Optimization of PRESS-localized metabolite measurements in the frontal lobes in vivo at 3T

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Introduction

PRESS localization with an echo time of 80 ms has been suggested to be advantageous for the estimation of glutamate (otherwise obscured by glutamine and macromolecules) at 3T in vivo (1), but few systematic comparisons have been performed with data acquired at shorter echo times.

Methods

Six normal volunteers were studied using a 3T GE scanner and an 8-channel receive head coil. PRESS-localized spectra from a 12cc volume in the right frontal lobe were acquired with a TR of 3s and a TE of both 30ms and 80ms. At each TE 64 averages were acquired with CHESS water suppression applied and 16 without. Spectra were analyzed using LCModel 5.2-1 (referred to as v5) and 6.1-4 (v6). Ratios to creatine (Cr) were calculated, along with concentrations scaled to the internal water peak -- the latter also allowed correction for the CSF content of the voxel, determined by segmenting a 3D T1-weighted volume using SPM 2 (Wellcome Dept. of Imaging Neuroscience, UCL, London). The coefficients of variation (CoV) of metabolite estimates among the control group were compared between the 2 echo times and the analytical methods used.

Results and Discussion

Good spectral quality was consistently obtained from this location, with signal to noise ratio (SNR) around 20 (Fig 1).

Scaling relative to the internal water peak, rather than to Cr, gave more consistent results for all metabolites except myo-inositol (Ins; Table 1), perhaps because water varies less between grey and white matter than creatine does. Scaling to either water or creatine was found to be necessary without effective B1 correction at 3T (data not shown). Water-scaled concentrations were however quite high (Table 2), probably due to the MR-invisible water pool in the tissue.

LCModel v6 generally performed better than v5, with the greatest difference seen for Glx, the combined peak of glutamine plus glutamate. Although the inclusion in the model of macromolecule peaks (especially at 2.0 ppm) might interfere with the reliable determination of glutamate (Glu) and glutamine (Gln), it appears to have been better than the C-spline fit to the baseline implemented in v5. Yet better results might be obtained with metabolite nulling or other techniques to eliminate the broad baseline signal.

Contrary to expectation, TE 80ms gave lower variability than TE 30ms for tNA (total N-acetylaspartate (NAA) plus N-acetyl-aspartylglutamate (NAAG)), Cr, and choline-containing compounds (Cho), probably due to the flatter baseline obtained. However, TE 30ms showed lower variability than 80ms for Glu, particularly when water scaling was used (Table 1). Water scaling in version 6 of LCModel also gave the best results for Glx. TE80 was not investigated for Glx, since the Gln component is largely dephased at this echo time. Myo-inositol also suffered significant signal loss at TE 80, as confirmed by its uniformly higher CoV than at 30ms.

This study had severe limitations: subject numbers were small, and the criterion of minimizing CoV is not necessarily a valid one. For example, the underlying macromolecule signal at TE 30ms might allow a more reproducible estimate of Glu that was nevertheless inaccurate. Additionally, the concentrations of Glu and Cr in particular would be expected to vary since the fraction of grey matter in the voxel varied widely, from 35 to 57%, and we and others have shown a strong tissue content dependence for these metabolites (2). In the current study we found a stronger relation between Glu and grey matter fraction at TE 80ms ($R^2 = 0.34$) than at TE 30ms ($R^2 = 0.21$).

Conclusion

From this limited study, the use of water-scaling in LCModel 6 to analyze spectra at TE 80 appears to give the most reliable results for NAA, Cr and Cho. The variability of glutamate remains high, but further study is needed to determine whether this is due to measurement error or genuine physiological variations. Work is ongoing with repeated measures, which suggests similar repeatability for Glu estimation at the 2 echo times.

Table 1: Coefficient of variation (%) of metabolite estimates in control frontal lobe at TE 30 and 80 ms, using LCModel version 5.2 (v5) and 6.1 (v6). Ratios to creatine (/Cr) and water-scaled estimates (/water) are shown, the latter normalized to 100% brain tissue content of the voxel (i.e. corrected for CSF). * indicates lowest CoV.

	v5 /Cr		**v6 /Cr**		**v6 /water**	
TE:	**30**	**80**	**30**	**80**	**30**	**80**
tNA	10.2	7.8	7.6	6.3	7.6	***2.9**
Cr	---	---	---	---	8.0	***6.9**
Cho	19.3	13.1	16.6	13.3	14.0	***9.6**
Ins	10.7	13.1	***7.5**	12.2	8.5	10.7
Glu	17.4	15.7	14.2	17.5	***11.9**	21.8
Glx	28.9	---	18.4	---	***11.4**	---

Table 2: Metabolite concentrations (mean ± SD, %CoV) estimated using LCModel 6.1 with water-scaling, corrected for CSF.

	TE 30	**TE 80**
tNA	11.4 ± 0.9, 8	18.6 ± 0.5, 3
Cr	6.6 ± 0.5, 8	11.5 ± 0.8, 7
Cho	1.8 ± 0.3, 14	3.3 ± 0.3, 10
Ins	5.0 ± 0.4, 8	12.4 ± 1.3, 11
Glu	7.4 ± 0.9, 12	17.5 ± 3.8, 22
Glx	8.1 ± 0.9, 11	---

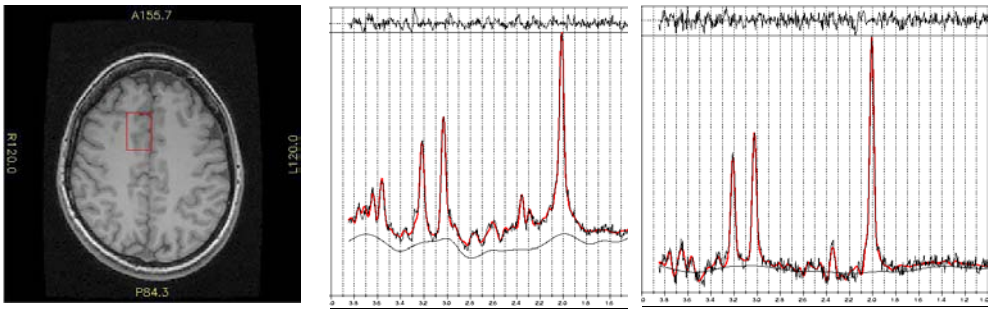

Figure 1: (Left to right) Example frontal voxel studied; fitted spectrum in LCModel 5.2 at TE 30ms; fit at TE 80ms.

References

1)Schubert F et al, Neuroimage 2004; 21:1762-1771.

2) McLean MA et al, Magn. Reson. Med. 2000;44:401-411.