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ORIGINAL ARTICLE

Impact of Background Parenchymal Enhancement in Preoperative Magnetic Resonance Imaging Breast Assessment for Women with Newly Diagnosed Breast Cancer

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ABSTRACT

Objectives: *To determine the influence of background parenchymal enhancement (BPE) in preoperative magnetic resonance imaging (MRI) breast assessment and its impact on subsequent management for patients with newly diagnosed breast cancer.*

Methods: *Consecutive patients with newly diagnosed breast cancer undergoing breast MRI examination for staging from January 2010 to July 2013 were retrospectively reviewed. The BPE categories of minimal, mild, moderate, or marked intensity (Breast Imaging Reporting and Data System MRI lexicon definitions) were retrospectively reported. Associations with abnormal interpretation rates (which defined as detection of additional findings other than the known malignant lesions that render clinical attention), presence of non-mass enhancement, mean number of additional breast masses, biopsy rates and cancer yield of additional lesions, mastectomy rates, and positive specimen margin rates for patients undergoing conservative breast treatment were compared using statistical tests.*

Results: *Of the 95 preoperative breast MRI examinations, women with marked enhancement had significantly higher additional abnormal interpretation rates (100.0%), rate of non-mass enhancement (85.7%), and mean number of additional breast masses (2.6 lesions per study) than those respective rates in women with moderate (65.0%; 35.0%; 1.2), mild (52.3%; 31.8%; 0.9), or minimal (41.7%; 20.8%; 0.3) enhancement ($p < 0.05$). No significant difference in other parameters among different BPE categories was observed.*

Conclusions: *Increased BPE on preoperative breast MRI was associated with higher abnormal interpretation rate, higher rates of non-mass enhancement, and an increased mean number of additional breast masses in women with known carcinoma of the breasts. However, it did not lead to significant difference in the subsequent management among the enhancement categories.*

Key Words: *Breast neoplasms; Magnetic resonance imaging*

中文摘要

術前磁共振乳房評估中背景實質強化對乳腺癌患者的影響

溫詠雪、李芷茵、呂振英

目的：找出背景實質強化（BPE）對於術前磁共振成像（MRI）乳房評估以及對新診斷的乳腺癌患

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者的後續治療的影響。

方法：回顧分析2010年1月至2013年7月期間為腫瘤分期而接受乳腺MRI檢查的所有新診斷的乳腺癌患者資料。按BI-RADS MRI定義，把病例的BPE分級為最低、輕度、中等或顯著強化。採用統計檢驗比較以下幾方面與BPE的關係：判讀異常率（即除了已知的惡性病變外，檢測到額外病灶而引起臨床關注）、非腫塊強化、額外的乳腺腫塊的平均數量、活檢率和額外的癌症病變率、乳房切除率、接受保乳治療者的標本邊緣陽性率。

結果：接受術前乳腺MRI檢查的共有95例。BPE為顯著強化的病例的判讀異常率（100.0%）、非腫塊強化的出現率（85.7%）和額外的乳腺腫塊平均數量（每個病例平均有2.6個灶），都比其他分級的BPE病例顯著增高：中度BPE（依次為65.0%，35.0%，1.2），輕度BPE（52.3%，31.8%，0.9），以及最低BPE（41.7%，20.8%，0.3）；p值<0.05。其他參數於不同分級的BPE病例之間均無顯著差異。

結論：在乳癌確診患者中，術前乳房MRI顯示的BPE增加與較高的判讀異常率、非腫塊物質的發生率和額外的乳腺腫塊的平均增加數量有關。然而，不同BPE分級患者的後續治療無顯著差異。

INTRODUCTION

The National Institutes of Health Consensus Development Panel in 1990 concluded that breast conservation is the preferred method of primary surgical therapy for women with early stage breast cancer.[1] Since then, preoperative breast magnetic resonance imaging (MRI) has taken an important role in detecting occult, synchronous breast cancer and in staging the local extent of the cancer for potential candidates for breast-conserving surgery. The detection of occult malignancy in preoperative MRI determines a patient's eligibility for breast-conserving surgery. Since identification of a lesion is based on the differential enhancement between neoplastic tissue and normal breast parenchyma,[2-6] problem arises when the appearance of the enhancement of the normal breast tissue overlaps with that of neoplastic tissue. We hypothesised that background parenchymal enhancement (BPE) may decrease the sensitivity of breast MRI by obscuring enhancing malignancies, thus, underestimating the extent of disease causing higher rate of positive margin. It may also diminish the specificity since benign enhancement may be misinterpreted as suspicious, leading to potential change of the surgical approach for resection of breast cancer.

To the best of the authors' knowledge, no study has been published assessing the influence of BPE on the detection of additional lesions in preoperative breast MRI and their subsequent management in terms of biopsy / surgical options after preoperative MRI of the breasts. Therefore, the purpose of our study was to determine the influence of BPE on preoperative breast MRI assessment and its impact on surgical management of patients with newly diagnosed breast cancer.

METHODS

Patients

Consecutive patients with newly diagnosed breast cancer or highly suspicious breast lesions that were subsequently shown to be malignant on histology undergoing breast MRI examinations for staging from January 2010 to July 2013 were retrospectively reviewed. Patients were required to be at least 18 years old, not having a history of breast implant, and not undergoing neoadjuvant treatment.

Magnetic Resonance Imaging Technique

All participants underwent contrast-enhanced dynamic breast MRI of both breasts. This was performed in prone position with a 1.5 T system (Achieva XR; Philips Medical Systems, Best, The Netherlands) using a dedicated breast surface coil. The following axial images were obtained: T1- and T2-weighted sequences with turbo spin echo (TSE), T2-weighted sequences with spectral-attenuated inversion recovery TSE and apparent diffusion coefficient. T1-weighted images were obtained before and after contrast injection at 1, 2, 3, 4, and 5 minutes.

Data Collection

Two breast imaging radiologists who were blinded to the results performed a consensus review of the breast MRI examinations. The BPE categories of minimal,

mild, moderate, or marked intensity (BI-RADS MRI lexicon definitions) were retrospectively reported (Figure 1). Associations with presence of non-mass enhancement (other than the index lesion), mean number of additional breast masses per patient (masses other than the index cancer, clinically and mammographically occult, with probably benign or suspicious features on MRI, measuring >0.5 cm in diameter), abnormal interpretation rates (identification of occult breast mass or non-mass enhancement in addition to the index cancer), biopsy rates of the newly identified lesions detected on preoperative MRI, cancer yield of biopsied lesions (defined as cancers resulting from additional biopsy), mastectomy rates of patients and positive specimen margin rates for patients undergoing breast conservative treatment in different BPE category were compared using chi-square tests. The significant value was set at $p < 0.05$.

RESULTS

Of the 95 preoperative breast MRI examinations, the overall frequencies of BPE categories were 25.3%

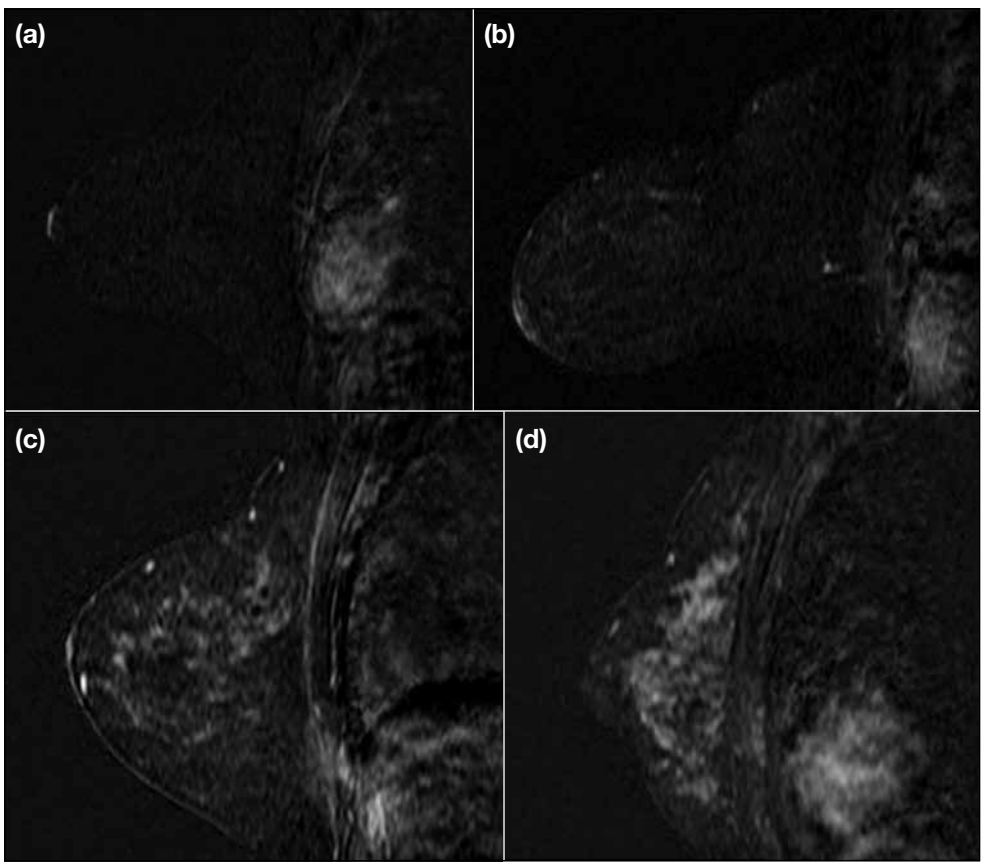

Figure 1. Sagittal contrast-enhanced T1-weighted fat-suppressed magnetic resonance images showing (a) minimal, (b) mild, (c) moderate, and (d) marked breast parenchymal enhancement.

Table 1. Abnormal interpretation (identification of occult breast mass or non-mass enhancement in addition to the index cancer), non-mass enhancement (other than index tumour), and mean number of additional masses (masses other than the index lesion, clinically and mammographically occult, with probably benign or suspicious features on MRI, measuring >0.5 cm in diameter) detected by preoperative MRI according to enhancement categories.

BPE category	No. of patients	No. of studies with abnormal interpretation (rates)	No. of studies with non-mass enhancement (rates)	Mean No. of additional breast masses per study
Minimal	24	10 (41.7%)	5 (20.8%)	0.3 (8/24)
Mild	44	23 (52.3%)	14 (31.8%)	0.9 (40/44)
Moderate	20	13 (65.0%)	7 (35.0%)	1.2 (24/20)
Marked	7	7 (100.0%)	6 (85.7%)	2.6 (18/7)
p Value	-	<0.05	<0.05	<0.05

Abbreviations: BPE = background parenchymal enhancement; MRI = magnetic resonance imaging.

for minimal (n = 24), 46.3% for mild (n = 44), 21.1% for moderate (n = 20), and 7.4% for marked (n = 7) enhancement. Women with marked enhancement had a significantly higher abnormal interpretation rate (100%) than women with moderate (65.0%), mild (52.3%), or minimal (41.7%) enhancement ($p < 0.05$) [Table 1].

The rates of non-mass enhancement were significantly higher for women in the marked BPE category (85.7%) than those for women in the moderate (35.0%), mild (31.8%), or minimal (20.8%) category ($p < 0.05$). The same was true for the mean number of additional breast masses detected in preoperative MRI, with significantly more lesions per study in the marked BPE category (2.6 lesions per study), compared with moderate (1.2), mild (0.9), or minimal (0.3) categories ($p < 0.05$) [Figure 2]. Eight lesions in the minimal or mild BPE category and one lesion in marked or moderate BPE category were biopsied; the difference was not statistically significant ($p = 0.1441$). The overall cancer yield for additional cancers identified in preoperative MRI from biopsy was 22% (n=2/9), with one positive biopsy from a lesion in the mild BPE category and one from the moderate BPE category.

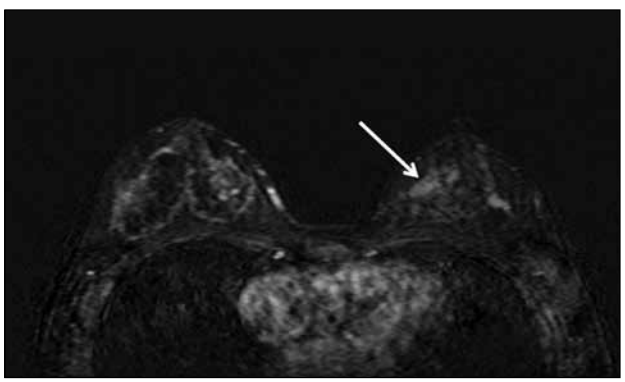

Figure 2. An illustration of moderate background enhancement in a 40-year-old woman with known ductal carcinoma in-situ in the upper inner quadrant of left breast (arrow). Several additional enhancing lesions are noted in bilateral breasts. This patient underwent left mastectomy and revealed unifocal disease. There was no evidence of malignancy in the contralateral breast upon 2-year follow-up.

Table 2. Rates of mastectomy and positive specimen margin in patients undergoing breast conservative treatment according to enhancement categories.

BPE category	No. of mastectomy	No. of positive margin
Minimal / mild	22/68 (32.4%)	5/33 (15.2%)
Moderate / marked	10/27 (37.0%)	2/12 (16.7%)
p Value	0.66	0.90

Abbreviation: BPE = background parenchymal enhancement.

Mastectomy rates were not affected by BPE, with 37.0% of women in the marked or moderate BPE category and 32.4% in the minimal or mild BPE category ($p = 0.66$) [Table 2]. The rates of positive specimen margin in women receiving breast conservative treatment were also not affected by BPE, with 16.7% in the marked or moderate BPE category and 15.2% in the minimal or mild BPE category ($p = 0.90$).

DISCUSSION

BPE has diffuse and nodular patterns. It is found to be associated with endogenous hormone levels corresponding to the phases of the menstrual cycle, being highest during weeks 1 and 4 and lowest during week 2.[7,8] It is believed to be related to the increased vascular permeability associated with oestrogen and the elevated metabolic activity associated with progesterone.[9]

Previous studies have found that BPE was influenced by age, with women younger than 50 years having more extensive BPE versus that in older women.[10] There is no association between BPE and amount of fibroglandular tissue.[11]

Our study found that increased BPE on preoperative breast MRI was associated with higher additional lesion detection rate on MRI in women with known carcinoma of the breasts. It, however, did not lead to a statistically significant change in the surgical approach for resection of breast cancer and the positive margin rate with breast conservation. Our results were similar to those by DeMartini et al,[10] whose study included a significant number of screening MRIs in high-risk patients rather than focusing on preoperative MRI. They showed a higher number of women in the moderate or marked BPE group initially assessed as having abnormal findings than those in the mild or minimal BPE group, with the final outcome of positive biopsy rate and cancer yield not being significantly different between the BPE groups. Our results are encouraging to the breast surgeons and breast radiologists who utilise breast MRI for preoperative planning.

There were some limitations in this study. First, the biopsy rate of the additional lesions detected on preoperative MRI was low. It was because many of the

patients had mastectomy planned after the preoperative MRI either due to extensive disease involvement, patient anxiety for fear of leaving a lesion behind or presence of multiple lesions. Therefore, biopsies were obviated. Second, it was conducted in a single centre with fellowship-trained specialists experienced in breast MRI interpretation. Therefore, our results may not be generalisable to all radiological centres. Third, our study focused on the impact of the management plan; long-term outcomes such as recurrence rate and survival rate were not studied.

CONCLUSIONS

Increased BPE on preoperative breast MRI was associated with higher abnormal interpretation rate, higher rates of non-mass enhancement, and an increased mean number of additional breast masses in women with known carcinoma of the breasts. It, however, did not lead to significant difference in biopsy rates, mastectomy rates, or the rates of positive specimen margin among the enhancement categories.

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