Correlation between Contrast Enhancement and Choline Level in Human Breast Cancer Studied by Quantitative Dynamic Contrast-Enhanced MR Imaging and Proton Chemical Shift Imaging

H-M. Baik[1], M-Y. Su[1], H. J. Yu[1], O. Nalcioglu[1]

[1]Tu & Yuen Center for Functional Onco-Imaging, University of California-Irvine, Irvine, CA, United States

Introduction

Functional MR techniques, such as dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) and proton single-voxel spectroscopy have both been used for improving the specificity in distinguishing malignant breast tumors from benign breast tumors [1]. Due to tumor heterogeneity proton chemical shift imaging (^{1}H-CSI) is a superior spectroscopic method than single-voxel spectroscopy [2], also it can cover a larger region in patients with locally advanced diseases. The purpose of this study was to investigate the correlation between contrast enhancement parameters (maximum enhancement percentage, K^{trans} and k_{ep}) measured in quantitative DCE-MRI and the Choline level measured by ^{1}H-CSI in human breast cancer.

Methods

Twenty-three patients with suspicious breast cancer were included in this MR study. The examinations were performed on a Philips Eclipse 1.5 T MR system with the dedicated bilateral breast coil. For DCE T_1-weighted MRI, a 3D SPGR (RF-FAST) pulse sequence was employed to acquire 32 axial images from both breasts, with TR= 10 ms, TE= 3.6 ms, 4 mm slice thickness, flip angle= 20°, matrix size= 256x128, FOV between 32 and 38 cm. Sixteen acquisitions were prescribed, 4 pre-contrast and 12 post-contrast. After the MR study was completed, ^{1}H-CSI was performed using a PRESS spin-echo sequence. The CSI grids were placed on the enhanced lesions obtained from DCE-MRI. The acquisition parameters were TR/TE 2000/270 ms, field of view (FOV) = 8 × 8 cm^2, 8 x 8 phase-encoding steps, and 8 acquisitions. Water suppression was accomplished with "CHESS" pulses, and lipid suppression was performed using an adjustable lipid saturation pulse. The acquired spectroscopic data were analyzed to obtain the spectrum. Within each voxel, the area of Cho peak at 3.22 ppm was measured and calculated with respect to the background noise level measured between 7.0 and 9.0 ppm as the Cho signal-to-noise ratio (SNR). For each spectroscopic voxel, the corresponding tissues in the dynamic contrast enhanced study were obtained, and the mean enhancement time course from tissues contained within that voxel was measured. The enhancement time course was then analyzed using the Tofts 2-compartmental pharmacokinetic model to derive K^{trans} and k_{ep} [3], also the enhancement percentage from the time point showing the maximum enhancement (2-3 minutes after injection) was calculated as $[(S_{max} - S_{base})/S_{base}]\times100$. In each subject, the voxels with detectable Choline peak were determined, then the enhancement kinetic parameters were correlated with Cho SNR within those voxels.

Results

Figure 1 shows a representative multi-voxel Cho metabolite map (A) and CSI grid (B) obtained from one patient with locally advanced breast cancer. In this case there were 17 voxels with detectable Choline peaks. The Cho voxel grid as shown in Fig. 1B was mapped onto the DCE-MRI images, and an enhancement kinetic curve was measured from tissues contained within each voxel. Of all 17 voxels in this case, the correlation plots between the maximum enhancement percentage and Cho SNR, and between the wash-out kinetic parameter (k_{ep}) and Cho SNR are shown in Fig.2. There was a positive correlation between the enhancement percentage with Cho SNR ($r = 0.79$, $p < 0.0001$). A higher Choline was associated with a higher contrast enhancement. The Cho SNR and k_{ep} were not significantly correlated ($r = -0.359$, $p = 0.156$), as shown in Fig. 2B. Among all 23 studied patients, 13 patients had detectable Cholne. There were a total of 107 voxels with detectable Cho. Combining all voxels from these patients, the maximum enhancement percentage was positively correlated with Cho SNR ($r = 0.601$, $p < 0.0001$), the K^{trans} was positively correlated with Cho SNR ($r = 0.531$, $p < 0.0001$), but k_{ep} was not strongly correlated with Cho SNR ($r = 0.271$, $p = 0.005$).

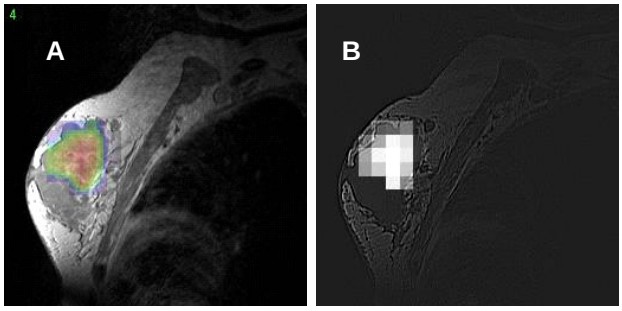

Figure 1. ^{1}H-CSI Cho map from a patient with locally advanced breast cancer. Cho metabolite map overlaid on the pre-contrast T1-weighted sagittal image (A) and Cho CSI voxel-grid (B).

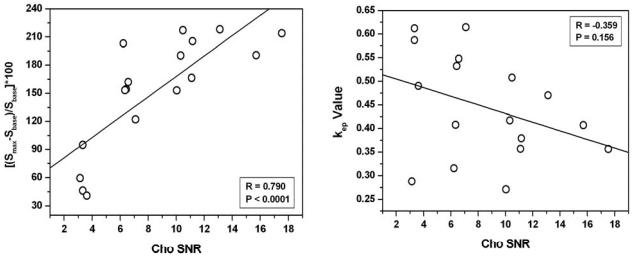

Figure 2. Correlation between maximum enhancement percentage and Cho SNR(left) and between the k_{ep} kinetic parameter and Cho SNR (right) from 17 voxels with detectable Cho peak from the patient shown in Fg.1. The maximum enhancement percentage was positively correlated with Cho level, but not k_{ep}.

Discussion

In this study a multi-voxel ^{1}H-CSI method with 1.0 × 1.0 × 1.0(or 1.5) cm resolution was applied to measure Choline map. Compared to a single-voxel spectroscopy technique it could better demonstrate the tumor heterogeneity, as shown in Fig. 1A. The Cho SNR was used for quantitative analysis. A significant correlation was found between the levels of Cho SNR and the maximum enhancement percentage and K^{trans}, indicating that in tissues with a higher Cho level there was a stronger signal increase in DCE-MRI. However, there was not a strong correlation between the wash-out parameter k_{ep} and Cho. The wash-out phase in enhancement kinetics was very important in making differential diagnosis. However it was common for a malignant tumor to show a plateau phase in enhancement kinetics than the wash-out phase. In this situation the Choline information may be used to improve the specificity. We believe that the combined DCE-MRI and high spatial resolution ^{1}H-CSI may have the potential clinical applications in breast cancer diagnosis.

References

[1]. Huang et al. Radiology 232:585-591 (2004). [2]. Jacobs et al. J Magn Reson Imaging 19(1):68-75 (2004). [3]. Tofts,. J Magn Reson Imaging 7, 91-101 (1997).

Acknowledgement This work was supported in part by NIH/NCI R01 CA90437