Biological and Clinical Sciences Research Journal
ISSN: 2708-2261
www.bcsrj.com
DOI: https://doi.org/10.54112/bcsrj.v2022i1.148
*Biol. Clin. Sci. Res. J., Volume, **2022**: 148*
Original Research Article

COMPARISON OF STRAIN ELASTOGRAPHY AND SHEAR WAVE ELASTOGRAPHY FOR DIFFERENTIATING MALIGNANT FROM BENIGN BREAST MASSES

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(Received, 17th April 2022, Revised 19th November 2022, Published 22nd November 2022)

Abstract: *To compare the diagnostic performance of shear wave and strain elastography in distinguishing benign and malignant breast lesions. A prospective study was carried out from 20th March 2020 to 20th March 2021 at the department of Radiology of Sahiwal, Multan, Lahore. The study included women who were lined for surgical excision or core needle biopsy and were examined using B-mode ultrasound and shear and strain wave elastography. A total of 30 female patients with 40 breast lesions were included in the study. Lesions were categorized on B-mode ultrasound as 3 BI-RADS 3, 18 BI-RADS 4A, 5 BI-RADS 4B, 7 BI-RADS 4C, and 7 BI-RADS 5. After performing a B-mode Ultrasound examination, US elastography was done. A 14-MHz transducer was used to obtain high-resolution images. For comparing the diagnostic performance of both, an area under the ROI curve (AUC) from data sets of shear and strain wave elastography was compared. The McNemar test was used for the comparison of sensitivity and specificity of both data sets. The mean age of the participants was 48.4 years (21-80years). 24 out of 40 lesions were benign while 16 were malignant. B mode US imaging showed the diameter of the lesion ranged from 0.5 to 5.2 cm. There was no significant difference between specificity and sensitivity of elastographic images. 6 breast masses showed discrepant results. After category 4a BI-RADs were selectively downgraded on the bases of cutoff values, AUCs showed improvement. Diagnostic performance of shear wave and strain elastography in distinguishing malignant and benign lesions is the same. Combining both has better diagnostic performance than using each individually.*

Keywords: Shear wave elastography, strain elastography, benign breast lesion, malignant breast lesion

Introduction

Ultrasound (US) elastography is a method for measuring stiffness of tissues. It was introduced in the early 1990s, and since then it has improved a lot. Benign and malignant breast tumors can be significantly differentiated using this technique (Cantisani et al., 2021; Liu et al., 2018). Shear wave and strain elastography are most frequently used for breasts (Barr, 2017). Strain elastography produces an image by low-frequency US pulse or by manual compression of tissues. In this strain between surroundings, tissue and lesion are determined. Practically, an elasticity score is frequently used to distinguish benign lesions from malignant ones. In shear wave elastography the speed at which shear wave propagates in the tissue is measured. This speed is associated with young modulus measured in kilopascals (Chou et al., 2021). Nowadays this technology is widespread, some forms are widely available commercially. Benign and malignant images have been distinguished using axial strain images formed by post deformation and deformation radiofrequency ultra sound (Brusseau et al., 2014).In addition to this, the association of tumor with surrounding tissue is clearly shown by shear strain wave elastography. Displacement or strain is the physical quantity measured in strain imaging, while shear wave speed is measured in shear wave imaging. Diagnostic performance of both is compared in various, which show both are equally effective for a distinction of malignant and benign lesions (Suvannarerg et al., 2019). Studies show that their diagnostic performance is the same, but specificity and sensitivity vary depending upon the breast thickness, histologic profile, and tumor grade of the lesion. There are vendor-specific US elastographic protocols; therefore, more research is

[Citation: Jamal, Y., Nighat, S., Irum, R., Khan, M.M., Sheikh R. (2022). Comparison of strain elastography and shear wave elastography for differentiating malignant from benign breast masses. *Biol. Clin. Sci. Res. J.*, **2022***: 148*. doi: https://doi.org/10.54112/bcsrj.v2022i1.148]

required. Practically, US elastographic images might have artifacts and demonstrations other than elastic modulus are induced. In strain elastography there is not a uniform distribution of stress in the body, curved boundaries get more stress. In shear wave elastography, tissue homogeneity may be wrongly assumed leading to an incorrect estimate of shear wave speed. Nonlinear tissues cause a decrease in elastographic contrast and an increase in shear wave speed. Consequently, the results of shear wave and strain imaging are not always the same. Recently, some systems are offering both shear and strain wave elastography. It is suggested that both are vital for breast imaging(Barr, 2019). In this study diagnostic performance of these both in distinguishing benign and malignant breast is compared and the precision of combined shear and strain elastography is evaluated.

Methodology

The prospective study was conducted from 20th March 2020 to 20th March 2021 at the department of Radiology of Sahiwal, Multan, Lahore. The study included women who were lined for surgical excision or core needle biopsy and were examined using B-mode ultrasound and shear and strain wave elastography. Those patients whose imaging results were inaccurate for analysis were excluded. A total of 30 female patients with 40 breast lesions were included in the study. Lesions were categorized on B-mode ultrasound as 3 BI-RADS 3, 18 BI-RADS 4A, 5 BI-RADS 4B, 7 BI-RADS 4C, and 7 BI-RADS 5. Breast biopsy and ultrasound examination were done by expert radiologists. After performing a B-mode Ultrasound examination, US elastography was done. A 14-MHz transducer was used to obtain high-resolution images. Firstly, strain elastography was done. Patient's position and plane were maintained for shear wave elastographic images. For getting strain elastographic images, the target lesion was focused upon by a rectangular region of interest (ROI) and was adjusted to incorporate the subcutaneous fat layer on the pectoralis muscle. The size of the lesion determined ROI size. Light manual compression was used for vertically compressing the target lesion. Strain elastographic images were obtained after adjusting the speed and pressure of manual compression. For shear waves, elastographic images pressure from the transducer was not used. The image was stabilized by immobilizing it for a few seconds after which the image was saved. Lesion and the surrounding tissue were captured using the system's built-in ROI. Quantitative values were shown in dark blue and red representing the lowest and highest stiffness respectively. For US-guided core needle biopsy, a freehand technique was used. The sample t-test was used for calculating elasticity ratio values for masses on shear wave elastography and strain ratio values for masses on strain elastography. For comparing the diagnostic performance of both, the area under the ROI curve (AUC) from data sets of shear and strain wave elastography was compared. The McNemar test was used for the comparison of sensitivity and specificity of both data sets. SPSS version 23.0 and Stata version 12.0 were used for statistical analysis. $P<.05$ was considered statistically significant.

Result

The mean age of the participants was 48.4 years (21-80years). 24 out of 40 lesions were benign while 16 were malignant. B mode US imaging showed the diameter of the lesion ranged from 0.5 to 5.2 cm. Malignant lesions included ductal carcinomas in situ, ductal carcinomas, and invasive lobular carcinomas. Benign lesions included adenosis, fibrosis, and fibroadenomas (Table 1). Malignant lesions had higher elasticity values than benign lesions. For diagnostic purposes, AUCs for elasticity value of shear wave elastography and strain ratio were not much different. Elasticity values of 68.7 kPa and strain ratio of 3.64 were used as cutoffs. There was no significant difference between specificity and sensitivity of both modalities. 2 malignant and 5 benign lesions had false-negative results, while 4 malignant and 2 benign lesions had false-positive results. 6 breast masses showed discrepant results (Table 2), 2 invasive ductal carcinomas were correctly diagnosed only on strain elastography, and 4 fibroadenomas on shear wave elastography only. Out of 16 malignant lesions, 2 invasive lobular carcinomas had false-negative results on both shear wave and strain elastography. After category 4a BI-RADs were selectively downgraded on the bases of cutoff values, AUCs showed improvement (Table 3). Comparing receiver operating curves for shear wave and strain elastography shows that combining both has better diagnostic performance than using each individually.

Table 1. Evaluation of masses for distinguishing benign and malignant nature

Variable	Strain ratio	Mean elasticity	Elasticity ratio
Benign	2.07±.98	39.14±25.55	5.27±3.6
Malignant	5.37±2.64	104.52±35.57	16.7±13.0
p	<0.001	<0.001	0.001
Sensitivity	96%	84%	91%
Specificity	85%	96%	73%
AUC	.93	.88	.87

Mean elasticity measured in kPa
Elasticity ratio measured in kPa

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Table 2. Discrepancy in results

Accurate diagnosis	BI-RADS	Strain ratio	Mean elasticity	Size in the US	Pathologic diagnosis
Strain	4B	6.0	50.2	.5	Grade 2IDC
Shear wave	4A	5.5	17.6	1.7	Fibroadenoma
Shear wave	4A	5.29	68.0	3.1	Fibroadenoma
Strain	4C	2.66	48.0	2.0	Grade 2 IDC
Shear wave	3	4.13	28.0	.4	Fibroadenoma

Size is measured in cm
Mean elasticity is measured in kPa

Table 3 Diagnostic performance following downgrading of BI-RADS category 4a masses

Modality	Sensitivity	Specificity	AUC	*p-value*
B mode the US	-	-	.723	-
Strain elasto-graphy	100%	81%	.950	<0.001
Shear wave elasto-graphy	100%	89%	.960	<0.001

Discussion

The results of our study showed that values of shear wave and strain elastography varied significantly for malignant and benign lesions. Their diagnostic performance in differentiating lesions was the same. These results were in line with the previous studies(Youk et al., 2014). In our study specificity and sensitivity of shear wave and strain didn't vary significantly. However, this is in contradiction with a study that reported shear wave elastography had higher sensitivity while strain elastography had higher specificity (Chang et al., 2013). Another study showed that strain elastography had better diagnostic performance than shear wave elastography(Barr and Zhang, 2015). Our study showed that diagnostic performance is improved when both modalities are used combined; however, 6 breast lesions had discrepant results. A study had similar findings which concluded that poor generation of shear waves in malignant tumors explains false-negative results(Barr, 2020).In this study, 4 fibroadenomas showed false-positive results and were imaged accurately only on shear wave elastography. US transducer compression was used for strain does not shear wave elastography. In strain elastography, skin is repetitively compressed because of which interobserver and interobserver variability is inevitable(Ahmed, 2020). False-positive results in strain elastography of benign lesions appear due to the presence of soft tissue in the vision field. Due to discrepant findings, there is the need to use standard B Mode US for interpreting the results. In this study, BI-RADS category 4c invasive lobular carcinoma on B-mode US imaging appeared benign on both shear wave and strain elastography. Small malignant lesions on a shear wave and strain elastography may produce false-negative results(Chamming's et al., 2019). Shear wave elastography is more reliable as compared to strain elastography; however high wave speed is induced due to precompression and may lead to false-positive results. In strain elastography, accurate image acquisition is interrupted by lesion size as it is difficult to compress skin surrounding a large lesion. Along with fibroadenomas, sclerosing adenosis and papillomas are stiff benign lesions(Yu et al., 2018). B-mode US imaging should be used along with elastography as in elastography slipping of transducer lead to inaccurate results. A study conducted on shear wave elastography showed that certain features, like maximum stiffness of mass, evaluated by shear wave elastographic images can enhance the accuracy of BI-RADS score(Berg et al., 2012). In our study, the elasticity ratio was obtained as maximum stiffness was unavailable. Though our study could not suggest a rule for combining elastographic techniques, results that combining both improve diagnostic ability. More research with larger data is required in this field. Limitations of this study include small data size and no follow-up of benign lesions in long term.

Conclusion

The diagnostic performance of shear wave and strain elastography in distinguishing malignant and benign lesions is the same. Combining both has better diagnostic performance than using each individually.

Combing these with B-mode US imaging improves the diagnosis.

Conflict of interest

The authors declared absence of conflict of interest.

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