Evaluation of Computer-Aided-Diagnosis (CAD) Software Tools for Tumor Detection using Dynamic Contrast Enhanced MRI

J. J-M. Chen[1], K. Chattrabhuti[1], D. Thomasson[1], C. Chow[1], S. Gupta[2], B. Kaufman[3], and J. Yao[1]

[1]Department of Radiology, NIH Clinical Center, Bethesda, MD, United States, [2]GE Healthcare, MD, United States, [3]Invivo, WI, United States

Introduction

Breast cancer is the second leading cause of cancer deaths in women after lung cancer. Dynamic Contrast Enhanced Magnetic Resonance Imaging (DCE-MRI) is an emerging image modality in locating, identifying, characterizing breast cancer, and has the potential for monitoring therapy [1]. Studies have shown that CAD systems may help radiologists determine the sizes and locations of cancers found on breast MRI more quickly and accurately [2]. In this work, we evaluate two such systems, a CAD software Cine Tool based on the General Kinetic Model (GKM) and the commercial DynaCAD™ workstation.

Materials and methods

We conducted our analysis on 14 patients with biopsy confirmed breast tumors (12 malignant and two benign) and 5 normal high risk patients. Bilateral DCE-MRI of the breast was performed on a 1.5 Tesla MRI system (GE Medical Systems) using a 3D SPGRE sequence ,TR 7.8 TE 4.2, 256 x 256 matrix size and 4-6 mm slice thickness. We acquired the dynamic data sets during and after injection of 0.1mmol/Kg (typically between 12 and 20cc) of gadolinium contrast at a rate of 2 cc/sec for a temporal resolution of 30 seconds.

The Cine Tool program computes two kinetic parameters for each pixel, K^{trans} and k_{ep}. The program then maps the individual parameters onto the breast MRI image using a continuous color spectrum. The DynaCAD program overlays the breast MRI with a continuous color map calculated from the wash-in and wash-out rate. The hue is calculated from the wash-out-rate, the brightness of each color is calculated from the wash-in rate [3]. Both systems highlight suspicious regions with color.

For patients with tumors, a region of interest was drawn around each tumor and a similar region of interest was drawn around normal appearing tissue in the contralateral breast. For the high risk patients, a single region of interest was drawn around a region of normal tissue. We applied approximately the same regions of interest for both CAD programs. In total, 14 tumor regions and 19 normal regions were evaluated. We then recorded the mean values for K^{trans}, k_{ep}, wash-in rate, and wash-out rate for each region and a ROC graph was produced using Excel (Microsoft).

Results and Discussion

To graphically display the results, figure 1 shows a scatter plot of the GKM parameters, k_{ep} vs. K^{trans}. Normal tissue and tumors segregate above and below specific K^{trans} and k_{ep} values. Figure 2 is a scatter plot of the DynaCAD wash-out rate vs. wash-in rate, showing that the wash-in rate may be used to distinguish between normal tissue and tumor regions. The ROC analysis is shown in Figure 3. We conducted 100 iterations of bootstrapping, which showed that with a 95% confidence interval, the areas under the curve (AUC) are [0.88, 0.94], [0.78, 0.88], [0.90, 0.95] and [0.44, 0.57] for K^{trans}, k_{ep}, wash-in rate, and wash-out rate, respectively. It shows that K^{trans} and DynaCAD's wash-in rate are the best parameters for distinguishing between tumor and normal tissue. While DynaCAD uses heuristic-based parameters, the physiological model-based GKM K^{trans} and k_{ep} further characterize the data with quantitative permeability values that may provide additional diagnostic significance.

The ROC curves of K^{trans} and wash-in rate intersect, indicating that the GKM program and DynaCAD program can complement each other. In addition, since K^{trans} and k_{ep} appear to independently distinguish between normal tissue and tumor in DCE MRI, combining the two parameters may help achieve as good or better sensitivity than DynaCAD alone with matching specificity.
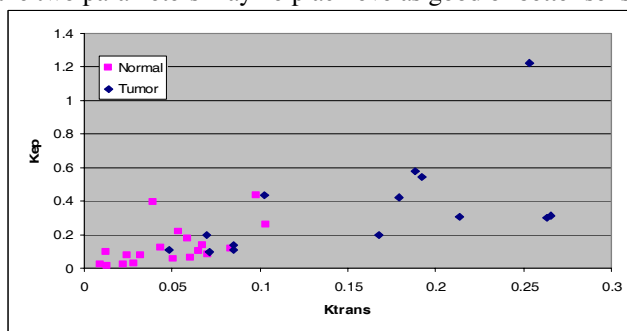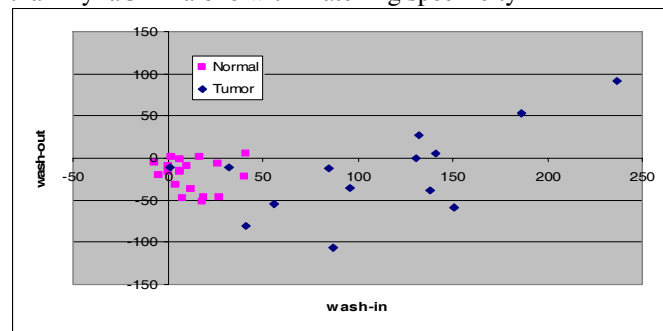

Figure 1. GKM k_{ep} vs. K^{trans}

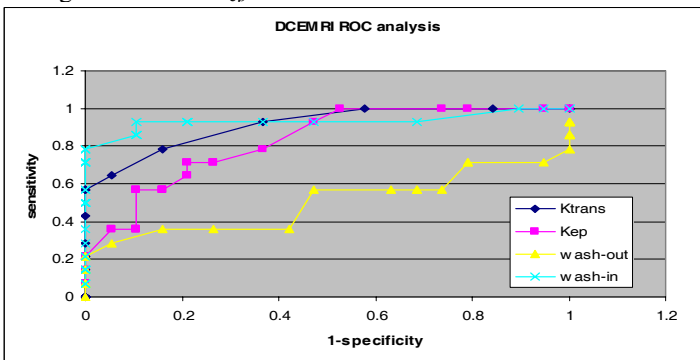Figure 2. DynaCAD wash-out rate vs. wash-in rate

Figure 3. ROC analysis of 4 parameters

References:

1. Thukral, A, Thomasson, D.M .,Chow, C.K., et. al. *Dynamic Contrast Enhanced MRI of Inflammatory Breast Cancer in Patients Receiving Bevacizumab: Initial Experience, Radiology in press.*
2. Giger, M.L. *Computer-aided Diagnosis in Diagnostic Mammography and Multimodality Breast Imaging.* in *RSNA Categorical Course in Diagnostic Radiology Physics: Advances in Breast Imaging - Physics, Technology, and Clinical Applications.* 2004. Chicago, IL. pp 205-217
3. DynaCAD manual