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Analysis of the Effect and Detection Rate of Magnetic Resonance Imaging Combined with Ultrasound Elastography in the Differential Diagnosis of Breast Cancer

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Abstract: *Objective*: To evaluate the differential diagnostic efficacy of magnetic resonance imaging (MRI) combined with ultrasound elastography (UE) for breast cancer. *Methods*: A total of 120 patients diagnosed with breast cancer admitted to the hospital from January 2023 to January 2025 were selected for MRI and UE diagnosis, and the differences in diagnostic efficacy between single and combined diagnostic methods were assessed. *Results*: The detection rate of breast cancer with combined diagnosis was higher than that with single diagnosis, and the detection rate of disease types with combined diagnosis was also higher than that with single diagnosis ($P < 0.05$). In terms of tumor classification, the detection rate calculated by combined diagnosis was significantly higher, and the accuracy and sensitivity obtained by combined diagnosis were high, with a low missed diagnosis rate determined, and $P < 0.05$ when comparing various methods. *Conclusion*: MRI combined with UE demonstrates superior efficacy in diagnosing breast cancer, enabling the differentiation of disease types and determination of tumor classification, with high diagnostic performance.

Keywords: Magnetic resonance imaging (MRI); Ultrasound elastography (UE); Breast cancer; Differential diagnosis; Detection rate

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1. Introduction

Breast cancer is a relatively common malignant tumor among women, with a complex pathogenesis involving factors such as abnormal hormone secretion, genetic predisposition, environmental changes, and unhealthy lifestyles [1]. In its early stages, breast cancer often presents without obvious symptoms, but as the disease progresses, symptoms such as nipple discharge and breast lumps may appear, and it is prone to involving the lymph nodes, leading to lymphadenopathy. Imaging techniques, primarily UE and MRI, are commonly used for

diagnosing this condition. These techniques can visually display characteristics such as tumor location, quantity, and firmness, with MRI offering high spatial resolution that enables the detection of even minute tumors, thereby improving disease detection rates [2]. When used in combination, UE and MRI can exert a synergistic effect, providing a comprehensive assessment of the relationship between the tumor and surrounding tissues, resulting in superior diagnostic performance. Based on this, this study selected 120 patients with breast cancer to evaluate the diagnostic role of MRI combined with UE.

2. Materials and methods

2.1. General information

The study spans from January 2023 to January 2025 and includes statistical data from 120 breast cancer patients. The patients' ages range from 23 to 67 years old, with an average age of (42.57 ± 3.67) years old; the disease duration ranges from 0.7 to 2 years, with an average of (1.05 ± 0.97) years; the number of breast tumors ranges from 19 to 37, with an average of (22.65 ± 3.18) tumors.

Inclusion criteria: Initial diagnosis of breast cancer; meeting the indications for imaging technology examination; presenting symptoms such as breast pain and breast lumps; having complete basic information; being informed about and consenting to the study. Exclusion criteria: Having a history of breast surgery; suffering from abdominal or pelvic malignancies; having concurrent immune dysfunction diseases; being pregnant or lactating; having psychiatric disorders; withdrawing from the study midway.

2.2. Methods

The diagnostic method for MRI involves selecting a Siemens superconducting magnetic resonance diagnostic instrument with a breast array coil (bilateral). Patients are instructed to maintain a supine position with their breasts in a naturally hanging state. A plain scan is first performed, with the inversion time set at 150 ms, the echo time at 75 ms, the repetition time at 9145 ms, the slice thickness at 2.8 mm, the matrix at 256*512 mm, and the single excitation time at 3.12 minutes. Perform dynamic contrast-enhanced scanning, with the echo time set at 4.6 ms, the repetition time at 12 ms, the slice thickness at 1.8 mm, the matrix at 512*512, the excitation angle at 25 degrees, and the single excitation time at 60 s. Evaluate the location and quantity of tumors, among other information, based on normal glandular signals, and assess the blood flow status around the tumors.

The diagnostic method for UE is as follows: Select a color Doppler ultrasound diagnostic instrument, set the probe frequency between 3–15 MHz, assist the patient in maintaining a supine position, and scan the tumor using grayscale ultrasound in longitudinal, transverse, and other sectional planes. Observe the tumor's shape, size, and echo characteristics, and evaluate the anatomical relationship between the tumor and surrounding tissues. Use Doppler ultrasound to assess the blood flow distribution characteristics inside and around the tumor.

2.3. Observation indicators

MRI references the Breast Imaging Reporting and Data Standards formulated by the American College of Radiology (ACR). Malignant tumors appear as low-signal intensity on T1/T2-weighted images, with inhomogeneous internal signals and spiculated or lobulated, irregular margins; benign tumors appear as high-signal intensity on T1/T2-weighted images, with smooth margins and an oval or round shape. Based on characteristics such as the time-signal intensity curve and peripheral enhancement, Type I is the inflow type, indicating a benign tumor; Type II is the plateau type, indicating an intermediate-type tumor; and Type III is the outflow type, indicating a malignant

tumor.

The diagnostic criteria for UE are based on the modified UE scoring criteria (by Luo Baoming). If the tumor appears predominantly or entirely green, it is scored as 1 point; if the tumor exhibits blue internally with a predominantly green periphery, it is scored as 2 points; if the internal proportions of blue and green are roughly similar, it is scored as 3 points; if the tumor is predominantly blue internally with only a small amount of green, it is scored as 4 points; a score of 5 points indicates that both the periphery and interior of the tumor are blue. A score greater than 3 indicates a malignant tumor.

Observe the detection rates of diseases such as medullary carcinoma, invasive ductal carcinoma, invasive lobular carcinoma, mucinous carcinoma, and ductal carcinoma in situ.

The tumor classification is determined using the Breast Imaging Reporting and Data System (BI-RADS) classification assessment method. Grade 0 indicates normal ultrasound results; Grade I indicates benign signs on ultrasound; Grade II indicates a clearly benign lesion on ultrasound; Grade III indicates abnormal ultrasound results with a 3–94% likelihood of malignancy upon biopsy; Grade IV indicates a 95% or higher likelihood of malignancy upon biopsy; Grade V indicates a pathological diagnosis of a malignant tumor.

Using pathological diagnosis results as the standard, accuracy is calculated as (number of true malignancies + number of true benign cases) / total number of cases in this group; sensitivity is calculated as number of true malignancies / (number of true malignancies + number of false benign cases); specificity is calculated as number of true benign cases / (number of true benign cases + number of false malignancies); the missed diagnosis rate is calculated as number of false benign cases / (number of true malignancies + number of false benign cases); and the misdiagnosis rate is calculated as number of false malignancies / (number of false malignancies + number of true benign cases).

2.4. Statistical analysis

The data was processed using SPSS 28.0 software. Measurement values were compared/tested using t-values, while count values were compared/tested using chi-square (χ^2) values. Statistical significance was considered as $P < 0.05$.

3. Results

3.1. Comparison of breast cancer detection rates between groups

The detection rate of breast cancer by MRI alone was 74.17% (89/120), by UE alone was 71.67% (86/120), and by combined diagnosis was 94.17% (113/120). The comparison between groups showed $\chi^2 = 22.813$, $P = 0.000$.

3.2. Comparison of disease type detection rates between groups

Among the pathological diagnosis results, there were 114 malignant cases and 6 benign cases. Using the pathological diagnosis results as the standard, the disease type detection rate of combined diagnosis was higher than that of MRI or UE alone ($P < 0.05$) (**Table 1**).

Table 1. Comparison of disease type detection rates between groups [n/%]

Method	Medullary Carcinoma	Invasive Ductal Carcinoma	Invasive Lobular Carcinoma	Mucinous Carcinoma	Ductal Carcinoma in Situ
Pathological Diagnosis (n)	12	62	20	10	10
MRI Single Modality	6 (50.00)	57 (91.94)	15 (75.00)	5 (50.00)	6 (60.00)
Ultrasound Elastography (UE) Single Modality	6 (50.00)	55 (88.71)	14 (70.00)	6 (60.00)	5 (50.00)
Combined Diagnosis (MRI + UE)	11 (91.67)	62 (100.00)	20 (100.00)	10 (100.00)	10 (100.00)
χ^2	6.020	6.948	6.902	6.667	6.667
P	0.049	0.031	0.032	0.036	0.036

3.3. Comparison of tumor classification detection rates between groups

The tumor classification detection rate of combined diagnosis was superior to that of MRI or UE alone ($P < 0.05$) (**Table 2**).

Table 2. Comparison of tumor classification detection rates between groups [n/%]

Method	n	Grade 0	Grade I	Grade II	Grade III	Grade IV	Grade V
MRI Single Modality	120	2 (1.67)	6 (5.00)	10 (8.33)	10 (8.33)	7 (5.83)	85 (70.83)
Ultrasound Elastography (UE) Single Modality	120	3 (2.50)	7 (5.83)	10 (8.33)	11 (9.17)	6 (5.00)	83 (69.17)
Combined Diagnosis	120	4 (3.33)	0 (0.00)	2 (1.67)	2 (1.67)	1 (0.83)	111 (92.50)
χ^2		0.684	6.863	6.197	6.781	4.608	23.321
P		0.710	0.032	0.045	0.034	0.100	<0.001

3.4. Comparison of diagnostic efficacy among groups

Under the premise of pathological diagnosis, combined diagnosis achieves higher accuracy and sensitivity, along with a lower rate of missed diagnoses. When comparing various methods, all show $P < 0.05$ (**Table 3** and **Table 4**).

Table 3. Analysis of diagnostic results among groups

Diagnostic Method		Pathological Diagnosis		Total
		Malignant	Benign	
MRI Single Modality	Positive	85	4	89
	Negative	29	2	31
Ultrasound Elastography (UE) Single Modality	Positive	83	3	86
	Negative	31	3	34
Combined Diagnosis	Positive	111	2	113
	Negative	3	4	7

Table 4. Comparison of diagnostic efficacy among groups [n/%]

Diagnostic Method	Accuracy	Sensitivity	Specificity	Missed Diagnosis Rate	False Positive Rate
MRI Single Modality	72.50 (87/120)	74.56 (85/114)	33.33 (2/6)	25.44 (29/114)	66.67 (4/6)
Ultrasound Elastography (UE) Single Modality	71.67 (86/120)	72.81 (83/114)	50.00 (3/6)	27.19 (31/114)	50.00 (3/6)
Combined Diagnosis	95.83 (115/120)	97.37 (111/114)	66.67 (4/6)	2.63 (3/114)	33.33 (2/6)
χ^2	28.229	28.485	1.333	28.485	1.333
P	0.000	0.000	0.513	0.000	0.513

4. Discussion

Breast cancer is a relatively common malignant tumor in women, primarily occurring in perimenopausal women aged 40–60 years old. It has a long-term impact on the physical and mental health of female patients [3]. Most breast cancer cells originate from the epithelial cells of mammary ducts, with a small number originating from acini. The disease has a strong concealment in onset, with no obvious symptoms in the early stages. However, the detection rate of early screening is relatively high, enabling early diagnosis and treatment, which leads to a better prognosis [4].

MRI and UE are commonly used imaging techniques for diagnosing this disease. MRI, a non-invasive diagnostic technique, reconstructs tissue information by acting on electromagnetic waves through the magnetic field generated by spinning atomic nuclei. MRI offers high soft tissue resolution, lacks radioactive effects, and can perform multi-planar scans of the mammary gland layer and subcutaneous tissue, allowing for clear observation of breast conditions and subsequent detection of breast cancer [5]. MRI has a relatively broad detection range and can acquire three-dimensional cross-sectional images to screen for distant metastatic lesions or tumor lesions in deep breast tissues. It provides a clear visualization of lesion conditions, facilitating accurate differentiation between benign and malignant tumors. Moreover, the scanning quality of MRI is not affected by factors such as tumor size, location, and glandular density, enabling tomographic scanning of breast tissues. This allows for the detection of tumor edge characteristics and changes in surrounding structures, thereby improving the detection rate of lobular carcinoma in situ or invasive lobular carcinoma [6]. UE utilizes the principle of tissue acoustic impedance reflection to generate breast images, displaying the softness or hardness of tumor tissues based on differences in acoustic impedance among various tissues, thereby determining tumor nature. Typically, malignant tumors are harder than benign ones, providing a basis for elastography. Composed of rigid tissue, malignant tumors closely adhere to surrounding tissues and exhibit an infiltrative growth pattern, reducing tumor mobility and resulting in decreased tissue elasticity and increased hardness [7]. In such cases, ultrasonic elastography can accurately determine tumor malignancy. The combined diagnosis using these two methods can compensate for the shortcomings of a single approach, leveraging their respective strengths to enhance disease detection efficiency.

The results showed that combined diagnosis had a significantly higher specific detection rate for breast cancer, disease types, and specific tumor classifications. It boasted high diagnostic accuracy and sensitivity, with a low rate of missed diagnoses. When compared, $P < 0.05$. The reasons for analysis are as follows: MRI can evaluate the spiculation changes at the edges of breast cancer tumors and observe differences in microvessel density. It offers high visibility of soft tissue structures such as breast glands, ducts, or fat, and can utilize dynamic

contrast-enhanced scanning to assess the hemodynamic characteristics and vascular richness of neovascularization in tumors, thereby determining tumor activity [8]. UE can evaluate the hardness or softness of tumors. Given that malignant tumors have a high cellular density and exhibit interstitial proliferation, they tend to be harder in texture, presenting a significant difference from the soft texture of benign tumors, which facilitates differentiation. Additionally, UE can qualitatively analyze tumor echo characteristics by leveraging tissue elasticity differences under the premise of dual-image comparison, reducing the impact of morphological grading or human factors on breast cancer diagnosis [9]. The combined diagnosis of these two methods can comprehensively cover multiple subtypes of breast cancer, accurately detect "hard cancers" lacking blood supply and tiny tumors, and ensure thorough examination. Moreover, a combined diagnosis can observe the degree of tumor infiltration, assess lymph node metastasis, effectively determine the type of tumor disease, and accurately classify it [10]. This multimodal diagnostic approach enables comprehensive and integrated acquisition of diagnostic information, systematically evaluates the biological characteristics of tumors, thereby reducing the likelihood of missed or misdiagnoses, and enhancing diagnostic efficacy.

5. Conclusion

In summary, MRI combined with UE demonstrates superior diagnostic efficacy for breast cancer, enabling differentiation of disease types and tumor classifications, and thus scientifically guiding treatment plans for breast cancer.

Disclosure statement

The author declares no conflict of interest.

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