ORIGINAL ARTICLE

DIAGNOSTIC ACCURACY OF SHEAR-WAVE ELASTOGRAPHY AS DECISION MAKING MODALITY IN THE EVALUATION OF SUSPICIOUS BREAST LESIONS

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ABSTRACT

OBJECTIVE: To determine the diagnostic accuracy of shear- wave elastography in determining breast malignancy in suspicious breast lesions needing further radiologic evaluation, keeping histopathology as gold standard. **METHODS:** This cross-sectional study was conducted in Radiology department, Dr. Ruth K. M Pfau Civil Hospital, Karachi from March 2016 to January 2017. This study included 170 patients referred for shear-wave elastography (SWE) with suspected malignant breast lesions considered BIRADS - 0 or IV on mammography or ultrasound. Elastography was performed after taking detailed history, breast examination, mammography and gray scale ultrasound. Elastography findings were recorded and compared with the histopathology. The primary performance outcomes of shear-wave elastography were determined in terms of sensitivity, specificity, accuracy, positive and negative predictive values against the histopathology. Post stratification chi square test was applied taking p-value ≤ 0.05 as significant. **RESULTS:** The mean age of the patients was 44.03 ± 9.31 years. Mean size of lump was 2.50 ± 2.29 cm with mean duration of 6.48 ± 3.29 months. Out of the 170 patients, 108 (63.5%) patients were diagnosed as malignant by shear-wave elastography while 109 (64.1%) patients by histopathology. The sensitivity of shear-wave elastography was 88.1% with specificity of 80.3%, positive predictive value of 88.8%, negative predictive value of 79.03% and an overall accuracy of 85.29%. **CONCLUSION:** SWE is a useful adjunct to mammography and conventional gray scale ultrasound to identify breast malignancy with good accuracy in suspicious breast lesion.

Keywords: Diagnostic Accuracy, Shear-Wave Elastography, Breast Malignancy, Breast Lesions, Histopathology

Introduction

Breast cancer is one of the leading causes of cancer death among female all over the world with an estimated 1.7 million new cases per year and 521,900 deaths.[1] In Pakistan about 90,000 new cases are reported every year with high incidence in Karachi and cause cancer-related death in 40,000 women per year resulting in great social, psychological and economic impact.[2]

Over time, there is progressive improvement of imaging techniques that had led to early detection of breast cancer and decline in mortality worldwide. But still a high numbers of false-positive and false-negative findings are reported. So to overcome this error, new diagnostic imaging techniques are adapted to characterize and diagnosis the lesion properly. Elastography is a new emerging imaging technique that allow quantitative measurement of tissue stiffness and provide two-dimensional color map of elasticity

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superimposed on the gray scale ultrasound.[3] Breast cancers are stiffer compared with normal tissues and benign masses.[3] There are two principal elastographic approaches i.e. Static (Strain) and transient (Shear wave) elastography.[3,4] Strain elastography provides qualitative information but not quantitative and is operator dependent while shear wave elastography is operator independent, quantitative and reproducible.[3,5]

Shear wave elastography (SWE) relies on an acoustic radiation force generated by a focused ultrasound beam automatically that induces the mechanical vibration of tissues so it is non-operator dependent.[3,6] This localized mechanical vibration of tissues correlates in direct proportion to the tissue elasticity, and tracks to calculate propagation velocity with options of mean, minimum and maximum elasticity in a region of interest.[7,8] SWE is a useful tool to characterize and differentiate breast masses as benign and malignant lesions based on their tissue stiffness.[3] SWE increases the accuracy and specificity of B-mode ultrasonography to identify the malignant breast masses and to reduce the biopsies for benign breast masses.[9,10] It also provides objective information for accessing preoperative prognosis or response to chemotherapy,[3,10] but its accurate clinical results are still not reported in detail.

There is a paucity of literature and local data particularly regarding the use of shear wave elastography for differentiating breast masses so the current study was conducted to determine the diagnostic accuracy of shear wave Elastography in determining breast malignancy in suspicious breast lesions categorized as BIRADS 0 or IV on mammography or ultrasound requiring additional imaging, taking histopathology as gold standard.

Methods

This study was a descriptive cross-sectional conducted in Radiology department, Dr Ruth K.M. Pfau Civil Hospital, Karachi (DUHS) from 2016 to January 2017. It comprised female patients between 20-60 years of age with suspicious malignant breast lesion on ultrasound or mammography BIRADS - 0 or IV. Patients who already diagnosed breast carcinoma, benign lesions on ultrasound or BIRADS II/III/V lesion on mammography were excluded from the study.

Sample size was calculated by taking prevalence of breast cancer in women in Pakistan = 38.2%,[11] sensitivity of shear wave elastography for breast cancer = 91%,[9] specificity of shear wave elastography for breast cancer = 82%.[9] Confidence level = 95% , margin of error = 6% and 7% for sensitivity and specificity respectively. The calculated sample size was 170. Written informed consent was obtained from each subject and permission was sought from institutional ethical committee.

Female patients referred to Radiology department for shear-wave elastography with suspected breast malignant lesions were selected according to inclusion criteria. Suspicious malignant breast lesion is defined as clinically suspected breast cancer patients with breast lump or bloody nipple discharge or both, showing BIRADS 0 or IV lesion on mammography or ultrasound. Detailed history and breast examination were done in each and every case. Elastography was performed with Aixplorer multiwave ultrasound system (France) by consultant radiologist and analyzed as benign and malignant breast lesion according to mean elasticity (Emean) value measured in kPa (kiloPascal). Cut-off value of 50 kPa for mean elasticity were selected for benign/malignant differentiation on shear wave elastography,[12-14] with sensitivity of 91%[9] and specificity of 82%.[9] Then elastography diagnosis was compared with histopathological diagnosis.

A database was developed on SPSS for windows version 21. Mean and standard deviations were calculated for quantitative variables like age, size of lump, and duration of disease. Frequency and percentage were calculated for qualitative variables as shear wave elastography and histopathological diagnosis of malignancy. The diagnostic accuracy of shear wave elastography was determined in terms of sensitivity, specificity, positive predictive value and negative predictive value and diagnostic accuracy against the gold standard i.e. histopathology. Post stratification applying chi square test taking *p*-value less than or equal to 0.05 as significant.

Results

Total 170 female patients were included in the study to determine the diagnostic accuracy of shear wave

elastography (SWE) in determining breast malignancy in suspicious breast lesion, taking histopathology as gold standard. The subjects were between 20-60 years of age with mean age of 44.03 ± 9.31 years. The mean size of lump was 2.50 ± 2.29 cm with minimum size of 0.5cm and maximum of 8.1cm. The overall mean duration of disease was 6.48 ± 3.29 months (Range: 1-12 months).

Out of 170 patients, 108 (63.5%) patients were diagnosed malignant and 62 (36.5%) were benign by shear wave elastography. Ninety six patients out of 108 (88.9%) who labeled as malignant lesion by SWE were proven malignant while other (11.1%) were came out to benign. Forty nine patients out of 62 (79%) who were labeled as benign lesion by SWE were came out benign on histopathology while the rest (21%) were found malignant on histopathology (Tab. 1).

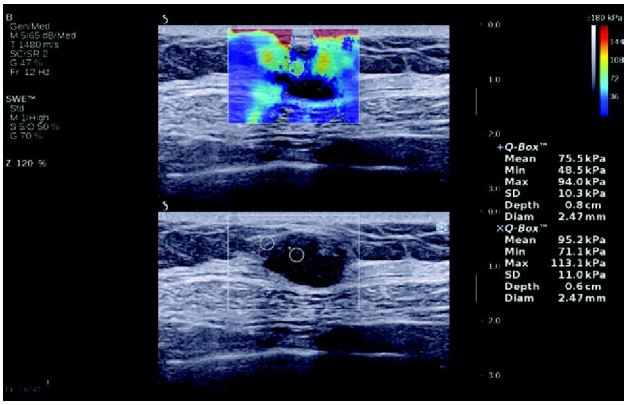

Figure 1: SWE and grayscale ultrasound of a malignant lesion. Shear wave imaging showed a heterogeneous color map (stiff) with E_{mean} of 75.5kPa. Gray scale B-mode ultrasound showed a lobulated hypoechoic lesion.

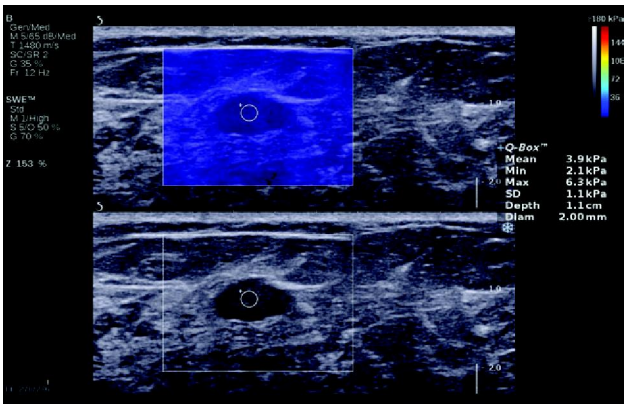

Figure 2: SWE and grayscale ultrasound image of a benign lesion. Shear wave imaging showed a homogenous blue color map (soft) with E_{mean} of 3.9 kPa. Gray scale B-mode showing a well defined oval hypoechoic mass.

This study showed sensitivity of 88.1%, specificity of 80.3%, PPV of 88.8%, NPV of 79.03% and accuracy of 85.29% when SWE diagnosis of breast lesion was compared with gold standard (histopathology).

	Histopathology			**p-Value**
SWE	Malignant (n=109)	Benign (n=61)	Total	<0.001*
Malignant (n=108)	96	12	108	
Begnin (n=62)	13	49	62	
Total	109	61	170	
Sensitivity	Specificity	PPV	NPV	Accuracy
88.1%	80.3%	88.8%	79.03%	85.29%

Chi square test was applied.
P-Value ≤0.05 considered as significant.
* Significant at 0.05

Table 1: Diagnostic accuracy of shear wave eleastography (SWE) with histopathology as gold standard to diagnose breast cancer (n=170)

Discussion

Breast cancer remains a major public health problem of female in both developed and developing countries due to associated high morbidity and mortality.[4] So the medical community is continuously struggling to improve imaging methods and to coordinate the multidisciplinary units. Elastography is a non-invasive evaluation of the stiffness of a lesion which basically correlates with the amount of fibrosis. It enhances the specificity of a breast lesion by precise characterization which reduces the false positive results so useful in avoiding the breast biopsy of benign lesion.[15] Elasticity is inversely proportional to the stiffness of the material and time taken to return to its natural condition.[4,15] Different tissues have different elasticity so they respond differently.[15]

This study showed 88.1% sensitivity, 80.3% specificity and 85.29% accuracy of SWE in evaluation of suspicious breast lesion which was comparable with the study done by Li et al[9] who determined the sensitivity of 91%, specificity of 82% and accuracy of 82.9%. It is also comparable to Itoh et al[16] who found sensitivity of 86.5%, specificity of 89.8% and accuracy of 88.3%. The current study showed higher sensitivity and specificity than that reported by Ianculescu et al[17] who reported a sensitivity of 80.4%

and a specificity of 73% but less than those of Barr et al.[18] (sensitivity 93%, specificity 89%), Olgun et al.[4] (sensitivity 97%, specificity 95%) and Evans et al.[13] (sensitivity 97%, specificity 83%). This study is comparable with the studies by Guo et al.[5] and Tsai et al.[19] in terms of sensitivity (89.7% vs. 84%). This variation in sensitivity might be due to variable tumor size as Evan et al.[13] found that small breast tumors are less stiff as compared to large ones and Yao et al.[20] determined that SWE had relatively low sensitivity in evaluation of breast lesions of <10mm.

The present study showed comparable results to the studies done by Chang et al[3] (sensitivity 89%, specificity 85%, PPV 85% and NPV 89%), Li et al[9] (sensitivity 91%, specificity 82%, accuracy 82.9%, PPV 82% and NPV 89%) and Amany et al.[21] (sensitivity 83.3%, specificity 88.1%, accuracy 86.7%, PPV 75% and NPV 92.5%) except the negative predictive value; mostly these studies used the combined B-mode ultrasound and elastography imaging in differentiating benign and malignant breast lesions. The current study showed comparable PPV (88.8%) to the studies conducted by Olgun et al.[4] and Evans et al.[13] Other contributing factor may be the difference that might existing in breast cancers composition that contributing the different stiffness in Asian and non-Asian women.

This study showed low specificity and NPV as compared to various international studies either due to different proportion of benign and malignant lesions in the study population, variation in age, different study population or variable combination of imaging modalities used with SWE. As a large proportion of cancers in study population promote the high PPV while a large proportion of benign lesions contributes to high NPV. The various studies suggested that SWE is an additional valuable tool to grayscale ultrasonography to distinguish the benign and malignant breast masses in order to reduce the repeat imaging and to decrease the biopsy of benign breast masses.[4,9,12]

Most of previous studies showed statistical heterogeneity, which might be due to different test/study procedures, study design, diagnostic threshold of mean elasticity for malignancy, variation in subject population/age or combinations of these factors.

There are certain limitations of this study. First, it was conducted on a small scale at a single centre and included the urban population. Second we used only one vendor's SWE equipment. The results and cut off values of one SWE system may not be applicable to the other manufactures' system. Another limitation was the low negative predictive value (NPV) in this study either due to different demographic influence or tumor morphology. Therefore these findings might not be applicable to whole population and warrants further research.

Conclusion

This study shows that the accuracy of shear wave elastography is quite satisfactory in our setup for identifying breast malignancy in suspicious breast lesions and reducing the rate of benign biopsy or follow-up. Though it is easy to perform during routine breast ultrasound examination adding only short extra-time but appropriate knowledge regarding its use and interpretation is required. Breast elastography is a non-invasive useful imaging tool; we highly recommend that it should be practiced into routine clinical practice especially in evaluation and decision of indeterminate lesion whether it should undergo biopsy or short term follow-up. And because of high heterogeneity, multicentre researches on a large patient population from different regions are necessary.

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