Detection of GABA Concentration in ACC and OCC by MEGA-PRESS

Darong Zhu[1], Song Chen[2], Xu Yan[3], Linfei Wen[2], Congyu Liao[2], Meng Chen[2], Keith Heberlein[4], and Jianhui Zhong[2]

[1]Hangzhou First People's Hospital, Hangzhou, Zhejiang, China, [2]Center for Brain Imaging Science and Technology, Department of Biomedical Engineering, Zhejiang University, Hangzhou, Zhejiang, China, [3]MR Collaboration NE Asia, Siemens Healthcare, Shanghai, China, [4]Siemens Medical Solutions USA, Inc, Malvern, PA, United States

Purpose: Glutamate (Glu) and gamma-aminobutyric acid (GABA) are very important neurotransmitters, and they play critical roles in mental illness such as depression and schizophrenia. However, neurological bases and mechanisms of GABA for quantifying specific diseases or characterizing regional neural function remain poorly understood. Metabolites such as GABA are difficult to detect owing to their lower concentration and *J*-coupling effect. MEGA-PRESS, a sequence based on *J*-difference spectral editing, can detect the regional variations of GABA concentration, which will be useful in investigating the concentration of GABA in different brain regions and its correlation with the function of the nervous system [1].

Methods: We used a robust prototype MEGA-PRESS pulse sequence to study the GABA concentration in brain regions of anterior cingulate cortex (ACC) and occipital cortex (OCC). There were 14 healthy volunteers (7 females) with age ranging from 23 to 36 (females: mean age±SD = 25±4 yr.; males: mean age±SD = 26±5yr.). All volunteers were in good health condition with no history of psychiatric or neurological illness and no use of psychiatric medication, and all subjects were refrained from use of caffeine, alcohol, tea for at least 12 hrs before MR measurement. Each volunteer was scanned for at least two times with a time gap more than 1 week. All the MRI and MRS scans were conducted on a 3T MAGNETOM Verio (Siemens AG, Erlangen, Germany) equipped with a 32-channel head coil. Traditional 3D-MPRAGE T1-weighted images were acquired to localize the voxel of interest (VOI) of spectroscopy. The T1-weighted MPRAGE images were segmented into gray-matter (GM), white-matter (WM), and cerebrospinal-fluid (CSF) maps using SPM8vbm8 [2]. Single-voxel spectroscopy data was acquired by using a prototype MEGA-PRESS sequence. VOI of spectroscopy was placed in two areas: (1) ACC with size of 20mm×30mm×40mm (A>>P: 40mm, R>>L: 30mm, F>>H: 20mm); (2) OCC with size of 30mm×30mm×30mm.

Results and Discussion: The spectra were corrected and analyzed with Gannet package [3]. Fig. 1. shows the location of the VOI in ACC and the differential spectrum of the corresponding voxel. Intraclass correlation coefficient (ICC) of GABA+ (ACC:0.547, OCC:0.853) revealed good results for repeated measures for volunteers. The coefficient of variation within session (CV_{ws}) reflected data stability of each session. The repeatability in OCC (maximal CV_{ws}:21.93%) was better than that in ACC (maximal CV_{ws}: 26.41%) as exhibited in Table 1. One important reason is that ACC is a primary region of emotional and conscious processing. Mental state and attention degree can easily affect the metabolic activity. It has been proved that neuronal activity can be regulated by modulation of neurochemical process [4]. Another reason is that the unconscious head motion has a more obvious influence on ACC because OCC is in contact with the coil and worked as a supporting point. Repeatability of metabolite ratios demonstrated better stability than single metabolite (Table 1). The between-session dispersion (CV_{bs}) of GABA+/Cr for ACC and OCC was 10.06% and 6.70%, respectively. GABA+ dispersion in OCC was more severe. It may be caused by wild scatter of the larger range of OCC data (OCC_{max}: 3.31, ACC_{max}: 2.67). CV_{bs} of GABA+/Cr measurement showed good repeatability results in OCC. The simultaneous ACC and OCC study revealed region-specific feature in both GABA+ concentration and GABA+/Cho for healthy volunteers in our study.

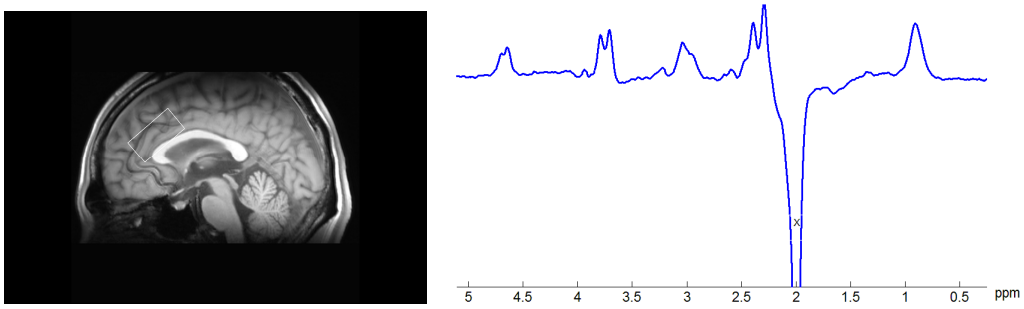

Fig. 1. VOI of MEGA-PRESS in ACC and the differential spectrum of this voxel, GABA+ signal is at 3.02ppm

Table 1. Repeatability and Reliability of GABA+ (Without MM-Suppression)

	ACC (n = 14)			OCC (n = 14)		
	GABA+	GABA+/Cr	GABA+/Cho	GABA+	GABA+/Cr	GABA+/Cho
CVws	[2.8%, 26.41%]	[1.07%, 21.97%]	[0.2%, 26.47%]	[0.28%, 21.93%]	[1.02%, 10.46%]	[0.76%, 18.68%]
CVbs	16.47%	10.06%	15.30%	22.92%	6.70%	13.18%
ICC	0.547			0.853		
Mean	2.64	10.34%	12.55%	3.31	10.89%	20.86%
Std	0.43	1.04%	1.92%	0.76	0.73%	2.75%

Conclusion: The study shows that the MEGA-PRESS pulse sequence can be used to reliably detect GABA in both ACC and OCC. Nevertheless, both CV_{ws} and ICC repeatability of OCC were better than that of ACC. The concentration of GABA+ in OCC was higher than that in ACC, revealing its region-specific feature. However, high variation of CV_{ws} in ACC suggests that caution is needed for using MEGA-PRESS due to its sensitivity to motion.

References: [1] Mescher M. et al, NMR Biomed. 1998, 11:266-272. [2] Ashburner, J. et al, NeuroImage. 2000, 11(6) 805-821. [3] Richard A.E. E. et al, JMRI. 2014, doi: 10.1002/jmri.24478 [4] Cleve M. et al, NeuroImage. 2015, doi: 10.1016/j.neuroimage.2014.10.042.