Are Kinetic Parameters Diagnostically Useful for Breast Lesions Exhibiting Nonmass-like Enhancement?

S. A. Jansen[1], X. Fan[2], G. Karczmar[2], M. Giger[2], H. Abe[2], and G. Newstead[2]
[1]University of Chicago, Chicago, IL, United States, [2]University of Chicago

Introduction: When analyzing lesion presentation on breast DCEMRI, the radiologist assesses both the morphology as well as the contrast media uptake and washout—or kinetics—of the lesion. The first step in assessing lesion morphology is to classify the type of enhancement as mass, nonmass or focus (Figure 1); subsequent descriptors (such as shape or enhancement pattern) are selected, which differ depending on the type of enhancement. The purpose of this study was to investigate whether the sensitivity and specificity of kinetic parameters can be improved by considering mass and nonmass breast lesions separately. The contrast media uptake and washout kinetics in benign and malignant breast lesions were analyzed using an empirical mathematical model (EMM), and model parameters were compared in lesions with mass-like and nonmass-like enhancement characteristics.

Methods: 34 benign and 78 malignant lesions were selected for review. One pre and five post-contrast images were acquired in the coronal plane using 3D T_1-weighted SPGR (TR/TE = 7.7/4.2 msec, flip angle = 30˚, slice thickness = 3 mm, and in plane resolution = 1.4 mm, 68 sec acquisition). An experienced radiologist classified the type of enhancement as mass, nonmass or focus, according to the BI-RADS lexicon. The radiologist then traced a small region of interest (ROI) around what was perceived to be the most enhancing part of the lesion on the first post-contrast image. The kinetic curve represents the signal intensity in the ROI vs. time. The kinetic curve was analyzed quantitatively using a three parameter EMM[1]: $\Delta S(t) = A \cdot \left(1 - e^{-\alpha t}\right) \cdot e^{-\beta t}$ where **A** is the upper limit of signal intensity, **α** is the rate of signal increase, **β** is the rate of signal decrease during washout. Several kinetic parameters were then derived from the EMM parameters: the initial slope (**$Slope_{ini}$**), curvature at the peak (**κ_{peak}**), time to peak (**T_{peak}**), area under the curve at 30 seconds (**AUC_{30}**) and the signal enhancement ratio (**SER**). The kinetic characteristics of benign and malignant lesions within mass and nonmass lesions were compared: (i) benign vs. malignant mass lesions, and (ii) benign vs. malignant nonmass lesions. Receiver operating characteristic (ROC) analysis was performed to compare the diagnostic performance of the EMM parameters on mass lesions vs. nonmass lesions.

Results: The type of enhancement found was: 70 mass lesions, 38 nonmass, 4 focus. For mass lesions, the EMM parameters **α**, **β**, **AUC_{30}**, **SER**, **$Slope_{ini}$**, **T_{peak}** and **κ_{peak}** differed significantly between benign and malignant lesions (p<0.03). For nonmass lesions, there were no statistically significant differences in any of the parameters for benign vs. malignant lesions (p>0.5). ROC curves were generated for each parameter; for all except **A** the A_z values were higher in mass lesions. The ROC curves for the primary and derived parameter with the highest A_z value for mass lesions (**SER**, **β**) are shown in Figure 2a, and for nonmass lesions (**A**, **$Slope_{ini}$**) in Figure 2b.

Discussion: Kinetic parameters could distinguish benign and malignant mass lesions, but were not useful in discriminating nonmass-like benign from malignant lesions. This suggests that the diagnostic utility of kinetic analysis of breast lesions, e.g., in computer aided diagnosis schemes, is likely improved if performed after identifying the lesion as mass or nonmass enhancement. Given that the physiological basis of enhancement is likely different in nonmass vs. mass lesions, it may be that new quantitative kinetic parameters need to be developed that are tailored for nonmass lesions. This task is of particular importance given that the majority of preinvasive ductal carcinoma *in situ* lesions present as nonmass-like enhancement. Future work will focus on a larger group of lesions with detailed pathology analysis, to investigate new parameters targeted at nonmass lesions. In addition, pixel by pixel analysis, acquiring high spatial/temporal resolution of MR images, or following the later phase of the kinetic curves for a longer time, could be used to help improve the differentiation of nonmass malignant from nonmass benign lesions.

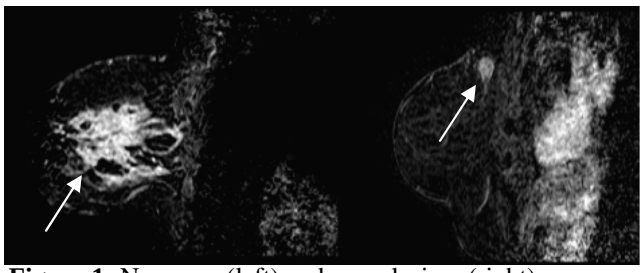

Figure 1: Nonmass (left) and mass lesion (right).

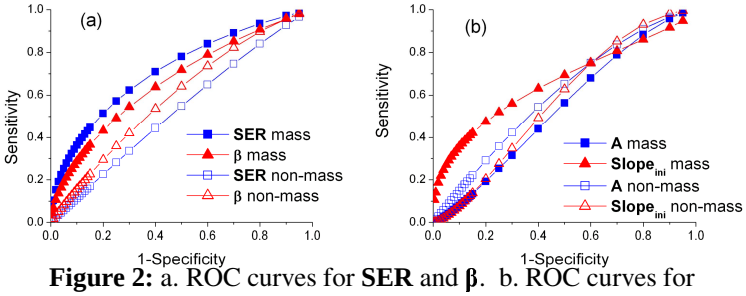

Figure 2: a. ROC curves for **SER** and **β**. b. ROC curves for **A** and **$Slope_{ini}$**

References: 1. Fan et al, JMRI, 2007 Jun;25(5):593-603.