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Original Article

The diagnostic value of sonoelastographic strain ratio in discriminating malignant from benign solid breast masses

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ABSTRACT

Objective: To detect the diagnostic efficiency of sono elastographic strain ratio in discriminating malignant from benign solid breast masses and compare it with the sono elastographic elasticity score method.

Patients and methods: This study included 120 histopathologically diagnosed solid breast masses from 120 females (mean age 38.2 years). Elastography score and strain ratio (SR) were performed for each mass. Receiver operating characteristic (ROC) curve was plotted for both methods.

Results: The benign lesions had significant lower SR (mean 2.12 ± 1.72) than that of malignant lesions (mean 6.91 ± 3.96). The AUC from ROC curve was 0.98 for elasticity score and 0.99 for SR. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of the elasticity score in the diagnosis of solid breast masses were 100%, 88%, 83.3%, 100% and 92.5% respectively, and of the strain ratio were 93.3%, 97.3%, 95.5%, 96.1% and 95.8% respectively (when cutoff value 3.77 was used). There is no statistically significant difference found between both methods.

Conclusion: SR has high diagnostic performance in differentiating malignant from benign solid breast masses, however there is no statistically significant difference between SR and elasticity score.

1. Introduction

There is a high number of females undergoing percutaneous or surgical biopsies for characterization of breast masses every day and in the end, the pathological result proved these masses to be benign in about 75% of these patients [1,2]. Moreover, both techniques are invasive and somewhat expensive, so there is increased demand for a noninvasive diagnostic method that decreases the number of biopsies [3–6].

Ultrasound has become a standard diagnostic imaging modality which is cheap, non-invasive and easily applied that is utilized for the diagnosis of breast cancer, especially in dense breast [7,8].

Elastography is a recently developed imaging methodology that gives data about the "stiffness" of a breast lesion relative to the background fibro glandular and adipose tissues. It can lead to increasing specificity of ultrasound in the diagnosis of breast masses. Today there are two accessible types of US elastography, which are the shear wave and strain elastography [9].

Elastography can be considered as an imaging correlate to physical examination using palpation to differentiate breast mass. With palpation, benign lesions commonly feel soft while malignant lesions tend to feel subjectively hard. Strain is diminished in hard tissues as compared to soft tissue [10].

The data acquired from strain elastography give qualitative information, and the five-point elasticity scoring system has been utilized in the discrimination of malignant from benign breast masses with a reported sensitivity of 70.1–98.6% and a specificity of 45.7–98.5% [10–13].

It has been found that the semiquantitative assessment of the stiffness of a breast lesion could be done by calculating strain ratio using the same level of breast tissue as a reference. It constitutes the relative compliance stiffness of lesion as compared to the surrounding tissues [14]. Waki et al. [15] stated that the strain ratio was representative of the elasticity ratio.

The objective of this study was to detect the diagnostic value of strain ratio in differentiating benign from malignant breast masses and compare it with the elasticity score method.

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2. Patients and methods

A total of 130 consecutive females (mean age 38.2 years) with 141 breast masses detected on mammography, ultrasound or palpation were included in this prospective study between December 2015 to October 2016. The study was approved by the institutional review board of our hospital and informed consent was obtained from all patients.

The inclusion criteria:

I. Solid breast masses by grey scale ultrasound examination.
II. Masses with subsequent histopathology confirmation.

The exclusion criteria:

I. Simple breast cysts.
II. Masses with no subsequent histopathology results.

A total of 120 breast masses following our inclusion criteria were included in result analysis.

The performing radiologists had 9 years, 12 years and 10 years of experience in breast sonography as well as 6, 7 and 5 years of experience in elastography respectively.

Imaging was performed with HI VISION Avius 1200 HITACHI ultrasound machine equipped with a high frequency linear probe (L74, 7–15 MHz). After grayscale US image acquisition, elastography was performed using the built-in elasto software with the patient lying supine.

The images were displayed in dual mode, the grayscale image on the left and the elastographic image on the right. The region of interest included the area from the pectoralis muscle to the subcutaneous fat. Frequent light compression was performed with the US transducer utilizing the freehand manual compression procedure.

The elastographic image was thus obtained and the hardness of the mass was shown in a color-coded mode. The color scale ranges from blue to red, the blue represent the hardest components with no strain while the red represent the softer components with the greatest elastic strain.

Each solid breast mass was given an elasticity score according to the 5 point elasticity score developed by Itoh et al. [10].

Score (1): strain is seen in the whole mass (the entire mass is uniform green).
Score (2): strain is not seen in parts of the mass (the mass has a mosaic blue & green appearance).
Score (3): strain is seen only at the peripheral parts of the mass and sparing its central part (the peripheral part is green & the central part is blue).
Score (4): the entire mass shows no strain (the whole mass is blue).
Score (5): no strain in the entire mass & in the surrounding breast tissue (both the whole mass & surrounding breast tissue are blue).

After that, a strain ratio was calculated for the mass utilizing the machine inherent software by choosing an ROI (region of interest) from the center of the mass and a corresponding ROI of the adjacent adipose tissue. SR value was shown on a static image.

3. Statistical analysis

Continuous variables were expressed as the mean ± SD and median (Range) and the categorical variables were expressed as a number (percentage). Continuous variables were checked for normality by using Shapiro-Wilk test.

The mean SR of benign and malignant lesions was compared using the Student *t* test.

The ROC curves were used to describe the diagnostic performances of the elasticity score and SR methods. The best SR cutoff to discriminate the benign from malignant masses was obtained from ROC curve by calculating the Youden's index. The two areas under the curve (AUC) were compared using z-test.

The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy were calculated for elasticity score and strain ratio and then compared by McNemar's test.

Statistical analyses were performed by SPSS for Windows version 18.0 software (SPSS Inc, Chicago, IL). p value < .05 was statistically significant.

4. Results

This study included 120 solid breast masses from 120 women. The final diagnosis was achieved by histopathological examination of the excisional biopsy or percutaneous needle biopsy.

Histological analysis revealed that 75 (62.5%) out of the 120 masses were benign (Figs. 2–5) and 45 (37.5%) were malignant (Figs. 6 and 7). The histopathological diagnoses were summarized in Table 1.

Lesion size ranged from 10 to 70 mm (mean 15 mm) in benign masses and from 15 to 45 mm (mean 20 mm) in the malignant masses.

Grey-scale US features of each mass were assessed including shape, margin, orientation to the chest wall, internal echogenicity (hypoechoic, isoechoic or complex) and posterior attenuation effect (Table 2).

The pathologic results were correlated with the findings of elastography score and SR (Tables 3 and 4).

Nine masses with elasticity score 3 were diagnosed as malignant while 8 lesions with elasticity score 3 were diagnosed as benign by histopathology. One lesion with elasticity score 4 was diagnosed as benign by histopathology (Table 3).

The mean SR for benign masses was 2.12 ± 1.72, which was significantly lower than the mean SR of malignant lesions (mean SR 6. 91 ± 3.96) (Table 4).

ROC curves were obtained to assess the diagnostic performance of elasticity score and SR (Fig. 1). Area under the curve (AUC) values and standard errors were calculated. Comparison of AUC values for elasticity score and strain ratio was done.

On the receiver operating characteristic curve analysis, the AUC value for elasticity score was 0.98 (95% confidence interval [CI] 0.96–1.00, p < .001) and for strain ratio (AUC 0.99; 95% CI 0.98–1.00 to 0.979; p < .001) (Table 5).

There was no statistical variability on the analysis between the two AUCs values. This implies a high diagnostic performance of both elasticity score and SR.

From the strain score ROC curve, a value of $\geq$3 was considered positive for malignancy with 100% sensitivity and 88% specificity. From the strain ratio ROC curve a cutoff value 3.77 gave 93.3% sensitivity and 97.3% specificity.

The sensitivity and specificity of elasticity score for detection of malignancy were 100% and 88% respectively. Also PPV 83.3%, NPV 100% and accuracy 92.5%. For the strain ratio the sensitivity, specificity, PPV, NPV and accuracy were 93.3%, 97.3%, 95.5%, 96.1% and 95.8% respectively (Table 5).

5. Disscussion

Over the years breast ultrasound elastography has evolved as an adjunct to the conventional US, becoming a valuable tool in clinical practice [16,17].

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