Performance of Automated Contrast Kinetics and Time of Arrival Mapping for DCE-MRI in Breast: Comparison to BIRADS

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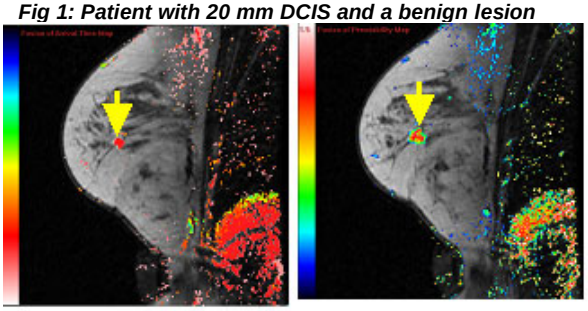
INTRODUCTION

Dynamic contrast-enhanced (DCE) MRI is showing increasing promise as a technique for non-invasive diagnosis of breast cancer as malignant lesions demonstrate an increased rate of contrast uptake and washout due to their high vascular volume and permeability [1-2]. Most of these studies show high sensitivity but reduced specificity for cancer detection and characterization. In many applications, Computer-Aided Diagnosis (CAD) has been used to improve both sensitivity and specificity of Breast MRI and X-ray mammography [3-6]. In previous work we developed a novel, fully automated algorithm [7-8] we have titled Contrast Kinetics with Arrival Time Segmentation (CKATS) that would identify and segment suspicious lesions and give functional metrics as voxel by voxel maps proportional to (i) high vascularity and (ii) high permeability – two features consistent with malignancy. The purpose of this work was to validate the performance of this algorithm in a blinded reader study of 14 patients (19 total lesions: 8 malignant and 11 benign) and show the improvement in specificity by combining these two metrics. To assess the added value of this CKATS algorithm, the results were compared to the MRI BIRADS criteria.

METHODS

Breast MRI data were acquired to assess suspicious lesions indicated by architectural distortion on X-ray mammography. For each case the following scans were performed: T1, T2, T1 fat sat, T2 fat sat, DCE and post contrast T1.The CKATS algorithm is based on three main steps: 1) automated segmentation of lesions based on common arrival time, 2) voxel by voxel mapping of contrast arrival time and uptake rate based on arrival time, 3) voxel by voxel mapping of rate constant based on Tofts model [9]. After automated segmentation, the arrival time, and the rate constant ($K_{ep} = K^{trans}/V_e$) are determined and presented as a voxel by voxel color map as shown in fig 1. The radiologist was blinded to the histopathology results before reading each case. The radiologist applied the BIRADS classification to T1 and T2 weighted anatomical images with and without fat saturation in addition to the DCE-MRI based on the following characteristics: Initial and delayed kinetic curve enhancement, shape, margins, distribution, enhancement pattern and associated findings. The results were then converted to a percentage of confidence level for malignancy based on the BIRADS assessment only. Mean arrival time and rate constant for each of the lesions identified by the radiologist was obtained. ROC plots [10] were calculated for BIRADS confidence level, mean arrival time and rate constant by using histopathology of the lesions as the gold standard. The percentage of confidence level for malignancy with BIRADS was varied to classify malignant and benign lesions to plot the ROC curve. The cut-off thresholds of the mean arrival time and rate constants were varied to obtain the ROC plots for these two metrics.

Fig 1: Patient with 20 mm DCIS and a benign lesion



(a) Arrival Time map for DCIS (medial slice)

(b) Rate constant map for a DCIS (medial slice)

(c) Arrival Time map for benign lesion (lateral slice)

(d) Rate constant map for benign lesion (lateral slice)

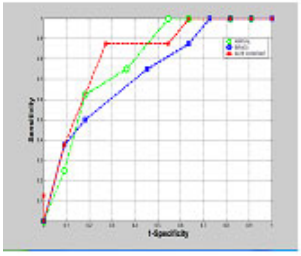


Fig 2: ROC plots of BIRADS (blue), Arrival (green), Rate constant (red)

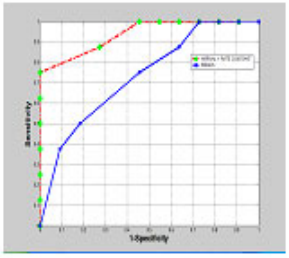


Fig 3: Comparison of combined results of Rate constant and Arrival (Red) with BIRADS (blue)

RESULTS and DISCSSION

ROC plots for the BIRADS, arrival time and rate constant are shown in fig 2. The thresholds of the two metrics were varied and combined them with equal weightage to obtain a combined ROC plot as shown in fig 3. Combining arrival time and rate constant showed a significant improvement suggestive of non-overlapping information from the two metrics thus improving the performance of the CKATS algorithm. Arrival time combined with rate constant gives information about the vascular component as well as the permeability of the lesion thus improving diagnosis.

CONCLUSIONS

Automated segmentation and functional mapping has shown improvement in specificity in this pilot study. Work is ongoing to perform this study on a larger patient group of 80 patients with architectural distortions in mammography.

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