confined to the visible margin of the lesion) and strain ratio 3.5. the final diagnosis was confirmed by core needle biopsy as ductal carcinoma *in situ*.

Some breast cancers may display benign features on elastography imaging (score 1-3) as patients with malignant lesions on chemotherapy (Figure 8).



(a) (b) (c)

Figure 7: 52 years female with history of right breast cancer managed with right MRM presented by palpable left breast lump. (a) Mammogram (CC view) showed ill-defined opacity at the inner quadrant of the left breast confirmed by core needle biopsy as ductal carcinoma in situ. (b) Conventional US showed marked hypoechoic lesion with irregular outlines and posterior acoustic shadowing.(C) elastography showed lesion with score 5 (a uniformly blue color signature beyond the lesion into the adjacent tissues) and strain ratio 95. The final diagnosis was confirmed by core needle biopsy as ductal carcinoma in situ.



(a) (b) (c)

Figure 8: 67 years old female patient (known case of left parasternal malignant breast mass on chemotherapy) (a) mammogram (CC view) could not assessed the lesion (b) conventional US showed hypo-echoic lesion noted at the parasternal region with irregular borders and detected vascularity on color Doppler. (c) elastography showed lesion with score 3 (the lesion produced a small central blue area that was surrounded by a green peripheral color.) and strain ratio 5.8

Discussion

Non-invasive diagnosis of the breast masses with imaging modalities remains one of the major concerns. Diagnostic US, the oldest of the cross-sectional imaging modalities, has struggled in recent years to stay competitive with the technical advancements in computed tomography and magnetic resonance imaging [16,17].

Sonography is the primary workup tool in young women. It is considered as a sensitive modality for detection of breast cancers, which is one of the varieties of factors leading to false-negative findings on mammography [18].

The diagnosis of breast masses by B-mode US depends mainly on their morphologic criteria. Biopsy is an indispensable method to confirm malignancy. Increased numbers of aggressive biopsies performed for benign abnormalities is an additional problem due to risk of infection, resultant anxiety, discomfort and increased costs [19].

In this study 21 lesions (58.3%) from 36 lesions were benign and 15 lesions (41.7%) from 36 were malignant.

According to BIRADS analysis of the conventional B mode US, there were 16(76.1%) lesions from 21 benign lesions had BIRADS 2 and 5 (23.8%)lesions had BIRADS 3. While among 15 malignant breast lesions, 3(20%) lesions had BIRADS 3, 2(13.3%) lesions had BIRADS 4, 5(53.3%) lesions had BIRADS 5 and 2 (13.3%) lesions had BIRADS 6.

From the diagnostic point of view, our results confirmed sensitivity (80%) and a relatively low specificity (76%) of conventional B mode ultrasound as 5 lesions showed false-positive results on the B-mode US. Moreover, the Mann–Whitney statistical test revealed that the mean rank of BI-RADS categories was significantly increased among malignant cases ($P < 0.001$). This was in close conformity with results reported by Ikeda., *et al*. who found that B-mode US based on the criteria of the BI-RADS had the sensitivity of 93.9%, specificity of 88.3% and accuracy of 90.6% for all breast lesions. Also, our results are approximately consistent with the studies of Thomas., *et al*. (sensitivity of 91.8% and specificity of 78%) and Navarro., *et al*. (sensitivity of 96.6%, specificity of 76.9%). These slight differences may be probably attributed to different prevalence of breast cancer, different patient selection criteria as well as difference in the number of the studied lesions and differences in the used equipments [20,21].

The interpretation of breast lesions detected on B-mode US relies mainly on morphological criteria. To improve the accuracy of ultrasonography, additional techniques can be used, including Doppler and harmonic imaging. Over the last decade, there has been increasing interest in imaging the elasticity of biological tissues to complement information from standard anatomical imaging. Sonoelastography can differentiate between benign and malignant lesions on the basis of their firmness. The lesion's contours, dimensions, color, SR, and appearance on elastography are some of the criteria used for differentiating benign from malignant lesions. The strain ratio represents the relative compliance stiffness of lesions compared with surrounding tissues. Malignant lesions, which are very stiff, deform less and are displayed in blue on the elastography images, whereas benign lesions deform much more easily and are depicted in green color [22,23].

Real-time elastography, a noninvasive method for revealing the physical properties of a tissue, has been developed as an alternative to breast biopsy. The elastographic information is immediately available and superimposed in color on the B-mode image. Sonoelastography is, therefore, not more time consuming than conventional breast US [11,24].

The ability of SE (sonoelastography) to evaluate the mechanical properties of different tissues is an useful diagnostic tool that provides further information about breast lesions in addition to the well known morphologic parameters such as shape, orientation, margins, internal structure and the presence of calcifications. These additional findings may be very useful in distinguishing malignant from benign solid lesions; as well, the stiffness of a mass as perceived at palpation plays an important role in the clinical assessment [25].

The intrinsic elasticity of biological tissue is altered by pathological processes. Since the real time elastography depicts functional tissue elasticity changes, its addition to B-mode US increased the per-formance in interpretation and final evaluation of breast masses [26,27].

The interpretation criteria in elastography consist of the qualitative parameter ‘elasticity score; ES’ and the quantitative parameter ‘strain ratio; SR’ [16].

Considering the elastography score on a total number of 36 lesions being classified according to modified Ueno and Ito elasticity score system. Among the benign lesions in our study 4 lesions had elastography score 1, 11lesions had score 2, 2 lesions had score 3 and 4 lesions had score 4.

Among 15 lesions malignant lesions in our study 3 lesions took elastography score 3, 9 lesions had score 4 and 3 lesions had score 5.

According to our study, considering the benign lesion with elasticity scores 1-3 and malignant lesion with elasticity scores 4-5, the sensitivity and specificity of sonoelastography were 80%, 80.95% respectively with PPV 75.0% and NPV 85.0% and accuracy 80.56%. Our results were slightly different from the studies of Thomas., *et al*. [14] (sensitivity of 91.8% and specificity of 78%) and Navarro., *et al*. [21] (sensitivity of 96.6%, specificity of 76.9%). These slight differences may be probably attributed to different prevalence of breast cancer, different patient selection criteria as well as difference in the number of the studied lesions and differences in the used equipment's.

In our study elastography showed equal sensitivity but higher specificity than conventional sonography : we obtained B-mode sonography sensitivity of 80%, specificity of 76%, a positive predictive value of 70% and a negative predictive value of 74%, compared with a sensitivity of 80%, a specificity of 80.95%, a positive predictive value of 75% and a negative predictive value of 85% for elastography. These results are in agreement with the other studies based on elasticity score as Navarro., *et al*. [21] who stated that B-mode sonography had a sensitivity of 96.6%, a specificity of 76.9%, a positive predictive value of 79.2% and a negative predictive value of 96.2%, compared with a sensitivity of 69.5%, a specificity of 83.1%, a positive predictive value of 78.9%, and a negative predictive value of 75.0% for elastography.

In our study combined B mode US and US elastography showed high sensitivity and specificity (86.4%, 90.4%) respectively compared to conventional US alone (80%, 76%) respectively or US elastography alone (80%, 80.95%) respectively. These results agreed with studies including Leong., *et al*. [28] that reported sensitivity and specificity were 88.5% and 78.6%, respectively, for combined imaging to differentiate between benign and malignant lesions. Our patients with simple breast cysts depicted the characteristic three layer pattern of blue–green–red pattern (positive BGR sign) with blue being the superficial color and red the deep one, with an ES of 1, even in large dimension lesions. This pattern was explained to be an aliasing artifact [29]. Our results corroborate findings reported by previous studies including Booi RC., *et al*. [29]. US elastography can help elucidate the cystic nature of lesions with confounding appearances at B-mode US Thus, elastography is useful for characterizing complex cysts with greater confidence, which can help avoid an unnecessary core biopsy in some instances.

Among benign lesions, fibroadenomas tumors represent the most common type of solid breast mass. At mammography, these lesions classically are seen as lobulated circumscribed masses with coarse calcifications in a "popcorn" configuration. US images typically demonstrate fibroadenomas as well-circumscribed hypoechoic masses that are wider than tall, such that the long axis is parallel to the skin. Occasionally, fibroadenomas can have confounding features at B-mode US, such as dimensions that are taller than wide. In such instances, sonoelastography can help to elucidate the benign nature of the lesion. This is matching with study conducted by Garra BS, Cespedes EI, Ophir J., *et al*. who proved as many as 73% of fibroadenomas could be differentiated from malignant tumors on the basis of elastographic size and brightness criteria [30].

Among 12 lesions of fibroadenomas, 4 lesions had elastography score 4(false positive), this agreed with studies including Giuseppetti GM, Martegani A., *et al*. who reported that fibroadenomas sometimes have elastographic size or stiffness features that are more typical of malignancy. Such false-positive elastographic findings tend to occur in fibroadenomas that are larger than 2 cm and contain calcifications [31].

In our study invasive ductal carcinoma typically is appreciably stiffer than normal tissues or benign lesions and was substantially larger on the elastogram than on B-mode US images. this were consistent with some studies by Kamoi K, Okihara K, Ochiai A., *et al*. wthich showed the area of increased stiffness that is often apparent with invasive ductal carcinoma on the elastograms may indicate tumor extension not apparent at B-mode imaging. In addition, some cancers that are seen as areas of shadowing on US images appear as discrete masses on elastograms.

Also sonoelastography is useful in diagnosing atypical carcinoma such as the very small or hyper echoic ones or those associated with acoustic enhancement [32].

Although uncommon, invasive ductal carcinoma can have the appearance of a benign well circumscribed round mass on B-mode US images.

In our study, three lesions from 15 malignant lesions were solid with areas of necrosis which show score with high strain, this was matching with studies including Insana MF, Pellot-Barakat C., *et al*, that reported, tumor necrosis can manifest as anechoic areas with acoustic enhancement that can mimic cysts. False-negative elastograms can also occur and are characterized by high strain [33,34].

Some breast cancer may display benign features (score 1-3) on elasticity imaging such as non differentiated DCI, inflammatory carcinoma, hyper cellular, necrotic or peudocystic maligant lesion deep small neoplastic nodules and large cancers over 2.5 cm in diameter [34].

Elastography is not indicated for the evaluation of post operative changes, diffuse lesions or large ones, which exceeds the probe length or its field of view [35].

In comparison between benign and malignant breast lesions as regarding to the strain ratio, benign lesions had a mean strain ratio of 1.64 ± 1.62 and malignant lesions had a mean strain ratio 22.56 ± 26.2, with cut of value of < 2, this was matching with Cohn's [36] study for strain ratio evaluation, when the researchers used a cut-off point of 3.05.In comparison to Zhao., *et al*. [37] stated that the strain ratios between benign lesion (2.26 ± 1.39) and malignancy (6.95 ± 4.08) were significantly different.

Conclusion

- We suggest that elastography should be used as an adjunct to the clinical B-mode examination of suspected breast cancer, and should not be used independently but as an additional role for conventional ultrasound examination assessed by the BIRADs scoring system and not as a separate examination.
- SE is widely available and easy to use in a clinical setting. The fact that SE is real-time and can be done bedside along with the B-mode examination makes the use of SE feasible in a lot of different anatomic areas. In breast cancer, SE has shown great potential and a good diagnostic performance in several studies.
- Real-time elastography has shown the potential to provide additional characterization of breast lesions and to improve the specificity for low suspicion lesions achieved at conventional US.

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