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Shear Wave Sonoelastography as an Important Diagnostic Tool in the Diagnosis of Breast Focal Lesion with Unclear Ultrasound Features

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Abstract

Aim: The evaluation of the role of Shear Wave Sonoelastography (SWE) in the diagnosis of the lesions with unclear ultrasound features.
Materials and method: 139 solitary lesions were evaluated in 2178 female patients examined in 2015. The age span was 20-70 years old. 34 cases selected had unclear ultrasound features. The patients underwent SWE and afterwards biopsy. The patients with clear ultrasound features for malignant or benign lesions and the patients that the last trimester underwent therapeutic or diagnostic invasive procedures were excluded from this study. The data concerning malignant lesions are presented in Table 1 and the data concerning benign lesions are presented in Table 2. The mean value of stiffness in malignant lesions has been compared with the one of benign lesions and the mean value of stiffness in fibroadenomas has been compared with the one in fibrocystic mastopathy. Statistical analysis was performed utilizing the student's test (t test) according to SPSS package (version 19.0 for Windows, SPSS Inc.,Chicago, Illinois, USA).
Results: 6 were malignant lesions, while 28 were benign. The differences between the averages of the stiffness values of malignant lesions and benign lesions (fibroadenoma and fibrocystic mastopathy) were statistically important according to student's test ($p<0,0001$). For the benign lesions, these differences were not important ($p=0,7257$).
Conclusion: SWE is a valuable tool in the differentiation of breast malignant lesions with unclear ultrasound features, making ultrasound a sensitive modality in general.

Keywords: breast, ultrasound, biopsy, wave.

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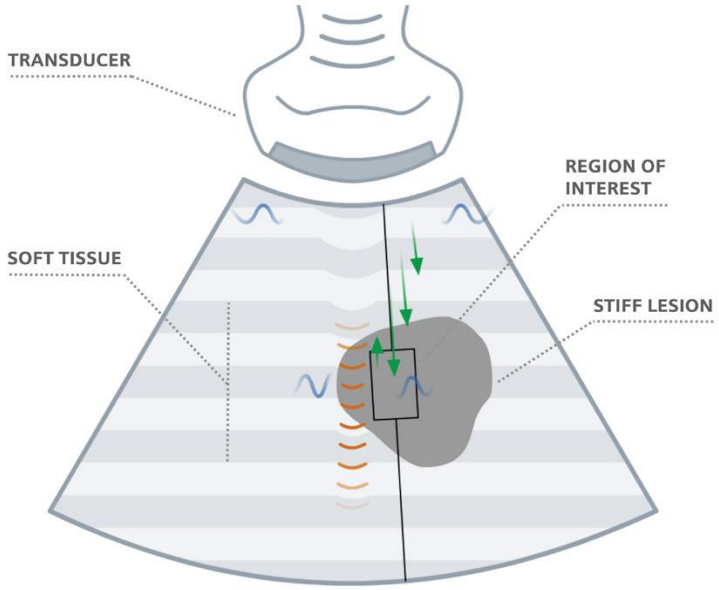
INTRODUCTION

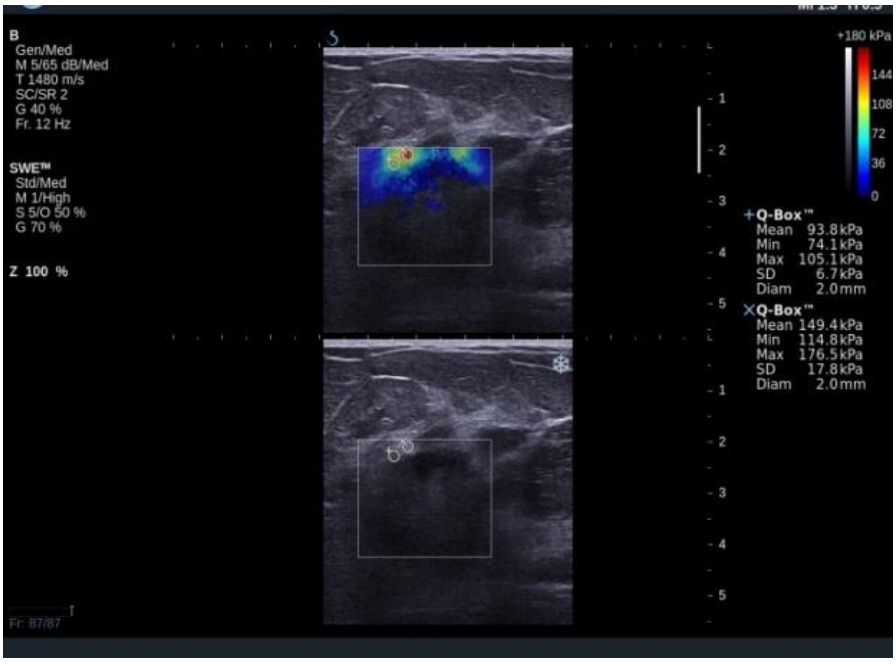
Actually, B-mode ultrasound combined with color Doppler is considered as the most important modality in routine breast exams, especially in the case of breasts with dense parenchyma and Bi-RADS 3 and 4 in mammography. Recent studies claim that ultrasound has some problems, especially regarding the over-diagnosis of unclear lesions and hence the recommendation of unnecessary biopsies (1). According to an author "Supplemental ultrasound screening for women with dense breasts has a high false-positive rate and substantially increases the number of unnecessary biopsies with little gain in quality-adjusted life years (QALYs)" (2). According to some other authors, the use of the ultrasound as a complementary method is not so cost-effective as "Supplemental ultrasonography screening for women with dense breasts would substantially increase costs while producing relatively small benefits" (3). To avoid these problems nowadays 3D mammography is being introduced in the practice of breast imaging exams, known also as digital breast tomosynthesis (DBT). According to some authors, the implementation of DBT has increased with 41% the chance of detecting invasive cancers. Regarding in situ carcinomas (DCIS) there is no change while it has decreased the unnecessary examinations for false-positive cases (4). However, it is still impossible to have DBT in all the centers for breast exams. Showing a consideration for the conclusions of the above mentioned authors, we can say that technological advances in ultrasound techniques tend to surpass these handicaps. One of these new methods is Shear Wave Sonoelastography (SWE). In conformity with some publications, SWE is an important tool, which is being developed to differentiate breast lesions and to decrease the number of unnecessary biopsies (5, 6, 7). This hypothesis is also supported by this study. Even if the physical principles of SWE don't represent the subject of this study, it is necessary to present a brief explanation of this technique. This modality uses automatic compressing pulses generated by the ultrasound probe which causes compression within the tissue under examination. This compression induces transversely oriented shear-waves. The speed of propagation of the shear-waves can be captured by the ultrasound system with the same probe. This speed is directly proportional to the stiffness of tissue, that means stiffer the tissue, higher the speed of propagation of shear-waves. The reconstruction software of the machine uses the formula $E \approx 3\ \rho v^2$ and Young's modulus to produce the electrographic image and to calculate the elasticity in kPa. Using extremely fast ultrasound acquisition sequences of 5000 frames/sec, the shear-waves and an associated elastogram can be subsequently captured in real-time (8). (Figure 1).

Figure 1. In this scheme it is shown how are produced and work shear –waves.



The color elastogram ranges from dark blue for the softest tissue to deep red for the hardest one. The values of the elasticity are measured placing the ROI circle inside the elastogram box (Figure 2c, d-3c).

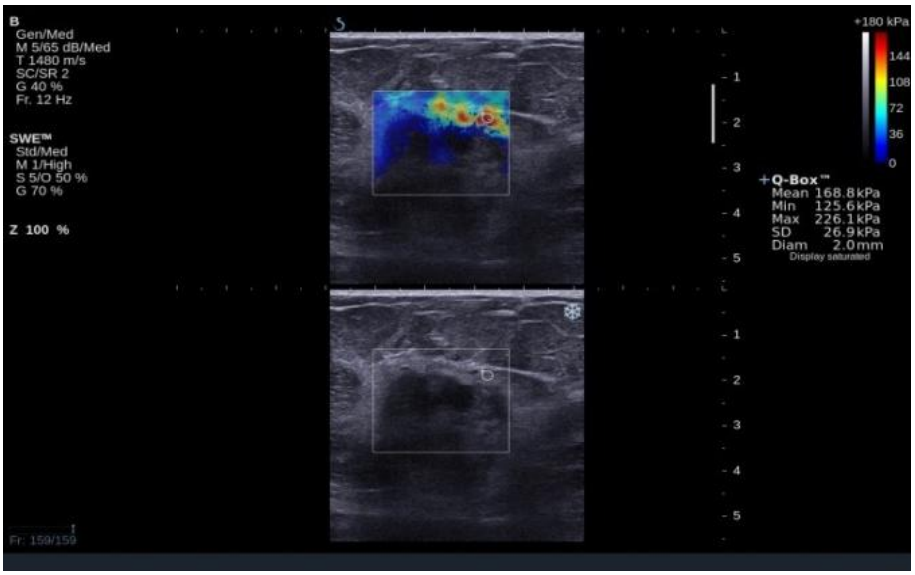
Figure 2. a-d. US images in B-mode shows an unclear lesion (white arrows) in the medial inferior quadrant of the right breast. The lesion was not evidenced in two previous ultrasound exams within the last trimester (a, b).



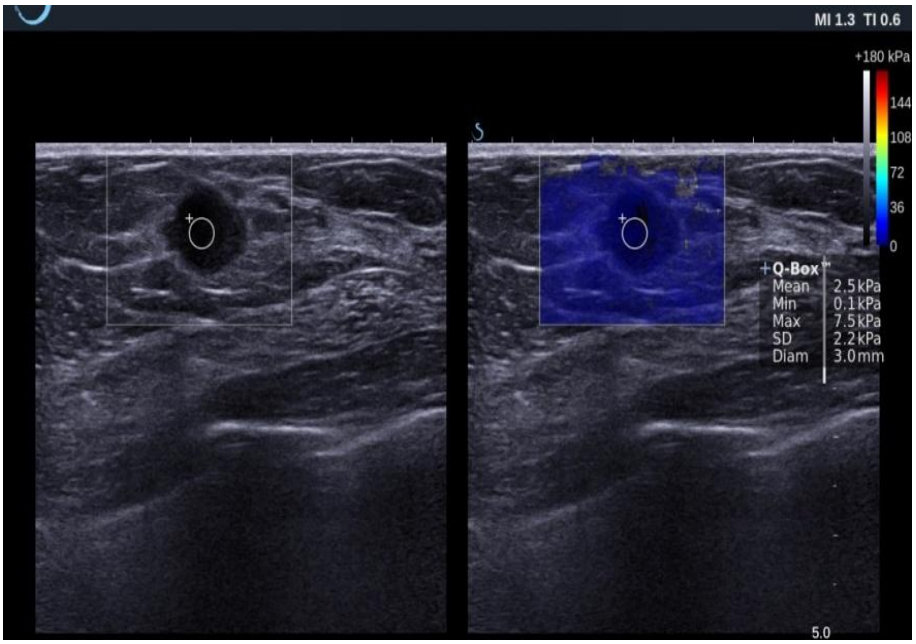
2 c

SWE shows stiffness up to 149 kPa in the tissue around the lesion, which is suspicious for malignancy BI-RADS 4. Yellow to red colors show the hard peripheral desmoplastic rim of the lesion. Blue color shows surrounding normal breast tissue (c, d). Core biopsy was performed and it resulted IDC grade II.

Figure 3. a-c. Hypoechogeneous lesion with clear polygonal contours (arrows) and diameters almost equal(a). There is minimal vascularisation (arrow) in the periphery (b). In SWE the values are low, approximately 2.5 kPa which suspects a benign lesion, that resulted fibroadenoma in biopsy. All the field inside the box is blue that means low stiffness (c).



2d

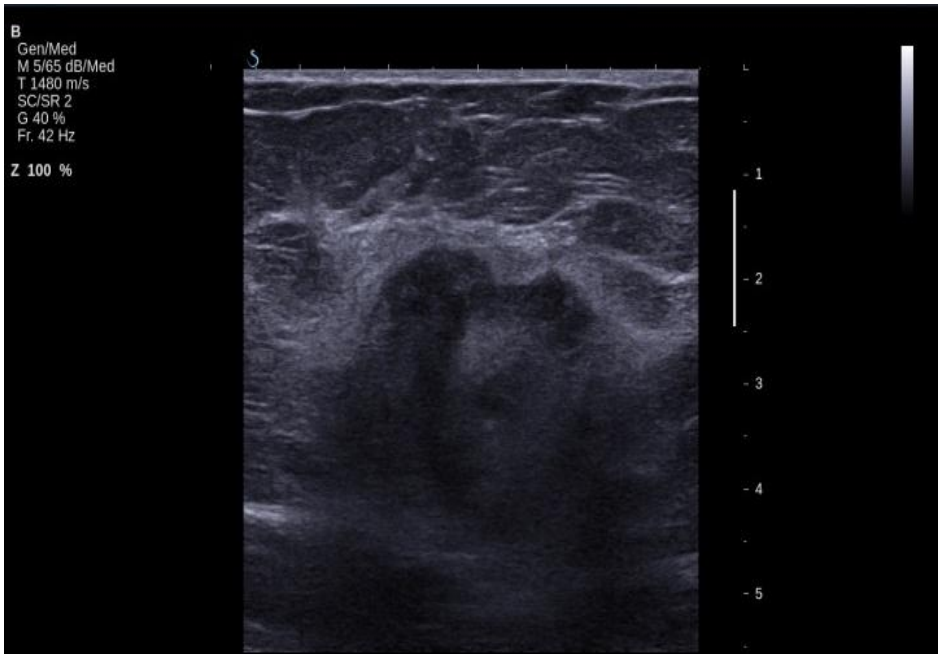


3c

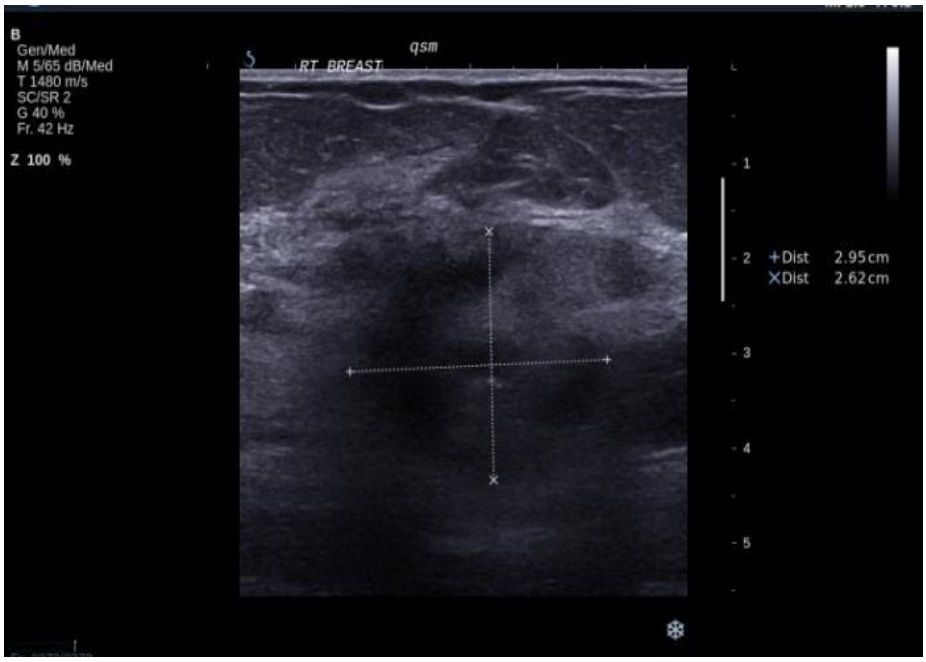
MATERIAL AND METHODS

This is a retrospective study that has reviewed 139 cases with solitary lesions in 2178 women examined during 2015. The age span was from 20 up to 70 years.

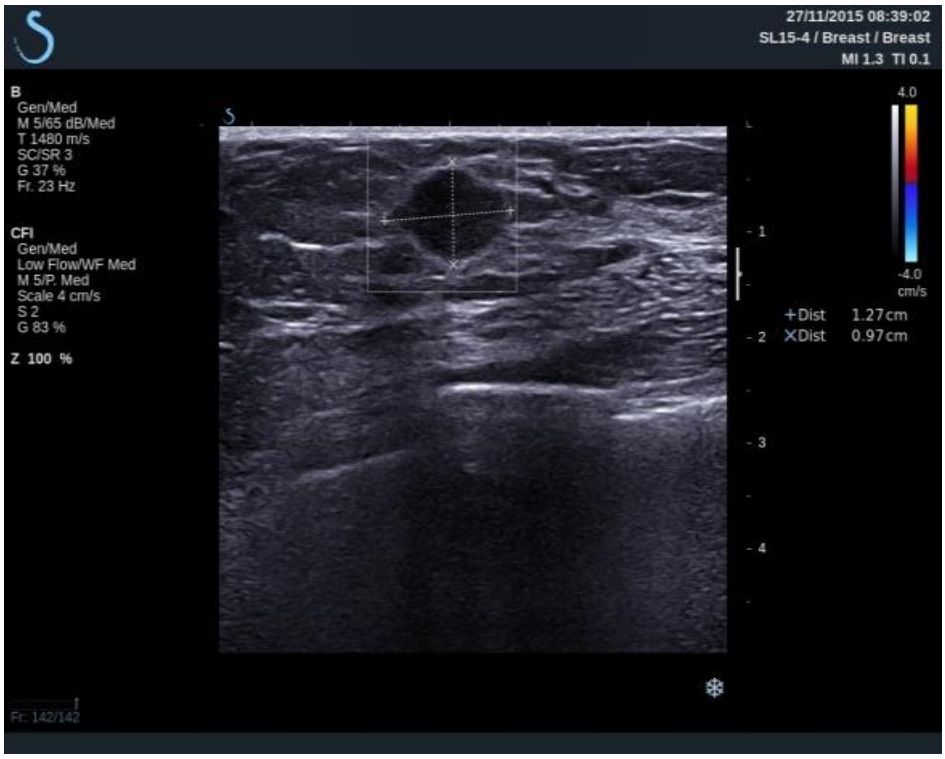
At the time of completion of this study all the diagnostic procedures of the above mentioned patients had finished. The case files were chosen according to the following criteria: 34 patients with lesions with unclear ultrasound features were selected. (Figure. 2a,b-3a,b)



2a



2b



3a

The patients with clear ultrasound features for malignant or benign lesions, as well as the patients who in the last 3 months underwent invasive therapeutic or diagnostic procedures were excluded from this study. The patients underwent B-mode US, SWE and subsequently biopsy exams. These exams were performed by professionals with 10 year experience in ultrasound exams and breast biopsies, and with at least three year of experience in utilizing the SWE method. Every sequence of SWE was at least 10s and minimally two orthogonal sequences were taken for every lesion (Fig.2c-d). ROI diameter was 2 mm. The threshold value for considering a lesion probably benign was taken 50kpa[5].

Higher values lesions were suspected as malignant. We find appropriate to explain this is a standard exam protocol in our cabinet. Afterwards, we did the correlation between the biopsy results and the SWE values.

Statistical analysis was performed utilizing the student's test (t test) according to SPSS package (version 19.0 for Windows, SPSS Inc., Chicago, Illinois, USA).

The mean value of stiffness in malignant lesions was compared with the one of benign lesions, and the mean value of stiffness in fibroadenomas was compared with the one in fibrocystic mastopathy. The SWE exams were performed with ***SuperSonic Imagine Aixplorer*** (Provence, France) device with linear probe SL15-4.

Tru-Cut biopsies and FNA-s were performed with ***GE LOGIQ S7*** expert device (GE Healthcare, United Kingdom) with linear probe 11L. The material was taken utilizing 16G or 18G needles, with 10-20 mm cut.

DISCUSSION

As it was proven previously, SWE improves the ability of the traditional ultrasound to identify the malignant lesions even when they have no clear characteristics.

Data Malignant Lesions	Stiffness (mean value)	Grade of malignancy	Age
IDC	149	2	46
IDC	170	3	55
IDC	110,5	2	61
IDC	137,8	3	72
Mucionous carcionoma	72	1	39
Mixt type	81	1	44
Mean value	120		

IDC (infiltrative ductal carcinoma).

Table 1. Values of stiffness and histological correlations for malignant lesions.

RESULTS

The data are displayed in Table 1 for malignant lesions and in table 2 for benign lesions.

6 cases out of 34 were malignant lesions, while 28 other were benign. The differences between the averages of the stiffness values of malignant lesions and benign lesions (fibroadenoma and fibrocystic mastopathy) were statistically important according to student's test ($p<0,0001$). For the benign lesions, these differences were not important ($p=0,7257$).

This is confirmed also by the results from some other publications that has similar conclusions with us, like Berg WA et al.(8), which shows improvement of specificity from 61,1% to 78,5% by using color and from 69,4% to 77,4% using elasticity values in kPa, without significant improvement in sensitivity. Also Au FW and Ghai S cite "there was a statistically significant difference in the values of the quantitative shear wave elastography parameters of benign and malignant solid breast masses",

and further "by adding shear wave elastography parameters to BI-RADS category 4a masses, we found that about 90% of them could be correctly downgraded to BI-RADS category 3, thereby avoiding biopsy". Another group of authors (Lee SH et al) (10), reports increased specificity from 17,4% to 62,1% for SWE color stiffness and 53,3% for elasticity values without loss in sensitivity.

The same authors have concluded that "The addition of SWE to B-mode US improved diagnostic performance with increased specificity for screening US-detected breast masses. BI-RADS category 4a masses detected at US screening that showed a dark blue color or a maximum elasticity value of 30 kPa or less on SWE images can be safely followed up instead of performing biopsy."

Mean value stiffness Fibradenomas	**Age**	**Mean value stiffness Fibrocystic m.**	**Age**
21	17	27,5	27
18	22	23,2	35
19,5	27	33	21
29	32	47	57
25	17	36,5	41
23	52	67	48
21	46	31,7	36
41	24	18	19
2,5	37	16	29
18	33	55	38
31	26	25	50
Mean value 22,6	30,33	24	42
		53	26
		14,8	33
		22	43
		21,7	22
		Mean value 32,2	36

Table 2. Values of stiffness and histological correlations for benign lesions.

There is a lot of evidence supporting the advantages of SWE as a novel method in breast masses diagnosis, but we cannot forget that even SWE has its limitations, as: it is an examination that lasts and is more expensive than B-mode US. The interpretation is depended on the imaging specialist experience, besides the improvements done to the SWE technique. Despite of the improvements regarding the ultrasound sensitivity and specificity, SWE is still behind in comparison to the tru-cut biopsy ultrasound guided, which has 91% sensitivity and 98% specificity (11).

As previously mentioned, with this innovative method, it is possible to reduce the unnecessary cases recommended for tru-cut biopsy, especially them with unclear ultrasound features, but not to minimize totally.

CONCLUSION

SWE is a valuable tool in the differentiation of breast malignant lesions with unclear ultrasound features, making ultrasound more sensitive modality in general. This method is not valuable to discriminate the benign lesions between them.

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Conflict of interest disclosure: Not available.

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