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ORIGINAL ARTICLE

Qualitative diagnosis of benign breast lesions and breast carcinoma with elastographic ultrasonic imaging

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Summary

Purpose: *To investigate the efficacy of ultrasonic elastography in the qualitative diagnosis of malignant and benign breast tumors.*

Methods: *The study included 200 female patients with benign (n=100) and breast carcinomas (n=100) treated between January 2015 and March 2017. Each patient underwent ultrasonic elastography before surgery and registration of the hardness score and lesion area diameter. Postoperatively the diagnosis was pathologically confirmed.*

Results: *The hardness scores of the benign group were below 3 points while in the malignant group was above 2 points (p <0.05). The average scores of the benign and breast carcinoma groups were 2.4±1.1 and 4.3±0.7 points, respectively. The lesion areas of the malignant group were 2.44 ± 1.63 cm² and of the benign group 1.03 ± 1.01 cm² (p <0.05). The accuracy, sensitivity, specificity, positive predictive value, negative predictive value and area under the curve (AUC) of ultrasonic elastography in the qualitative diagnosis of breast carcinoma were 86.73, 88.62, 84.47, 87.20, 86.14% and 91%, respectively.*

Conclusion: *In the qualitative diagnosis of benign and breast carcinomas, ultrasonic elastography can contribute to the accurate diagnosis of the disease and can be used with success in clinical practice.*

Key words: *breast carcinoma, benign and malignant, ultrasonic elastography*

Introduction

Breast carcinoma is a common malignancy in females with most of the patients aged between 50 and 55 years [1,2]. Breast tumors can be classified into benign tumors and breast carcinoma, the benign form being more common [3]. A correct diagnosis of all type of cancers should be confirmed by histological and immunohistochemical examinations [4-7].

The pathogenesis of breast carcinoma is not clearly identified. Exposure to endocrine disruptor chemicals is considered one of the risk factors for development of breast cancer, especially in chronic exposure [8-10].

Researchers focus on new biomarkers and new methods for early diagnosis and prognosis of breast carcinoma. Dennison et al. [11] used fine-needle aspiration cytology to diagnose benign or malignant breast tumors. They showed on 143 patients with breast carcinoma that the sensitivity of fine-needle aspiration cytology associated with core biopsy was 100% and the examination methods can be used complementarily to confirm the diagnosis. Zhe et al. [12] studied the application of diffuse reflectance spectrophotometry in the diagnosis of breast carcinoma, compared Monte Carlo inverse model with the partial least square method, and

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extracted the diagnostic characteristics from the diffuse reflection spectrum. The experiment suggested that diffuse reflectance spectrophotometry based on Monte Carlo inverse model could provide reliable analysis of physiological and structural characteristics for the differentiation between benign and malignant breast tumors.

The aim of this study was to differentiate the benign breast lesions from breast carcinoma using ultrasonic elastography.

Methods

Case selection

Two hundred females with breast tumors that were admitted to the department of ultrasound of the Affiliated Hospital of Jining Medical University, Shandong, China, between January 2015 and March 2017 were included in this study. The patients were divided into 2 groups: benign group – 100 patients, and breast cancer group – 100 patients, pathologically confirmed after surgery. The patients with benign lesions were aged 25-69 years with an average of 43.2 ± 4.3 years. The patients with breast carcinoma were aged 23-66 years with an average of 43.6 ± 5.5 years. The diameter of benign and malignant tumors ranged between 0.6-8.3 cm. In 200 patients 226 nodules were found and examined. This study has been approved by the medical ethics committee of the hospital and all participating patients signed informed consent.

Ultrasonic elastography

The principle of ultrasonic elastography can be described as follows: The elasticity data of different tissues are obtained based on the changes of ultrasonic wave signals through compressing or decompressing tissues manually, coded by different colors and finally used to cover the two-dimensional image; then the elasticity is scored based on the obtained color two-dimensional elastogram [13].

The patients' breasts were scanned using a MYLab69 color Doppler ultrasonic detector (Esaote Group, Italy) (frequency 8-12 MHz). During examination, the patient laid on the bed with hands clasped in the head and with the elbows extended outward to expose both breasts and armpits. Then, the high-frequency linear array probe was coated with medical ultrasonic couplant.

Firstly the lesions were examined. The position, size and blood flow of the lesions were recorded, followed by the performance of elastography. The probe slightly touched the skin where the lesions located. With the probe vertical to the skin, the initiation of imaging was performed. When colors became stable, the detection results under gray scale and elasticity were recorded.

Elastography scoring

For elastography scoring the 5-point method was used as described by Itoh et al. [14]. Severe deformation of lesions and green lesions were scored as 1 point; deformation of most lesions, green lesions and blue-center of lesions were scored as 2 points; deformation of lesion edges and similar area of blue and green lesions were scored as 3 points; no obvious deformation around lesions and blue lesions (little green) were scored as 4 points; no deformation of lesions and blue lesions were scored as 5 points. Under such scoring standards, lesions with a presenting score of more than 3 points were determined as breast carcinoma, while lesions with score less than 3 points were determined as benign lesions.

Construction of the receiver operating characteristic (ROC) curve

While drawing ROC curve [15,16], the horizontal coordinate was specificity and the vertical coordinate was sensitivity. Then, the area under curve (AUC) was calculated. When the AUC was less than 0.5, it indicated that the condition was inconsistent with practice; when the AUC was 0.5, it indicated that the diagnostic results had no practical significance; when the AUC was more than 0.5, it suggested the examination was accurate; 0.5 to 0.7 stands for low accuracy, 0.7 to 0.9 for moderate accuracy, and higher than 0.9 for high accuracy.

Statistics

Statistical Package for Social Sciences (SPSS) 15.0 software (IBM Corporation, USA) was used to statistically analyze the obtained data. Measurement data were expressed as mean ± standard deviation. The comparison between groups was performed using Student's t-test. A p value<0.05 indicated that the difference was statistically significant.

Results

Hardness score

The results of the hardness of breast lesions detected in this study are shown in Table 1.

The hardness of the benign lesions was scored as 1 to 3 points, 1 point for 41%, 2 points for 44% and 3 points for 15%; the hardness of the malignant lesions was scored more than 2 points: 2 points for 3%, 3 points for 10%, 4 points for 39% and 5 points for 48%. The difference of hardness score between the two groups was statistically significant (p <0.05). The average hardness scores of

Table 1. Scoring of the hardness of breast lesions

Group	*Benign group (n)*	*Malignant group (n)*
1 point	41	0*
2 points	44	3*
3 points	15	10*
4 points	0	39*
5 points	0	48*

* p<0.05, comparing the malignant with benign group

the benign and malignant lesions were 2.4 ± 1.1 points and 4.3 ± 0.7 points, respectively.

Lesion area

The average area of lesions of the 100 patients with benign lesions was 1.03 ± 1.01 cm^2, while the lesion area for patients with breast carcinoma was 2.44 ± 1.63 cm^2 ($p < 0.05$; Table 2).

Elastography score

The diagnostic results of benign and malignant breast lesions based on elastography score were compared with the pathological examination results to obtain the accuracy, sensitivity, specificity, positive predictive value and negative predictive value of ultrasonic elastography. There were 226 nodules in the 200 cases of benign and malignant lesions. The number of nodules in breast carcinoma with different elastography scores and the pathological results are shown in Table 3.

For convenience purposes, the nodules that were scored as benign and pathologically diagnosed as benign were set as A; the nodules scored as benign and pathologically diagnosed as malignant were set as B; the nodules scored and pathologically diagnosed as benign were set as C; the nodules which were scored and pathologically diagnosed as malignant as D. Accuracy = A + D/number of nodules; sensitivity = D/B+D; specificity = A/A+C; positive predictive value = D/C+D; negative predictive value = A/A+B.

As shown in Table 4, the accuracy, sensitivity, specificity, positive predictive value and negative predictive value of ultrasonic elastography were 86.73% (196/226), 84.47% (87/103), 87.20% (109/125) and 86.14%(87/101), respectively.

ROC curve

Figure 1 shows the ROC curve drawn after confirming the elastography score of breast lesions according to the pathological results. It could be noted from Figure 1 that the curve was sharp initially, indicating that the resolution was accurate; the AUC of elastography was 0.91, suggesting a high accuracy and a very good sensitivity and specificity and it was significantly different from 0.5 ($p < 0.05$), revealing that such a qualitative diagnosis of breast lesions was relatively accurate.

Table 2. Area of lesions of breast lesions

Area range of lesions, cm^2	*Benign group (n)*	*Malignant group (n)*
0-0.5	20	0
0.5-1	45	15
1-1.5	21	31
1.5-2	14	30
> 2	0	24
Average hardness score ± standard deviation (cm^2)	1.03±1.01	2.44±1.63*

*p<0.05

Table 3. The number of breast nodules with different elastography scores and pathological results

Elastography score	*Benign (n)*	*Malignant (n)*	*Total (n)*
1 point	16	2*	18
2 points	39	1*	40
3 points	32	11*	43
4 points	9	35*	44
5 points	7	74*	81

*p<0.05 comparing the malignant group with the benign group

Table 4. Evaluation of the results of breast lesions based on the scoring method and the pathological examination results

*Pathological results**	*Benign (n)*	*Malignant (n)*	*Total (n)*
Benign	87	14	101
Malignant	16	109	125
Total	103	123	226

*p<0.05 comparing the malignant group with the benign group

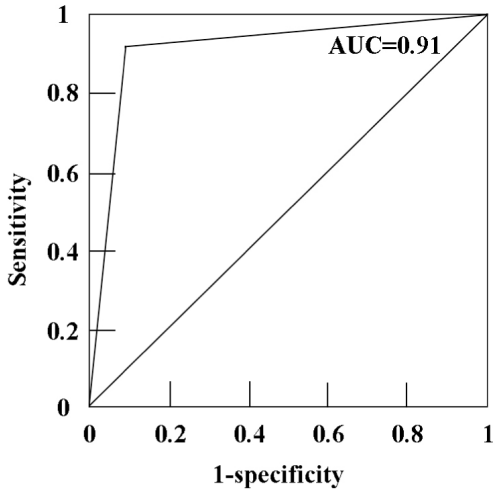

Figure 1. ROC curve of the ultrasonic elastography score. The horizontal and vertical coordinates are specificity and sensitivity, respectively. The area under the ROC curve was calculated and its value was between 0 and 1. When it was <0.5, it meant inconsistency with the reality and when it was 0.5 it meant the result had no values. When it was >0.5 but <1 it meant the result had high accuracy.

Discussion

Breast carcinoma, a common disease with high incidence among females, exerts great impact on the physical and emotional health of the patients [17-19]. Early diagnosis of breast carcinoma can help to timely perform surgery, prevent metastasis and improve the patient survival rate [20]. Starting from the studies that showed a protective effect of dietary polyphenols on breast cancer [21], new complementary therapies have been tried along with chemotherapy, such as plant extracts with anticarcinogenic activity containing polyphenols, resveratrol and flavonoids, farnesiferol C, depsidones etc. [22-28]. Conventional chemotherapeutic treatment is accompanied by many adverse effects with severe consequences among which immunosuppression and secondary infections difficult to treat with fungi from Aspergillus or Fusarium genum [29] and antibiotic-resistant germs [30,31], vitamin K-dependent coagulopathies [32] and psychiatric disorders that often require clinical differential diagnosis with psychosis [33].

In conventional treatment, breast carcinoma is preoperatively diagnosed by gray scale or color Doppler technology. However, due to rather poor specificity of these methods, it is difficult to determine whether a tumor is benign or malignant, hence these methods have large limitations in diagnosis [34,35].

Ultrasonic elastography can provide color images of lesions in the identification of benign lesions and breast carcinoma, and the hardness of lesions can be determined according to the images; as a result, the diagnostic accuracy of breast carcinoma can be improved [36]. English et al. [37] compared the efficacy of ultrasonic elastography and equivalent mode B ultrasonic imaging and the accuracy of the two methods. It emerged that the quality of images obtained through ultrasonic elastography was higher and the estimated area of tumor was also more accurate. Liu et al. [38] investigated the mechanical heterogeneity of quantifying benign and malignant breast lesions with ultrasonic elastography and found that the distribution of Young's modulus in malignant breast lesions was more heterogeneous compared to that in benign breast lesions which could be used for distinguishing benign lesions from breast carcinoma. Breast carcinoma with condensed fibrous tissue proliferation is invasive when carcinoma cells are growing [39]. The results of this study suggested that the hardness of benign breast lesions was significantly lower as compared with breast carcinoma ($p<0.05$). The hardness of the lesions of patients in the malignant group was higher than 2 points, most had 4 or 5 points, while the hardness of lesions in the benign group was less than 3 points, most had 1 or 2 points. Moreover, it was found that the area of lesions of the patients with benign breast lesions was smaller compared with breast carcinoma ($p<0.05$). Hence, this method has a clinical significance in the identification and differentiation of benign lesions from breast carcinoma.

In this study, benign and malignant lesions were scored as 2.4±1.1 points and 4.3±0.7 points, respectively ($p<0.05$).

Conclusion

In conclusion, ultrasonic elastography can fruitfully contribute to the identification of benign and malignant breast lesions. This study confirmed the significant efficacy of ultrasonic elastography in the diagnosis of benign and malignant breast lesions, which provides a reference for the application of ultrasonic elastography in the clinical diagnosis of breast carcinoma.

Conflict of interests

The authors declare no conflict of interests.

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