Quantitative Proton Single-Voxel MR Spectroscopy in Malignant Breast Tumors at 3T: a Preliminary Study

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Introduction

In vivo proton MR spectroscopy (^{1}H-MRS) has been shown to improve cancer diagnosis based on elevated choline-containing compounds (tCho). However, despite the improved specificity, previous breast ^{1}H-MRS studies at 1.5T have also shown a variable sensitivity (67% - 92%) from study to study [1]. Tumor size and histological type are two main issues affecting the tCho measurements. One approach is to use the scanner at a higher magnetic field, but it may suffer from a worse field inhomogeneity problem. No large cohort study has been reported from 3T yet. In this study, *in vivo* quantification of tCho signal from the malignant breast tumors at 3T was carried out with the AMARES method [2] using a prior knowledge. The Cramer-Rao lower bound (CRLB) was used as a measure of fitting accuracy. The uncertainty in the estimated tCho level was the standard deviation (SD) of the tCho signal amplitude as estimated using the CRLB.

Methods

Ten patients with breast cancer were included in this MR study. The examinations were performed on a Philips Achieva 3T MR system with the dedicated bilateral breast coil. After dynamic contrast-enhanced MRI study was completed, single-voxel MRS was performed using a standard PRESS sequence. The spectroscopic voxel was carefully positioned to maximize coverage of the contrast-enhanced lesions and minimize the inclusion of adipose tissue. After shimming procedure water suppression was accomplished with a selective excitation (CHESS pulses), and lipid suppression was achieved by using frequency-selective lipid suppression. The acquisition parameters were TR/TE = 2500/120 ms, and acquisition averages of 128. A fully relaxed, unsuppressed spectrum was also acquired to measure the water peak (16 averages). The absolute tCho concentration in malignant breast tumors was calculated and was expressed as a concentration in units of mmol/kg. The used T_2 relaxation times were 269 ms for tCho, and 97 ms for water. The T_1 relaxation times were 1513 ms for tCho, and 746 ms for water [3].

Results

12 MR spectra were acquired from 10 patients with biopsy-confirmed breast cancer. In all patients, the median size of these tumors was 3.3 cm (range 2.5 – 8.5 cm) measured as the largest dimension of the breast lesions in the axial subtraction images. The spectroscopic voxel size was a range of 2.7 - 8.0 mL. A mean tCho resonance was detected at 3.23 (range; 3.17 – 3.26) ppm in the 12 breast spectra. The fitted tCho peak had Gaussian linewidth of 9.1 Hz and 21Hz, and the fitted water peak had a Lorentzian linewidth of 13 Hz and 26 Hz at 3T. The absolute tCho levels in this work were a range of 0.19 – 3.05 mmol/kg in 12 malignant breast spectra. Figure 1 and 2 provide examples of MR and MRS measurement using 3.0T. The spectroscopic voxel was carefully positioned to maximize the coverage of the hypointense lesion on the centered sagittal image (Fig. 1A and Fig. 2A). The tCho peak at 3.23 ppm is clearly visible in the water-fat suppressed spectrum (Fig. 1B and Fig. 2B).

Discussion

The quantification of tCho in breast tumors by ^{1}H-MRS is great interest because such compounds have been linked to malignancy. In this study, an internal reference method for the absolute quantification of tCho metabolite in malignant breast tumors at 3T was demonstrated. After T_1 and T_2 relaxation times were corrected, the tCho levels in this work had a range of 0.19 – 3.05 mmol/kg from 12 MR spectra of ten patients with malignant breast lesions. This result was consistent with previously published values by Bolan et al. [4] and Baek et al. [5]. 2 (17%) of 12 lesions showed that the CRLB exceeded the estimate. Therefore, we conclude that the internal method using the fully relaxed water as a reference could be used for quantifying tCho metabolite accurately in breast cancer patients using a 3T scanner.

References

[1]. Jacobs et al., JMRI 19:68-75 (2006). [2]. Vanhamme L et al., JMR 129:35-43 (1997). [3]. Baek et al., MAGMA 19:96-104 (2006). [4]. Bolan et al., Magn Reson Med 50: 1134-1143 (2003). [5]. Baek et al., MRI 26:523-531 (2008).

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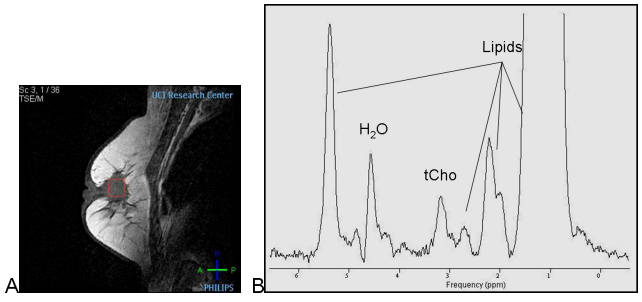

Figure 1 shows the MR and MRS measurement of a patient with invasive ductal carcinoma. **A:** On pre-contrast images one lesion showed very dark intensity signal with irregular shape in a centered sagittal slice. The spectroscopic voxel (size, 1.6 × 1.6 × 1.6 cm^3) is superimposed on the hypointense lesion in the pre-contrast sagittal image. **B:** The MR spectrum was measured from the selected lesion. The tCho peak at 3.23 ppm is clearly visible in the water-fat suppressed spectrum. The Gaussian model fitting of the tCho peak produces a measurement of [*tCho*] = 0.99 ± 0.35 mmol/kg.

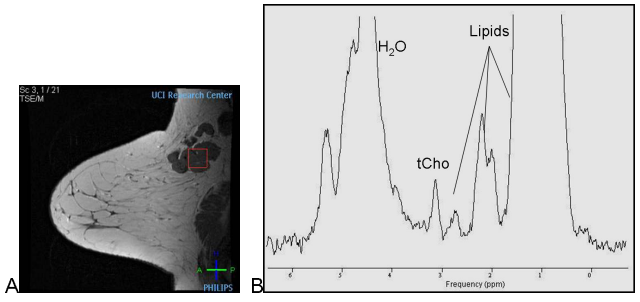

Figure 2 shows the MR and MRS measurement of a patient with multiple enlarged and partially clumped lymph nodes. **A:** On pre-contrast images multiple lymph nodes showed very dark intensity signal in left axillary and intra-mammary. The spectroscopic voxel (size, 1.8 × 1.6 × 1.8 cm^3) is superimposed on the lesion in the pre-contrast sagittal image. **B:** The MR spectrum was measured from the selected lesion. The tCho peak at 3.23 ppm is clearly visible in the water-fat suppressed spectrum. The Gaussian model fitting of the tCho peak produces a measurement of [*tCho*] = 0.82 ± 0.26 mmol/kg.