Int J Clin Exp Med 2019;12(10):12500-12505
www.ijcem.com /ISSN:1940-5901/IJCEM0099333

*Original Article*

# Ultrasound elastography combined with breast imaging reporting and data system for diagnosis of small breast lesions

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Received July 7, 2019; Accepted September 3, 2019; Epub October 15, 2019; Published October 30, 2019

**Abstract:** *Background:* Ultrasound scans with Breast Imaging Reporting and Data System (BI-RADS) are often used for diagnosis of breast lesions. However, diagnosis of small lesions is still not ideal. Ultrasound elastography (UE) is a new method used to evaluate benign and malignant tumors by evaluating the relative hardness of lesions. The current study aimed to investigate the value of UE combined with BI-RADS for diagnosis of small breast lesions. *Methods:* Sixty-six female patients with 76 small breast lesions (diameter < 1 cm) were enrolled. Conventional ultrasound scans and UE examinations were performed on the breast lesions. Images of conventional ultrasound scans were categorized based on BI-RADS. UE categories were corrected from conventional ultrasound BI-RADS categories. Diagnostic efficiency levels between conventional ultrasound scans and UE were compared. *Results:* Using BI-RADS category ≥ 4 as a positive diagnostic value, sensitivity, specificity, and accuracy levels of UE were significantly higher than those of conventional ultrasound scans, respectively (P < 0.01). The area under curve in UE was significantly higher than that in conventional ultrasound scans (P < 0.01). *Conclusion:* UE combined with BI-RADS can improve diagnostic efficiency levels of small breast lesions. Therefore, it is worthy of clinical application.

**Keywords:** Ultrasound elastography, BI-RADS, small breast lesions

## Introduction

Breast cancer is the most common malignant tumor in females of childbearing age. Incidence rates of breast cancer have shown an obvious upward trend in recent years [1]. In clinic, occurrence and development of breast cancer can lead to a decrease of median survival time for patients, producing poor prognosis [2]. It has been confirmed that the size of breast tumors is closely related to prognosis. Early diagnosis is very important for treatment of breast cancer [3]. Imaging examinations have non-invasive, convenient, and economical advantages. They play an important role in early diagnosis of benign and malignant tumors [4-6]. Ultrasound scans have been widely used in clinical diagnosis and treatment of many lesions. It is a conventional method for detection of breast masses. Ultrasound scans identify benign and malignant breast masses depending on characteristics of the gray scale and color Doppler blood flow of lesions. However, ultrasound manifestations of some benign and malignant masses have a certain overlap. Thus, there are some limitations in diagnosis [7, 8]. Ultrasound elastography (UE) is a new method used to evaluate benign and malignant tumors by evaluating the relative hardness of lesions. With application of UE, early detection rates of breast cancer have increased [9, 10]. Small breast lesions with diameters < 1 cm are often in the early stages of disease development. Due to the small focus and lack of specificity, there are still some difficulties in early diagnosis and qualitative diagnosis [11]. In 2003, the American Radiology College (ACR) formulated the Breast Imaging Reporting and Data System (BI-RADS) and introduced ultrasound diagnosis. These have made diagnosis of breast lesions more standardized and accurate [12]. However, diagnosis of small lesions using ultrasound scans is still not ideal. In this study, conventional ultrasound scans and UE were applied to patients with small breast lesions. Diagnostic results of these patients concerning benign and malignant breast lesions based on BI-RADS categories were analyzed. The objective was to improve the diagnostic accuracy of early small breast lesions.

## Patients and methods

### *Patients*

Sixty-six female patients with 76 breast lesions, receiving breast mass surgery in Wuhan Fourth Hospital (Wuhan, China), from May 2014 to June 2017, were enrolled in this study. The patients were 27-67 years old, with an average age of 43.2±5.5 years old. The diameter of lesions was less than 1 cm, with an average of 0.77±0.21 cm. Lesions in all patients were diagnosed by puncturing or pathology. All patients received UE examinations and conventional US before the operation. None of the patients had received chemotherapy. Selected patients had no history of breast surgery. The present study was approved by the Ethics Committee of Wuhan Fourth Hospital. Informed consent was obtained from all participants.

### *Examination methods*

Ultrasound examinations were performed using Hitachi HI VISION Preirus color Doppler ultrasonic diagnostic instrumentation. Real-time elastic technology software was installed. The probe frequency was 5-13 MHz. Patients lied in the supine position and breasts were fully exposed. Radial-pattern scanning was then performed, using the nipple as the center. Bilateral axillary fossas were scanned at the same time. Conventional ultrasound (two-dimensional ultrasound) was used to observe lesion boundaries, shapes, sizes, echoes, envelopes, microcalcification, and blood flow. The lesions were graded according to BI-RADS categories. Next, the maximum section of the lesions was selected. Ultrasound mode was switched to UE. The area of interest was adjusted to more than 2 times to the lesion area. The elastic map and gray scale map were displayed using the real-time double-plane pattern. Clear and stable images were saved and analyzed. At the same time, the average hardness of the lesion was obtained. Acquisition and analysis of elastic images were completed by one experienced ultrasound doctor.

### *Evaluation methods*

UE scores were evaluated using the 5-point method, as follows: 1 point: All or most of the lesion was green; 2 points: The central lesion was blue and the surrounding area was green; 3 points: The proportion of the lesion showing green was close to that of the lesion showing blue; 4 points: The whole lesion was blue, with a small amount of green lesion inside; and 5 points: The lesion and surrounding tissues were blue, with or without green display inside. Scores of no less than 4 points were used as the standard for diagnosing malignancies.

BI-RADS categories were as follows: 0 category: Ultrasound examination could not comprehensively assess the lesions, with other imaging examinations necessary for further diagnosis; 1 category: Ultrasound examination showed no abnormalities and routine follow-ups were recommended for 1 year; 2 category: Ultrasound examination showed benign lesions and follow-ups, based on age and clinical symptoms, were recommended for 0.5-1 year; 3 category: The possibility of benign lesions was large and the possibility of malignant lesions was less than 2%. Short-term follow-ups were recommended for 3-6 months; 4 category: Malignant lesions were suspected, with a malignant possibility of 3%-95%, with a biopsy recommended; 5 category: Malignant possibility was > 95% and a biopsy must be performed; and 6 category: Malignant lesions were confirmed by pathological examination. Some experts believe that the single BI-RADS 4 categories do not adequately communicate the risk of cancer to doctors. Thus, they recommended a sub-category scheme: 4A: Low suspicion for malignancy; 4B: Intermediate suspicion of malignancy; and 4C: Moderate concern, but not classic for malignancy.

Lesions with BI-RADS category 1-3 were defined as benign. Those with BI-RADS category 4-5 were defined as malignant. Combined with UE scores, BI-RADS categories of small breast lesions were corrected as follows: 1) For lesions with BI-RADS category 3. If the UE score was 4-5 points, the category was upgraded by one grade; If the UE score was 1-2 points, the category was unchanged; and 2) For lesions with

**Table 1.** Pathological diagnosis results of breast lesions

| Pathological type | n | Percentage (%) |
|---|---|---|
| Fibroadenoma | 16 | 21.05 |
| Fibrous cystic breast disease | 12 | 15.79 |
| Intraductal papilloma | 10 | 13.16 |
| Inflammatory mass | 4 | 5.26 |
| Vascular lipoma | 1 | 1.32 |
| Invasive carcinoma | 26 | 34.21 |
| Intraductal carcinoma | 4 | 5.26 |
| Mucus carcinoma | 2 | 2.63 |
| Malignant phyllodes tumor | 1 | 1.32 |

**Table 2.** Conventional ultrasound BI-RADS categories and pathological findings

| BI-RADS category | n | Pathological finding [n (%)] | |
|---|---|---|---|
| | | Benign | Malignant |
| 2 | 10 | 10 (100.00) | 0 (0) |
| 3 | 16 | 13 (81.25) | 3 (18.75) |
| 4A | 17 | 13 (76.47) | 4 (23.53) |
| 4B | 15 | 5 (33.33) | 10 (66.67) |
| 4C | 13 | 2 (15.38) | 11 (84.62) |
| 5 | 5 | 0 (0) | 5 (100.00) |

BI-RADS, Breast Imaging Reporting and Data System.

**Table 3.** UE BI-RADS categories and pathological findings

| BI-RADS category | n | Pathological finding [n (%)] | |
|---|---|---|---|
| | | Benign | Malignant |
| 2 | 10 | 10 (100.00) | 0 (0) |
| 3 | 25 | 25 (100.00) | 0 (0) |
| 4A | 12 | 1 (8.33) | 11 (91.67) |
| 4B | 12 | 5 (41.67) | 7 (58.33) |
| 4C | 12 | 2 (16.67) | 10 (83.33) |
| 5 | 5 | 0 (0) | 5 (100.00) |

UE, ultrasound elastography; BI-RADS, Breast Imaging Reporting and Data System.

BI-RADS category 4-5, if the UE score was 1-2 points, the category was downgraded by one grade. If the UE score was 3-5 points, the category was unchanged.

*Statistical analysis*

Statistical analysis was performed with SPSS 20.0 software (SPSS Inc., Chicago, IL, USA). Using pathological results as the gold standard, sensitivity, specificity, and accuracy levels of conventional ultrasound BI-RADS categories and UE BI-RADS categories were calculated. Diagnostic efficiencies of two methods were analyzed using receiver operating characteristic (ROC) curves. The area under the curve (AUC) between the two methods was compared using Z tests. $P < 0.05$ indicates statistical significance.

## Results

*Pathological diagnosis results*

For the 76 breast lesions in 66 patients, pathological examinations confirmed 43 cases of benign lesions and 33 cases of malignant lesions. In 43 cases of benign lesions, there were 16 cases of fibroadenoma, 12 cases of fibrous cystic breast disease, 10 cases of intraductal papilloma, 4 cases of inflammatory mass, and 1 case of vascular lipoma. In 33 cases of malignant lesions, there were 26 cases of invasive carcinoma, 4 cases of intraductal carcinoma, 2 cases of mucus carcinoma, and 1 case of malignant phyllodes tumor (**Table 1**).

*Conventional ultrasound BI-RADS categories and pathological findings*

Conventional ultrasound BI-RADS categories and pathological findings are shown in **Table 2**. There were 23 and 20 pathologically benign cases which were benign and malignant in the conventional ultrasound BI-RADS category, respectively. There were 3 and 30 pathologically malignant cases which were benign and malignant in the conventional ultrasound BI-RADS category, respectively.

*UE BI-RADS categories and pathological findings*

UE BI-RADS categories and pathological findings are shown in **Table 3**. There were 35 and 8 pathologically benign cases which were benign and malignant in the conventional ultrasound BI-RADS category, respectively. There were 0 and 33 pathologically malignant cases which were benign and malignant in the conventional ultrasound BI-RADS category, respectively.

*Distribution of lesions with BI-RADS category corrected from conventional ultrasound to UE*

Distribution of lesions with the BI-RADS category corrected from conventional ultrasound

**Table 4.** Distribution of lesions with BI-RADS categories corrected from conventional ultrasound scans to UE

| Conventional ultrasound BI-RADS category | UE BI-RADS category | n | Pathological finding |
|---|---|---|---|
| 3 | 4A | 3 | Malignant |
| 4A | 3 | 12 | Benign |
| 4B | 4A | 4 | Malignant |
| 4C | 4B | 1 | Malignant |

BI-RADS, Breast Imaging Reporting and Data System. UE, ultrasound elastography.

**Table 5.** Sensitivity, specificity, and accuracy levels of conventional ultrasound scans and UE

| Index | Conventional ultrasound | UE | $\chi^2$ | P |
|---|---|---|---|---|
| Sensitivity | 90.91% | 100.00% | 9.523 | 0.002 |
| Specificity | 53.49% | 81.40% | 17.739 | < 0.001 |
| Accuracy | 69.74% | 89.47% | 9.117 | 0.003 |

UE, ultrasound elastography.

scans to UE are shown in **Table 4**. There were 3, 12, 4, and 1 case in which the BI-RADS category was corrected from conventional ultrasound scans to UE by 3 to 4A, 4A to 3, 4B to 4A, and 4C to 4B, respectively.

*Comparison of diagnostic efficiency between conventional ultrasound scans and UE*

Diagnostic efficiency levels between conventional ultrasound scans and UE were compared. Using BI-RADS category ≥ 4 as positive diagnostic value, sensitivity, specificity, and accuracy levels of conventional ultrasound scans and UE were calculated (**Table 5**). Sensitivity, specificity, and accuracy levels of UE were significantly higher than those of conventional ultrasound, respectively ($P < 0.01$). The ROCs of conventional ultrasound scans and UE are shown in **Figure 1**. The AUCs and test results are shown in **Table 6**. The AUC in UE was significantly higher than that in conventional ultrasound scans ($P < 0.01$), suggesting that UE provides better diagnostic efficiency, compared with conventional ultrasound scans.

## Discussion

Incidence and fatality rates of female breast cancer rank first and fourth in female malignant tumors, respectively. Breast cancer has become the first major cancer threatening women's health [13]. Ultrasound examinations have been widely used in the screening of breast diseases due to economy, simplicity, and non-invasion. However, ultrasound examinations are often greatly influenced by subjective factors. The description of diagnosis results is not standardized [14]. This, to a certain extent, has reduced the diagnostic value of ultrasound scans. BI-RADS categories were first applied to mammography. With the introduction of ultrasound technology, they have gradually expanded to a variety of breast diseases. However, most BI-RADS categories are based on two-dimensional ultrasound scans. For small breast lesions limited to a minimal range, there is no obvious invasion of cancer tissues to surrounding tissues and no obvious blood flow signal in the lesions. Characteristics of two-dimensional ultrasound images are not specific. Thus, it is easy to misdiagnose [15, 16]. Therefore, further improving the accuracy of ultrasound BI-RADS categories in the diagnosis of breast cancer is worthy of further investigation.

UE is a new type of breast ultrasound examination technology based on tissue soft hardness diagnosis. UE produces different degrees of deformation through elastic coefficient differences among different tissues. It transforms it into real time color imagery. With an increase of lesion hardness, the malignancy degree of breast lesions increases. This provides diagnostic value for the nature of lesions [17, 18]. In a previous study [19], UE combined with BI-RADS was applied for diagnosis of breast lesions with diameter ≤ 2 cm. Results showed that UE can give BI-RADS some help in the differentiation of small benign and malignant breast lesions. The addition of UE to BI-RADS can improve the diagnostic performance in < 2 cm lesions. In the present study, UE combined with BI-RADS was applied to differentiate benign and malignant breast lesions with diameter < 1 cm. Present results were satisfactory.

In the present study, there were 3 cases upgraded from conventional ultrasound BI-RADS category 3 to UE BI-RADS category 4A. Postoperative pathology confirmed these 3 cases as malignant. There were 12 cases downgraded from conventional ultrasound BI-RADS category 4A to UE BI-RADS category 3.

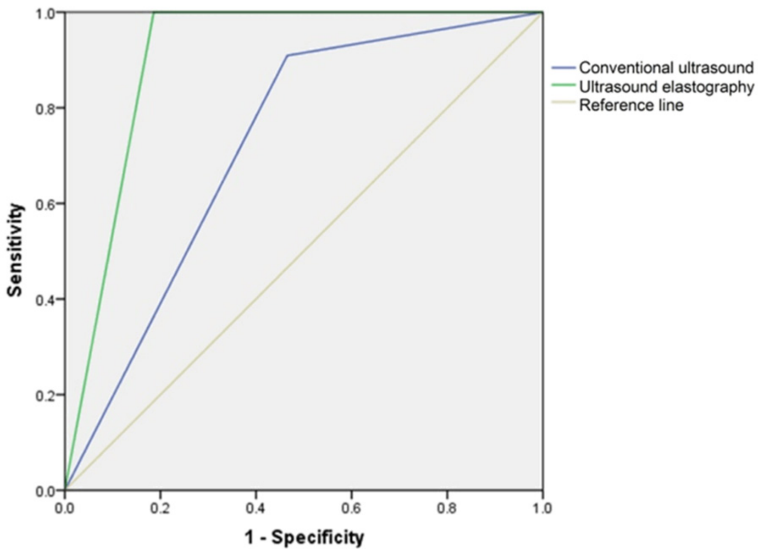


**Figure 1.** Receiver operating characteristic curves of conventional ultrasound scans and ultrasound elastography.

**Table 6.** Comparison of the area under the curve between conventional ultrasound scans and UE

| Method | AUC | SE | 95% CI | Z | P |
|---|---|---|---|---|---|
| Conventional ultrasound | 0.722 | 0.046 | 0.607-0.819 | 2.668 | < 0.001 |
| UE | 0.907 | 0.030 | 0.818-0.962 | | |

UE, ultrasound elastography.

Postoperative pathology confirmed these 12 cases as benign. Using BI-RADS category ≥ 4 as a positive diagnostic value, sensitivity, specificity, and accuracy levels of UE were significantly higher than those of conventional ultrasound scans, respectively ($P < 0.01$). The AUC in UE was significantly higher than that in conventional ultrasound scans ($P < 0.01$). Results suggest that UE is an important supplement to conventional ultrasound scans. UE combined BI-RADS categories can improve the differential diagnosis abilities of benign and malignant breast lesions.

UE also has some limitations. First, for the same elastic image of the same lesion, scores of different physicians will be different. Second, with the growth of the mass, the internal pathological structure of the lesions will correspondingly change. This affects the accuracy of UE [20]. For example, calcification, collagenous, or fibrous interstitial hyperplasia may appear in some benign lesions during the process of enlargement. This will easily lead to a partial hardening of the internal texture, resulting in higher elasticity scores [21]. In some malignant lesions, when liquefaction and necrosis of cell components occur, the lesions become soft. Thus, elasticity scores decrease [22]. Third, for larger masses, the diagnostic value of elastic scores will also decrease [23].

In conclusion, UE combined with BI-RADS can improve the diagnostic efficiency of small breast lesions. It has provided more comprehensive and objective diagnostic information for clinical practice and has important application value. The current study had some limitations, however. First, the sample size of this study was relatively small. Larger sample sizes will make future results more convincing. Second, this study only observed qualitative indexes of lesions. Quantitative indexes, including UE area ratios, were not included. In future studies, sample sizes should be further increased. More indexes should be considered, leading to more satisfactory outcomes.

## Disclosure of conflict of interest

None.

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