Improved Measurement of Choline-Containing Compounds in Malignant Breast Tumors using Multiple Long-TEs Averaging MR Spectroscopy

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

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

Introduction

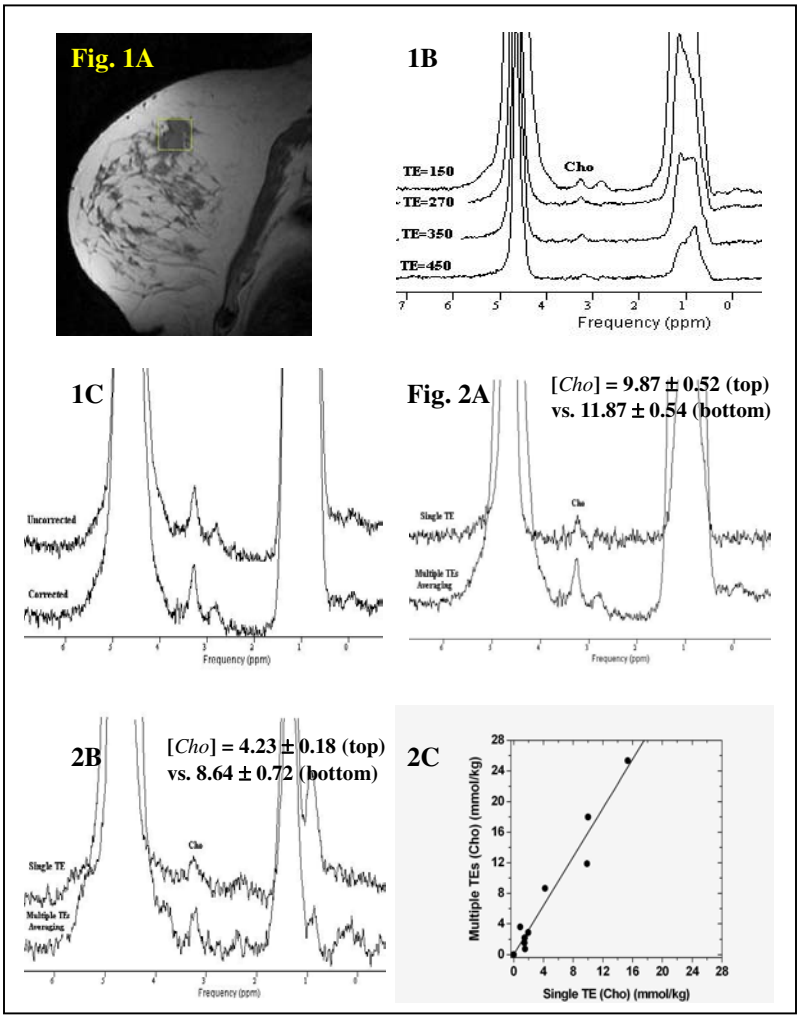
The measurement of choline-containing compounds (Cho) in the breast using a clinical 1.5T scanner is still difficult due to low sensitivity and spectral resolution compared to high field (4.0 T) [1-2]. The spectral quality is further degraded by patient's physiological respiratory motion because the respiration-induced B_0 field distortions produce frequency shifts for each spectrum during an averaging spectral acquisition. Recently, Bolan et al. [3] demonstrated that these shifts in the breast MRS reduce the ability to measure Cho concentrations. Therefore, we need to investigate the optimum data acquisition method for improving Cho measurement. In this study we applied the multiple TEs averaging method with frequency-shift correction to quantify Cho concentration in malignant breast lesions. This method has been also used to cause cancellation of *j*-coupled resonances (i.e., lipid signals) while causing constructive addition of uncoupled resonances (i.e., Cho) [4]. The measured Cho levels were compared to that measured using the standard method with a single TE obtained from the same voxel to demonstrate the feasibility of this technique for improving Cho quantification.

Methods

Ten patients with biopsy-confirmed breast cancer were included in this study. The examinations were performed on a Philips Eclipse 1.5 T MR system using the dedicated bilateral breast coil. Single-voxel ^{1}H-MRS was performed using a PRESS sequence. The spectroscopic voxel size was either 5.8 mL or 8.0 mL. After shimming procedure water suppression was accomplished with CHESS pulses, and lipid suppression was independently attenuated by using inversion recovery (STIR)-based fat signal nulling. The standard spectrum was acquired using a single TE of 270 ms, with TR= 2000 ms and 128 acquisition averages. In the multiple-TEs method, individual spectrum was subsequently obtained from separated frames using TE of 150, 270, 350, and 450 ms at the same TR of 2000 ms, and 32 averages for each TE. The total acquisition time was exactly the same. A fully relaxed, unsuppressed spectrum was acquired to measure the water peak. The phase variation was corrected retrospectively by frequency-shifting between individual spectra prior to averaging. Postprocessing consisted of zero-filling of 4096 points, Gaussian apodization of 5 Hz, Fouier transformation, and phasing and baseline correction. A narrow frequency range (0.6 ppm) was selected to fit small Cho peak without contamination from neighboring water and lipid peaks. AMARES for MRS quantitation tool was employed to analyze both the standard spectra and multiple-TEs averaging spectra obtained from the same malignant breast lesion. The absolute Cho concentration was calculated by using the fully relaxed water as an internal reference, and expressed in units of mmol/kg.

Results

Figure 1 shows the MRI and MRS measurement from a patient with a breast carcinoma. The hypointense lesion was clearly visible on pre-contrast sagittal view T_1-weighted image, and the spectroscopic voxel was carefully positioned to maximize the coverage of the hypointense lesion (A). The Cho peak around 3.20 ppm is detectable in each long-TE spectrum prior to averaging (B). Figure 1C shows an example of multiple long-TEs averaging acquisition with and without frequency correction. There is no significant difference in the measured Cho linewidth between corrected and uncorrected groups because the frequency variation was relatively small (i.e., mean Cho linewidth = 3.33 vs. 3.47 Hz). After fitting, the spectrum obtained from multiple TEs averaging demonstrated increased Cho concentration compared to that measured by a single TE (Fig. 2A and B). When plotted the Cho values measured from multiple TEs vs. single TE, in 9 of 10 cases the Cho level measured by multiple TEs was higher (mean 7.48 vs. 4.68 mmol/kg). The difference is significant at $P = 0.036$ by Paired *t*-Test, as shown in Figure 2C. However, there was a linear correlation between these two sets of measurements ($R^2 = 0.94$).



Discussion

This study demonstrated the feasibility of using the multiple long-TEs averaging ^{1}H MR spectroscopy technique for improving Cho measurement in malignant breast tumors. After frequency correction a higher Cho peak was found, and the quantitative concentration was also higher compared to the results obtained using the conventional single TE technique. The results suggest that this technique can provide a higher sensitivity for Cho detection in breast tumors. Since it can be easily implemented in most commercial scanners, it may have potential applications in improving breast cancer diagnosis accuracy and in monitoring response to neoadjuvant chemotherapy.

References [1] Huang et al. Radiology 232:585-591 (2004). [2] Bolan et al. MRM 50:1134-1143 (2003). [3] Bolan et al. MRM 52:1239-1245 (2004). [5] Hurd et al. MRM 40:343-347 (1998).

Acknowledgement This work was supported in part by NIH/NCI R01 CA90473 and CA BCRP #9WB-0020.