Diagnostic Value of Breast Proton Magnetic Resonance Spectroscopy at 1.5T in Different Histological Types

H-M. Baek[1,2], J-H. Chen[2,3], O. Nalcioglu[2], and M-Y. Su[2]

[1]Department of Radiology, UT Southwestern Medical Center, Dallas, TX, United States, [2]Center for Function Onco-Imaging, University of California-Irvine, Irvine, CA, United States, [3]Department of Radiology, China Medical University Hospital, Taichung 404, Taiwan

Introduction:

The diagnostic value of breast ^{1}H MR spectroscopy is typically based on the detection of elevated level of choline-containing compounds (tCho), which is a marker of active tumor [1]. However, previous breast ^{1}H-MRS studies at 1.5T have shown a variable sensitivity (67% - 92%) from study to study [2]. Tumor size and type are two main issues affecting the tCho measurements. In this study we investigated the impact of these two factors on diagnostic performance of breast ^{1}H-MRS, with histological findings as the reference standard. The performance in different tumor size groups, and between invasive cancer (IDC, ILC, mixed type), DCIS, and benign lesions were evaluated.

Methods:

105 patients with breast tumors (e.g., 99 malignant tumors and 6 benign tumors) 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. After the MR study was completed, single-voxel MRS was performed using a PRESS sequence. The spectroscopic voxel size was from 3.4 to 8.0 mL (1.5-2 cm cubic voxel). After shimming procedure, water suppression was accomplished with "CHESS" pulses, and lipid suppression was achieved by using frequency-selective lipid suppression. The acquisition parameters were TR/TE 2000/270 ms, and acquisition averages of 128. A fully relaxed, unsuppressed spectrum was also acquired to measure the water peak (24 averages). The MR spectrum was further analyzed with great care by one spectroscopist when a tCho peak could be clearly identifiable above the baseline noise (i.e., signal to noise ratio > 2). We quantified the absolute tCho levels by fitting a Gaussian line-shape model to the data and using the unsuppressed water signal as an internal reference [3]. The Cramer-Rao lower bounds (CRLB) for tCho quantification were calculated, which is an estimate of the uncertainty in the peak amplitude determined by AMARES. A radiologist determined the size measurement based on the maximum intensity projection (MIP) of the subtraction images. The longest dimension and the longest perpendicular dimension of the MIP were measured. The equivalent one dimensional tumor size was calculated by taking square root of their product [4]. The malignant lesions were divided into three size groups as 1.0-1.9 cm (Group-I), 2.0-2.9 cm (Group-II), and 3.0 cm or above (Group-III).

Results:

The spectroscopic voxel was carefully positioned to maximize the coverage of the hypointense lesion on the pre-contrast images (Fig. 1; up). The tCho peak at 3.22 ppm is clearly visible in the water-fat suppressed spectrum (Fig. 1; down). The measured tCho level in 65 true positive lesions were from 0.08 – 9.99 (mean ± SD, 2.7 ± 2.3 mmol/kg), consistent with the previously published value (e.g., 1.38 – 10 mmol/kg) by Bolan et al [5]. The mean size of 99 malignant tumors was 2.9 cm (range 1.1 – 8.6 cm). The sensitivity increased from 46% (Group-1, 1.0-1.9 cm), to 70% (Group-2, 2.0-2.9 cm), to 82% (Group-3, 3.0 cm & above), in a statistically significant manner ($P < 0.0001$, two-sided exact Kruskal-Wallis test). Table 1 presents the sensitivity of ^{1}H-MRS in different histopathological lesion groups. The sensitivity was higher in invasive carcinomas (71%) than in ductal carcinoma in situ (27%) ($P < 0.03$). Of the 6 benign lesions, MRS detected one as false positive. The mean tCho level was higher in invasive cancer (2.65 mmol/kg) than in DCIS (1.57 mmol/kg), and that of the false positive benign lesion was 0.66 mmol/kg.

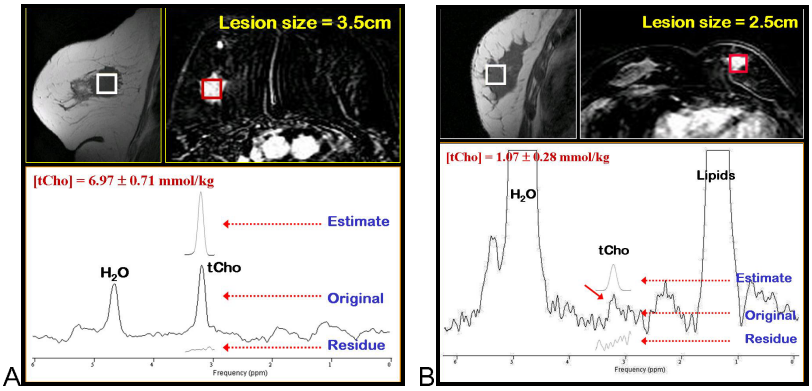

Figure 1 shows the MRI and MRS measurements in a patient with invasive ductal carcinoma (A) and a patient with ductal carcinoma in situ (B): (up) Sagittal view pre-contrast and enhanced axial image and (down) Elevated tCho level measured from the selected voxel.

Table 1. Sensitivity of breast ^{1}H MR spectroscopy in different histological types

Histological types	No. of true positives	No. of false negatives	Sensitivity	Mean tCho (mmol/kg)
Invasive carcinoma	62	26	71%	2.65
IDC	49	17	74%	2.49
ILC	5	5	50%	2.70
Mixed Type	8	4	67%	3.92
DCIS	3	8	27%	1.57
Benign	1(false +)	5(true -)		0.66

IDC=invasive ductal cancer, ILC=invasive lobular cancer, DCIS=ductal carcinoma in situ.

Discussion:

We investigated the impact of malignant lesion size and type on the sensitivity of ^{1}H-MRS. The sensitivity was higher in larger lesions compared to smaller lesions. More than half of lesions smaller than 2.0 cm (54%) had false-negative diagnosis, because of the lack of a detectable tCho signal. When a smaller size was chosen (<1.5 cm), the sensitivity was further decreased (29%, 4/14). Therefore, further improvement in the signal-to-noise ratio (SNR) may enhance the detection of tCho and improve the diagnostic sensitivity. 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 or higher yet (7T). We have also shown that the sensitivity of breast ^{1}H-MRS was dependent on the lesion type (between benign, DCIS, and invasive cancer). The tCho levels were found to be higher in invasive cancer compared to DCIS, possibly associated with more aggressive behavior or faster cell replication in invasive cancer. The sensitivity was higher in IDC compared to ILC, which was possibly related to the infiltrating phenotype of ILC thus more susceptible to the fat contamination problem.

References: [1]. Negendank et al. NMR Biomed 5:303-324 (1992). [2]. Jacobs et al., JMRI 19:68-75 (2006). [3]. Baek et al., MAGMA 19:96-104 (2006). [4]. Saito et al. Radiat Med 25:339-345 (2007). [5]. Bolan et al., Magn Reson Med 50: 1134-1143 (2003).

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