Dynamic contrast enhanced breast MR combined with the multiparametric MR ISODATA vector model in breast lesion diagnosis: preliminary results

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INTRODUCTION: Dynamic contrast enhanced (DCE) magnetic resonance imaging has been used for the differential diagnosis of enhancing breast lesions[1]. Specific patterns of enhancement have been associated with benign or malignant breast lesions. However, in some cases the pattern of enhancement may be equivocal. The addition of a multiparametric ISODATA vector model of breast lesion may clarify equivocal cases. This vector model using an objective (unsupervised) computer segmentation algorithm termed the Iterative Self-Organizing Data Analysis Technique (ISODATA) has shown utility in differentiating benign from malignant breast lesions[2,3]. Therefore, using DCE results on breast lesions, the addition of ISODATA model was evaluated as an adjunct diagnostic tool in clinical breast diagnosis.

METHODS: 28 patients with indeterminate morphological features underwent DCE imaging on a GE 1.5T MR scanner using a dedicated phased array breast coil. Dynamic MR imaging sequences was performed using a localizer, sagittal T1 fast 2D SPGR scan (TR/TE=100/4msecs,FOV=18x18cm, matrix=256×128, Slice thickness=1.7-2.5mm, temporal resolution=15secs) obtained before and after intravenous administration of gadolinium. Time intensity curves were generated from the most enhancing region of the breast as persistent (Type 1), plateau (Type 2), or washout (Type 3) pattern enhancement[1]. All image analysis was accomplished using Eigentool software [4,5] and lesion areas were defined using ISODATA [2,3]. ISODATA tissue clusters were tested for similarity using the inner product between tissue signature vectors and classified as normal or abnormal[2]. This permitted mapping of different tissue types based on tissue signatures extracted from ISODATA. To evaluate classification accuracy for angular separation, we implemented leave-one-out cross validation (LOOCV). We started with our training set of 16 malignant and 12 benign masses. For each case in this set, we removed the case, computed angular-separation statistics (prior, mean, standard deviation) for the two classes based on the remaining 27 cases, and classified the case that we left out using these statistics. The differences in the angular separation of the benign and malignant groups were evaluated using an independent student's t-test. Statistical significance was set at $p<0.05$.

RESULTS: 28 patients (age range, 18-80 yrs; median, 51 years) were studied, 12 benign and 16 malignant tumors. Angular separation statistics using LOOCV correctly classified 16/16 malignant cases, and 8/12 benign cases, for an overall accuracy of 24/28 (86%). Malignant lesions exhibited time intensity curves in 2/16;type 3, 10/16;type 2, and 4/16;type 1 with corresponding vector characteristics of 20.7±0.80°(type 3), 16.6°±4.3°(type 2), and 15.1°±4.6°(type 1). Whereas, benign lesions had time intensity curves in 2/12;type 3, 4/12;type 2, and 6/12;type 1 with corresponding vector characteristics of 26.4±1.6°(type 3), 24.2°±7.1°(type 2), and 28.1°±10.5°(type 1). In the equivocal cases (type 2), the ISODATA correctly classified 12/14(86%). A representative MR data set from a 74-year-old patient with invasive ductal carcinoma is shown in Fig 1. The DCE analysis demonstrated a plateau type 2 that may or may not be definitive in diagnosing this type of breast tissue (Fig 2). However, the angular separation of the abnormal tissue was 19° from normal tissue (fatty tissue), whereas, glandular tissue had an angular separation of 7.1°. Overall, the angular separation for malignant lesions was 16.5°±4.1° and benign lesions 27.1°±8.3°. In addition, the angular separation between benign and malignant tumors was significantly ($p<0.002$) different.

DISCUSSION: Dynamic MR imaging of the breast has proven useful in assisting the diagnosing of breast cancer. It has been demonstrated that a washout pattern (type 3) is a strong indicator of malignancy and is independent of other criteria. The other patterns of enhancement are more associated with benign lesions and may lead to equivocal results. In this work, we demonstrate that an integrated proton MR data set using the ISODATA model can give additional information that will assist with diagnosis in breast cancer. However, larger clinical studies are needed before this technique can become routinely available.

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Fig 1. The multiparametric ISODATA theme map on a 74-year-old patient with invasive ductal carcinoma. The angular separation was 19°. The DCE curve is shown to the right.

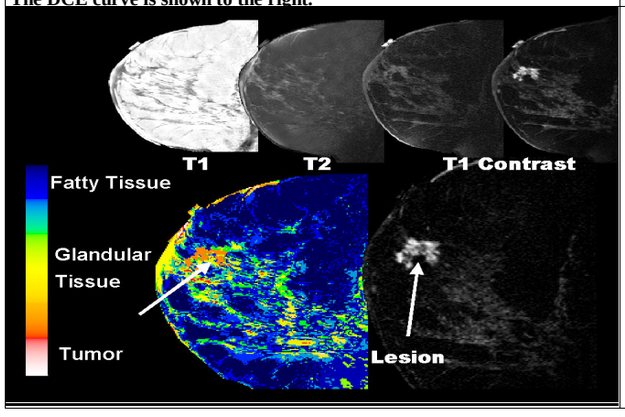

Fig 2. DCE time intensity type 2 curve from a 74 yr patient shown in Fig 1. The vertical axis is the signal intensity and the horizontal axis is image number in the temporal sequence.