Glutamate Mapping at 3 and 4 Tesla in Human Brain using Short TE Proton Echo Planar Spectroscopic Imaging

S. Posse[1], R. Otazo[2], A. Caprihan[2], J. Xu[2], T. Li[2], C. Gasparovic[2], D. Holten[2], J. R. Alger[3], B. Mueller[4], K. O. Lim[5], K. Ugurbil[6]

[1]Psychiatry, University of New Mexico, Albuquerque, NM, United States, [2]MIND Institute, University of New Mexico, Albuquerque, New Mexico, United States, [3]Radiology, University of California, Los Angeles, California, United States, [4]Psychiatry, University of Minnesota - Center for Magnetic Resonance Research, Minneapolis, MN, United States, [5]Psychiatry, Center for Magnetic Resonance, Minneapolis, MN, United States, [6]Radiology, Center for Magnetic Resonance, Minneapolis, MN, United States

Introduction:

Mapping multiplet resonances, such as glutamate, is of considerable clinical interest. Measurement of glutamate in cortical regions is challenging, necessitating excellent suppression of peripheral lipids. To this end we developed short TE Proton-Echo-Planar-Spectroscopic-Imaging (*PEPSI*) [1] with 8-slice outer volume suppression and demonstrate the feasibility of mapping glutamate and myo-inositol at high field (3 and 4 Tesla).

Methods:

Measurements were performed on healthy volunteers using a 3 T Siemens Trio scanner and a 4 Tesla Bruker MedSpec scanner, equipped with quadrature head coils and 8-channel surface array coils. PEPSI data were acquired from a para-axial slice at the upper edge of the ventricles with TR 2 s and short TE (12-14 ms), using 32x32 spatial matrix, minimum pixel size of 6 mm and 8-step phase cycle. Complete 8-slice outer volume suppression was applied along the perimeter of the brain (fig.1). Saturation pulse flip angles were optimized to minimize lipid contamination. Data at 4 Tesla were acquired with ramp sampling correction and larger spectral width (1.18 kHz as compared to 0.92 kHz at 3 Tesla). Even- and odd-echo data were reconstructed separately using a water reference scan for automatic phasing and frequency shift correction as described previously [1]. Spectra were quantified using LCModel fitting [2]. Absorption mode spectra from individual array coils were summed. Metabolic images were computed using relative concentration values from LCModel. Cramer-Rao lower bounds were mapped to assess regional differences in quality of fit.

Results:

High quality spectra were obtained from central and peripheral regions of the selected volume (fig.1). Lipid contamination at 3 Tesla was minimal, even in peripheral regions (Figs.1). Similar results were obtained at 4 Tesla (Figs.2), but with better spectral resolution, higher sensitivity and smaller Cramer-Rao lower bounds. Metabolite maps display relatively uniform concentrations and decreased quality of fit in the fontal lobe (Fig.3 and 4).

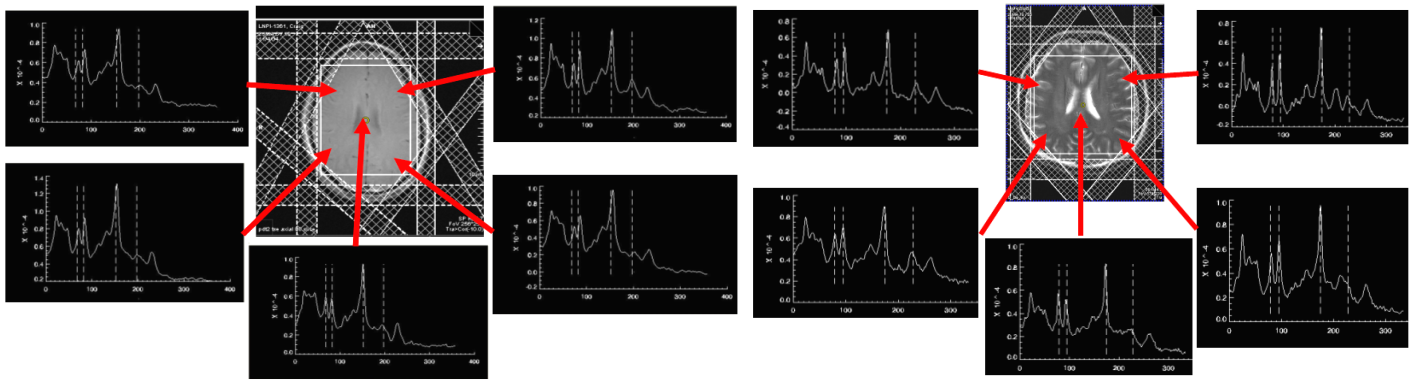

Fig.1 (left): TE 12 ms metabolite mapping at 3 Tesla (2 cm slice, 1 cm in-plane resolution, 16 minutes acquisition time, CP coil). Cramer-Rao lower bounds: NAA - 5%, Cr - 5%, Cho - 6%, Glu - 9%, myo-Ins - 13%. **Fig.2** (right): TE 14 ms metabolite mapping at 3 Tesla (1.5 cm slice, 1 cm in-plane resolution, 8 minutes acquisition time, CP coil). Cramer-Rao lower bounds: NAA - 3%, Cr - 5%, Cho - 5%, Glu - 9%, Ins - 11%

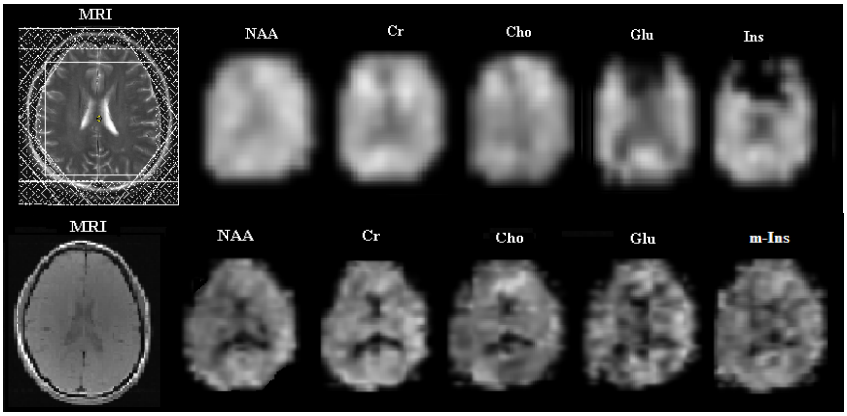

Fig.3: Metabolite images corresponding to the data shown in Fig.2. The fitting of multiplet resonances in frontal cortex is impaired due to susceptibility related line broadening.

Fig.4: High spatial resolution metabolite images at 3 Tesla using the 8-channel array coil (TE: 12 ms, 1 cm slice, 6 mm in-plane resolution, 16 minutes acquisition time). Cramer-Rao lower bounds: NAA - 8%, Cr - 7%, Cho - 11%, Glu - 16%, myo-Ins - 18%

Discussion:

These data show feasibility of whole-slice mapping of glutamate and myo-inositol with high-speed spectroscopic imaging at 3 and 4 Tesla. Sensitivity at 4 Tesla was higher than at 3 Tesla, but slightly increased contamination from peripheral lipids due to B1-inhomogeneity was noted. Further improvements in data quality and water suppression are expected by correcting frequency drifts due to shim heating, by improved spectral LCModel fitting using basis sets that include macromolecules, and by using outer volume suppression with reduced improved B1-sensitivity. 3D spatial encoding is being tested. Further studies are necessary to characterize spatial resolution limits, minimum feasible TE and test-retest reliability.

Literature: (1) Posse, S., Magnetic Resonance in Medicine, 33, 34-40, 1995 (2) Provencher, S., Magn Reson Med 30:672-679, 1993.

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