

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

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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 with and without 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-confirmed 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-lineshape model to the data. Metabolite basis set signals (e.g., tCho and H₂O) were simulated in SIMULATION in jMRUI software (e.g., $S = S_0 \times \exp(-\alpha t - \beta t^2) \times \exp(i(2\pi ft + \phi_0))$) 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-unsuppressed 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 \pm 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 ($r^2 = 0.462$, $p = 0.001$ in Figure 4).

Discussion

In vivo quantification of tCho in breast tumors by ¹H-MRS is 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 ($r^2 = 0.462$, $p = 0.001$). 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

- [1]. Doddrell et al., J Magn Reson 1986;70:176-180.
- [2]. David et al., Concepts Magn Reson 2001;13:260-275.
- [3]. Spielman et al., Magn Reson Med 1989;12:38-49.
- [4]. Kumar et al., J Magn Reson Imaging 2006;24:325-332.
- [5]. Ratiney et al., NMR Biomed 2005;18:1-13.
- [6]. Baek et al., Magn Reson Imaging 2008;26: 523-531.

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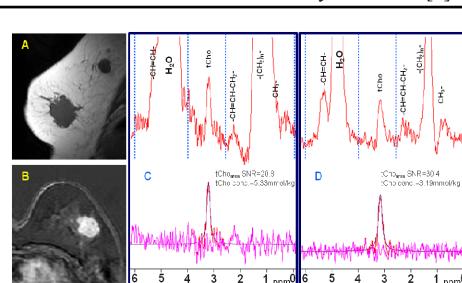


Figure 1. MRI and MRS study of a patient with IDC

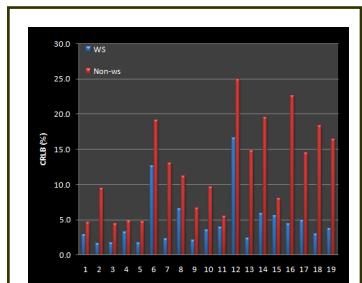


Figure 3. CRLB (%) for QUEST fits

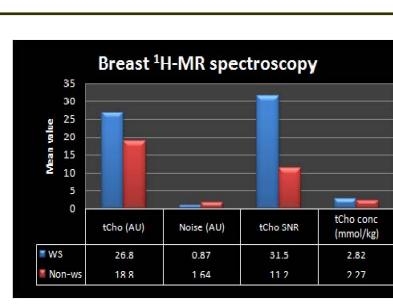


Figure 2. MRS results with and without WS

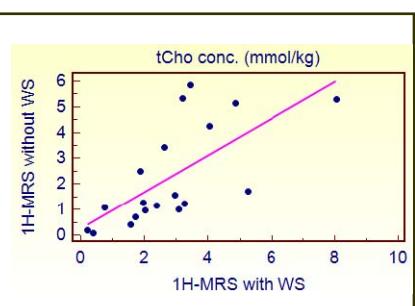


Figure 4. tCho correlation: WS vs. Non-WS