Reproducibility Study of Whole-Brain Spectroscopic Imaging with Automated Quantification

M. Gu[1], D. Mayer[1], E. Sullivan[2], A. Pefeeferbaum[2], and D. Spielman[1]

[1]Radiology, Stanford University, Stanford, California, United States, [2]Psychiatry and Behavioral Sciences, Stanford University

Introduction

Brain ^{1}H-MRSI has become an important clinical tool Although widely used, most brain MRSI sequences suffer from drawbacks including limited spatial coverage, insufficient water and lipid suppression, long scan times, low SNR and lack of robust automated spectral quantification. To address these limitations, we implemented a fast 3D whole-brain 1.5T MRSI sequence with efficient and robust water and lipid suppression, spiral k-space readout trajectories, and an 8-channel phased-array coil targeting the three major brain metabolites (NAA, Cr, Cho). A computer program was also implemented to automatically phase the spectrum from each voxel and coil before combining the signals for optimal SNR. LCModel software [4] was then used to analyze the combined spectra from each voxel in order to generate metabolite signal and ratio maps. In this abstract, we assessed the reliability and reproducibility of the sequence and the data processing methods.

Methods

A spectral-spatial 90 degree RF pulse and two identical dualband spectral-spatial 180 degree pulses were incorporated into a PRESS sequence for localization, partial excitation of water and excitation of Cho, Cre and NAA [1]. The PRESS box was prescribed to encompass the whole brain on the axial images and thus only used to suppress unwanted signals from tissue inferior to the brain. Lipid resonances were further suppressed using inversion recovery with an adiabatic non-spectral selective inversion pulse and 170ms of recovery time. In-plane spatial and spectral information (k_x, k_y,k_f) was encoded using repeated spiral k-space trajectories [2]. Encoding in z direction (k_z) was performed using standard phase encoding. The signal from each of the 8 phased-array coils was reconstructed and phased using the residual water peak. Phased spectra for each voxel and coil were then combined, weighted by water signal, to achieve maximum SNR [3]. The combined spectrum of each voxel was passed to LCModel for quantification [4]. Concentrations of Cho, Cr and NAA and concentrations ratios of Cho to Cr and NAA to Cr were generated for each voxel.

Eight healthy subjects, 6 male, 2 female, with ages ranging from 27 to 31 years old, were recruited for a reproducibility study. Seven subjects were each scanned once within a 1 month interval to determine inter-subject variability while one female subject was scanned 6 times within a 2-week period for the assessment of intra-subject variability. A fast spin echo sequence with echo time of 80ms was performed on the subject after the MRSI scan to generate high-resolution structural images for the accurate identification of regions of interest. To study inter-regional variability, 5 regions of interest (ROIs) as shown in Figure 1, covering the frontal lobe, parietal lobe, temporal lobe, occipital lobe and basal ganglia and thalamus, were drawn on the high-resolution structural images to generate masks for each ROI. Final metabolite values were obtained by averaging signals from all voxels within each ROI.

Results

All data were collected at 1.5T using a General Electric (G.E. Medical Systems, Milwaukee, WI) scanner with 8-channel phased-array coil with the following MRSI acquisition parameters: TI/TE/TR=170/144/1500ms, 32cm FOV, 32x32 matrix size, 1 cc voxel, 8 NEX and 13 minute acquisition. Representative metabolite maps and metabolite ratio maps with associated high resolution structural images are shown in Figure 2. The inter-subject and intra-subject regional reproducibility results are given in Table 1 with mean and coefficients of variation (CVs) of metabolite ratios obtained from 8 subjects. The inter-subject CVs of the five ROIs ranged from 6.1% to 11% for NAA/Cr and 7.2% to 12.1% for Cho/Cr. The intra-subject regional reproducibility results are obtained using data obtained from the 6 scans of the same subject. The intra-subject CVs of five ROIs ranged from 4.7% to 12.7% for NAA/Cr and 2.7% to 7.1% for Cho/Cr.

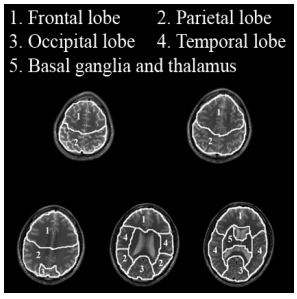

Figure 1. Five ROIs.

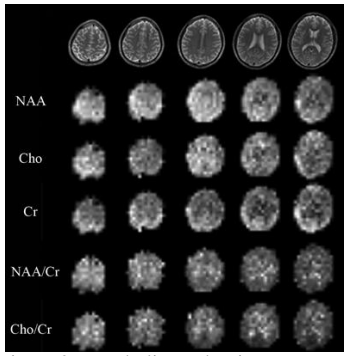

Figure 2. Metabolite and ratio maps from 1 subject.

Region of interest	Inter-subject Variability				Intra-subject Variability			
	NAA/Cr		Cho/Cr		NAA/Cr		Cho/Cr	
	Mean	CV	Mean	CV	Mean	CV	Mean	CV
Frontal lobe	1.80	6.1	0.27	7.2	1.68	8.9	0.23	2.7
Parietal lobe	1.89	6.8	0.29	12.1	1.88	4.7	0.24	3.0
Occipital lobe	1.90	8.9	0.30	10.2	1.88	5.6	0.28	3.7
Parietal lobe	1.68	11.0	0.31	8.8	1.7	7.4	0.29	4.0
Basal ganglia and thalamus	1.68	6.6	0.30	8.8	1.67	12.7	0.26	7.1

Table 1. CVs of metabolite ratios from inter-subject and intra-subject studies.

Conclusion

This study assessed the repeatability of a 1.5T volumetric MRSI sequence using spectral-spatial RF pulses, spiral readout gradients, and automated data analysis tools. Inter- and intra-subject metabolite ratio CVs from anatomically defined brain ROIs were found to be comparable to those reported for single-voxel experiments. Such measures of reliability are critical to the experimental design and data interpretation necessary for any subsequent clinical research studies.

Acknowledgements

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