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Multimodal MRI Enhancement Combined with Diffusion-Weighted Imaging for the Differential Diagnosis of Non-Lactating Mastitis and Breast Cancer

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Abstract: *Objective*: To explore the value of multimodal MRI enhancement scanning and diffusion-weighted imaging in differentiating non-puerperal mastitis (NPM) and breast cancer. *Methods*: From September 2022 to September 2024, 56 patients with breast diseases were selected as samples and grouped according to disease type. Twenty-eight patients with breast cancer were included in Group A, and 28 patients with NPM were included in Group B. All patients underwent multimodal MRI enhancement scanning and diffusion-weighted imaging. The MRI results, time-signal intensity curves, ADC values, lesion intensity, and imaging signs were compared between the two groups. *Results*: There were no significant differences in enhancement characteristics, lymph node enlargement, and margins between Group A and Group B ($P > 0.05$). The proportion of outflow curves in Group A was higher than that in Group B ($P < 0.05$). The ADC value in Group A was lower than that in Group B, and the lesion intensity was higher than that in Group B ($P < 0.05$). There were significant differences in imaging signs, such as abscess or sinus, ascending time-signal curve, and mammary duct dilation between Group A and Group B ($P < 0.05$). *Conclusion*: Multimodal MRI enhancement scanning and diffusion-weighted imaging techniques can be used to diagnose breast diseases. Comprehensive analysis of time-signal intensity curves, lesion intensity, imaging signs, and ADC values can differentiate between NPM and breast cancer.

Keywords: Breast cancer; NPM; MRI; Enhanced imaging; Diffusion-weighted imaging

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1. Introduction

NPM includes various pathological types such as submammary abscess and granulomatous mastitis. Initially, there are no specific inflammatory symptoms, and it is often detected during health screenings. As NPM progresses, patients may develop nodules, lumps, fever, and other symptoms. Some patients experience acute onset, manifesting as breast redness, swelling, pain, and even fistulas [1]. Currently, the specific pathogenesis of NPM is not yet clear and may be related to duct obstruction, immune system disorders, infections, etc. Breast

cancer progresses rapidly, manifesting as breast lumps, areolar skin itching, nipple discharge, etc. If not treated early, cancer cells can metastasize through the lymphatic and blood systems, potentially threatening life [2]. Clinically, surgical biopsy is often used to differentiate between NPM and breast cancer, but biopsy is an invasive procedure and cannot be promoted as a primary screening technique. With the maturity of imaging technology, MRI is gradually being used in the screening of breast diseases, offering advantages of multi-functional and multi-sequence imaging, guiding physicians in the differential diagnosis of breast diseases [3]. Based on this, this article explores the diagnostic value of multimodal MRI enhancement scanning and diffusion-weighted imaging using a sample of 56 patients with breast diseases who visited the hospital from September 2022 to September 2024.

2. Materials and methods

2.1. Materials

A sample of 56 patients with breast diseases who visited between September 2022 and September 2024 is selected and grouped according to disease type. Group A consisted of patients aged 32–55 years, with a mean age of (43.19 ± 1.28) years. Among them, 16 cases had left-sided and 12 cases had right-sided breast diseases. Group B consisted of patients aged 33–55 years, with a mean age of (43.21 ± 1.33) years. In this group, 15 cases are left-sided and 13 cases are right-sided. The baseline data of breast diseases in Group A are compared with those in Group B, with $P > 0.05$.

2.2. Inclusion and exclusion criteria

2.2.1. Inclusion criteria

(1) First occurrence of unilateral breast lesion

(2) Pathology suggesting NPM or breast cancer

(3) Signed informed consent

2.2.2. Exclusion criteria

(1) Accompanied by other malignancies

(2) History of breast surgery

(3) Lactational mastitis

2.3. Methods

MRI examination is performed using a Siemens AVanto 1.5T MRI scanner. Patients are instructed to lie in the prone position correctly, and MRI scanning is initiated according to the principle of head-first, maintaining the natural suspension of both breasts in the coil. Patients are guided to place their arms on both sides of the body, and scanning is performed from the axillary region until images of the lower edge of both breasts are obtained. Breast three-plane localization is performed to acquire T1WI, T2WI, and enhanced scanning images. After completing the pre-enhancement scanning operation, gadolinium diethylenetriamine pentaacetic acid (Gd-DTPA) contrast agent is prepared and injected into the elbow vein, with a dose controlled at 0.2ml/Kg and a flow rate of 3ml/s.

2.4. Observation indicators

Scanning results; recording enhancement features, lymph node enlargement, edges, and other indicators; time-intensity curve, recording outflow, plateau, and ascending curve types; recording ADC values and lesion intensity during MRI scanning; and documenting the detection of imaging signs.

2.5. Statistical analysis

Data are processed using SPSS 23.0 software. Chi-square test is used to analyze categorical data (% recorded), and the t-test is used for continuous data (mean ± standard deviation recorded). Statistical differences are considered significant at $P < 0.05$.

3. Results

3.1. Scanning results

There was no difference in the proportion of enhancement features, lymph node enlargement, and edges between Group A and Group B ($P > 0.05$), as shown in **Table 1**.

Table 1. Analysis of scanning results (n,%)

Group	Enhancement pattern		Lymph node enlargement		Margin definition	
	Non-mass-like	Mass-like	Present	Absent	Clear	Indistinct
Group A (*n*=28)	20 (71.43%)	8 (28.57%)	19 (67.86%)	9 (32.14%)	5 (17.86%)	23 (82.14%)
Group B (*n*=28)	23 (82.14%)	5 (17.86%)	22 (78.57%)	6 (21.43%)	6 (21.43%)	22 (78.57%)
X^2	0.9016		0.8195		0.1131	
P	0.3424		0.3653		0.7366	

3.2. Time-signal intensity curve

The proportion of outflow-type curves in Group A was higher than that in Group B ($P < 0.05$), as shown in **Table 2**.

Table 2. Analysis of time-signal intensity curves (n,%)

Group	Washout pattern	Plateau pattern	Persistent pattern
Group A (*n*=28)	12 (42.86%)	14 (50.00%)	2 (7.14%)
Group B (*n*=28)	4 (14.29%)	12 (42.86%)	12 (42.86%)
X^2	4.9778	0.1915	8.8889
P	0.0257	0.6617	0.0029

3.3. ADC values and lesion intensity

The ADC value in Group A was lower than that in Group B, and the lesion intensity was higher than that in Group B ($P < 0.05$), as shown in **Table 3**.

Table 3. Analysis of ADC values and lesion intensity (n,%)

Group	ADC value ($\times 10^{-3}$ mm²/s)	Lesion intensity
Group A (*n*=28)	1.05 ± 0.21	433 ± 32
Group B (*n*=28)	1.38 ± 0.36	425 ± 43
t	4.1898	0.7898
P	< 0.0001*	0.4331

3.4. Imaging signs

There were significant differences in imaging signs such as abscess or sinus, ascending time-signal curve, and mammary duct ectasia between Group A and Group B ($P < 0.05$), as shown in **Table 4**.

Table 4. Analysis of imaging signs (n,%)

Factor		Group A (n=28)	Group B (n=28)	X^2	P
Abscess/Sinus tract	Yes	2(7.14)	22(78.57)	20.7407	0.0000
	No	26(92.86)	6(21.43)		
Boundary	Clear	5(17.86)	4(14.29)	0.1383	0.7100
	Blurry	23(8.21)	24(85.71)		
Vascular tortuosity and thickening at the center of the lesion	Yes	13(46.43)	14(50.00)	0.0461	0.8300
	No	15(53.57)	14(50.00)		
Swollen lymph nodes	Yes	19(67.86)	20(71.43)	0.0319	0.8582
	No	9(32.14)	8(28.57)		
Ascending time signal curve	Yes	4(14.29)	24(85.71)	17.7778	0.0000
	No	24(85.71)	4(14.29)		
Mammary duct dilation	Yes	3(10.71)	23(82.14)	19.1453	0.0000
	No	25(89.29)	5(17.86)		
Morphology	Regular	4(14.29)	2(7.14)	0.4978	0.4805
	Irregular	24(85.71)	26(92.86)		

4. Discussion

NPM belongs to the category of chronic inflammatory lesions of the breast, with pathological features including hyperplasia, deterioration, and exudation of breast tissue on the affected side. It exhibits non-caseating necrosis and non-bacterial infectious lesions, and the inflammatory lesions have blurred boundaries with adjacent glands. Breast cancer, on the other hand, is a malignant tumor-like lesion. During its growth, cancer foci stimulate the body to produce large amounts of proteolytic enzymes, which can damage healthy glandular structures. The edges of the lesions appear spiculated or crab-like, and lymph node metastasis occurs as the disease progresses [4]. The treatment options for NPM and breast cancer are different, and clinical diagnosis often relies on pathological examination to analyze the nature of breast diseases. However, this is an invasive procedure that some patients with breast diseases cannot tolerate [5]. With the development of imaging technology, MRI technology has gradually matured, allowing for the analysis of breast disease properties from multiple aspects such as hemodynamics, morphology, and differences in water molecule diffusion during scanning. This approach has a high accuracy rate in differential diagnosis [6]. However, relying solely on multimodal MRI-enhanced scanning to observe blood flow changes can lead to misdiagnosis if NPM and breast cancer patients exhibit overlapping hemodynamic features. Similarly, focusing only on diffusion-weighted imaging to observe water molecule diffusion in patients with breast diseases can also result in misdiagnosis if NPM and breast cancer patients have similar ADC values. Therefore, to improve diagnostic efficacy, this article adopts a combined diagnostic method of multimodal MRI enhancement and diffusion-weighted imaging to distinguish between NPM and breast cancer.

Based on the data analysis in this article, there is no difference in the proportion of enhancement features, lymphadenopathy, and margins between Group A and Group B ($P > 0.05$). The reason for this is that although multimodal MRI enhanced scanning can obtain hemodynamic information, the differences in scan results between NPM and breast cancer patients are not significant due to variations in fat content, glandular density, and tissue structure among patients with breast lesions [7]. Another set of data indicates that the proportion of outflow curves is higher in Group A than in Group B ($P < 0.05$). The reason for this is that during diffusion-weighted imaging, the focus is on observing microscopic changes in water molecule movement in breast tissue. There is a high sensitivity to observe favorable water molecule flow and diffusion, which can objectively reflect histological changes and cancer lesion typing characteristics. Therefore, scanned data can serve as a basis for physicians to qualitatively analyze breast diseases. Enhanced scanning provides dynamic feedback on patients' blood flow characteristics, allowing for the identification of lesion properties by observing changes in the time-signal intensity curve. For example, an outflow curve often suggests malignant breast lesions, while a plateau curve suggests benign breast lesions. However, to ensure the accuracy of MRI scan results, patients should remove metal objects from their bodies before scanning, as they can alter the uniformity of the magnetic field and affect the examination results. Patients should also inform the physician of any allergies to contrast agents or medications and should schedule appointments 7–14 days after menstruation [8].

Another set of data indicates that Group A has a lower ADC value and higher lesion intensity than Group B, with $P < 0.05$. This suggests that doctors can assist in differentiating between NPM and breast cancer by analyzing changes in ADC values and lesion intensities in patients with breast diseases. In this paper, multi-modal MRI enhanced scanning technology is selected for differential diagnosis of diseases, and hemodynamic fluctuation data of the affected breast is obtained. The immediate time-signal intensity curve can objectively feedback the internal proliferation process of breast lesions. Combined with diffusion-weighted imaging scanning, the analysis of water molecule diffusion movement, and quantitative analysis of tissue lesions with ADC values can guide clinical diagnosis in multiple aspects. Furthermore, the combined scanning of multi-modal MRI enhanced scanning and diffusion-weighted imaging technology can avoid image artifacts and deformations, and has high image spatial resolution and signal-to-noise ratio, which is beneficial for improving imaging clarity [9]. The final set of data shows significant differences in imaging signs such as abscess or sinus formation, ascending time-signal curves, and breast duct dilation between Group A and Group B, with $P < 0.05$.

The analysis of the reasons reveals that patients with NPM have severe inflammatory reactions in their bodies, which can easily generate inflammatory granulation tissue, abscesses, and even sinuses to facilitate the discharge of inflammatory secretions. However, breast cancer lesions are invasive, and during disease progression, breast tissue undergoes necrotic and liquefied changes without the formation of abscesses or sinuses. NPM lesions progress in a localized manner, resulting in relatively clear lesion boundaries, while breast cancer proliferates rapidly and infiltrates adjacent tissues, leading to relatively blurred boundaries. However, the boundary characteristics of the two diseases are not significant in the early stages of the disease. Long-term inflammatory stimulation in NPM patients can cause vasodilation and thickening, while the growth of breast cancer lesions increases the demand for blood, leading to an increase in the number of local new blood vessels with tortuous and thickened features to support lesion growth. Therefore, there is no difference in the signs of vascular tortuosity and thickening between the two groups of patients. NPM patients experience inflammatory factor-induced continuous stimulation of lymph nodes, leading to symptoms of enlarged lymph nodes with soft texture, strong activity, and pain. Breast cancer patients may also experience enlarged lymph nodes due to cancer metastasis, but the masses

are hard, immobile, and painless.

NPM is a benign breast lesion, so during MRI scanning, the signal gradually increases after the contrast agent enters the body, and the time-signal curve can be maintained for a long time. However, in breast cancer patients, changes in vascular permeability and rapid increases in the number of blood vessels cause the signal to gradually decrease after the contrast agent enters the body. Under inflammatory stimulation, NPM patients experience breast hyperplasia and edema on the affected side, leading to increased duct pressure and prone to duct obstruction and stenosis, manifesting as duct dilation. Furthermore, continuous secretion of inflammatory factors in the body can further increase duct pressure and exacerbate duct dilation symptoms, while duct dilation is not obvious in breast cancer patients. Under the influence of increased inflammatory factor secretion, NPM patients may experience changes in tumor morphology. However, there are differences in the range and direction of inflammatory factor diffusion among different patients, which can stimulate breast tissue swelling and cause irregular breast morphology. Breast cancer patients may also experience changes in breast morphology due to the infiltrative growth of tumor lesions, so there is no difference in breast morphology changes between the two groups [10].

5. Conclusion

In summary, multi-modal MRI enhanced scanning and diffusion-weighted imaging technology can assist doctors in the differential diagnosis of NPM and breast cancer. Observing changes in imaging signs, ADC values, lesion intensity, and time-signal intensity curves provides high accuracy and has promotional value.

Disclosure statement

The author declares no conflict of interest.

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