Thalamic and subcortical GABA in human brain at 7T

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Introduction: For purposes of SNR, the majority of measurements of GABA have been primarily performed in superficial locations using local surface coils. However because of its potential roles in movement control and seizures, the measurement of GABA in subcortical nuclei is of significant interest for neurological studies. In these regions however significant challenges are present because of Bo shimming and the need to eliminate the macromolecule resonance. We used a transceiver array at 7T in the human brain to evaluate thalamic and putamen GABA in comparion to white and gray matter.

Methods: All data were acquired with a Varian Magnex DirectDrive 7T MR system using a 8x1 transceiver array. The transceiver array was used with RF shimming to optimize multiple RF distributions to achieve 1kHz B1 transmission over large volumes sufficient for planar spectroscopic spin echo imaging with outer volume suppression. A double echo selective homonuclear polarization transfer ("SHPoT") experiment was used for GABA detection (1). This single shot method achieves selectivity through initial broad band suppression of the 3.0ppm region followed by magnetization transfer between the coupled 1.9-3.0ppm spins. At a total TE=40ms, GAMMA simulations with phantom verification shows that the efficiency of GABA detection is ~50%. To eliminate the transfer of the overlapping macromolecule resonance at 3.0ppm (1.7-3.0ppm coupling), a narrow band CHESS pulse is applied at 1.6ppm. In implementation, the accurate suppression of macromolecule requires excellent Bo shimming (conditions of poor Bo homogeneity could result in an apparent increase in GABA signal). In this study a 4th-partial 5th order shim insert (Resonance Research Inc.) was used with non-iterative Bo shimming. For all studies, a 1cm thick AC-PC angulated slice was taken to include the thalamic and subcortical nuclei. The ROI used for shimming included the majority of the entire slice with the exclusion of a small ovoid over the frontal anterior ventricle (Fig. 1). All studies were acquired as 16x16 spectroscopic images (TR 1.5s). Each study comprised of 3 GABA (with macromolecule suppression) (~20min), a GABA+mm (6.4min) and a NAA measurement. The entire duration of the study was typically ~1hr15min.

Results: The performance of the shim insert was demonstrated through determination of the standard deviation of Bo over the ROI ($\sigma_{Boglobal}$). $\sigma_{Boglobal}$ as using 1st and 2nd order shims was compared with that from 1st-4th order shims. Averaged over 5 volunteers, $\sigma_{Boglobal}$ decreased from 16.4±2.7 to 8.3±0.54. Fig. 1 shows GABA spectra from the thalamus, putamen/caudate and mixed gray/white matter tissue from a single volunteer. As can be seen, the macromolecule suppression results in an approximately 50% decrease in the detected 3.0ppm resonance. Table 1 shows the GABA/NA, GABA/Cr and NA/Cr values from the various regions (n=5 healthy volunteers).

Fig. 1. GABA data from a single volunteer. All spectra are shown with equal scaling. The circles on the scout indicate the ROI used for Bo shimming.

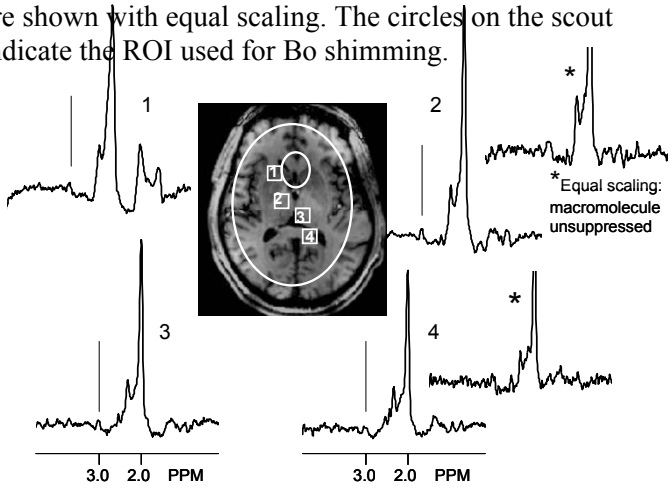

Table: GABA data with/without MM suppression

		GABA/Cr	GABA/NA	NA/Cr
MM suppressed	BG	0.152±0.025	0.111±0.013	1.36±0.20
	Thal	0.149±0.014	0.112±0.016	1.35±0.18
	Mixed WM	0.160±0.026	0.097±0.023	1.68±0.14
	Mixed GM	0.181±0.013	0.118±0.006	1.54±0.12
Without MM suppression	BG	0.298±0.046	0.219±0.036	
	Thal	0.280±0.065	0.213±0.057	
	Mixed WM	0.246±0.139	0.160±0.099	
	Mixed GM	0.290±0.054	0.189±0.038	

Conclusions: Subcortical GABA can be detected at 7T with the selective homonuclear polarization transfer acquisition given specific attention to shimming and macromolecule suppression. The results are very consistent with studies using homonuclear editing (2), with the contribution of the macromolecule resonance increasing the apparent GABA concentration by a factor of ~two.

Refs: (1) Pan et al ISMRM 2009; (2) Hetherington et al MRM 1998 39:6