



Original Article

Clinical roles of breast 3T MRI, FDG PET/CT, and breast ultrasound for asymptomatic women with an abnormal screening mammogram

Chen-Pin Chou^{a,b,c,d}, Nan-Jing Peng^{b,e}, Tsung-Hsien Chang^f, Tsung-Lung Yang^{a,b}, Chin Hu^{b,e}, Huey-Shyan Lin^g, Jer-Shyung Huang^{a,b}, Huay-Ben Pan^{a,b,h,*}

^a Department of Radiology, Kaohsiung Veterans General Hospital, Kaohsiung, Taiwan, ROC

^b National Yang-Ming University School of Medicine, Taipei, Taiwan, ROC

^c Department of Medical Laboratory Sciences and Biotechnology, Fooyin University, Kaohsiung, Taiwan, ROC

^d National Defense Medical Center, Taipei, Taiwan, ROC

^e Department of Nuclear Medicine, Kaohsiung Veterans General Hospital, Kaohsiung, Taiwan, ROC

^f Department of Medical Education and Research, Kaohsiung Veterans General Hospital, Kaohsiung, Taiwan, ROC

^g School of Nursing, Fooyin University, Kaohsiung, Taiwan, ROC

^h Department of Medical Imaging and Radiological Sciences, I-Shou University, Kaohsiung, Taiwan, ROC

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Abstract

Background: Magnetic resonance imaging (MRI) and fluorodeoxyglucose positron emission tomography/computed tomography (FDG PET/CT) show promise for molecular cancer imaging. We evaluated 3T MRI, FDG PET/CT, and ultrasound images for asymptomatic women with an abnormal screening mammogram.

Methods: The Institutional Review Board of Kaohsiung Veterans General Hospital (Kaohsiung, Taiwan) approved the study. Patients provided written informed consent. A total of 11,865 screening mammograms of 118,65 women were performed at our facility between January 2011 and December 2012. Fifty-three asymptomatic women (mean age, 53.3 years) whose screening mammograms had a Breast Imaging Reporting and Data System (BI-RADS) category of 4 or 5 were ultimately enrolled in this study. Breast 3T MRI, FDG PET/CT, and breast ultrasound were performed before biopsy. All imaging modalities were compared by lesion-by-lesion analyses.

Results: Fifty-nine breast lesions (28 malignant and 31 benign lesions) from 53 women were analyzed. The sensitivity, specificity, and accuracy for 28 breast cancers were 96%, 77%, and 86%, respectively, for breast 3T MRI; 50%, 100%, and 76%, respectively, for FDG PET/CT; and 61%, 87%, and 74%, respectively, for breast ultrasound. One 0.8-cm invasive breast cancer was missed by the screening mammogram, but detected by breast 3T MRI and FDG PET/CT. The sensitivity for detecting breast cancer was significantly higher with MRI than with PET/CT or ultrasound (for all, $p < 0.01$). The specificity for detecting breast cancer was significantly higher for PET/CT than for breast MRI ($p = 0.02$). The sensitivity exhibited by 3T breast MRI and FDG PET/CT for 16 noninvasive breast cancers was 94% and 25%, respectively.

Conclusion: On screening mammograms, breast 3T MRI showed higher sensitivity but less specificity than FDG PET/CT for detecting asymptomatic breast cancers.

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Keywords: breast cancer; breast ultrasound; fluorodeoxyglucose positron emission tomography-computed tomography; magnetic resonance imaging; screening mammogram

Conflicts of interest: The authors declare that there are no conflicts of interest related to the subject matter or materials discussed in this article.

* Corresponding author. Dr. Huay-Ben Pan, Department of Radiology, Kaohsiung Veterans General Hospital, 386, Ta-Chung First Road, Kaohsiung 813, Taiwan, ROC.

E-mail address: r2207759@ms19.hinet.net (H.-B. Pan).

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1. Introduction

Physicians have used conventional breast imaging tests such as mammograms and breast ultrasound for diagnosing patients with a lump in the breast. Early breast cancers are usually not palpable and show only subtle findings on a mammogram.^{1–3} Mammograms are widely used for breast cancer screening, but overdiagnosis and underdiagnosis can occur in screening tests.^{1–3} Women assessed by the Breast Imaging Reporting and Data System (BI-RADS) as category 4 or 5 on a screening mammogram are usually recommended for a definitive diagnosis with a biopsy. Approximately 10 women per 1000 screened women require further breast biopsy because of the suspicion of breast cancer.⁴ The biopsy recommendation rates, the breast cancer detection rates, and the ratio of malignant to benign biopsies are correlated with a radiologist's experience in interpreting screening mammograms.⁵ The average percentage of biopsy-proven breast cancers among screened women with a BI-RADS category of 4 or 5 was reportedly 34%.⁶ A recent study has shown an increasing trend in the biopsy rate and a decrease in the percentage of malignant biopsy results for women receiving screening mammogram.⁵

A false-positive screening mammogram is associated with a heightened breast cancer concern, uncertainty regarding the benefits of screening, and a belief that abnormal test results do not indicate that women have cancer.⁷ Additional or alternative imaging tests after an abnormal screening mammogram are of particular importance to screened women, breast surgeons, and breast radiologists. Women who hesitate to have a biopsy may seek second opinions from other breast specialists or undergo alternative breast imaging tests such as breast magnetic resonance imaging (MRI), fluorodeoxyglucose (FDG) positron emission tomography/computed tomography (PET/CT), and breast ultrasound. Positron emission tomography or FDG PET/CT has an important role in breast cancer staging, and is used to predict breast cancer recurrence and to restage breast cancer after therapy.⁸ An MRI scan with a dedicated breast surface coil is very sensitive in its capacity to detect clinically and mammographically occult breast cancer in the contralateral breast in women with recently diagnosed breast cancer.⁹ Magnetic resonance imaging is the most effective tool for screening breast disease in women at high risk.¹⁰ Recent research has found that 3T MRI yields a higher breast cancer detection rate and positive predictive value than 1.5T MRI for screening women.¹¹ However, MRI may also miss certain early calcified cancers that are commonly visible on a mammogram, and it has a higher false-positive rate.¹² The newly developed PET/MRI fusion imaging modality is another investigative tool that could provide even further enhanced diagnostic capability in the future. We investigated the clinical applications of breast 3T MRI, FDG PET/CT, and breast ultrasound for predicting breast cancer in women with abnormal mammograms.

2. Methods

2.1. Participants

This prospective study was compliant with the Health Insurance Portability and Accountability Act (HIPAA) and

approved by the Institutional Review Board (IRB) of Kaohsiung Veterans General Hospital in Kaohsiung, Taiwan (IRB number VGHKS11-CT4-13). All research participants provided written informed consent. A total of 11,865 screening mammograms from 11,865 women were obtained at our facility between January 2011 and December 2012. Among these women, 1209 (10.2%) women had screen-positive results and were in BI-RADS category 4 or 5.¹³ They were thereafter invited to participate in this study. Fifty-five women finished the complete imaging tests. However, two women who ultimately refused to undergo biopsy were excluded. The remaining 53 women (mean age, 53.3 years; age range, 40–64 years) underwent breast 3T MRI, FDG PET/CT, and breast ultrasound before biopsy (Figures 1 and 2). Their final histopathology findings were compared with the results of all imaging tests.

2.2. Full field digital mammogram

Asymptomatic women who had a final BI-RADS category of 4 or 5 on the mammogram were recommended to undergo biopsies for positive screening results. These women each had standard full field digital mammogram (Selenia Model; Hologic Inc., Bedford, MA, USA), which consisted of the mediolateral oblique (MLO) view and the craniocaudal (CC) view. Furthermore, other diagnostic mammograms with additional views were performed for these equivocal mammographic findings.

2.3. 3T MRI

With the patient prone, all MRI images were acquired with a 3T scanner (Skyra; Siemens, Erlangen, Germany) that used a 16-channel bilateral breast coil. After axial localizer scanning, morphological studies and dynamic studies were performed.

The dynamic study was performed using T1-weighted fast low angle shot (FLASH) three-dimensional (3D) MRI with fat-suppressed sequence and the following parameters: repetition time/echo time (TR/TE), 4.7/1.7 ms; flip angle, 10°; iPAT acceleration factor with GRAPPA, 2; matrix, 384 × 384; field of view, 320 mm × 320 mm; slice thickness, 1 mm; and voxel size, 0.8 mm × 0.8 mm × 1 mm. The temporal acquisition (range, < 60 seconds) was performed according to the volume of the breasts and the field of view. Dynamic contrast-enhanced MRI was started simultaneously with the injection of 1.0M gadobutrol (Gadovist; Schering AG, Berlin-Wedding, Germany) at a dose of 0.1 mmol/kg body weight by a power injector at a rate of 2–3 mL/s and followed by a 10-mL saline flush. The 3D sequence was acquired before the injection and six times continuously after the injection of the contrast agent. The acquired images were analyzed at a workstation (Syngo; Siemens) for post processing with commercial software (Syngo).

2.4. FDG PET/CT imaging

Women who participated in this study fasted for at least 6 hours before undergoing FDG PET/CT imaging. Their serum

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