Application of abbreviated protocol of magnetic resonance imaging in breast cancer high-risk people

Baogao Liu1, Wancheng Sun1

1 Breast Imaging Center of affiliated Hospital of Gansu Medical University, Lanzhou, Gansu, China

Abstract: Objective: To evaluate the validity of two abbreviated protocol (AP) of MRI in comparison with a full diagnostic protocol (FDP) of MRI in the breast cancer high-risk people. Materials and Methods: Seventy-eight female participants with high-risk of breast cancer were recruited for the study, who were underwent MRI and surgical treatment. Two AP [AP-1: consisting of the first post-contrast subtracted (FAST) and maximum-intensity projection [MIP] images; AP-2: AP-1 combined with diffusion weight imaging (DWI)] and FDP images were analyzed separately, and the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of breast cancer detection were calculated. Results: Histological examination revealed 32 malignant lesions and 46 benign lesions. The average interpretation time of the AP-1 and AP-2 were (78±25) s and (91±29) s, while the average interpretation time of the FDP was (205±54) s (F=12.355, P<0.05). The sensitivity of the AP-1, AP-2, and FDP were respectively 93.8%, 100%, and 100%, and the specificity of the three MR protocols were respectively 76.1%, 91.3%, and 93.5%. In addition, the PPV of the AP-1, AP-2, and FDP were respectively 73.2%, 88.9% and 91.4%, and the PPV of the three MR protocols were respectively 94.6%, 100% and 100%. There was no significant difference among three MR protocols in sensitivity of breast cancer (F=2.142, P>0.05). However, the specificity of AP-1 was significantly lower than that of AP-2 (P<0.05) and FDP (P<0.05), while there was no difference between AP-2 and FDP (P>0.05). Conclusions: The AP may be efficient in the breast cancer screening with high-risk, and FAST+MIP images combined with DWI of MRI are helpful to improve specificity of breast cancer detection.

Keywords: Breast neoplasms; Magnetic resonance imaging; First post-contrast subtracted; Maximum-intensity projection; Diffusion weight imaging


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Breast cancer high-risk groups have attracted much attention because of the high incidence of cancer. Early screening for high-risk groups of breast cancer is of great significance to improve the survival rate and quality of life for patients. Magnetic resonance imaging has good soft tissue resolution and multi-plane imaging performance, and has unique advantages in the detection and diagnosis of breast lesions. Therefore, it has become a consensus that additional breast MRI examination should be performed annually on the basis of mammography (MG) in high risk groups of breast cancer [1]. However, the shortcomings of full diagnostic protocol (FDP) in breast screening, such as time-consuming and expensive, have limited its application and promotion in breast screening [2]. The purpose of this study is to explore whether the abbreviated protocol (AP) can effectively improve the accuracy of breast can-
cer diagnosis in high-risk breast cancer patients and provide accordance for more effective and economical breast screening.

Information and Method

Research object: From January 2015 to December 2017, females who underwent breast examination in the Mamography Center of the Affiliated Hospital of Gansu Medical University were selected as subjects. High risk groups were screened through questionnaires and clinical history, of whom seventy eight patients with MRI and pathological data were enrolled in the study. The specific high-risk group entry criteria included [3]: 1) Patients with significant genetic predisposition to breast cancer (including BRCA1/2 carriers, family history of breast cancer, and patients with epithelial ovarian cancer); 2) Previous cases of breast ductal or lobular moderate to severe atypical hyperplasia or lobular carcinoma in situ; 3) Previous chest radiotherapy; 4) Other high risk factors (including childbearing history, lactation, menarche and abnormal postmenopausal time). The subjects were 35~78 years old, with an average age of 49.7 years. Pre menopausal females underwent examination in a week after menstruation. The study was inspected and approved by the Ethics Committee of Nanjing Medical University. All subjects signed informed consent forms.

MRI examination: Subjects underwent MRI examination with Siemens Area D13 1.5 T superconducting MR scanner, 8 channel phased array surface coils. In prone position, patients' breasts were hung in the coil symmetrically. Plain scan included fast spin echo of transversal position, T1WI (TR 8.7 ms, TE 4.7 ms, layer of 3 mm, gapless)+fat suppression, sagittal position FSE T2WI (TR 4880 ms, TE 60 ms, layer of 3 mm, gapless)+fat suppression. Diffusion weight imaging (DWI) used single shot echo planar imaging technology (TR 4200 ms, TE 65 ms, layer of 3 mm, gapless), with b value of 0 and 1000 s/mm2. With fast low angle shot 3-dimensional (Flash 3D) sequence, patients underwent TIWI imaging of bilateral breast transverse (TR 4 ms, TE 1.55 ms, layer of 1.5 mm, gapless). After finishing the first dynamic scanning, Gadolinium contrast agent was injected into the elbow vein with a high-pressure syringe at a speed of 0.2 ml/s at a dose of 0.2 mmol/kg. At the same time, patients underwent scanning for 8 consecutive phases.

MRI data analysis: All the original images were processed automatically by Siemens syngo MR workplace. Two senior imaging diagnosticians read and recorded the required time sequentially and independently according to AP-1, AP-2 and FDP. AP-1 required that it was needed to read the frist postcontrast subtracted (FAST) and maximum-intensity projection (MIP) imaging; based on AP-1, AP-2 needed to read DWI imaging in addition; FDP needed to read all the MRI imaging. To avoid result bias, the intervals among 3 reading methods needed to reach 1 month at least when adopting 3 methods. If there were difference between 2 reader's conclusion based on the same method, it was required to take a discussion to reach the same conclusion. According to BI-RADS classification standard, the sensitivity, specificity, positive predictive value and negative predictive value of the three methods were calculated.

Statistical analysis: SPSS 16.0 was used to analyze the data; One-way ANOVA was used to compare the reading time of the three methods. McNemar's test was used to evaluate the diagnostic ability of the three methods for breast lesions. The difference was statistically significant when P<0.05.

Results

Pathological result: Pathological findings of 78 patients showed 32 malignant lesions, including 11 cases of ductal carcinoma in situ, 16 cases of invasive ductal carcinoma, 3 cases of medullary carcinoma and 2 cases of mucinous carcinoma, and there were 46 cases of benign lesions, including 15 cases of breast hyperplasia, 18 cases of fibroadenoma, 9 cases of cyst, 2 cases of intraductal papilloma and 2 cases of granuloma.

To make a diagnosis, the reading time of AP-1 and AP-2 was (78±25) s and (91±29) s respectively; in addition, time needed by FDP was (205±54) s, showing the significant difference among 3 methods (F=12.355, P<0.05). There was no significant difference between AP-1 and AP-2 (P > 0.05), but time needed by FDP was...
significantly longer than AP-1 and AP-2 ($P < 0.05$).

For 32 cases of malignant lesions, AP-1 correctly diagnosed 30 cases, in which 2 cases were judged as "benign lesions", AP-2 and FDP detected all 32 cases of breast cancer, obtaining a 100% diagnostic accuracy (See Figure 1 and 2).

For 46 cases of benign lesions, 35 were correctly diagnosed by AP-1, 42 were correctly diagnosed by AP-2, and 43 were correctly diagnosed by FDP. The sensitivity, specificity, positive predictive value and negative predictive value of the three methods were shown in Table 1. There was no significant difference in the sensitivity of the three methods ($F = 2.142, P > 0.05$), but the specificity was statistically significant ($F = 21.538, P < 0.05$). The specificity of AP-1 was significantly lower than that of AP-2 ($P < 0.05$) and FDP ($P < 0.05$). There was no significant difference between AP-2 and FDP ($P > 0.05$).

### Table 1. Comparison of the breast cancer diagnostic capabilities of AP-1, AP-2 and FPD (%)

<table>
<thead>
<tr>
<th>Method</th>
<th>Sensibility</th>
<th>Specificity</th>
<th>Positive Predictive Value</th>
<th>Negative Predictive Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP-1</td>
<td>93.8</td>
<td>76.1</td>
<td>73.2</td>
<td>94.6</td>
</tr>
<tr>
<td>AP-2</td>
<td>100.0</td>
<td>91.3</td>
<td>88.9</td>
<td>100.0</td>
</tr>
<tr>
<td>FDP</td>
<td>100.0</td>
<td>93.5</td>
<td>91.4</td>
<td>100.0</td>
</tr>
</tbody>
</table>

### Discussion

MG has always been the preferred method for breast examination. However, due to the overlap of normal breast tissue, the structure of the breast is poorly distinguished. Therefore it is possible to omit the lesions hidden in the deep breast or under the axillary, or misjudge some overlapping artifacts as false positive. Therefore, the sensitivity and specificity of early detection of breast lesions by MG is not ideal. Even for breast masses touched by clinicians, studies have shown that 15% - 50% of breast lesions can not be shown in mammography [4-6]. MRI is not affected by breast density. It can clearly display the morphology, internal characteristics and surrounding tissue structure of the lesion by multi-parameter and multi-directional imaging, especially can effectively detect hidden and tiny breast nodules. From above, it has become an important method for early detection of breast cancer, especially for women with high risk. Numerous studies have shown that MRI has high sensitivity and specificity in the early diagnosis of breast cancer [2,7-8]. However, the widely used breast FDP has many problems, such as too many scanning sequences, long time consuming and expensive price, which have restricted the wide application of MRI in breast screening.

![Figure 1](image1.png)

**Figure 1.** A 43-year-old woman with invasive ductal carcinoma. FAST (A) and MIP (B) of MRI showed a 10 mm enhancing nodule without tumor vessels on the right, and it was considered probably benign lesion; C: DWI showed obviously high single, and it was considered malignant lesion; D: Pathology showed invasive ductal carcinoma (HE staining, × 100).

![Figure 2](image2.png)

**Figure 2.** A 40-year-old woman with invasive ductal carcinoma. FAST (A) and MIP (B) of MRI showed a 12 mm enhancing nodule without tumor vessels on the left, and it was considered probably benign lesion; C: DWI showed obviously high single, and it was considered malignant lesion; D: Pathology showed invasive ductal carcinoma (HE staining, × 100).
In recent years, some scholars have applied AP to the study of breast lesions, and achieved good results. Kuhl et al. [9] carried out a study of 443 asymptomatic women with negative results detected by MG showed that 11 cases of breast cancer were detected by reading only FAST and MIP images, and the detection rate increased by 1.83%. The performance of this rapid 3-minute MRI method was consistent with that of the conventional 21-minute MRI method, with a sensitivity of 100.0% and a specificity of 94.4%. Morris of Sloan Kettering Cancer Center in the United States highly praised the study, saying that AP detection performance is superior to MG, can become the standard for breast cancer screening [10]. Subsequently, some scholars have also carried out related studies, such as Moschetta et al. [11] found that AP can significantly reduce the detecting time and radiologist reading time, but won't reduce the diagnostic accuracy of breast lesions. Heacock et al. [12] also confirmed that AP had a high detection rate for breast cancer, and its imaging features were correlated with pathology. Although the imaging sequences selected by the above study are different, the results show the application value of AP. The average reading time of AP-1 and AP-2 used in this study was 78 s and 91 s respectively, which was significantly lower than that required by FDP. There was no difference in the sensitivity of AP-1 and AP-2 to diagnose breast cancer between above 3 methods, also showing that AP can not only greatly shorten the patient's examination time and the doctor's diagnosis time, but also has the same early detection potential as conventional MRI scan.

DWI, as a functional MR imaging technique, can assess the movement of water molecules in tissues at an early stage and provide information about the biological characteristics of tumor tissues. Recent studies have shown that dynamic enhanced MR combined with DWI can effectively distinguish benign and malignant breast lesions from [13-14]. In this study, 35 out of 46 benign lesions were detected by AP-1 protocol, and the specificity of FDP protocol for breast cancer detection was still relatively low. The reason may be related to the fact that the images of other phases in FDP can highlight the structural features of the lesion after enhancement and provide the corresponding types of enhancement curves. Kuhl et al. [9] also considered that the early arterial phase after contrast injection was the most suitable for breast cancer visual enhancement, while the other phase images were mainly used to observe the structural characteristics of the enhanced. Therefore, in order to further improve the specificity of AP in the diagnosis of benign and malignant breast lesions in high-risk groups, this study, on the basis of reading the FAST and MIP images, used the improved method of combined DWI, whose diagnosis time was not significantly different, but the diagnostic efficacy and FDP method was equivalent.

In summary, although more clinical studies are needed for the use of AP in large-scale breast MRI screening, AP may be an effective breast cancer screening method for high-risk groups of breast cancer, and DWI may help to improve the specificity of breast cancer detection.

References

[7] Harnett A, Smallwood J, Titshall V, et al. Diagnosis and treatment of early breast cancer, including locally advanced...


