Kinetic Assessment of Breast Lesions Using the Signal Enhancement Ratio from Rapid Radial DCE-MR Images

L. Dougherty[1], R. C. Boston[2], M. A. Rosen[1], L. W. Nunes[3], P. J. Moate[2], H. K. Song[1], and M. D. Schnall[1]

[1]Radiology, University of Pennsylvania, Philadelphia, PA, United States, [2]School of Veterinary Medicine, University of Pennsylvania, [3]Radiology, Pennsylvania Hospital

Introduction

Recent research has shown that rapid radial DCE-imaging can provide high spatial resolution for architectural assessment as well as high temporal resolution for better characterization of the kinetic response [1]. The kinetic assessment of breast tumors using the signal enhancement ratio (SER) [2] has been shown to be a predictor of malignant disease while being independent of the T1 relaxation time and image intensity scaling. In this work, DCE-MR images of the breasts were acquired using an undersampled radial trajectory and the kinetic response was assessed using SER. Lesion characterization was correlated with histopathologic findings to determine the diagnostic performance.

Methods

IRB approval was obtained prior to the start of this study. One hundred twenty six (126) subjects with palpable or mammographically-visible suspicious findings were recruited. From these cases, 94 had subsequent pathologic correlation. Images were acquired using 1.5T MR scanners. The initial 59 cases were acquired using a General Electric Signa and the remaining used a Siemens Sonata scanner. Additionally, the first 103 cases were performed unilaterally while the remaining cases were simultaneous bilateral exams. Subjects were placed in the prone position, with the breasts gently compressed within a dedicated breast coil. The contrast-enhanced images were acquired using a fast 3D spoiled gradient-recalled back-projection sequence using 512 data samples/projection with 48 projections, and 32 phase encoding steps in the slice direction (TR/TE, 10/4; flip angle=20°; ±74 kHz sampling bandwidth). Images were acquired using 24 cm FOV and ~3 mm thick slices. The fat signal was suppressed using a spectral inversion pulse played-out twice per slice group. A high-resolution baseline volume was acquired followed by dynamic imaging started simultaneously with the intravenous injection of 0.1-mmol/kg gadopentetate dimeglumine (Magnevist, Berlex Laboratories, Wayne, NJ). Contrast was administered over a 10-second interval and followed by a saline flush. Data were acquired over the following 6-minute period with ~15 s temporal resolution.

Two radiologists (LWN, MAR) experienced in MR breast imaging, read the images independently and were blinded to the biopsy results. Each reader placed an ROI on the most enhancing region of the lesion. From the time resolved ROIs, the signal intensity data were obtained and fit to a five parameter modified logistic equation given by [3]:

$$SI(t) = \frac{P_2 + (P_5 \bullet t)}{\{1 + \exp(-P_4 \bullet (t - P_3))\}} + P_1$$

In this heuristic model, P_1 is the baseline signal, P_2 is related to the magnitude of the peak signal, P_3 is the time of the maximum rate of increase of signal, P_4 is the maximum rate of signal enhancement and P_5 is the terminal slope of the signal enhancement curve. Lesions were considered to be enhancing if their peak intensity increased from baseline by at >50%. From the fitted curve, three points were selected: S_0 was a baseline, pre-contrast intensity, S_1 was the intensity at 60 s post-contrast, and S_2 was the intensity at 350 seconds. SER was calculated by: **SER = $(S_1-S_0)/(S_2-S_0)$**. **Figure 1** shows a representative image and the time signal intensity with the fitted curve on the same plot. The curve fit takes advantage of the high temporal resolution and allows for a SER that is less sensitive to signal fluctuations.

Results

Each reader identified 64 enhancing lesions from which time signal intensity plots were measured and fitted. SER was calculated for each case and a ratio 0.8 was chosen as the cutoff between benign (< 0.8) and malignant (≥ 0.8) lesions (**Figure 2**). The diagnostic performance for reader one was: Sensitivity = 90%, Specificity = 97%, PPV=96%, NPV=92%, and the diagnostic accuracy was 94%. For the second reader: Sensitivity = 93%, Specificity = 92%, PPV=90%, NPV=94% and the diagnostic accuracy was 92%.

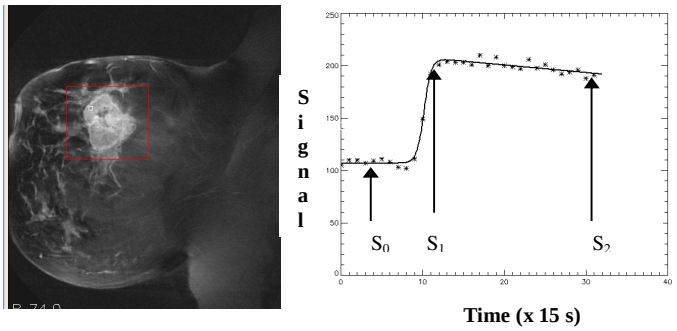

Figure 1. left) Post-contrast breast image with a malignant lesion. **Right)** time/signal intensity plot with fitted curve superimposed. S_0, S_1, and S_2 are time points at which signal intensities are used to calculate the signal enhancement ratio (SER). Contrast injection was initiated after the 8th time point.

Conclusion

The assessment of breast lesions using the signal enhancement ratio is a powerful predictor of benign or malignant disease.

1. Doughetry L, *et al.* Magn. Reson. Med., 57:220-225, 2007.
2. Li KL, *et al.* Magn Reson Med , 58:572-581, 2007.
3. Moate PJ, *et al.* Magn Reson Imaging 22:467–473, 2004.

Supported by NIH 1RO1-CA90699

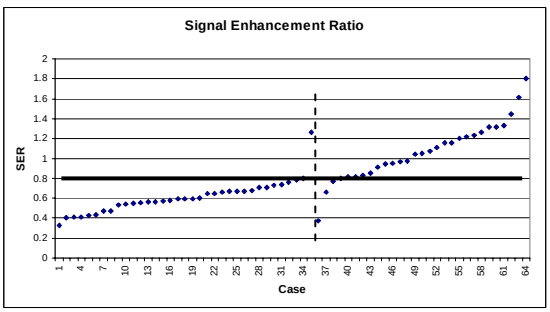

Figure 2. Signal enhancement ratio (SER) plotted for each case. Lesions with an SER < 0.8 were classified as benign and lesions with an SER ≥0.8 were classified malignant. Cases to the left of the dashed line were benign on biopsy and those to the right, malignant. There was 1 false positive and three false negatives for this reader.