Regional T1 Relaxation Time and Tissue Content Changes of Hippocampus in Bipolar Disorder

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Introduction: The hippocampus and amygdala appear to be important regions in the pathophysiology of mental disorders. Decreased gray matter (GM) density of amygdala in bipolar disorder (BD) patients has been reported but it is unclear whether hippocampus also exhibits similar abnormalities. The goal of this work was to identify whether hippocampal tissue content changes occur in BD by using T_1-based tissue segmentation methods. The rationale for our approach was: 1) brain T_1 relaxation times changes are associated with certain neurological disorders that exhibit tissue changes, e.g. multiple sclerosis, and 2) the T_1 for GM (1329ms), white matter (WM, 814ms) and cerebral spinal fluid (CSF, 3320 ms) are quite different at high fields (e.g., 4 T) [1]. We hypothesized that alterations in tissue content would be detectable by T_1 relaxography at 4T if there is such a tissue content change associated with BD.

Methods: Six medication-free, euthymic BD patients were studied (M3/F3; age: 20.2±4.7). Nine healthy volunteers (M5/F4; age: 27.7±9.5) served as a comparison group. MRI data were acquired with a 4T Varian INOVA system using a volume TEM head coil. To determine the GM and WM content for each MRI voxel, quantitative T_1 maps were generated using a 15-slice, 7-point inversion recovery imaging sequence with TR of 4 sec, 1.5-mm-thick planes (without gap). The T_1 from each pixel was determined by fitting the time course of the magnetization using a simplex algorithm with T_1 and the initial magnetization as the free parameters. The results of the iteration were presented as 256x256 images of T_1. The tissue type of each MRI voxel was assigned using the quantitative T_1 values. Pixels with T_1 between 600 and 1070 msec, 1071 and 2435 msec, and above 2435 msec were assigned as WM, GM and CSF, respectively. The examples of WM and GM images are in Figures 1a and 1b, respectively. The size and positions for the region of interest (ROI) in hippocampus are displayed in Figure 2. T_1 values for individual positions were determined by outlining the ROI on the calculated T_1 image, and calculating the mean and standard deviation (SD) of the pixels enclosed within the ROI.

Results: Table 1 shows the summary of hippocampal T_1 relaxation times in healthy and patient groups. Only the patients' T_1 value at position L5 (left anterior hippocampus) was significantly lower than corresponding healthy T_1 values (*p=0.03*). The T_1 of amygdala in the patient group was not significantly different from healthy values (left side: 1397±51 ms vs. 1332±208 ms; right side 1222±100 ms vs. 1308±174 ms). On average, patients' hippocampal gray matter contents (GM%) were lower than the healthy subjects but none were significantly different. However, BD patients' GM% at position L5 showed a trend to be significantly lower than the healthy value (*p*=0.07). Also the BD patients' SDs were larger than the SDs in healthy group, suggesting a larger variation of hippocampal GM% in the BD patients.

Discussion: Several pathologic processes, such as the changes in neuronal or glial volumes or cell loss, might result in alterations of GM%. The present work identified GM% changes in BD patients using T_1-based tissue segmentation methods. With this small sample size in this preliminary study, we found patients' T_1 at left anterior hippocampus was lower than healthy subjects and the corresponding GM% also showed a trend to be lower. However, these results should be viewed as preliminary. Nonetheless, this work suggests that high-field MR relaxography might be an additional useful tool for characterizing brain tissue abnormalities associated with bipolar disorder.

Figure 1

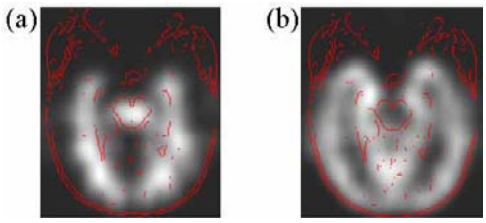
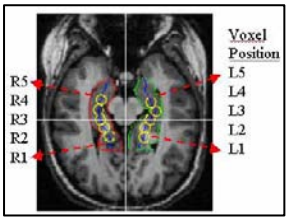


Figure 2



References:

1. Mason GF. *J Magn Reson* 1997; 126, 18.

Table 1. Summary of hippocampal T_1 relaxation time (msec) in healthy volunteers and BD patients.

	L1	L2	L3	L4	L5	R1	R2	R3	R4	R5
Healthy	1140±152	1190±171	1284±111	1295±81	1436±117	1189±350	1241±188	1162±139	1330±77	1401±78
Patient	1046±142	1144±222	1196±95	1298±55	1318±123*	1083±172	1257±134	1268±66	1330±74	1438±37

* *p=0.03* v.s. healthy values.

Table 2. Summary of hippocampal gray matter content (GM%) in healthy volunteers and BD patients.

	L1	L2	L3	L4	L5	R1	R2	R3	R4	R5
Healthy	53.4±6.6	53.1±10.1	50.3±10	59.2±9.7	77.5±5.1	53.9±5.7	51.6±10.5	48.3±10.5	61±9.5	79.6±7.9
Patient	51.2±15.2	46.5±24	44.6±21.8	52.3±15.7	64.1±19.8**	55.1±12.4	48.0±21.9	42.7±24.1	55.5±21.0	74.0±20.0

** *p=0.07* v.s. healthy values.