Feasibility of Quantitative Proton MR Spectroscopy Without Water Suppression in In Vivo Malignant Breast Lesions at 1.5T

H.-M. Baek∗

∗Advanced Imaging Research Center, UT Southwestern Medical Center, Dallas, Texas, United States

Introduction

Water suppression technique (e.g., CHESS [1]), which saturates water signal prior to data acquisition, is used as a routine in in vivo proton MR spectroscopy (1H-MRS). However, the in vivo 1H-MRS acquired with water suppression has also several disadvantages: partial suppression of other metabolite signals, magnetization transfer effects, increased total RF power deposition, increased acoustic noise by spoiler gradient pulses [2]. Therefore, in vivo 1H-MRS acquired without water suppression has increased attention in recent years. The water signal can serve as a high SNR, internal reference for calculating relative metabolite concentrations, correcting line shape distortions, and adjusting for intervoxel frequency shifts [3]. Recently, in vivo 1H-MRS acquired with water suppression has been proven helpful for the detection and therapy response monitoring of breast cancer based on total choline-containing compounds (tCho). However, the role of 1H-MRS acquired without water suppression is less established [4]. In this study, we applied in vivo 1H-MRS without and with water suppression for quantifying the tCho peak in malignant breast tumors, and investigated the association between them. The aim of our study was to determine whether quantitative results from the breast cancer can show good agreement between the estimated tCho levels in water-suppressed and unsuppressed spectra.

Methods

Nineteen patients with invasive ductal carcinoma were included in this study. The inclusion criteria were patients with biopsy-conformed of diagnosis of malignant lesions that measured 1.9 cm or larger on MR images. The MRI/MRS study was performed using a 1.5 T MR scanner with a standard bilateral breast coil (Philips Medical Systems, Cleveland, Ohio). Single-voxel 1H-MRS was performed using a point-resolved spin-echo sequence (PRESS). The spectroscopic voxel size was from 3.4 to 8.0 ml. (1.5-2 cm cubic voxel). The acquisition parameters were TR/TE=2000/270 ms, and acquisition averages of 128. Water-unsuppressed spectra were also acquired to measure tCho signals (32 averages). We quantified tCho peak amplitude and signal to noise ratio by fitting a voigt-linehape model to the data. Metabolite basis set signals (e.g., tCho and H2O) were simulated in SIMULATION in jMRUI software (e.g., S = S0 × exp(-ατ) × exp(i(2πft+φ0)) and quantified with QUEST [5]. The Cramer-Rao lower bounds (CRLB) were used as a measure of fitting accuracy. Uncertainty in the tCho concentration was presented as the standard deviation. For absolute quantification, the amplitude of the tCho metabolite estimated by the QUEST was converted to concentrations (mmol/kg) using water as an internal standard. The tCho concentration was calculated using measured T1 and T2 values for intensity correction [6].

Results

Figure 1 shows a representative MRI and MRS measurement from a patient with carcinoma. MR spectroscopic voxel is superimposed on the hypointense lesion (A) and on the enhanced axial subtraction image (B). The tCho peak at 3.22 ppm is clearly visible in the 1H-MRS acquired without (C, top panel) and with water-fat suppression (D, top panel). For an accurate tCho quantitation, in this study water (range, 4.0 – 6.0 ppm) and fat (0.0 – 2.6 ppm) components of the signals were removed in a preprocessing step using HLSVD filter (Fig 1C and D, bottom panel). The voigt model fitting of the tCho peak produces a measurement of SNR (20.8 vs. 30.4 AU) and tCho concentration levels (5.33 vs. 3.19 mmol/kg) in the water-unsuppressed and suppressed spectra, respectively. As shown in Figure 2, tCho area SNR was significantly lower in water-suppressed spectra than in water-suppressed spectra (11.2 vs. 32.5, p = 0.0001) because of 4 times less data acquisition averages. However, no significant difference were observed in the absolute concentration levels (2.27 vs. 2.82 mmol/kg, p = 0.378). The measured tCho level in 19 water-unsuppressed spectra were from 0.09 – 5.86 mmol/kg (mean ± SD, 2.27 ± 1.96 mmol/kg), consistent with the previously published value (e.g., 0.09 –10.0 mmol/kg). The CRLB for QUEST spectral fits were less than 25% for the tCho peaks (Figure 3). A significant linear correlation was found between the tCho levels obtained from the water-unsuppressed and suppressed spectra (r² = 0.462, p =0.001 in Figure 4).

Discussion

In vivo quantification of tCho in breast tumors by 1H-MRS is of great interest because the elevated tCho level has been linked to malignancy. The present study investigated the QUEST method with simulated basis set for accurate spectral fitting of in vivo water-unsuppressed breast cancer spectra. To fit small tCho peaks without bias from neighboring water and lipid resonances, the dominant water and lipids signals in the spectrum were removed. Soft constraints were also imposed for a faster and more accurate quantitation during spectral fitting. The frequency constraint range was restricted to 0.1 ppm (e.g., 3.18 – 3.28 ppm). The voigt model performed reasonably well in our water-unsuppressed spectra, and showed small deviations in fitting errors (Fig. 3). The large range in tCho levels (0.09 – 5.86 mmol/kg) may reflect the intrinsic heterogeneous nature of breast lesions. There was a statistically significant correlation between the estimated tCho concentration levels by 1H-MRS with and without water suppression (r² = 0.462, p = 0.001). This result demonstrates the feasibility of in vivo quantitative 1H-MRS without water suppression for the measurement of tCho concentrations from in vivo malignant breast lesions.

References


Acknowledgement

This study was supported in part by NIH/NCI No. CA90437, CA127927, and the California BCRP No. 9WB-0020 and No. 12FB-003.