Original Investigation

Application of Abbreviated Protocol of Magnetic Resonance Imaging for Breast Cancer Screening in Dense Breast Tissue

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Rationale and Objectives: The study aimed to evaluate the usefulness of an abbreviated protocol (AP) of magnetic resonance imaging (MRI) in comparison to a full diagnostic protocol (FDP) of MRI in the breast cancer screening with dense breast tissue.

Materials and Methods: There are 478 female participants with dense breast tissue and negative mammography results, who were imaged with MRI using AP and FDP. The AP and FDP images were analyzed separately, and the sensitivity and specificity of breast cancer detection were calculated. The chi-square test and receiver operating characteristics curves were used to assess the breast cancer diagnostic capabilities of the two protocols.

Results: Sixteen cases of breast cancer from 478 patients with dense breasts were detected using the FDP method, with pathologic confirmation of nine cases of ductal carcinoma in situ, six cases of invasive ductal carcinoma, and one case of mucinous carcinoma. Fifteen cases of breast cancer were successfully screened using the AP method. The sensitivity showed no obvious significant difference between AP and FDP ($\chi^2 = 0.592$, $P = 0.623$), but the specificity showed a statistically significant difference ($\chi^2 = 4.619$, $P = 0.036$). The receiver operating characteristics curves showed high efficacy of both methods in the detection of breast cancer in dense breast tissue (the areas under the curve were 0.931 ± 0.025 and 0.947 ± 0.024, respectively), and the ability to diagnose breast cancer was not statistically significantly different between the two methods.

Conclusions: The AP of MRI may improve the detection rate of breast cancer in dense breast tissue, and it may be useful in efficient breast cancer screening.

Key Words: Breast cancer; magnetic resonance imaging; abbreviated protocol; breast screening.

INTRODUCTION

Breast cancer, the most common or second most common cancer in women worldwide (1,2), has gradually gained prevalence. Early detection of breast cancer can improve the duration of survival and quality of life in patients (3). Extensive screening can detect breast cancer early, thus screening plays an increasing important role in breast care. Mammography (MG) is the preferred method of screening for breast tissue because it is simple, convenient, affordable, and irreplaceable in the detection of microcalcifications (4). Studies have shown that, within groups of the same age, there are two to six times higher risk of breast cancer in dense breasts than in non-dense breasts, but MG detection sensitivity in dense breasts is much lower than that in fatty breasts (5–8). For example, Mendelson et al. found that the detection rate of breast cancer using MG was only 30% in dense breasts and 80% in fatty breasts (8). This clearly shows a limitation of using MG in breast screening.

Magnetic resonance imaging (MRI) has outstanding soft tissue resolution and multiplanar imaging capability, thereby offering unique advantages in the detection and diagnosis of breast lesions. The American College of Radiology (ACR) included breast MRI in the fourth edition of the Breast Imaging Reporting and Data System (BI-RADS) in 2003. The use of MRI has been standardized in breast examination (9). Dynamic contrast-enhanced MRI (DCE-MRI), a more advanced technique for breast MRI, allows an analysis of breast lesions through both morphologic and hemodynamic changes, with a sensitivity of 100% and specificity of up to 97% for breast cancer detection (10). However, the lengthy inspection time and high medical cost incurred by DCE-MRI have limited its use in breast MRI screening. Currently, it is used as a supplementary examination of certain breast cancers in high-risk populations (11).

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From 2009 to 2010, Kuhl et al. of Aachen University Hospital (12) studied 443 cases of MG-negative and asymptomatic women, and found that by merely reviewing the first postcontrast subtracted (FAST) and maximum intensity projection (MIP) images, 11 cases of breast cancer were detected, with the detection rate increasing by 18.3 per 1000. This 3-minute abbreviated protocol (AP) of MRI had a high performance (100% sensitivity and 94.4% specificity) consistent with the 21-minute routine full diagnostic protocol (FDP). Morris at Sloan Kettering Cancer Center (USA) (13) found that the AP enabled a better detection performance than MG, and hence recommended that AP should become the standard protocol for breast cancer screening. In the present study, the use of AP in the screening of dense breasts was studied, and whether it can improve the detection rate of breast cancer in dense breast was investigated, with the aim of providing additional evidence for more effective and economical methods of breast screening.

MATERIALS AND METHODS

Participants

Female participants who had undergone MG from January 2013 to March 2015 were recruited to the study. Breast density was classified based on the ACR standards (9). In the present study, among 542 MG-negative women classified as having dense breasts, 478 underwent routine breast MRI. Women with a family history of breast cancer were excluded in this study. The subjects were 30 to 71 years old, with a mean age of 49.3 years. Premenopausal women were imaged 1 week after menstruation.

MRI Examination Techniques

In this study, MRI was performed using an eight-channel dedicated phased-array breast coil on a 3.0T magnet (Area D13, Siemens, SHealthineers, Erlangen, Germany). The patients assumed a prone position with both breasts symmetrically positioned in the coil. The axial scans included fast spin echo (FSE) T_1WI, T_2WI + fat suppression, and the sagittal scans included FSE T_2WI +fat suppression. For DCE-MRI, a Flash 3D sequence (transverse T_1WI bilateral breast imaging with the following parameters: repetition time (TR) of 4 ms, echo time (TE) of 1.55 ms, thickness of 1.5 mm, no interval) was used. After the first dynamic scan (mask), contrast agent Gadolinium-diethylene triamine pentaacetic acids (Gd-DTPA) was injected via the cubital vein at a rate of 0.2 mL/s and a dose of 0.2 mmol/kg using a high-pressure syringe. The scanning started as soon as the contrast agent was injected, and eight phases were continuously scanned in a total scan time of 12 minutes and 32 seconds.

Data Analysis

All of the raw images were processed in a syngo MR workplace, and subtraction images were automatically obtained. The subtraction images at each phase were MIP reconstructed and time-signal intensity curves were rendered. Two senior radiologists, with experience in breast imaging of at least 10 years, independently read the films in two steps. They first drew a conclusion based on AP (FAST + MIP) images and then read all of the FDP images to draw the second conclusion, and the time to interpret the AP and FDP was measured. In order to avoid recall bias, two interpretation sessions were projected at least 1 month apart and cases were randomized. When the two radiologists' assessments on either FDP or AP did not match, a third senior radiologist, with 15 years of specialized breast imaging experience, was called to independently analyze the material and determine the final conclusion. In this study, all MRI findings were retrospectively described using the BI-RADS MRI categories. The sensitivity, specificity, positive predictive value, and negative predictive values of the two methods were calculated.

Statistical Analysis

The SPSS16.0 (SPSS Inc., Chicago, IL) statistical software was used for statistical analysis. The paired *t* test was used to assess differences of interpretation time between AP and FDP. The chi-square test and receiver operating characteristics (ROC) curves were used to compare the diagnostic capabilities of AP and FDP on breast cancer. A *P* value less than 0.05 was considered to indicate statistical significance.

RESULTS

When using the FDP as a diagnostic criterion, among the 478 cases of dense breasts, 41 lesions were detected in 39 patients. Subsequent biopsy and surgical pathology showed 16 breast cancers in 16 lesions and 23 cases of benign breast lesions in 25 lesions (Table 1). Malignant lesions were found in the upper outer quadrant in 10 cases, upper inner quadrant in 2 cases, lower outer quadrant in 3 cases, and lower inner quadrant in 1 case. Benign lesions were located in the upper outer quadrant in 12 cases, upper inner quadrant in 5 cases, lower outer quadrant in 5 cases, and lower inner quadrant in 3 cases.

In this study, the average interpretation time of the AP was 42 ± 18 seconds, whereas the average interpretation time of

TABLE 1. Pathology of 41 Benign and Malignant Lesions

Pathology	No
Malignant (*n* = 16)	
Ductal carcinoma in situ	4
Invasive ductal carcinoma	11
Mucinous carcinoma	1
Benign (*n* = 25)	
Hyperplasia	8
Fibroadenoma	11
Papilloma in situ of duct	2
Cyst	3
Granuloma	1