Robust quantification of choline compounds in the breast at 1.5T using prior knowledge and optimized detection methods

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Introduction:

Proton MRS to determine choline compounds has the potential to improve specificity in breast cancer diagnosis. However, as the choline signal (~3.2 ppm) has to be detected in the presence of dominating lipid and water signals, artefacts can interfere with this signal, which can lead to wrong choline assessments. Moreover, since the choline signal amplitude depends on various factors such as shim quality and coil sensitivity, proper quantification is essential. Recently, a method was presented addressing both problems on a 4T system by eliminating lipid artefacts using echo-time (TE) averaging and by the absolute quantification of choline compounds using the water signal as an internal standard [1]. At 1.5 T, still the major clinical field strength, the assessment of choline is more difficult due to lower sensitivity and spectral resolution.

Here, we present a method to improve the quantitative assessment of choline compounds in the breast at 1.5T, including localised acquisition with TE averaging, but in combination with MEGA signal suppression. In addition a water signal is acquired at long TR and short TE as an internal reference for absolute quantification and prior knowledge to fit the choline signal.

Methods:

Examinations were performed on a 1.5T MR system (Siemens, D) equipped with an open breast coil (Machnet, NL). In total, 20 patients participated in this study, of which 12 had proven malignancy. A contrast enhanced MRI was performed to locate the region for localised MRS. A PRESS sequence with TE averaging was used with MEGA [2] water and lipid suppression. For accurate localisation, numerically optimized MAO pulses were used. The pulses for MEGA water and lipid suppression were located around the final refocusing pulse of the PRESS sequence, with a Shinar le Roux optimized frequency profile as indicated in figure 1. The echo time (TE) was varied from 120ms to 270ms in 64 steps. Each step was averaged 4 times with phase cycling. The repetition time (TR) was set to 1.5s for high SNR per unit of time. For proper prior knowledge of the phase, frequency and linewidth parameters, the sequence was repeated with only two steps in the TE changes with the RF power of the MEGA pulses set to zero. An additional waterfile is acquired for quantification using a PRESS of two averages at a TE of 20ms and a TR of 5s. All fits are performed with MRUI, and quantified in unit of mM/kg with standard deviations (SD) based on Cramer-Rao lower bounds, using the formula as described in reference 1, with the T2 and T1 values for 1.5T [3].

Results:

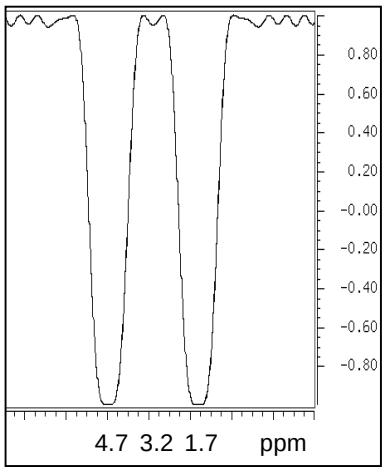

Figure 1: Frequency profile of the MEGA pulse

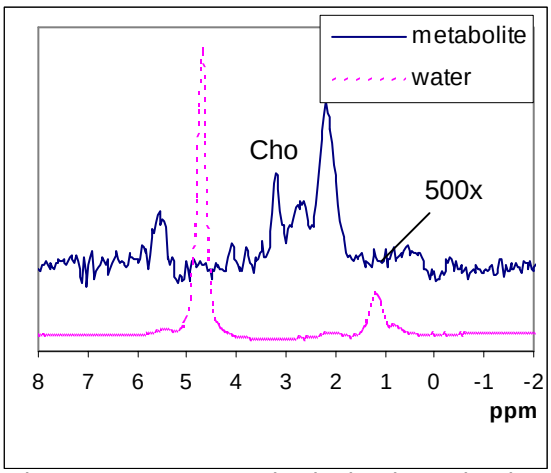

Figure 2: MR spectrum clearly showing a signal for choline. Note the efficient lipid and water suppression.

tCho [mM/kg]	SD [mM/kg]	water (a.u.)	shim (Hz)	
9.98	1.72	26.7	12	malignant
6.66	4.09	3.6	11	malignant
3.61	0.63	22.8	12	malignant
2.89	8.07	12.9	14	malignant
2.63	1.64	10.5	11	malignant
1.37	2.01	7.4	11	malignant
0.68	3.58	6.2	13	malignant
0.68	0.80	14.9	10	malignant
0.00	1.47	16.3	14	malignant
0.00	4.23	10.6	13	malignant
0.00	6.21	13.9	15	malignant
0.00	7.64	5.2	18	malignant
0.94	0.67	21.0	16	benign
0.00	2.61	4.4	16	benign
0.00	4.68	9.6	14	benign
1.26	236.08	6.1	11	birads2
0.54	0.31	22.8	7	birads2
0.00	0.29	29.9	9	birads2
0.00	2.44	15.3	13	birads2
0.00	7.06	2.1	14	birads2

Table 1: Quantified results after fits of all 20 patients.

Figure 2 shows a typical MR spectrum of the breast with a choline signal. Although the intrinsic lipid signal within the selected voxel was about 500 times higher than the choline signal, the residual lipid signal in the final spectrum is low. The absolute choline levels determined by this approach (table 1) are in the same range as published previously [1]. Standard deviations differ substantially between patients, which depend on the size of the tumor.

Discussion/conclusion:

A user independent method for absolute quantification of choline compounds in breast lesions at 1.5T is demonstrated. The combination of TE averaging with MEGA water and lipid suppression leads to non-distorted MR spectra. These spectra can be used for robust fitting using prior knowledge from the corresponding water signal. As the practical line width of choline is much broader than expected from its long T2 value[1], it is mainly determined by the shim quality in the breast and therefore properties of the water signal can be used as prior knowledge. The current data suggest that this technique employed at 1.5T could be used to diagnose suspicious breast lesions.

Reference:
[1] Bolan et al. MRM50 :1134(2003)
[2] Mescher et al. NMR Biomed. 11:266(1998)
[3] Bakken et al. MRM46:189(2001)