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The Application Value of Ultrasound Imaging in the Differential Diagnosis of Benign and Malignant Breast Nodules of BI-RADS 3 and Above

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Abstract: *Objective:* To explore the diagnostic value of ultrasound imaging for breast nodules of breast imaging-reporting and data system (BI-RADS) category 3 and above. *Methods:* From June 2021 to July 2022, 163 patients with breast nodules of BI-RADS 3 or above were selected as the research subjects. After pathological diagnosis, 24 cases were malignant breast nodules of BI-RADS 3 or above, while 139 cases were benign breast nodules of BI-RADS 3 or above. The diagnosis rate of malignant and benign breast nodules of BI-RADS 3 or above, including 95% CI, was observed and analyzed. *Results:* The malignant and benign detection rates of conventional ultrasound were 88.63% and 75.00%, respectively, and the malignant and benign detection rates of ultrasound imaging were 93.18% and 87.50%, respectively, with 95% CIs greater than 0.7. *Conclusion:* Ultrasound imaging can help improve the diagnostic accuracy of benign and malignant breast nodules of BI-RADS 3 and above and reduce the misdiagnosis rate.

Keywords: Ultrasound; Ultrasound imaging; Breast imaging-reporting and data system (BI-RADS) category 3 and above; Diagnosis

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1. Introduction

Benign breast diseases account for approximately 80% to 90% of breast cancers, among which nodules of breast imaging-reporting and data system (BI-RADS) category 3 and above are one of the important characteristics of breast cancer. However, as the number of nodules of BI-RADS 3 and above increases, ultrasonic examination is also facing more and more challenges, making it difficult for clinicians to judge whether the nodules are benign or malignant. Ultrasound radiomics is a new method that has emerged in recent years. It can use various imaging technologies, including radiomics, computer vision, artificial intelligence, etc., to extract bioinformatics features related to image features from massive images. Based on this, a discriminant model is established to predict the disease's development trend [1,2]. Ultrasound examination, as the main imaging examination method for breast diseases, has the advantages of simple operation, non-invasive, painless, and radiation-free, and is suitable for extensive clinical screening and early diagnosis. The BI-RADS classification standard was developed by the American College of Radiology and is used to evaluate the likelihood of benign and malignant breast masses. BI-RADS 3 or above nodules indicate a higher possibility of malignancy and require further diagnosis. Ultrasound radiomics can extract many high-dimensional feature information from ultrasound images, including morphological features, hemodynamic features, etc. This information can reflect the nodule's internal structure and blood flow, thereby evaluating its benign and malignant nature. Classifying and identifying features through machine learning algorithms can improve the accuracy and reliability of benign and malignant nodules. In addition, ultrasound imaging can also comprehensively analyze the shape, edge, internal echo, calcification, etc., of breast masses and provide clinicians with a more comprehensive diagnostic basis based on clinical history, age, and other factors. Doctors can formulate more precise treatment plans based on the diagnostic results of ultrasound imaging and the patient's specific conditions. Currently, radiomics research has become one of the hot topics for scholars at home and abroad. This article aims to explore the value of ultrasound imaging in the differential diagnosis of BI-RADS 3 and above nodules to improve clinicians' ability to judge benign and malignant breast cancer and reduce its missed diagnosis and misdiagnosis rates.

2. Materials and methods

2.1. General information

A total of 163 patients with breast nodules of BI-RADS 3 or above in Baoding No.1 Central Hospital from June 2021 to July 2022 were selected as the research subjects. After pathological diagnosis, 24 of them were found to be malignant breast nodules of BI-RADS 3 or above nodules, of which 139 cases were benign breast nodules of BI-RADS 3 or above. There was no statistical difference in the general information of the two groups of patients. The entry criteria were that they were consistent with breast nodules of BI-RADS 3 or above and had no other comprehensive metabolic disease or mental illness. The exclusion criteria were patients with incomplete clinical data and other major diseases.

2.2. Method

2.2.1. Ultrasound imaging

Ultrasound radiomics diagnosis of breast nodules classified as BI-RADS 3 or above mainly involves the following steps: (1) Conducting an ultrasound examination of the breast to obtain ultrasound images; (2) Extracting features relevant to breast nodules from these images, such as morphological and hemodynamic features. These features can reflect the internal structure and blood flow of the nodules, aiding in determining their benign or malignant nature; (3) Among the extracted features, those significantly impacting benign-malignant judgment are selected, effectively reducing the number of features and improving diagnosis efficiency; (4) Appropriate machine learning algorithms, such as support vector machines, decision trees, or neural networks, are utilized to design classifiers for the extracted features and their corresponding benign and malignant nodules; (5) Known benign and malignant breast ultrasound image datasets are employed to train and verify the classifier, significantly enhancing its accuracy and reliability; (6) Based on the classifier's classification results, BI-RADS 3 and above are outputted along with the probability of benign and malignant nodules. This step furnishes doctors with an auxiliary diagnostic basis, aiding them in making more accurate diagnoses.

2.2.2. Ultrasound diagnosis

Ultrasound diagnosis was carried out using color Doppler flow imaging (CDFI) technology and Doppler blood flow perfusion imaging technology to diagnose breast nodules in BI-RADS 3 and above (including papillary, cystic-solid nodules, and other types of breast nodules in BI-RADS 3 and above).

2.3. Observation indicators

The diagnosis rate of malignant and benign breast nodules of BI-RADS 3 and above, including 95% CI, is shown in **Figure 1**.

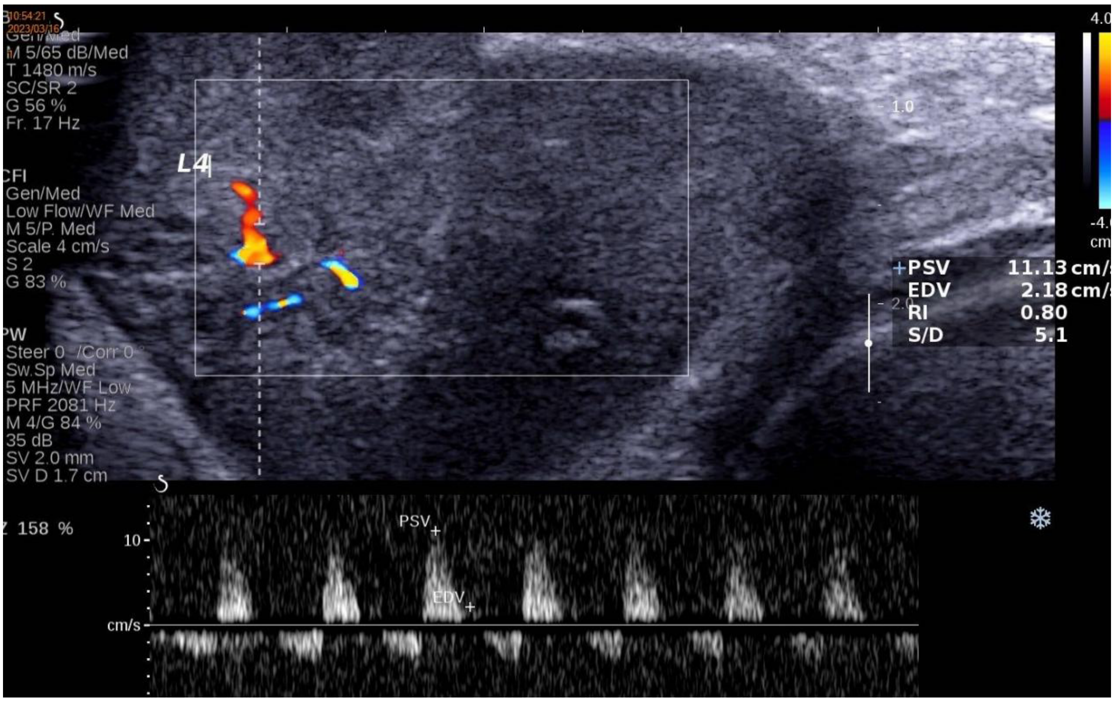

Figure 1. Superficial small organs: bilateral breasts + double axillary soft tissues and axillary veins

2.4. Statistical analysis

SPSS 22.0 statistical software was employed for data analysis. Data were expressed as either mean ± standard deviation (SD) or percentage. The *t*-test and the χ^2 test were utilized for data comparison. Statistical significance was indicated by $P < 0.05$.

3. Results

The patients were diagnosed by pathology, with 24 cases in the malignant group and 139 cases in the benign group. Conventional ultrasound's malignant and benign detection rates were 88.63% and 75.00%, respectively. The malignant and benign detection rates of ultrasound imaging were 93.18% and 87.50%, respectively, and 95% CI are all greater than 0.7, as shown in **Table 1**.

Table 1. Diagnostic performance of ultrasound imaging

Pathological results		Malignant (*n* = 24)	Benign (*n* = 139)	Accuracy	95% CI
Conventional ultrasound	Malignant	19	20	79.17%	0.862
	Benign	5	119	85.61%	0.791
Ultrasound imaging	Malignant	23	13	95.83%	0.901
	Benign	1	126	90.65%	0.842

4. Discussion

Breast nodules refer to tumors found during ultrasound examination. Nodules of BI-RADS 3 and above are often accompanied by varying degrees of calcification, which is a typical characteristic of breast cancer. Ultrasound examination has high sensitivity and specificity in the diagnosis of breast cancer and can help clinicians detect nodules early. In clinical work, ultrasonography is mainly used for the diagnosis and differential diagnosis of breast masses. However, in nodules of BI-RADS 3 and above, the sensitivity and specificity of ultrasonic examination are low. Su *et al*. analyzed 337 cases of BI-RADS 3 and above breast nodules. They found that the masses in the high ultrasound density group (0.73 ± 0.19) and the low ultrasound density group (0.58 ± 0.11) had a higher ultrasound diagnosis compliance rate and diagnosis sensitivity. In comparison, the low ultrasound density group (0.56 ± 0.07) and the high ultrasound density group (0.58 ± 0.11) have lower diagnostic coincidence rates and diagnostic sensitivity. Still, it should be noted that the high ultrasound density group and the low ultrasound density group are not independent of each other but influence each other [3]. In addition, nodules of BI-RADS 3 and above usually have a higher risk of malignancy.

The development of radiomics can be traced back to the 1980s. There have been many reports on its application in breast cancer, but most of them are based on pathology reports or clinical data. In recent years, more and more radiomics research has been conducted on breast tumors, and it has gradually begun to be integrated with clinical practice. Currently, there are two main methods for extracting radiomic features: based on computer vision technology and artificial neural network technology. There are two main types of methods based on computer vision technology. One is to segment the image and perform feature analysis based on feature selection and extraction algorithms. The main methods include the fuzzy C-means (FCM) algorithm, principal component analysis (PCA), and neural network methods. The other type uses a gray level co-occurrent matrix (GLCM) on the image to extract texture and color features to build a classification model. The former is more intuitive in extracting features but is time-consuming and laborious; the latter is more effective in extracting features but requires professional knowledge. Currently, methods based on computer vision technology are widely used in ultrasound imaging. Guo's research based on ultrasound imaging found that ultrasound imaging can improve the ability to identify breast cancer, with a sensitivity and specificity of 80% and 85%, respectively [4]. Therefore, research based on ultrasound imaging can improve the ability to identify breast tumors.

In this study, patients were diagnosed pathologically, with 24 cases in the malignant group and 139 cases in the benign group. The malignant and benign detection rates of conventional ultrasound were 88.63% and 75.00%, respectively, and the malignant and benign detection rates of ultrasound imaging were 93.18% and 87.50%, respectively, and the 95% CIs were greater than 0.7. Studies have shown that radiomics is an important part of big data analysis. Ultrasound radiomics can quantify and mine structural features in images to identify benign and malignant breast nodules. Differential diagnosis of knots provides more effective information. This is mainly because when ultrasound imaging studies diagnose BI-RADS 3 and above nodules, multiple technologies are combined, including traditional ultrasound imaging technology, computer vision, artificial intelligence, etc. Current research by Qi [5], Wang [6], Wang [7], Mira [8], Li [9], and Li [10] have shown that ultrasound based on multi-modal fusion radiomics analysis can improve the accuracy of diagnosis of benign and malignant nodules of BI-RADS 3 and above; ultrasound radiomics analysis based on image segmentation method can improve the accuracy of diagnosis of benign and malignant nodules of BI-RADS 3 and above; based on image ultrasound radiomics analysis using feature extraction methods can improve the accuracy of differential diagnosis of benign and malignant nodules of BI-RADS 3 and above. Shi [11], Qu [12], Huang [13], and other researchers have found that multi-modal fusion-based ultrasound image radiomics analysis can improve the accuracy of benign and malignant diagnosis of BI-RADS 3 and above nodules. Compared with conventional ultrasound image segmentation methods, its prediction accuracy is higher (AUC = 0.842).

Ultrasound, as a non-invasive, simple, and economical examination method, can detect small breast lesions and plays an important role in the early diagnosis and differential diagnosis of breast tumors [14]. However, due to the increase in the number of BI-RADS 3 and above nodules and the varying sizes of breast lesions, the difficulty in the differential diagnosis of benign and malignant breast cancer has increased, making it difficult for clinicians to make judgments [15]. Ultrasound radiomics is a medical data mining method based on ultrasound images. By mining the bioinformatics features related to the benign and malignant breasts in the images, the non-structural information in the images is converted into structured data, thereby assisting clinicians in making correct decisions [16].

In summary, radiomics is a new research method that can identify benign and malignant nodules of BI-RADS 3 and above. However, there are still some problems in current radiomics research, such as the lack of multi-center, large-sample studies. The quality control and analysis methods of research and radiomics are not uniform. Ultrasound imaging mainly utilizes technologies such as computer vision and artificial intelligence, which have the advantages of convenience and speed and do not require pathological diagnosis. With the continuous development of radiomics technology, radiomics will play a greater role in clinical applications. They can be applied to different benign and malignant breast diseases to diagnose them and guide clinical treatment differentially. However, radiomics research is still in its infancy, and more research is needed to verify its diagnostic value. It is believed that as the research of radiomics in the diagnosis of breast cancer gradually deepens, radiomics will play a greater role in the differential diagnosis of benign and malignant breast diseases.

Disclosure statement

The author declares no conflict of interest.

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