Motor Cortex GABA Concentration as measured by Double-Quantum Filtering

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INTRODUCTION

Gamma-aminobutyric acid (GABA) is a major inhibitory neurotransmitter in the central nervous system. A derangement in its metabolism is implicated in various neurological diseases. Abnormal concentrations may play a role in neuronal death resulting from excessive activation (excitotoxicity), a pathophysiological mechanism implicated in disorders such as ischemic stroke, traumatic brain injury, epilepsy and various neurodegenerative conditions. Accurate measurement of GABA *in vivo* would improve our understanding of such disorders and could assist in monitoring treatments that target GABA metabolism. To date, it has been difficult to reliably measure GABA because of its low concentration and significant signal contamination from other resonances. Our objective was to test the feasibility of a locally developed double-quantum filtering (DQF) spectroscopic sequence to measure GABA in the human motor cortex.

METHODS

Experiments were carried out at 3.0 T in an 80-cm bore magnet (Magnex Scientific PLC), interfaced to a SMIS console. A 28-cm diameter quadrature birdcage coil was used for RF transmission and reception. The GABA level in human motor cortex was measured with a single-voxel proton DQF sequence. Following a slice-selective 90° excitation, a 28.6-ms dual-band 180° RF pulse, tuned to 3.01 and 1.89 ppm, was used to prepare the GABA target antiphase coherence [1]. The maximum available antiphase coherence was attained at an optimized echo time of 49.4 ms and produced the maximum GABA signal. A yield of 36%, obtained from a phantom test, was used for assessment of the observed GABA signal. Four healthy volunteers were recruited and screened to exclude neuropsychiatric disorders. A 25×25×50 mm^3 voxel was positioned in the motor cortex, as shown in Fig. 1. Spectral acquisition parameters were TR 2.4 s, NT 256, spectral width 5 kHz, acquisition time 820 ms. Two subjects had 3 acquisitions each in a single MR session. The FIDs were apodized with a 3-Hz exponential and a 6-Hz Gaussian function before Fourier transformation. Only zero-order phase correction was used for the DQF data. FASTMAP was used for shimming. The linewidth of the water signal at TE = 24 ms was typically ~5 Hz. The phase optimization of the antiphase-to-DQ coherence conversion 90° pulse (slice-selective) was accomplished using the water signal. Water distribution (grey matter, white matter and CSF) within the voxel was obtained by recording the 1-D projection following the STEAM sequence. Double-inversion recovery was used to discriminate the water signals between the three compartments [2]. Separation of the CSF water from GM and WM was achieved with a long TE (800 ms). GABA concentrations were derived using the water signal as an internal reference.

RESULTS AND DISCUSSION

The typical voxel location in a subject and the accompanying tissue water compartmentation is demonstrated in Fig. 1. GABA spectra for the 8 measurements is displayed in Fig. 2. GABA levels were consistent within subjects who had multiple measurements (Table 1). Table 2 summarizes the results.

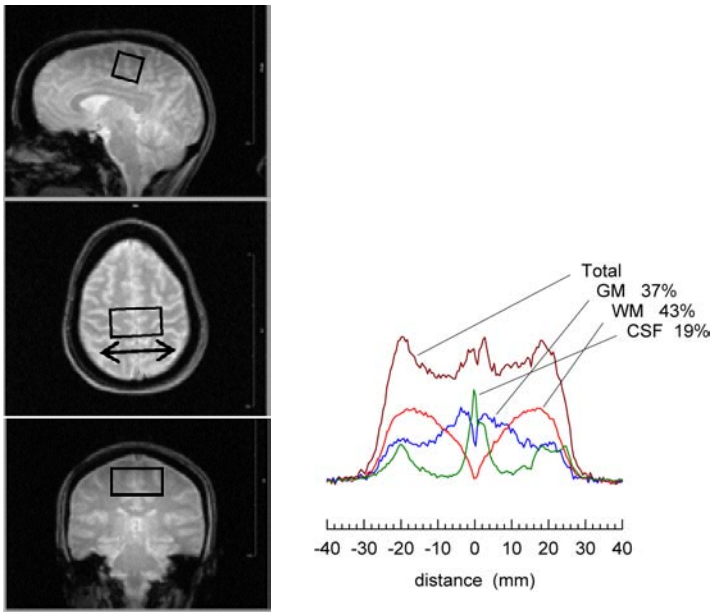

FIG 1. (left) Typical positioning of a 25×25×50 mm^3 voxel in the motor cortex. (right) Profiles of GM, WM and CSF water in the direction indicated by an arrow in the transverse image.

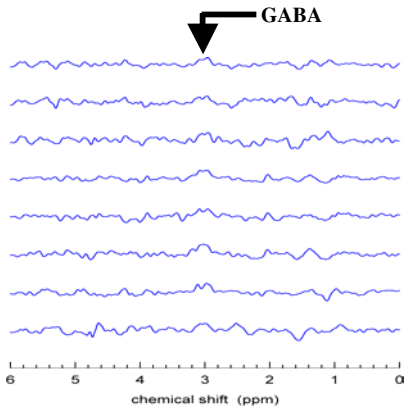

FIG 2. A stack of 8 *in vivo* GABA DQF spectra from the human motor cortex in 4 subjects. TR = 2.4 s. NT = 256. The FID was filtered with a 3-Hz exponential and 6-Hz Gaussian function before Fourier transformation.

TABLE 1. GABA concentrations in 4 healthy subjects. Two subjects had 3 measurements in a single MR session.

	[GABA] (mM)		
	# 1	*# 2*	*# 3*
Subject 1	0.59	0.61	0.65
Subject 2	0.82	0.77	0.87
Subject 3	0.82		
Subject 4	0.64		

TABLE 2. Mean motor cortex GABA level and fractions of GM, WM and CSF water within the voxel. (mean ± SD).

[GABA] (mM)	*GM (%)*	*WM (%)*	*CSF (%)*
0.72 ± 0.11	37 ± 3	41 ± 3	22 ± 6

REFERENCES

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2. T.W. Redpath *et. al.* Br J Radiol 1994;67:1258.

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