Assessment of in Vivo DCIS Grade: A Model Incorporating Dynamic Contrast Enhanced and Diffusion Weighted Imaging Parameters on Breast MRI

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Introduction Ductal carcinoma in situ (DCIS) is a pre-invasive malignancy encompassing a broad spectrum of disease ranging from clinically indolent to an aggressive precursor of invasive breast cancer. While survival of treated DCIS approaches 100%, there are concerns that some women may undergo unnecessary therapy for a quiescent malignancy that would not impact their health if left untreated. Pathologically, it is known that high grade (HG) DCIS correlates with a greater risk of progression to invasive disease and local recurrence than does non-high grade (low or intermediate grade, NHG) DCIS [1-2]. Dynamic-contrast-enhanced (DCE) MRI more accurately detects DCIS than mammography [3], but there have been conflicting reports on its use for differentiating DCIS grades [4, 5]. Our recent studies demonstrate that diffusion weighted imaging (DWI) detects DCIS and may be able to discriminate between HG and NHG DCIS [6]. There are no studies to date combining DCE and DWI features to discriminate DCIS grade. The aim of this study was to develop a model incorporating DWI and DCE variables to assess in vivo DCIS grade.

Methods After IRB approval, we retrospectively reviewed 55 consecutive pure DCIS lesions (19 HG, 36 NHG) that underwent breast MRI at 1.5T with both DCE and DWI (b=0, 600 s/mm^2) scans. We analyzed the DCE kinetics features of each lesion using a computer aided evaluation system (CADstream, Merge Healthcare Inc) and DWI features including contrast-to-noise ratio (CNR) and apparent diffusion coefficient (ADC) using in-house software (Image J, NIH public domain). Univariate and multivariate logistic regression modeling was used to optimally discriminate HG from NHG DCIS based on the following variables: maximum lesion size (greatest MRI dimension), enhancement kinetics (percent persistent, plateau, and washout; peak initial enhancement (PE); worst curve type), ADC, and DWI CNR. Discriminative abilities of models were compared using areas under the receiver operating characteristic curve (AUC).

Results In univariate analyses, HG lesions exhibited lower mean CNR (p=0.02) and larger mean maximum lesion size (p=0.01), allowing discrimination of HG from NHG by CNR (AUC=0.70, p=0.004) and maximum lesion size (AUC=0.71, p=0.018), Figure 1. No significant difference in ADC was observed between HG and NHG. PE was the only kinetics variable to approach significance, with HG exhibiting higher PE (AUC=0.59, p=0.051). A multivariate model combining CNR and maximum lesion size most significantly discriminated HG from NHG (AUC=0.81, p<0.001, figure 1), followed by a model combining CNR and PE (AUC=0.76. p=0.001). Combining all three variables did not improve model performance due to correlation between maximum lesion size and PE (r=0.36, p=0.01). An example demonstrating imaging characteristics and analysis of a HG DCIS lesion in a NMLE pattern is shown in figure 2.

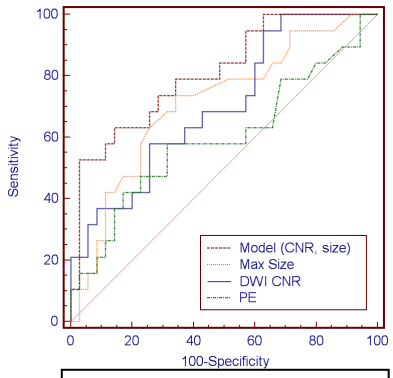

Figure 1. ROC curves

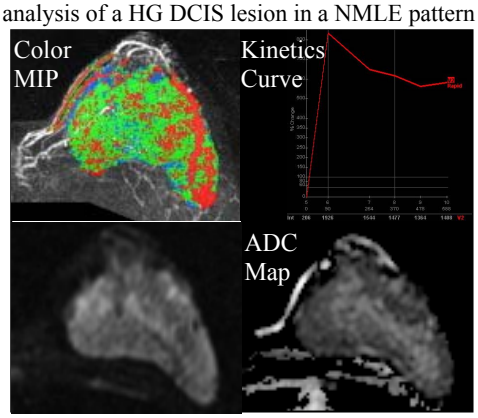

Figure 2. Appearance of a HG DCIS lesion involving the entire left breast on DCE MRI and DWI (maximum lesion size = 79 mm). Kinetics curve demonstrates rapid initial enhancement (PE = 834%). Cover overlay map on maximum intensity projection image (MIP) demonstrates mixed delayed kinetics with 16% washout. The lesion demonstrates high signal on DWI (CNR = 3.28) and ADC map confirms restricted diffusion (ADC = 1.08 x 10^{-3} mm^2/s).

Discussion As outlined by a recent NIH State of the Science Conference on DCIS [7], there is a critical need to identify MRI characteristics that augment current DCIS risk stratification. To date, specific MRI features that reliably assess in vivo DCIS grade have not been identified. Our study suggests that DCIS grade can be successfully discriminated using both DCE and DWI characteristics. Individually, DCE maximum lesion size and DWI CNR provided the greatest discriminative abilities. A model incorporating these two variables was most accurate in discriminating HG from NHG DCIS. Further study may yield a model combining MRI characteristics with histopathology data for improved targeted therapy of DCIS.

References

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