Can Contrast-Enhanced MRI Be Used to Identify Those Breast Tumors at High-Risk for Disease Recurrence with High Specificity Even Prior to Preoperative Chemotherapy?

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INTRODUCTION

Dynamic contrast enhanced (DCE) magnetic resonance imaging (MRI) has been used to differentiate between benign and malignant breast tumors. Prior studies have also reported a comparison between DCE-MRI findings and prognostic indicators in breast cancer. However there have been few published reports to support the prognostic value of contrast-enhanced breast MRI for stratifying patients into good vs. poor prognostic categories. The purpose of this study was to evaluate the predictive value of high spatial resolution signal enhancement ratio (SER) [1,2] MR imaging performed prior to neoadjuvant chemotherapy in patients with breast cancers.

METHODS

From 1995 to 2002 high spatial resolution three-time point contrast-enhanced (CE) MRI data were acquired from 48 patients with invasive breast cancers, who preoperatively underwent four cycles of adriamycin and cytoxan chemotherapy. Based on the most recent follow-up information to August 2007, patients were divided into 'no-recurrence ' and 'recurrence' groups. Two hypotheses were formulated for predicting disease recurrence using SER imaging based on its close relation to the redistribution rate constant (k_{ep}) [3]. Hypothesis 1: The volume (in voxels) of malignant breast tissue, which is characterized by a SER value above the threshold corresponding to the upper limit value of mean k_{ep} in benign breast tumors, is an important predictor of disease recurrence. Hypothesis 2: The volume (in voxels) of cancerous breast tissue infiltrating into the breast parenchyma, which can be observed on a high spatial resolution SER map, is also an important predictor of disease recurrence. Volume measurements (in voxels) were tabulated for SER values between set ranges, and cut-off criteria were defined to predict disease recurrence after surgery.

RESULTS

Figure 1 displays boxplots of the number of voxels with high (Hypothesis 1) and low (Hypothesis 2) SER for the two groups(1: no recurrence; 2: recurrence) from pre-chemotherapy CE MRI. Fig. 1a: SER between 0.47 and 0.71; Fig. 1b: SER greater than 1.45. Interquartile range (i.e., 25%-75%) shown by box; extreme values shown by whiskers; and median shown by bar within the box. *P*-value of the difference between the two groups evaluated using Wilcoxon rank-sum test is given at the top of each box. It was found that breast tumor volume calculated from the number of voxels with SER values above a threshold corresponding to the upper limit of mean k_{ep} in benign tumors (0.88 min^{-1}) and the volume (in voxels) of cancerous breast tissue infiltrating into the parenchyma (Such infiltrating voxels were of low SER corresponding to $k_{ep} < 0.20$ min^{-1}) were important predictors of disease recurrence. In our study, 60% (6/10) of patients with early recurrence (recurred within 1.6 years) were identified prior to chemotherapy. None of the recurrence-free patients was misidentified as likely to recur. Figure 2 shows patients at high risk for disease recurrence predicted with SER imaging performed before neoadjuvant chemotherapy. Top row: tumors with the number of blue voxels (volume of parenchymal infiltration) above a cut-off level of 10000 voxels, i.e., 11.0 cm^3. Bottom row: tumors with number of red voxels (rapidly enhancing tissue) above a cut-off level of 6000 voxels, i.e., 6.6 cm^3. The six patients with recurrence predicted by pre-chemotherapy SER imaging were all deceased at final follow-up and accounted for 67% (6/9) of the total number of deceased patients.

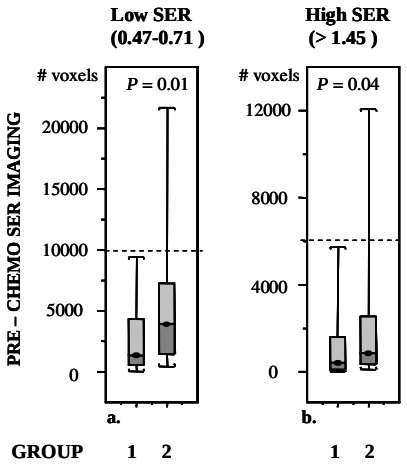

Fig. 1. Comparison of the number of voxels with high and low SER between the no recurrence and recurrence groups.

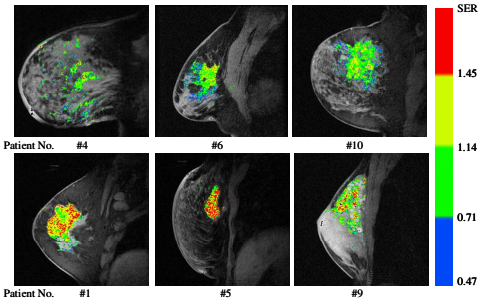

Fig. 2. patients at high risk for disease recurrence identified with SER imaging before neoadjuvant chemotherapy

CONCLUSION

High spatial resolution SER imaging is valuable in prediction for patients who are at high risk of disease recurrence and death even prior to preoperative chemotherapy.

References: 1. Esserman et al. Contrast-Enhanced Magnetic Resonance Imaging to Assess Tumor Histopathology and Angiogenesis in Breast Carcinoma. Breast J 1999; 5: 13-21. **2**. Hylton. Vascularity assessment of breast lesions with gadolinium-enhanced MR imaging. Magn Reson Imaging Clin N Am 2001; 9: 321-332, vi. **3**. Li KL, Henry RG, Wilmes LJ, et al. Kinetic assessment of breast tumors using high spatial resolution signal enhancement ratio (SER) imaging. Magn Reson Med 2007; 58: 572-581.