Neurochemical profile of the striatum and hippocampus in mice at 16.4 T using *in vivo* ^{1}H NMR spectroscopy

D. K. Deelchand[1], I. Iltis[1], G. Adriany[1], E. Colonna[1], M. Marjanska[1], K. Ugurbil[1], and P-G. Henry[1]
[1]Center for Magnetic Resonance Research, University of Minnesota, Minneapolis, MN, United States

Introduction

Higher magnetic field strength is advantageous for NMR spectroscopy due to increased spectral dispersion and increased signal-to-noise. This in turn has led to higher quantification precision for a wide range of biochemical compounds, both in human brain and in rodent brain [1, 2]. Most recently, it was reported that the quantification of the neurochemical information was improved in the rat brain at 16.4 T [3]. In the present study, we aimed at demonstrating the feasibility of *in vivo* ^{1}H NMR spectroscopy in the mouse brain at 16.4 T.

Methods

6-week old mice (n=3) were studied on a 16.4 T/26 cm horizontal-bore magnet equipped with a 12 cm gradient coil insert and interfaced to a Varian DirectDrive console. The animals were anesthetized with 1% isoflurane in a mixture of 50% oxygen: 50% nitrous oxide. A quadrature surface RF coil was used for both RF transmission and reception. Localized *in vivo* ^{1}H NMR spectra were measured in the striatum (VOI of 4.25 µL) and hippocampus (VOI of 4.4 µL) using the LASER sequence [4] (TE = 16.5 ms, TR = 4 s, spectral width = 8 kHz, 8192 complex points). In addition to the metabolite spectra, macromolecule spectra (metabolite-nulled) were acquired in each region. Each voxel was positioned in the brain using transverse and sagittal fast spin-echo images. B_0 shimming was performed with FASTMAP resulting in a water linewidth of ~20 Hz in both brain regions. The measured linewidth of the methyl group of tCr was ~16 Hz. The spectra were analyzed with LCModel using two basis sets (one for hippocampus and one for striatum) containing 19 simulated metabolite spectra and one macromolecule spectrum acquired independently in each region.

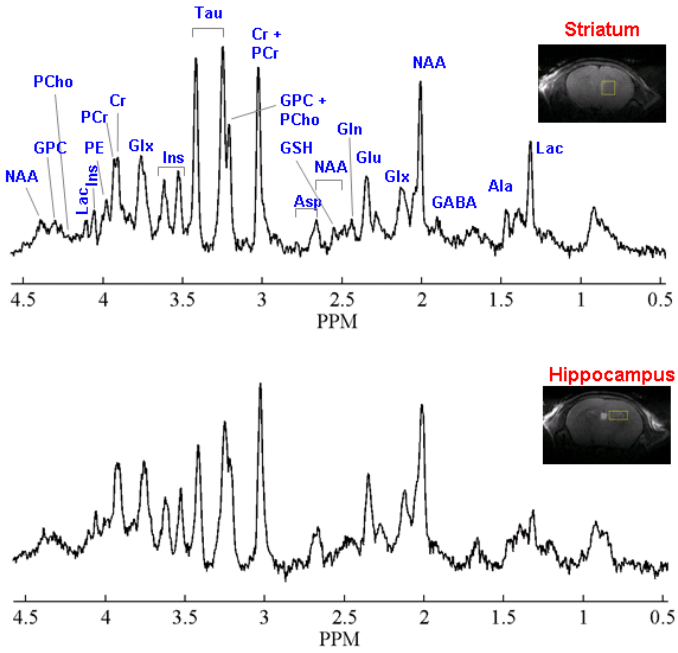

Figure 1: *In vivo* ^{1}H LASER NMR spectra (512 averages) measured in striatum (VOI= 4.25 µL, top) and hippocampus (VOI= 4.4 µL, bottom) in mouse at 16.4 T.

Results and Discussion

Figure 1 shows a typical ^{1}H LASER spectra acquired in the striatum and hippocampus of the mouse. Because of excellent spectral resolution and the increased spectral dispersion at 16.4 T, signals from the methyne group of *N*-acetylaspartate (NAA) and methylene group of choline compounds (resonating next to the water peak at 4.2 – 4.4 ppm) were resolved and fitted with LCModel (Figure 1). More importantly, LCModel analysis of the ^{1}H spectra resulted in the quantification of 17 and 16 metabolites (out of 19) with Cramér-Rao Lower Bound (CRLB) lower than 20% in the hippocampus and the striatum respectively. The remaining 3 metabolites in the striatum had CRLB < 25%.

The regional differences between striatum and hippocampus were directly visible on the spectra: for example, taurine and lactate signals were higher in the striatum compared to the hippocampus (Figure 1). LCModel analysis also revealed that ascorbate, glutamate, NAA, creatine and phosphocreatine were lower in the striatum compared to the hippocampus (Figure 2). These differences are consistent with previous observations in mice at 9.4 T [5].

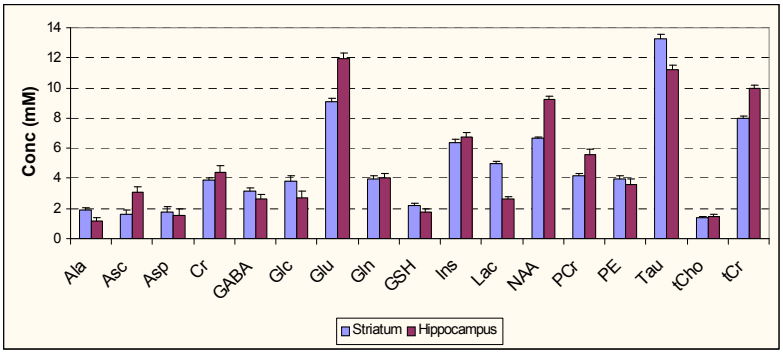

Figure 2: Concentration of metabolites in the striatum and hippocampus. Error bars represent the CRLB of the metabolite concentrations.

In summary, the study shows that high quality *in vivo* ^{1}H spectra can be obtained from different brain regions in the mouse at ultra-high field using small voxels, with excellent spectral resolution and accurate localization.

References

[1] Tkac et al MRM 2009; [2] Mlynarik et al JMR 2008; [3] Hong et al. MRM 2010; [4] Garwood et al. JMR 2001; [5] Tkac et al. MRM 2004.

Acknowledgement

This work was supported by funding from P41 RR008079, P30 NS057091 and S10 RR025031.