Association of Lesion and Background Parenchyma in Diagnostically Challenging Breast Lesions

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INTRODUCTION: DCE-MRI has a high sensitivity (80-95%); but its variable specificity (65-72%) leads to unnecessary biopsies. The patients who are recommended for biopsies have not only suspicious findings on the lesions of interest, but also often have other pre-existing conditions, such as known cancers in the ipsilateral and/or contralateral breasts or some high risk factors including history of cancer treatment. Thus, considering these factors in interpreting the DCE-MRI data of the indeterminate lesion may improve the diagnostic accuracy. However, there is a paucity of studies on the relationship between lesions and background parenchyma (BP), particularly for the group of patients undergoing biopsy [1,2]. It is poorly understood how existing lesions would affect the contrast uptake kinetics in the BP and other indeterminate lesions. Hence, the objective of this study was to investigate MR contrast-enhancement kinetics of breast background parenchyma and lesions using quantitative measures and to investigate the feasibility of improving the discrimination between benign and malignant tumors.

METHODS: Between November 2011 and October 2012, 102 consecutive women underwent a MRI guided biopsy. Indications for the breast MRI were newly diagnosed with breast cancer, 51 (50%), high-risk screening, 46 (45%), and others, 5 (5%). The electronic medical records of these patients were retrospectively reviewed. Lesions were classified as benign and malignant based on histology.

DCE-MRI was performed on a 3T Tim Trio system (Siemens, Germany) using a dedicated 7 channel breast coil (Invivo). MR biopsies were performed using the Suros ATEC device. For these patients, unilateral DCE-MRI using a 3D radial VIBE sequence (TR/TE = 3.57/1.72 ms, FA = 10 deg, FOV 280 mm, resolution 1.4 x 0.9 x 1.5 mm, 420 radial views/frame) with fat suppression was acquired for five consecutive frames (duration 55 sec each). Injection of contrast agent, Gd-DTPA (Magnevist, Bayer), was administered after the first frame.

After review of the MRI images and associated report, a single reader manually drew regions of interest (ROI) around the lesion (LS). A second ROI was drawn around the entire breast on a separate single image that did not contain the suspicious lesion. Quantitative analysis of dynamic signal enhancement in the breast parenchyma (BP) was performed using a linear principal component analysis (PCA) method proposed by Eyal et al. [3]. PCA transformation was applied to the second ROI to decompose the datasets into eigenvalues, eigenvectors, and projection coefficient maps. The primary principal component represents the contrast enhancement kinetics of the BP. The PCA method was then applied to two additional slices for each patient; the average of the three slice results was used as the final measure. Post-image processing was performed using an in-house software written in IDL.

The initial enhancement ratio (IER) was calculated as the percent increase of the signal between the first and third frames, and delayed enhancement ratio (DER) as the percent increase of the signal between the first and fifth frames. IER and DER were measured for lesion and BP, as well as for the adjacent internal mammary artery (IMA). The IER and DER values of lesion and BP were divided by those of IMA to generate normalized IER (NIER) and normalized DER (NDER).

The Kruskal-Wallis test was used to detect a statistical difference among the five groups. Regression analysis was performed to measure the association between the LS and BP kinetic parameters in each group.

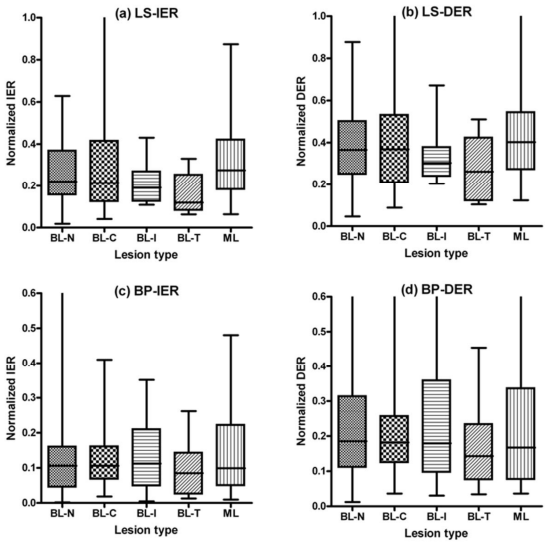

Figure 1. Comparison of lesion and BP enhancement kinetics between patient groups. LS, lesion; BP, background parenchyma; IER, initial enhancement ratio; DER, delayed enhancement ratio; BL, benign lesion; N, no other cancer or cancer history; C, cancer in contralateral breast; I, cancer in ipsilateral breast; T, treated; ML, malignant lesion.

RESULTS: One hundred two women had 102 lesions: 63 (62%) biopsy-proven benign, 18(18%) high-risk and 21 (20%) cancers (11 IDC and 10 DCIS). Average size of the lesion was 1.6cm, range 0.4 - 8.0 cm. We classified the above lesions into 5 groups: BL-N (Benign Lesion in asymptomatic patient), BL-C (Benign Lesion with a newly diagnosed cancer in contralateral side), BL-I (Benign Lesion with a newly diagnosed cancer in ipsilateral side), BL-T (Benign Lesion and treated for prior breast cancer) and malignant lesion (ML). We found no difference in IER and DER amongst the lesion types. (Fig 1) Similar results were obtained with the normalized measures, NIER and NDER. Regression analysis between the lesions and the BP (Fig 2) shows scatter plots for the 5 groups. The positive regression for BL-N was statistically significant ($P < 0.001$, $R^2 = 0.4371$). The ML almost reached statistical significance (p=0.08). Similar observation was made with DER; a significant regression in BL-N ($p = 0.0001$, $R^2 = 0.4159$) and a marginal significance for the ML ($p = 0.0525$, $R^2 = 0.2151$).

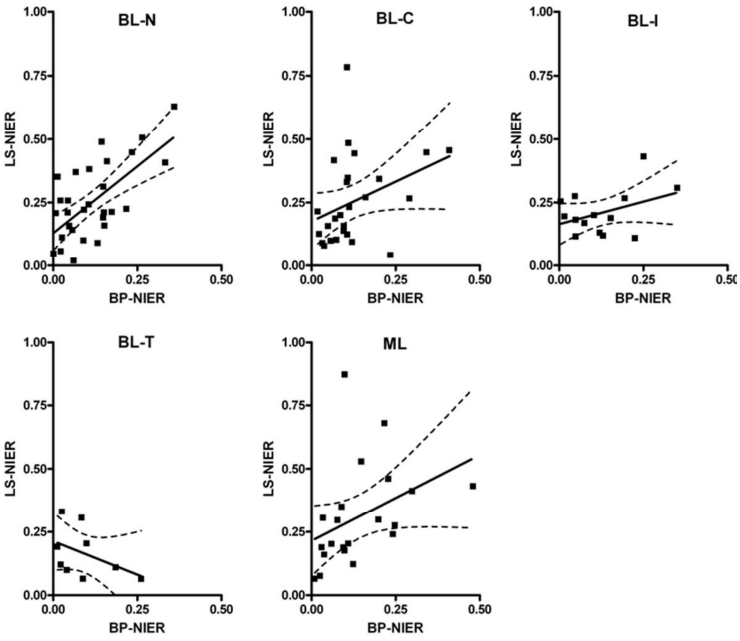

Figure 2. Scatter plots between the contrast enhancement characteristics of BP and lesion. Each plot corresponds to a unique combination of biopsied lesion type (BL or ML) and patient condition (N, C, I, and T, as defined in Figure 1 caption). Solid lines are for regression with 95% confidence intervals shown by dashed lines. A statistical significance was found only in BL-N ($r^2 = 0.44$, $p < 0.001$).

DISCUSSION: BP is an important factor to be considered to improve the diagnostic accuracy of DCE-MR. In our study, we have demonstrated that the PCA-based approach can be used to measure contrast enhancement kinetics of the BP. Also, the use of fast imaging methods, such as radial VIBE allows a more detailed kinetic analysis of LS and BP and may increase MR specificity.

REFERENCES 1. Boyd NF et al. New England Journal of Medicine 2007; 356:227-236. 2. King V et al. Radiology 2011; 260:50-60. 3. Eyal E, J Magn Rson Imaging 2009; 30:989-998.