An Observational Study Assessing Role of Ultrasound Elastography in the Evaluation of Breast Lesions

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Abstract

Aim: The aim of the present study was to evaluate the role of ultrasound elastography in the evaluation of breast lesions.

Methods: The present study was a prospective observational study conducted in Department of Radiodiagnosis. Study period was one year. During study period total 100 patients underwent ultrasound elastography examination followed by core needle/surgical biopsy for histopathological study.

Results: On histopathological study 78% lesions were benign, while 24% were malignant. Fibroadenoma (37%), fibrocystic changes (17%), galactocele (6%) and mastitis (7%) were common benign findings while invasive ductal carcinoma, mucinous carcinoma and invasive papillary carcinoma were malignant lesion findings. On ultrasound elastography score examination, scores of 1 (24%), 2 (39%), 3 (16%), 4 (7%) and 5 (14%) were noted. Scores 1 to 3 were considered benign and 4 and 5 malignant. On statistical analysis we calculated sensitivity (94/88%), specificity (83.62%), positive predictive value (93.57%), negative predictive value (85.35%) and accuracy (94.71%) of ultrasound elastography with histopathological report.

Conclusion: Ultrasound elastography is a useful non-invasive diagnostic modality in differentiating benign from malignant breast lesions thereby reduces waiting, cost, discomfort and anxiety of a biopsy.

Keywords: Ultrasonography breast, elastography, biopsy, Breast Malignancy

Introduction

Mammography and ultrasonography (US) are the diagnostic methods which have shown the highest sensitivity in the detection of breast cancer. However, both methods present some limitations. Mammography performed in dense breasts may often yield false-negative results. [1] US is sensitive in the detection of lesions, but specificity is poor as most solid lesions are benign. In order to obtain an acceptable specificity, various characteristics of the lesions must be evaluated according to the BI-RADS criteria defined by the American College of Radiology (ACR). [2] Unfortunately, the BI-RADS criteria generate a significant number of false positive results. [3] This limitation leads to an increase in biopsies with a cancer "detection rate" of only 10%–30%. [4,5]

Many biopsies are performed in benign lesions causing discomfort to the patients and increased costs.

To overcome these limitations and obtain a more accurate characterization of breast lesions, US elastography was introduced. This technique combines US technology with the basic physical principles of elastography. US elastography is noninvasive and assesses tissue deformability by providing information on the elasticity. [6,7] It is based on the premise that there are significant differences in the mechanical properties of tissues that can be detected by applying an external mechanical force. [8,9]

Elasticity is the property of a body or substance that enables it to be deformed when it is subject to

an external force and resume its original shape or size when the force is removed. Different tissues are expected to respond differently according to the specific elastic modulus. [10] Tissue deformation is inversely proportional to the stiffness of the material, and response time (i.e. return to the natural condition) varies as a function of the histotype. [11] In general, adipose tissue is more easily deformed, and fibrous tissue returns to the initial condition more slowly than adipose or muscle tissue. [12]

Elastography is a non-invasive imaging technique in which local tissue strains are measured directly or indirectly by application of external stress. The tissue displacement is measured and a calculation of tissue stiffness is made based on tissue displacement. [13] Shear-wave elastography (SWE) reduces operator dependency which was encountered previously in free hand elastography. [14] A quantitative assessment of viscoelastic properties of tissue is obtained by inducing mechanical vibrations through a focused beam, which is expressed as Young's modulus or displayed as a color overlay of the lesion. [15] SWE is reported to have excellent diagnostic performance in distinguishing benign breast masses from malignant lesions. [16]

The aim of the present study was to evaluate the role of ultrasound elastography in the evaluation of breast lesions.

Materials and Methods

The present study was a prospective observational study conducted in Department of Radiodiagnosis, PMCH, Patna, Bihar, India. Study period was one year. During study period total 100 patients underwent ultrasound elastography examination followed by core needle/surgical biopsy for histopathological study.

Inclusion Criteria

• Female with suspected breast lesions on ultrasound/ clinical examination, later underwent core-needle biopsy or surgical biopsy with conclusive histopathologic diagnosis

Exclusion Criteria

• Already diagnosed cases, history of breast malignancy, recurrent lesions

• Inconclusive histopathology reports

• Not willing to participate

Patients were referred from department of general surgery for ultrasonography evaluation and department of pathology helped to get final histopathology reports.

Procedure was explained and a written informed consent was taken from patients. Demographic, clinical details were noted. Elastography examinations were performed using an Antares ultrasound system (Siemens Medical Solutions, Mountain View, CA) with integrated elastography software (eSie Touch elasticity imaging) and a multifrequency linear transducer (VFX13-5). Elastography image acquisition was performed by single radiologists with more than 10 years of experience in breast sonography and previously trained on breast elastography. For the elastography examination, the region of interest was superimposed semi transparently on the B-histopathologic diagnoses obtained from core-needle biopsy, or surgical biopsy, depending on the case. Details were noted in Microsoft excel sheet. Statistical analysis was done using descriptive statistics.

Results

Table 1: Final diagnosis of core needle/surgical biopsy results

Diagnosis	N	%
Benign	78	78
Fibroadenoma	37	37
Fibrocystic changes	17	17
Mastitis	7	7
Galactocele	6	6
Cyst	6	6
Abscess	5	5
Duct ectasia	3	3
Lactating adenoma	1	1
Phylloid tumor	1	1
Malignant	14	14
Invasive ductal carcinoma (IDC)	`8	`8
Mucinous carcinoma	3	3
Invasive papillary carcinoma (IPC)	3	3

On histopathological study 78% lesions were benign, while 24% were malignant. Fibroadenoma (37%), fibrocystic changes (17%), galactocele (6%) and mastitis (7%) were common benign findings while invasive ductal carcinoma, mucinous carcinoma and invasive papillary carcinoma were malignant lesion findings.

Table 2: Elastography score and histopathological diagnosis

Elastography score	Benign	Malignant	Total
1	24	0	24
2	39	0	39
3	11	5	16
4	1	6	7
5	0	14	14
Total	75	25	100

On ultrasound elastography score examination, scores of 1 (24%), 2 (39%), 3 (16%), 4 (7%) and 5 (14%) were noted. Scores 1 to 3 were considered benign and 4 and 5 malignant.

Table 3: Statistical values

Sensitivity	TP/(TP/FN)	94.88 %
Specificity	TN/(TN/FP)	83.62 %
Positive Predictive Value	TP/(TP+FP)	93.57 %
Negative Predictive Value	TN/(TN+FN)	85.35 %
Accuracy	(TP+TN)/(TP+TN+FP+FN)	93.71 %

On statistical analysis we calculated sensitivity (94/88%), specificity (83.62%), positive predictive value (93.57%), negative predictive value (85.35%) and accuracy (94.71%) of ultrasound elastography with histopathological report.

Discussion

Breast cancer is the most common cancer diagnosed in women globally and the second most common malignancy overall, after lung cancer. [17,18] The incidence of breast cancer has been on the rise over the last few decades. The incidence of breast cancer is the highest in Pakistan (50.1/100,000). [19] Data collected from 1995-1997 shows that breast cancer accounts for almost one-third of all female cancers in Karachi. [19] With more than half the population at risk, the incidence of breast cancer has alarmingly increased over the last few decades. [20] Breast cancer is uncommon before age 25 but the risk steadily increases with age, doubling every 10 years until menopause and slows dramatically afterwards. [21]

Elasticity is one of the important characteristics of tissues that may change under the influence of pathologic processes, such as inflammation and tumor development. Usually, a malignant lesion tends to be harder than a benign lesion because of its high cellularity and surrounding tissue desmoplasia. [22,23] Benign lesions on SE appear similar to the adjacent tissue and have a smaller diameter than on B- mode USG images. [24] Malignant tumours have reduced elasticity and also display larger dimensions on elastography due to accompanying desmoplastic reaction. [25] Aysar S K [26] studied 80 patients, 31 breast lesions were malignant and 49 were benign. B-mode ultrasound

was performed, and the lesions were categorized agreeing to the (BI-RADS) where chi-square statistical test uncovered that BI-RADS categories were essentially expanded among malignant cases (P < 0.001). On histopathological study 78% lesions were benign, while 24% were malignant. Fibroadenoma (37%), fibrocystic changes (17%), galactocele (6%) and mastitis (7%) were common benign findings while invasive ductal carcinoma, mucinous carcinoma and invasive papillary carcinoma were malignant lesion findings. [27]

On ultrasound elastography score examination, scores of 1 (24%), 2 (39%), 3 (16%), 4 (7%) and 5 (14%) were noted. Scores 1 to 3 were considered benign and 4 and 5 malignant. On statistical analysis we calculated sensitivity (94/88%), specificity (83.62%), positive predictive value (93.57%), negative predictive value (85.35%) and accuracy (94.71%) of ultrasound elastography with histopathological report. While Kumar AMS[27] noted that sensitivity, specificity and diagnostic accuracy of B-mode USG was calculated to be 71.74%, 90.91% and 81.11% and that for elastography was 95.65%, 68.18% and 82.22% respectively. They concluded, elastography may complement conventional B-mode USG to improve the diagnostic performance, which helps to reduce false- positive results and therefore is useful in avoiding unnecessary breast biopsy. Ultrasound has been proven to improve diagnostic sensitivity when added to screening mammography in high-risk women with dense breasts. However, the downside was an increased false-positive rate and lower positive predictive value. [28]

Conclusion

Ultrasound elastography is a useful non-invasive diagnostic modality in differentiating benign from malignant breast lesions thereby reduces waiting, cost, discomfort and anxiety of a biopsy.

References

1. Saarenmaa I, Salminen T, Geiger U, Heikkinen P, Hyvärinen S, Isola J, Kataja V, Kokko ML, Kokko R, Kumpulainen E, Kärkkäinen A, Pakkanen J, Peltonen P, Piironen A, Salo A, Talviala ML, Haka M. The effect of age and density of the breast on the sensitivity of breast cancer diagnostic by mammography and ultasono graphy. Breast Cancer Res Treat. 200 1 May;67(2):117-23.

2. Liberman L, Menell JH. Breast imaging reporting and data system (BI-RADS). Radiol Clin North Am. 2002 May;40(3):409-30, v.

3. Athanasiou A, Tardivon A, Tanter M, Sigal-Zafrani B, Bercoff J, Deffieux T, Gennisson JL, Fink M, Neuenschwander S. Breast lesions: quantitative elastography with supersonic shear imaging--preliminary results. Radiology. 2010 Jul;256(1):297-303.

4. Duncan JL 3rd, Cederbom GJ, Champaign JL, Smetherman DH, King TA, Farr GH, Waring AN, Bolton JS, Fuhrman GM. Benign diagnosis by image-guided core-needle breast biopsy. Am Surg. 2000 Jan;66(1):5-9; discussion 9-10.

5. Chiou SY, Chou YH, Chiou HJ, Wang HK, Tiu CM, Tseng LM, Chang CY. Sonographic features of nonpalpable breast cancer: a study based on ultrasound-guided wire-localized surgical biopsies. Ultrasound Med Biol. 2006 Sep;32(9):1299-306.

6. Krouskop T.A., Dougherty D.R., Vinson F.S. A pulsed Doppler ultrasonic system for making noninvasive measurements of the mechanical properties of soft tissue. J Rehabil Res Dev. 1987;24(2):1–8.

7. Ophir J, Céspedes I, Ponnekanti H, Yazdi Y, Li X. Elastography: a quantitative method for imaging the elasticity of biological tissues. Ultrason Imaging. 1991 Apr;13(2):111-34.

8. Chen EJ, Novakofski J, Jenkins WK, O'Brien WD. Young's modulus measurements of soft tissues with application to elasticity imaging. IEEE Transactions on ultrasonics, ferroele ctrics, and frequency control. 1996 Jan; 43(1):191-4.

9. Frey H. Realtime-Elastographie. Ein neues sonographisches Verfahren für die Darstellung der Gewebeelastizität [Realtime elastography. A new ultrasound procedure for the reconstruction of tissue elasticity]. Radiologe. 2003 Oct;43(10):850-5.

10. Shiina T, Nitta N, Ueno E, Bamber JC. Real time tissue elasticity imaging using the combined autocorrelation method. J Med Ultrason (2001). 2002 Sep;29(3):119-28.

11. Nightingale K, Soo MS, Nightingale R, Bentley R, Trahey G. In vivo demonstration of acoustic radiation force impulse (ARFI) imaging in the thyroid, abdomen, and breast. In2001 IEEE Ultrasonics Symposium. Proceedings. An International Symposium (Cat. No. 01CH37263) 2001 Oct 7 (Vol. 2, pp. 1633-1638). IEEE.

12. Nightingale K, Soo MS, Nightingale R, Bentley R, Stutz D, Palmeri M, Dahl J, Trahey G. Acoustic radiation force impulse imaging: remote palpation of the mechanical properties of tissue. In2002 IEEE Ultrasonics Symposium, 2002. Proceedings. 2002 Oct 8 (Vol. 2, pp. 1821-1830). IEEE.

13. Faruk T, Islam MK, Arefin S, Haq MZ. The Journey of Elastography: Background, Current Status, and Future Possibilities in Breast Cancer Diagnosis. Clin Breast Cancer. 2015 Oct;15(5):313-24.

14. Xue Y, Yao S, Li X, Zhang H. Benign and malignant breast lesions identification through the values derived from shear wave elastography: evidence for the meta-analysis. Oncotarget. 2017 Sep 21;8(51):89173-89181.

15. Athanasiou A, Tardivon A, Tanter M, Sigal-Zafrani B, Bercoff J, Deffieux T, Gennisson JL, Fink M, Neuenschwander S. Breast lesions: quantitative elastography with supersonic shear imaging--preliminary results. Radiology. 2010 Jul;256(1):297-303.

16. Goddi A, Bonardi M, Alessi S. Breast elastography: A literature review. J Ultrasound. 2012 Sep;15(3):192-8.

17. Malvia S, Bagadi SA, Dubey US, Saxena S. Epidemiology of breast cancer in Indian women. Asia Pac J Clin Oncol. 2017 Aug; 13 (4):289-295.

18. Ferlay J, Soerjomataram I, Dikshit R, Eser S, Mathers C, Rebelo M, Parkin DM, Forman D, Bray F. Cancer incidence and mortality worldwide: sources, methods and major patterns in GLOBOCAN 2012. Int J Cancer. 2015 Mar 1;136(5):E359-86.

19. Yip CH. Breast cancer in Asia. Methods Mol Biol. 2009; 471:51-64.

20. Shaukat U, Ismail M, Mehmood N. Epidemiology, major risk factors and genetic predisposition for breast cancer in the Pakistani population. Asian Pac J Cancer Prev. 2013; 14 (10):5625-9.

21. McPherson K, Steel CM, Dixon JM. ABC of breast diseases. Breast cancer-epidemiology, risk factors, and genetics. BMJ. 2000 Sep 9;32 1(7261):624-8.

22. Awad FM. Role of supersonic shear wave imaging quantitative elastography (SSI) in differentiating benign and malignant solid

breast masses. The Egyptian Journal of Radiology and Nuclear Medicine. 2013 Sep 1; 44(3):681-5.

23. Yoon JH, Kim MH, Kim EK, Moon HJ, Kwak JY, Kim MJ. Interobserver variability of ultrasound elastography: how it affects the diagnosis of breast lesions. American Journal of Roentgenology. 2011 Mar;196(3):730-6.

24. Hall TJ, Zhu Y, Spalding CS. In vivo real-time freehand palpation imaging. Ultrasound in medicine & biology. 2003 Mar 1;29(3):427-35.

25. Burnside ES, Hall TJ, Sommer AM, Hesley GK, Sisney GA, Svensson WE, Fine JP, Jiang J, Hangiandreou NJ. Differentiating benign from malignant solid breast masses with US strain imaging. Radiology. 2007 Nov;245(2): 401-10.

26. Keiteb AS, Ibraheem SA. Accuracy of Elastography for Differentiation Benign and Malignant Breast Lesions. Biomedical Journal of Scientific & Technical Research. 2019 Mar 6;16(2):11849-56.

27. Kumar A, Tanwar NS. Evaluation of breast lump using elastography, histopathology and its diagnostic accuracy. International Surgery Journal. 2019 Jan 28;6(2):574-80.

28. Berg WA, Bandos AI, Mendelson EB, Lehrer D, Jong RA, Pisano ED. Ultrasound as the primary screening test for breast cancer: analysis from ACRIN 6666. Journal of the National Cancer Institute. 2016 Apr 1;108(4): djv367.