The relationship between 1H MRS and brain morphology at the corresponding locations in Methamphetamine users

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Target Audience:

Researchers and clinicians with interest in brain disorders and/or in MRI and MRS studies in addition

Purpose:

Methamphetamine (MA) is a highly addictive drug that induces neurotoxicity [1, 2]. Abnormal brain metabolite levels in MA users demonstrated low N-acetylaspartate (NAA) and high Choline (Cho) in white matter and gray matter [3-6], and significantly increased myo-inositol (mI) in frontal gray matter (FGM) [4]. In the studies of brain morphology, reduction of cortical thickness, change of striatum volume and change of white matter volume (WMV) were associated to the MA use [7-10]. However, the relationship between the change of metabolites and the change of brain volume at the same brain region has never been reported. Therefore, we aim to explore the association between the change of MRS in 4 voxel locations and the change of brain volume and cortical thickness at the corresponding locations or region in MA users and healthy control (HC).

Methods:

Fifteen MA users and 10 HC, mean age 25.73±5.18 years and 23.1±2.6 years respectively, were recruited with age, gender and education matched. The study was approved by local institutional review board. The inclusion criteria for MA volunteers were single MA drug users for at least 12 months and regularly used at least 4 times per week before having treatment. MRI and MRS of brain were acquired on a 1.5 Tesla, Achieva, Philips, Netherland MR Scanner. Axial T1-weighted images with 3D FFE pulse sequence, repetition time (TR) = 20 ms, echo time (TE) = 4.6 ms, flip angle= 30°, and voxel size = 0.94x0.94x1 mm^3 were used for MRI acquisition. A single voxel ^1H MRS was applied for MRS study in 4 locations including Frontal White Matter (FWM), Basal Ganglia (BG), FGM and Posterior Gray Matter (PGM) using point resolved spectroscopy (PRESS) pulse sequence with the following parameters: TR /TE = 2000/35 ms, number of signal averages (NSA) = 192, voxel size = 20×20×20 mm^3. Segmentation of GM/WM, cortical thickness mapping and regional structure volumes were done by the FreeSurfer (FS) version 5.3 developed by Martinos Center for Biomedical Imaging. (http://surfer.nmr.mgh.harvard.edu/). Spectral analysis was done by LCmodel. Statistical analysis significant differences between MA and HC groups regarding brain volume and metabolic ratios were determined by the unpaired t-test at 95% confidence interval using GraphPad Prism version 4.

Results:

At the left FWM voxel of MRS, MA users demonstrated significant lower total NAA (tNAA)/Cr compared to HC (p=0.01) (Fig.1) which corresponds to the trend of reduction (no statistical significance) of left FWM volume by 3.14% in MA group compared to that of the HC (p=0.28). The ratio of mI/Cr at FGM MRS voxel showed significant higher in MA compared to HC (p = 0.04) (Fig. 2) which correlated to the significant thinner of the cortex ($p < 0.05$) as shown in Fig. 3(a) and 3(b) with blue mapping indicated by white arrows. The other 2 voxel locations, BG and PGM showed lower tNAA/Cr by 4.08% and 1.06% respectively corresponds to left BG volume decrease by 1.55% and a smaller region of thinner cortex as indicated by yellow arrows in Fig. 3(a) and 3(b).

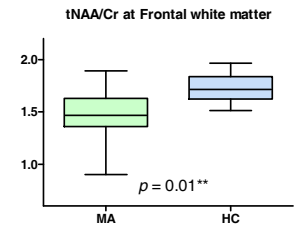


Figure 1. Boxplot of the tNAA/Cr at Frontal white matter.

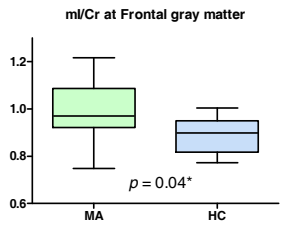
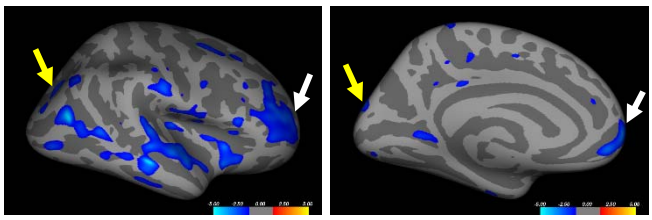


Figure 2. Boxplot of the mI/Cr at Frontal gray matter.



(a) (b)

Figure 3. Cortical mapping in lateral view of right hemisphere 3(a) and medial view of left hemisphere 3(b) that average thickness different between MA users and HC groups. The white arrows show significant different region which is the part of FWM and the yellow arrows show significant different regions which is the part of PGM.

Discussion and conclusion:

Reducing of tNAA/Cr is associated to neuronal and axonal injury which correlates to the decrease of FWM volume. Increasing of mI/Cr at FGM voxel was associated to glial proliferation. Increasing of the metabolite ratio at FGM connected to significant thinner of cortical thickness at FGM and PGM. At BG MRS voxel location, decrease of tNAA/Cr associated with decreasing of BG volume. This may caused by toxicity of methamphetamine to dopamine receptor in BG. The changes in brain metabolites detected by MRS tend to provide an outcome supported by structural brain MRI.

Reference

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