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Breast Magnetic Resonance Image (MRI) Guideline: Breast Imaging Study Group of Korean Society of Magnetic Resonance in Medicine Recommendations

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The purpose of this study is to establish an appropriate protocol for breast magnetic resonance imaging (MRI) in the discipline of image quality standards. The intention of the protocol is to increase effectiveness of medical image information exchange involved in construction, activation, and exchange of clinical information for healthcare.

Keywords: Breast; Magnetic resonance imaging; Guideline

INTRODUCTION

The Health Insurance Review and Assessment Service in Korea commissioned the Korean Society of Radiologists to contribute to efforts to reduce unnecessary radiation exposure caused by indiscriminate duplication of examinations using high-priced imaging equipment, such as computed tomography (CT), as published in the CT Examination and Review Guidelines (1). The number of examinations in which high-end imaging equipment is used, such as MRI equipment as well as CT, has increased markedly, hence increasing cost of public medical treatment. The number of duplicated examinations is increasing, implying a squandering of national medical resources. So, a standard protocol must be developed and implemented to validate the need for re-imaging of high-priced image inspections. In breast imaging, mammography and breast ultrasound are the most common modalities. However, because of the recent surge in the number of breast cancer patients and ubiquity of breast implants, breast MRI is one of the main breast-imaging modalities (2). For breast MRI examinations, a breast MRI certification program is administered by the American College of Radiology (ACR) in the United States. Recommendations were also published in 2010, including the Breast MRI protocol and indications by the European Society of Breast Cancer Specialists (EUSOMA) (2, 3).

In this study, a specialist group of Korean domestic breast-imaging experts was

recruited to establish standard protocol for breast MRI examination suitable for a domestic medical environment based on foreign recommendations (4). The purpose of this study is to facilitate clinicians' and radiologists' understanding of the disease by providing images taken using standardized inspection protocol even when patients are transferred to a medical institution.

MATERIALS AND METHODS

Recommended protocols of breast and MRI scans were reviewed, and a questionnaire was prepared by a responsible researcher. We selected nine consenting participants with more than 15 years of experience in breast imaging as chief professors in the breast department at university hospitals in Korea to establish an expert panel. Participants completed a total of three Delphi Agreement rounds to prepare a consensus on the Breast MRI Protocol.

The Delphi method was used to generate standard test protocol. Researchers reviewed Delphi surveys by examining foreign recommendations, and a questionnaire was completed by the expert panel of radiologists. The Delphi survey was conducted via e-mail. To gather a comprehensive opinion of an expert panel, we referred to literature and related materials, and formulated questions including open types, optional types, and a 9- point-scale short-answer types q. Questionnaires were then completed through the first round. Based on results of the first Delphi survey round, the research team conducted a second round using a 9-point short-answer questionnaire. After completion of the second round, the nine breast radiologists discussed the questions and completed the third questionnaire. The final protocol was established by agreement in the third round.

To complete the survey, participants responded to each question within categories ranging from 1 point (strongly disagree) to 9 points (strongly agree). Responses were defined as 1 to 3 points = disagree, 4 to 6 points = not known, and 7 to 9 points = agree. For each question, if the response was 7 to 9 points or more (> 75% of the total respondents), participants agreed with the question.

RESULTS

The agreed-upon breast MRI recommendation protocol is a 1.5 tesla (T) or higher device that acquires images in prone position using a breast-dedicated coil and includes T2-

Table 1. Breast MRI Recommended Protocol Summary

Indication
- Pre-operative stage determination after diagnosis of breast cancer/Breast cancer staging before treatment planning
- Evaluation of response to neoadjuvant chemotherapy
- Screening test of high-risk group including BRCA mutation carrier
- Patients with breast augmentation or reconstruction
- If foreign substances injected into the parenchyma are not available for examination other than MRI
- Occult primary breast cancer
- Other follow-up of lesions found in breast MRI
Machine and patient's position
- Obtain images of both breasts while patient is in a prone position using a breast dedicated coil in devices with more than 1.5T
Imaging plane
- The image plane can be obtained by a radiologist, who is comfortable with reading, but both breasts should be included, and the scan range must have no missing areas.
Pulse sequence (must include at least 4 of the following pulse sequences)
- T2-weighted images
- Three or more T1-weighted images (pre-enhancement, early-enhancement, and second-enhancement)
Considerations when evaluating imaging quality
- Water content should be well separated in T2-weighted images
- Contrast enhanced T1-weighted images should be taken by fat suppression technique or should include subtraction images
- Contrast-enhanced T1-weighted images should include images taken between 60 and 120 seconds after contrast injection and images taken after 4 minutes
- The slice thickness of contrast enhanced T1-weighted images should be less than 3 mm and should not have gaps
- The spatial in-plane resolution of contrast enhanced T1-weighted images should be less than 1 mm^2, should be less than 1.5 mm^2
- Temporal resolution of contrast enhanced T1-weighted images should be less than 120 seconds

Table 2. Options for Further Image Interpretation

1. Both breasts and chest walls are examined with a breast-specific bilateral breast coil. In the prone position, the raised breast is positioned well in the center of the breast coil, and both arms are raised sufficiently to incorporate the axilla into the breast coil as much as possible.
2. The most appropriate examination period is from 7 to 14 days in the menstrual cycle.
3. Immediately after intravenous injection of 0.1-0.15 mmol/kg of contrast medium, the image is repeated several times for the shortest time and with the thinnest slice (3 mm or less).
4. Diffusion weighted image (at high b value = 750-1000)
5. Axilla sequence (sufficient field of view [FOV] is included enough to include neck ~ nipple)
6. Reconstruction images are obtained with sagittal MPR (without subtraction) and MIP image (with subtraction) using dynamic contrast enhanced T1WI in the early phase (90 seconds after contrast injection).
7. For breast silicone implants, add a silicone selective sequence.
8. Interpretation and determination through the breast MRI part in ACR-BIRADS.

weighted and pre-contrast T1-weighted images. Contrast-enhanced images are acquired at least twice, between 60 and 120 seconds after contrast injection, and images are taken after four minutes. The contrast-enhanced T1-weighted image should be less than 3 mm in thickness, should have a temporal resolution of less than 120 seconds, and have an in-plane pixel resolution of less than 1.5 mm^2. The Delphi agreement of the Korean breast-imaging expert panel established recommendation protocol of the effective breast MRI (Table 1). We obtained consent for the other additions (Table 2).

DISCUSSION

The breast and MRI recommendations from the United States and Europe are similar (2-4). For breast imaging, breast-cancer screening and treatment recommendations of each country are well structured with minimal controversy. Conferences for drafting the Delphi questionnaire resulted in similar recommendations. Final agreed-upon recommendations for Europe and the United States were based on the following: indications from devices, patient attitudes, images, pulse sequences, and clinical imaging considerations. Indications for breast MRI include pre-operative staging of newly diagnosed breast cancer (ipsilateral and contralateral), evaluation of the effect of neoadjuvant chemotherapy, screening of women at high risk of breast cancer, evaluation of women with breast implants, and occult primary breast carcinoma (search for breast cancer in patients with metastases, negative mammography, and ultrasound). When needle biopsy cannot be performed, suspected local recurrence and problem solving (equivocal findings at mammography or ultrasound) could also be indications for breast MRI (2, 3, 5-10). For breast MRI, only a breast-dedicated coil is required to obtain a relatively readable image, although most devices that can attach a breast coil require 1.5T or more. So, the device specification of the recommendation is 1.5T or more. For the image plane, it is advisable to acquire three T1-weighted images in addition to the T2-weighted image as specified in United States standards, although scanning can be performed without missing any part of image acquisition. Contrast-enhanced T1-weighted images should be taken with a gap of less than 3 mm and should include fat saturation techniques or subtraction images (2, 3, 8, 10). This specification is the same as the U.S. standard. In addition, temporal resolution of contrast-enhanced T1-weighted images should be less than 120 seconds. This recommendation is beneficial for radiologists, particularly those in general hospitals unfamiliar with breast MRI. In addition to basic protocols, for other high-tech general hospitals in which a large number of breast MRIs are performed, additional tests are performed as required using computer-aided diagnosis (CAD), diffusion-weighted image (DWI), etc. (7, 8). MIP images, not previously been agreed upon, were proposed as items that could receive additional points in evaluation of clinical images in the future.

Evaluation of breast MRIs should be performed by a dedicated breast radiologist. The report should contain indication for the scan, relevant clinical information, and type and dose of administered contrast media. Interpreting and deciding on the breast MRI must be performed according to the American College of Radiology Breast Imaging-Reporting and Data System (ACR BI-RADS) (10, 11). The final assessment must be categorized into one of

the BI-RADS breast-MRI final-assessment categories:

0 = incomplete (additional imaging evaluation is needed);
1 = negative (no abnormalities);
2 = benign finding;
3 = probably benign finding (short-term follow-up suggested);
4 = suspicious abnormality (biopsy should be considered);
5 = highly suggestive of malignancy (appropriate action should be taken);
6 = known biopsy-proven malignancy (typically reserved for MRI scans made for cancer staging or to prepare for neoadjuvant chemotherapy) (2, 11).

In conclusion, the expert panel of Korean breast radiologists agreed on recommendations similar to those currently used in the U.S. and Europe, and this study is beneficial for breast MRI in medical image information exchange.

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