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ORIGINAL ARTICLE

Mammography combined with breast dynamic contrast-enhanced-magnetic resonance imaging for the diagnosis of early breast cancer

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Abstract

Objective The aim of this study was to investigate the application of mammography combined with breast dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) for the diagnosis of early breast cancer.

Methods Mammography and DCE-MRI were performed for 120 patients with breast cancer (malignant, 102; benign; 18).

Results The sensitivity of mammography for early diagnosis of breast cancer was 66.67%, specificity was 77.78%, and accuracy was 68.33%. The sensitivity of MRI for early diagnosis of breast cancer was 94.12%, specificity was 88.89%, and accuracy was 93.33%. However, the sensitivity of mammography combined with DCE-MRI volume imaging with enhanced water signal (VIEWS) scanning for early diagnosis of breast cancer was 97.06%, specificity was 94.44%, and accuracy was 96.67%.

Conclusion Mammography combined with DCE-MRI increased the sensitivity, specificity, and accuracy of diagnosing early breast cancer.

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Key words breast carcinoma; mammography; nuclear magnetic resonance; dynamic enhancement; time signal curve

In recent years, there has been an upward trend in the incidence of breast cancer in our country, and it tends to occur at a younger age. Further, breast cancer has become one of the most common malignant tumors in women, and is therefore one of the most significant threats to a woman's health. Based on the statistics, breast cancer mortality in China has increased by 96% over the last thirty years [1]. Early detection, diagnosis, and treatment plays an important role in the prognosis of breast cancer, and imaging examination is important for the detection and diagnosis of breast cancer. Mammography is widely used for the diagnosis of breast cancer and breast screening, and with the technological advancements in recent years, magnetic resonance imaging (MRI) for breast examination plays an important role in breast cancer detection, diagnosis, and operation method selection. In this study, we aimed to investigate the application of mammography combined with breast dynamic contrast-enhanced (DCE) MRI for the early diagnosis of breast cancer.

Patients and methods

Patients

A retrospective analysis was conducted of 120 patients, who underwent MRI examination at our hospital (Sichuan Cancer Hospital, Chengdu, China) from November 2008 to December 2012. The patients were women, aged 28–72 years (mean age, 47 years), who were definitely diagnosed after pathological examination. Out of the 120 patients, 102 patients had malignant cancers (50 with invasive ductal carcinomas, 23 with invasive lobular carcinomas, 12 with ductal carcinomas, 12 with papillary carcinomas, and 8 with mixed carcinomas), while 18 patients had benign cancers.

Methods

Mammography

Mammography was performed using a PHILIP MammoDiagnostDR machine with automatic exposure conditions. The patients underwent mammography with

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standard craniocaudal, mediolateral oblique, and mediolateral when needed. Additionally, patients with dense or multiple glands, or those who had undergone mammary gland transplantations were examined in the spot compression view. Galactography was performed when a nipple discharge was observed.

MRI

MRI was performed using a Siemens Avanto 1.5T MRI machine, and the patients were positioned in the prone position on the dedicated phase array breast surface coil, with both the breasts suspended in the coil tank. The patients were fitted with a high-pressure syringe injection channel, and then the inversion recovery fat-suppressed T2WI axial scan was performed along with breast DCE-MRI VIEWS scanning (3D volumetric interpolated spoiled gradient echo fat-suppressed T1WI axial scan). The sequence parameters were as follows: TR, 4.4 ms; TE, 1.5 ms; FA, 12; matrix 512 × 338; FOV, 320 mm × 320 mm; and thickness, 1 mm (continuous uninterrupted scanning). The first scanning was performed for Mask, with a scanning time of 1 min, and the intravenous bolus injected was Gd-DTPA (0.2 mmol/kg; rate 1.5 mL/s). Five DCE scans were performed, and the parameters of the scans were automatically copied for Mask's, with a 1-min scanning period for each scan. Subtraction images were generated automatically in sequence, which were five breast angiographies obtained after injection of the contrast medium. Five plain and enhanced images were processed using the mean curve software. The central area of the lesion was selected as the region of interest (ROI), and a time-signal intensity curve of the ROI was generated.

Statistical analysis

All data were statistically analyzed using the SPSS11.5 software. The results of the mammography and DCE-MRI were analyzed with χ^2 test. The sensitivity and specificity of the differential diagnosis for benign and malignant lesions and the accuracy of the diagnosis when using mammography, DCE-MRI, and mammography combined with DCE-MRI were calculated separately.

Results

Mammography for the early diagnosis of breast cancer

The data showed that 72 cases were malignant, while 48 were benign. The sensitivity of mammography for early breast cancer diagnosis was 66.67% (68/102), specificity was 77.78% (14/18), accuracy was 68.33% (82/120; Table 1). The mammography showed that the benign breast tumor was mostly round or oval soft tissue masses with a clear boundary and soft texture, popcorn-like or shell-like shaped with a ring calcification and clinical palpation. Hu YS [2] showed that the imaging features of the breast tumor on mammography were divided into eight characteristics: round tumors, petal-shaped masses, leaf-shaped masses, burr-like masses, translucent round masses, calcified lumps, fuzzy masses, and cystic wall masses, as well as seven indirect characteristics, such as malignant calcification, big ducts, tunnel symptoms, thick signs, abnormal blood vessels, horned masses, and spire signs. The diagnosis symptoms in malignant tumors were as follows: one burr-like mass, translucent ring masses, calcified lumps, or spire signs; one or more petal-shaped masses, leaf-shaped masses, fuzzy masses with indirect symptoms; two more indirect symptoms with round tumors; and calcified lumps with malignant calcification or with two more indirect symptoms.

Table 1 The result of mammography compared with pathological results (*n*)

Mammography	Pathological results		Total
	Malignant tumors	Benign tumors	
Positive	68	4	72
Negative	34	14	48
Total	102	18	120

Table 2 The results of breast DCE-MRI compared with pathological results (*n*)

DCE-MRI	Pathological results		Total
	Malignant tumors	Benign tumors	
Positive	96	2	98
Negative	6	16	22
Total	102	18	120

The difference between mammography and DCE-MRI was statistically significant ($\chi^2 = 43.230$, $P < 0.0005$)

DCE-MRI for early diagnoses of breast cancer

The data showed that 98 tumors were malignant and 22 were benign. The sensitivity of mammography for diagnosis was 94.12% (96/102), specificity was 88.89% (16/18), and the accuracy was 93.33% (112/120; Table 2). DCE-MRI VIEWS scans had higher spatial and temporal resolution, which could further improve the clarity of the lesion and also show tumor blood vessels, chest wall invasion, and lymph node metastasis of the breastbone hind, mediastinum, axilla, and around the breast. The time-signal curve should reflect hemodynamic changes in the disease status. Enhancement of benign breast tumors showed sharp edges, shape, and uniform or diffuse regions with patchy strengthening, and the DCE-enhanced time-signal intensity curve showed a continued rising type (type I) or fast-rise platform type (type II). The morphological features of malignant tumors were mostly blurred or thin spiculate outlines, irregularly shaped or with lobular symptoms, signal heterogeneity, or periph-

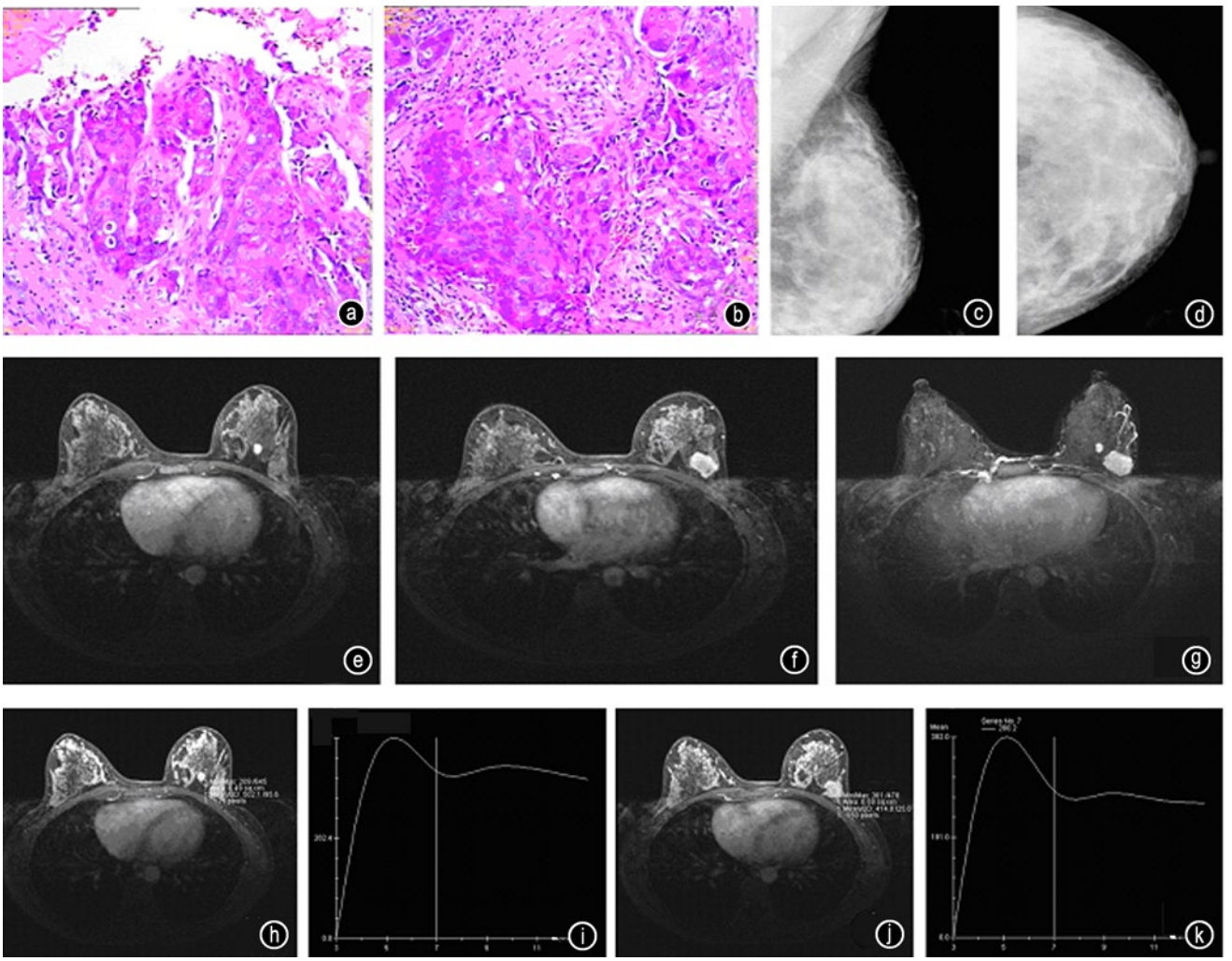

Fig. 1 (a and b) left internal mammary invasive ductal carcinoma as confirmed by biopsy; (c) mammography with standard craniocaudal and (d) mammography with mediolateral oblique showed high-density breast glands and suspicious nodules in left internal mammary, (e and f) DCE-MRI showed it was multicentric breast cancer; (g) tumor adjacent vessels thickening and increased in subtracted images; (h–k) the time-signal intensity curve showed fast rise downhill type (type III)

Table 3 Mammography combined with breast DCE-MRI compared with pathological results (*n*)

Mammography combined with breast DCE-MRI	Pathological results		Total
	Malignant tumors	Benign tumors	
Positive	99	1	100
Negative	3	17	20
Total	102	18	120

eral enhancement on DCE-MRI. Since the pathological features of breast cancer were similar to those of abnormal new rich blood vessels, the DCE time-signal curve showed a fast-rise downhill type (type III) or fast-rise platform type (type II) [3–4].

Mammography combined with breast DCE-MRI for the early diagnosis of breast cancer

Our data showed that the sensitivity, specificity, and accuracy of only mammography were 66.67% (68/102), 77.78% (14/18), and 68.33% (82/120), respectively. However, when using DCE-MRI combined with mammography, the sensitivity, specificity, and accuracy of the differential diagnosis of benign and malignant lesions were found to be improved [97.06% (99/102)， 94.44% (17/18), 96.67% (116/120), respectively; Table 3]. All 28 patients for whom the mammography image of the mammary glands were unclear were examined by DCE-MRI, which clearly showed small lesions within the glands, and malignancy of these lesions can be diagnosed through analysis of the image and the time-signal intensity curve. As shown in the Fig. 1 case of left internal mammary invasive ductal

carcinoma, as confirmed by biopsy, showed high-density breast glands and suspicious nodules in the left internal mammary gland on mammography. Further examination by DCE-MRI showed multiple enhancement sites, abundant blood supply, and the fast-rise downhill type (type III), which indicate multicentric breast cancer. Six cases of intraductal cancer in this set of data showed clustered calcification on molybdenum photography, which is a manifestation of early-stage cancer, while contract-enhanced MRI only showed patchy enhancement; based on these results breast cancer was diagnosed.

Discussion

Mammography is an accurate technique, relatively inexpensive, and convenient, and therefore, is an important method used for diagnosis of breast cancer. When aided by a computer, its resolution and calcification detection rate can be further improved. Calcification within the breast and simple clustered calcification are important early signs of breast cancer and may sometimes be the sole sign of malignancy [5]. Liang HM *et al* [6] reported that molybdenum photography is unparalleled by any other imaging method for the detection of calcification, but it also has limitations. For example, lesions may be overlapped by breast glands when the latter are abundant, in which case the entire lesion may be partially concealed or false-negative are also possible; deep- and high-position lesions as well as small lesions within high-density breast glands may be overlooked [7–8]. For patients with prosthesis implants, misdiagnosis can be a problem since only limited pressure can be applied to the breast. In such cases, MRI can be used for accurate diagnosis. DCE-MRI can effectively reveal the detailed structure of the lesions, and show high sensitivity and accuracy for early diagnosis of breast cancer [94.12% (96/102) and 93.33% (112/120), respectively, for this set of data]. These features are especially useful for detection of lesions in cases with multicentric breast cancer, which helps in the designing of operations [9]. In addition, it also reveals the hemodynamic features of the lesions noninvasively, which greatly aids in the diagnosis of malignancy. However, MRI is not very effective in detecting lesion calcification, takes a long time, generates noise, requires complete cooperation of the patients, and is an expensive technique. Therefore, currently, MRI cannot completely replace mammography as a common method for breast cancer screening. These data indicate that combined use of mammography and contrast-enhanced MRI can effectively improve the sensitivity, specificity, and accuracy of early diagnosis of breast cancer. Therefore, for cases with an indefinite diagnosis after mammography and when a detailed structure of the lesion needs to be clarified, DCE-MRI can be performed to aid diagnosis and development of a more a detailed treatment plan. Yang L *et al* [10] reported that mammography is more effective for the detection of calcified ductal carcinomas, thereby suggesting that despite the advantages of enhanced MRI, mammography features should also be considered to improve the accuracy of the diagnosis of ductal breast cancer. These results suggest that mammography and DCE-MRI should be used in combination for the early diagnosis of breast cancer.

Conflicts of interest

The authors indicated no potential conflicts of interest.

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