



Comparison of the clinical application value of mo-targeted X-ray, color doppler ultrasound and MRI in preoperative comprehensive evaluation of breast cancer

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ABSTRACT

Objective: To investigate the clinical application value of the Mo-targeted X-ray examination, color Doppler ultrasound and magnetic resonance imaging (MRI) in the diagnosis and preoperative comprehensive evaluation of breast cancer.

Methods: Among 170 breast cancer patients, they underwent Mo-targeted X-ray examination, color Doppler ultrasound and MRI before surgery to evaluate the lesions in breast, axillary lymph nodes and the availability of breast-conserving surgery.

Results: The detection rates using color Doppler ultrasound examination and MRI were higher than that in the Mo-targeted X-ray examination, which were 90%, 94% and 82%, respectively ($P < 0.01$ or 0.05). With the result of pathological examination as the golden criteria, we found that specificities of Mo-targeted X-ray examination, color Doppler ultrasound examination and MRI in evaluating the metastasis in axillary lymph nodes were similar (85.11%, 77.66% and 79.79%; $P > 0.05$). Before surgery, the sensitivities and accuracies of the color Doppler ultrasound examination and MRI were higher than those using the Mo-targeted X-ray examination, which were 73.21%, 82.14%, and 28.57%, 76.00%, 80.67% and 64.00% ($P < 0.01$ or 0.05). Before surgery, the accuracy rate of MRI in evaluating the breast-conserving surgery was higher than those of Mo-targeted X-ray examination and color Doppler ultrasound (92.00%, 83.33% and 84.67%; $P < 0.05$).

Conclusion: Combined application of Mo-targeted X-ray examination, color Doppler ultrasound and MRI shows a higher accuracy in diagnosis of breast cancer and evaluation of axillary lymph node metastasis, which is conducive to the selection of surgical methods.

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1. Introduction

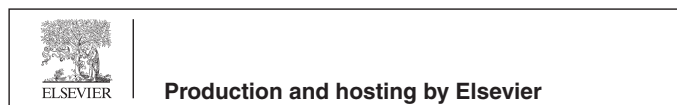
Breast cancer is one of the most frequent malignancies in females, and with the in-depth research on the breast cancer, diagnostic technique also experiences a rapid development, in which surgical resection has evolved from the massive elimination into the precise elimination; in addition, the breast-conserving surgery and sentinel lymph node biopsy (SLNB) have minimized the trauma with the maximal retention of tissues and functions

(Ciatto et al., 2013; Durand et al., 2015; Li et al., 2018). However, to realize the early diagnosis and precise resection of breast cancer, comprehensive but accurate preoperative evaluation is critical. Color Doppler ultrasound and Mo-targeted X-ray examination have been widely applied in clinical examinations, while MRI in recent years has also gradually been used in diagnosis and treatment of breast-associated diseases. MRI, with a promising resolution in soft tissues, can evaluate the tumor range precisely, and provides critical value in diagnosis of breast lesions and rational selection of treatment methods (Friedewald et al., 2014; Haas et al., 2013). In this study, before surgery, we performed the Mo-targeted X-ray examination, color Doppler ultrasound and MRI with dynamic contrast enhancement to evaluate the breast lesions and axillary lymph nodes, so as to explore the value of these three methods in diagnosis of breast cancer and selection of surgical methods.

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2. Materials and methods

2.1. General data

Between January and December in 2017, we selected 170 cases of female patients with breast cancer aged between 31 and 82 years old who were admitted to this hospital for treatment. Before surgery, they all agreed to receive the breast-conserving surgery, and evaluations were carried out using Mo-targeted X-ray examination, color Doppler ultrasound and MRI for the breast lesions and axillary lymph nodes. Pathological examination showed that all patients had breast cancer, in which there were 105 with invasive ductal carcinoma, 14 with invasive lobular carcinoma, 12 with mucinous adenocarcinoma and 39 with intraductal carcinoma, and there were 63 patients with lymph node metastasis. Based on the preoperative imaging evaluation and intraoperative pathological examination, 91 patients received the breast-conserving surgery and 79 received the radical resection of breast; 107 patients additionally performed the SLNB, while 63 performed the axillary lymph node resection.

2.2. Methods

2.2.1. Color doppler ultrasound

Mylab Doppler Ultrasound Diagnostic Apparatus was used with the transducer frequency being set as 7–12 MHz to observe the lesions, and record the site, morphology, size, boundary, echoes, calcification, blood flow and the adhesions of lesion to the skin, nipple and pectoralis major. For axillary lymph nodes, we observed the size, morphology, boundary, internal echoes, lymph node echoes and blood flow signals.

2.2.2. Mo-targeted X-ray examination

GE Senographe 2000D Digital Breast X-ray Machine (USA) was used for regular craniocaudal (CC) and mediolateral oblique (MLO) photographing for bilateral breasts, and, if necessary, local amplified photographing was performed. In addition, we also observed the edge, morphology, density, calcified lesion and adhesion of lesions to the skin, nipple and pectoralis major. For axillary lymph node, we also observed the edema, number, size and morphology.

2.2.3. Mri

Siemens Trio Tim 3.0T was applied with the 8-channel coil specific for breast. During examination, bilateral breasts of patients overhung naturally in the center of coil for cross sectional, sagittal and coronary scanning with T₁ weighted imaging, T₂ weighted imaging and enhancement scan sequence. Magnevist solution (0.1 mmol/kg) was used as the contrast agent, and injected rapidly within 10 s, followed by rinsing with 10 mL 0.9% normal saline. During MRI, we observed the size, morphology, burr-shaped edge, sharpness of boundary, enhancement in internal signals of tumor, and the adhesions of lesion to the skin, nipple and pectoralis major; at the same time, time-signal enhancement curves were prepared for analysis, and according to the shape of curve, they were divided into three types, i.e. Type I (continuous increase), Type II (platform) and Type III (clearance). Through MRI, we observed the size, morphology, lymph node and corticomedullary boundaries.

2.2.4. Evaluation criteria

Site, number, range and status of axillary lymph nodes were evaluated in accordance with the results of Mo-targeted X-ray examination, color Doppler ultrasound, MRI and pathological examination, so as to validate the availability of patients

comprehensively of breast-conserving surgery and SLNB. Patients who were not eligible to the breast-conserving surgery turned to the radical breast resection, and those with positive responses to the pathological examination of sentinel lymph nodes, or with axillary lymph node metastasis, would receive the axillary lymph node dissection. Breast-conserving surgery was carried out for patients conforming to the following conditions: early breast cancer in Stage I or II; tumor size between Stage T₁ and T₂, especially for tumor with diameter within 3 cm; appropriate ratio of breast size to the tumor size; breast shape remaining promising after surgery. Contraindication for breast-conserving surgery: active connective tissue diseases; poor tolerance to the radiotherapy; history of radiotherapy on the affected breast or chest wall; tumor adjacent to or invading the nipple; extensive lesion, or multi-center lesions; extensive distribution of suspicious malignant micro-calcified lesions, which made it difficult to form negative margin or ideal shape; tumor with positive margin after extensive resection, and no guarantee on the pathological negative margin after second resection; patients refused to receive the breast-conserving surgery; inflammatory breast cancer.

2.3. Statistics

SPSS 16.0 software was applied in statistical analysis. Measurement data, presented in mean \pm standard deviation ($\bar{x} \pm s$), were compared using *t* test, and enumeration data were compared with chi-square test. *P* < 0.05 suggested that the difference had statistical significance.

3. Results

3.1. General data

General data of patients were presented in [Table 1](#).

3.2. Detection rates of three imaging methods for breast cancer

In Mo-targeted X-ray examination, breast cancer usually manifests following features: high-density lumps with vague boundaries, irregular morphology or zigzag edge, or calcified lesions in line or branch arrangement with merged signs, including the skin hollow, nipple retraction, thickened skin or twisted structure. Among 170 patients, 139 were diagnosed as breast cancer through the Mo-targeted X-ray examination with a detection rate of 81.76%; in the remaining 31 patients, lesions that were not discovered mainly distributed in the breast tissues with abundant compacted glands without any lesions of lump.

In color Doppler ultrasound, breast cancer usually exhibits following features: solid lump with vague boundary, rough edge, uneven internal echoes, declined posterior echoes; edema or hollow in skin; nipple hollow; sand-like calcification; abundant blood

Table 1
General data of patients.

Item	Case (n)
Type of breast cancer	105
Invasive ductal carcinoma	14
invasive lobular carcinoma	12
Mucinous adenocarcinoma	39
Intraductal carcinoma	63
Lymph node metastasis	107
Yes	91
No	79
Surgical type	105
Breast-conserving surgery	14
Radical breast resection	12

flow inside and surround the lesions (vascular resistance index > 0.70). Among 170 patients, 153 patients were diagnosed as the breast cancer using color Doppler ultrasound, with a detection rate of 90%; in the remaining 17 patients, 12 patients presented tiny, clustered calcified lesion in Mo-targeted X-ray examination, and 5 presented lesions in regular shape with poor blood supply.

As for MRI manifestations, breast cancer manifests following features: tumor in lump-like enhanced irregular morphology with irregular or rough edge, internal enhancement, or uneven, or irregular circular enhancement; tumor in non-lump enhancement, and duct with line- or segment-shaped enhancement; in internal enhancement features, cluster cobble-like enhancement, or cluster circular enhancement in combination with TIC II or III were considered as the malignancy. In 170 patients, MRI detected 160 patients with breast cancer with a detection rate of 94.12%; in remaining 10 patients, 8 of them presented tiny and clustered calcified lesion in Mo-targeted X-ray examination, and 2 presented lesions in regular morphology with no evident enhancement. Color Doppler ultrasound and MRI showed a higher detection rate than the Mo-targeted X-ray examination, and the differences had statistical significance ($P < 0.05$ or 0.01 ; Table 2).

3.3. Evaluation of the axillary lymph node metastasis using three imaging methods

Results of evaluation of the axillary lymph nodes after scan are presented in Table 2. With the result of pathological examination as the golden criteria, we found that specificities of Mo-targeted X-ray examination, color Doppler ultrasound examination and MRI in evaluating the metastasis in axillary lymph nodes were similar (85.11%, 77.66% and 79.79%; $P > 0.05$). Before surgery, the sensitivities and accuracies of the color Doppler ultrasound examination and MRI were higher than those using the Mo-targeted X-ray examination, which were 73.21%, 82.14%, and 28.57%, 76.00%, 80.67% and 64.00% ($P < 0.01$ or 0.05). Differences

Table 2
Detection rates of three imaging methods for breast cancer.

Imaging examination	Imaging manifestations	Detection case (n)/rate (%)
Mo-targeted X-ray examination	High-density lumps with vague boundaries, irregular morphology or zigzag edge, or calcified lesions in line or branch arrangement with merged signs, including the skin hollow, nipple retraction, thickened skin or twisted structure.	139/81.76%
Color Doppler ultrasound	Solid lump with vague boundary, rough edge, uneven internal echoes, declined posterior echoes; edema or hollow in skin; nipple hollow; sand-like calcification; abundant blood flow inside and surround the lesions (vascular resistance index > 0.70).	153/90%
MRI	Tumor in lump-like enhanced irregular morphology with irregular or rough edge, internal enhancement, or uneven, or irregular circular enhancement; tumor in non-lump enhancement, and duct with line- or segment-shaped enhancement; in internal enhancement features, cluster cobble-like enhancement, or cluster circular enhancement in combination with TIC II or III were considered as the malignancy.	160/94.12%

of the sensitivities and accuracies between MRI and color Doppler ultrasound in evaluating the axillary lymph nodes showed no statistical significant, despite the former higher than the latter ($P > 0.05$) (see Table 3).

3.4. Evaluation of the availability of patients for breast-conserving surgery using three imaging methods

With the pathological examination results as the golden criteria, we found that preoperative MRI had a higher accuracy than the Mo-targeted X-ray examination and color Doppler ultrasound (92.00% vs. 83.33%, or 84.67%; $P < 0.05$; Table 4).

4. Discussion

It has been widely recognized that breast cancer is one of the malignancies with a decrease in morbidity rate and mortality rate, which is contributed by the early discovery, diagnosis and treatment due to the effective imaging examinations. In this study, in cases with compacted breast gland or increased number of glands, the detection rate of lesion using the Mo-targeted X-ray examination was lower than those using color Doppler ultrasound and MRI, but in those failing to be detected using Mo-targeted X-ray examination, color Doppler ultrasound failed in 17 patients and MRI failed in 10. All these cases were confirmed in postoperative pathological examination as the intraductal carcinoma. Thus, in early diagnosis of breast cancer lesions, Mo-targeted X-ray examination is superior. According to the literature, it is reported that Mo-targeted X-ray examination has a higher sensitivity (>95%) on the micro-calcified lesions (McCarthy et al., 2014; McDonald et al., 2015). Misdiagnosis of color Doppler ultrasound mainly occurred in intraductal carcinoma cases with only micro-calcified lesion but no lump, or mucinous adenocarcinoma cases with inadequate blood supply, insufficient information on the hemodynamics or atypical morphological features. In lesions with invasive-carcinoma-induced lumps, color Doppler ultrasound could detect accurately through the morphological features, changes in blood flow and vascular resistance index. MRI, with a promising resolution of soft tissues and no radiation damage, can attain a higher sensitivity in comprehensive analysis through the morphological description of enhanced scan in combination with the dynamic TIC (McDonald et al., 2016). However, diagnosis of intraductal carcinoma in an early stage requires the Mo-targeted X-ray examination.

With a continuous improvement in the early diagnostic rate of breast cancer, development in comprehensive treatment and the increase in life quality, breast-conserving surgery has become the mainstream method for treatment of breast cancer in European nations and USA, and the rate of breast-conserving surgery is increasing in China in recent years. Multiple retrospectively studies have shown that breast-conserving surgery is superior to the radical breast resection (Rose et al., 2013; Skaane et al., 2013; Li et al.,

Table 3
Evaluation of the axillary lymph node metastasis using three imaging methods (n).

Item	Pathological examination results	
	Metastasis	No metastasis
Mo-targeted X-ray		
Metastasis	18	16
No metastasis	45	91
Color Doppler ultrasound		
Metastasis	46	24
No metastasis	17	83
MRI		
Metastasis	52	22
No metastasis	11	85

Table 4

Evaluation of the availability of patients for breast-conserving surgery using three imaging methods.

Item	Pathological examination results	
	Breast conservation	No breast conservation
Mo-targeted X-ray		
Breast conservation	91	24
No breast conservation	4	51
Color Doppler ultrasound		
Breast conservation	88	19
No breast conservation	7	56
MRI		
Breast conservation	86	4
No breast conservation	9	70

2019). Full awareness of the contraindications of breast cancer for breast-conserving surgery is critical to the success of surgery, directly affecting the postoperative local recurrence rate and survival rate of patients and displaying the importance of right choice before surgery. In the breast-conserving surgery, imaging examination plays an important role in confirming the range of lesion and guaranteeing the negative margin. In this study, in patients that were eligible to the breast-conserving surgery through Mo-targeted X-ray examination and color Doppler ultrasound, we found that 4 patients had invasion adjacent to the nipple in MRI examination, 6 patients failed to receive breast-conserving surgery due to multi-focal or multi-center lesions. MRI can better identify the outline, boundary, internal structure and relationship among glands surrounding the lesions in comparison with other methods, which is conducive to the discovery of the multi-focal or -center lesions that could not be identified by other imaging methods, and to the evaluation of the invasion of lesions to the nipple, fascia pectoralis, pectoralis major, serratus anterior and intercostal muscles. Thus, it can be used as an auxiliary method in evaluation of breast cancer before surgery and the breast-conserving surgery (Houssami et al., 2008; Li et al., 2019). Prior to stipulation of the surgery, breast enhancement MRI examination can be considered regarding the breast-conserving surgery. Superior to other examination technique, MRI can increase the negative margin rate at the first time with a decrease of rate in second surgery (Houssami et al., 2014). Clinical practice and research have shown that the multi-center lesions have the invasion ability similar to the major lesions, and the possibility of MRI in overstating the lesions might be due to the satellite lesions, in-situ ductal carcinoma and lymphatic vessel invasion surrounding the tumor lump, which are regarded as the risk factors of recurrence (Mariscotti et al., 2014). However, the high sensitivity of MRI also bring forward the issue of false positive results: Due to the suspicious lesions discovered by MRI, patients who are eligible to the breast-conserving surgery turn to the radical breast resection. In this study, 9 patients received the radical breast resection due to the diagnosis of multi-focal and multicenter lesions discovered by MRI.

Severe trauma, numbness, pain, paresthesia and limited motor range of shoulder joints, or even lymphatic edema caused by axillary lymph node resection severely affect the life quality of patients. Evidence-based medicine has proved that for breast cancer patients with negative responses of axillary lymph nodes, SLNB, a kind of staging technique with micro invasion, can predict the status of axillary lymph nodes accurately, with which these patients can avoid the axillary lymph node resection safely (Bresser et al., 2010; Mercier et al., 2015). Thus, precise evaluation for the metastasis in axillary lymph node before surgery can better guide the physicians to choose the rational methods. In this study, we applied the Mo-targeted X-ray examination, color Doppler ultrasound and MRI to evaluate the axillary lymph node before surgery and compare with the postoperative pathological results.

Results showed that sensitivities and accuracies of color Doppler ultrasound and MRI in evaluating the axillary lymph nodes were higher than those using the Mo-targeted X-ray examination. Metastatic lymph nodes detected by Mo-targeted X-ray examination were usually enlarged abnormally and solid, but those in small volume or distant area in an early stage can hardly be detected. In addition, Mo-targeted X-ray examination could not display the internal structure and blood flow distribution of lymph nodes, manifesting a poor efficiency in evaluating the status of lymph nodes. Color Doppler ultrasound can precisely evaluate the metastasis in lymph nodes through reflecting the size, morphology, internal echoes, corticomedullary structure in lymphatic portal and the distribution of blood flow. Nevertheless, it is limited in detecting the excessively small lymph nodes or those in deep position in axillary region due to the influence of transducer. Different from the conventional Mo-targeted X-ray examination and color Doppler ultrasound, MRI is excellent in high resolution of space and soft tissues, displaying the spatial structure and relationship with surrounding tissues of lymph nodes (Derias et al., 2016). In evaluating the axillary lymph nodes of this study, MRI showed higher sensitivities and accuracies than the color Doppler ultrasound, but the difference had no statistical significance. For patients with negative responses of axillary lymph nodes to the preoperative evaluation, SLNB is available, but considering the false positive results, patients may directly undergo the axillary lymph node resection. Under the color Doppler ultrasound, suspicious lymph nodes can be located precisely for biopsy with minimal invasion, which can help the physicians to choose the surgical methods more precisely (Jochelson et al., 2013).

5. Conclusion

Through the comparative studies of Mo-targeted X-ray examination, color Doppler ultrasound and MRI, we found that MRI excels in the preoperative evaluation of availability for breast-conserving surgery, Mo-targeted X-ray examination in an early detection of lesions, and color Doppler ultrasound in evaluating the axillary lymph nodes and ultrasound-guided biopsy. Thus, comprehensive application of these imaging methods can evaluate the distribution of lesions and the status of axillary lymph nodes, so as to help the physicians to choose the rational surgical methods and predict the prognosis, displaying a promising clinical application value.

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