Abnormalities in Regional Brain Volumes in Adolescent Methamphetamine Users

G. R. King[1], D. Alicata[2], C. Cloak[1], T. Ernst[1], I. Chin[1], and L. Chang[1]
[1]Medicine, John A. Burns School of Medicine, Honolulu, HI, United States, [2]Psychiatry, John A. Burns School of Medicine, Honolulu, HI, United States

Introduction: Methamphetamine (METH) consumption in adults is associated with structural changes in the brain, for instance with smaller limbic and hippocampal volumes that correlated with poorer word recall (Thompson et al. 2004). In addition, others have reported enlarged mesolimbic, striatal and cortical volumes in METH users (Chang et al 2005; Jernigan et al. 2005). However, whether brain volumes also are abnormal in adolescents METH users whose brains are still developing is unknown. Female adolescents with and without a history of METH abuse were evaluated in this study.

Methods: Ten female adolescent METH users and 10 age-matched female comparison subjects (ages 12 to 23 years) were recruited from the island of Oahu, Hawaii. MR scans were performed on a 3 Tesla Siemens Trio scanner (Siemens Medical Solutions, Erlangen, Germany), using a sagittal high-resolution 3D magnetization-prepared rapid gradient echo (MP-RAGE) (TR/TE/inversion time (TI) = 2200/4.91/1000 ms, 208x256x144). Cortical reconstruction and volumetric segmentation was performed on each MRI, using the FreeSurfer image analysis suite (http://surfer.nmr.mgh.harvard.edu/). The reconstruction process focused on 17 distinct regions (including caudate, putamen, nucleus accumbens, and cortical gray matter). Each subject also had a battery of detailed neuropsychological tests as well as a neuropsychiatric evaluation, including the Brief Psychiatric Rating Scale (BPRS) and Symptom Check lists (SCL-90).

Results: There were no significant differences in age (METH: 18.81±0.92; Controls: 18.21±0.2) or education (METH: 11.00±0.87; Controls: 11.50± 0.72). Despite the relatively small number of subjects analyzed, METH users showed significantly lower cortical (gray matter) volumes (-4.87%), but no significant differences in white matter. Larger subcortical volumes were observed in these adolescent female METH users compared to matched female controls (Figure 1). Performance on the WAIS Digit Symbol task was positively associated with left putamen volume (r =0.70, p = 0.026, Fig.2). Furthermore, the size of the 4th ventricle was associated with several usage variables (Figure 2).

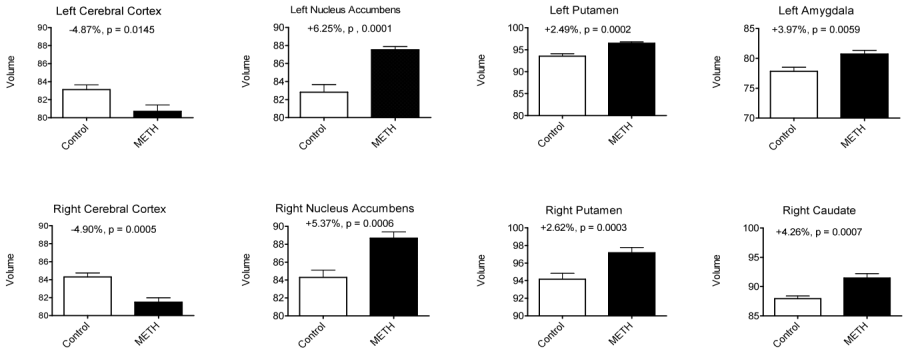

Figure 1. Brain volumes in female METH and control subjects as determined by FreeSurfer software suite.

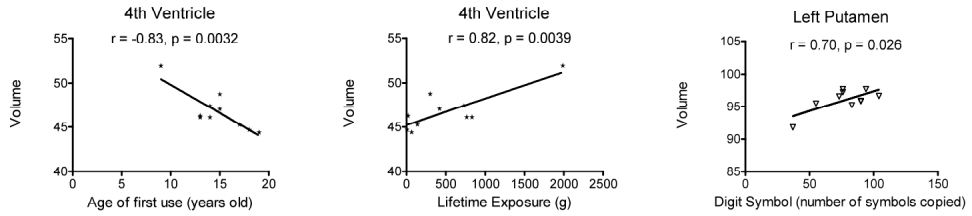

Figure 2. Correlations between METH use statistics and brain volumes, and between WAIS Digit Symbol performance and brain volume.

Discussion: These findings in adolescent female subjects are consistent with those in adult METH users, including enlarged limbic areas such as the nucleus accumbens (Jernigan et al 2005) and enlarged striatal structures (Chang et al 2005). However, unlike the previous finding of larger cortical volumes in adults (Jernigan et al 2005), we observed smaller cerebral cortical volumes in our female adolescent METH users. This reduction in cortical volume may result from the effects of METH on the developing adolescent brain, perhaps by disruption of normal developmental processes. The reductions in subcortical volumes might have contributed to their poorer psychomotor performance, since we observed a correlation between putamen volume and the digit symbol task. Further analyses will include a larger sample size, and comparing male and female METH users.

Acknowledgements: This study is jointly supported by: NINDS (2U54 NS039406-06; U54 NS56883-01), NIDA (1K24-DA016170, 5K02-DA16991), NCRR (G12RR003061 & P20RR11091), and the U.S. President's Office of National Drug Control Policy.

References: Chang L, et al, Biol Psychiatry 2005;57(9):967-974. Gaser C, et al. Am J Psychiatry 2004;161(1):154-156. Jernigan TL, et al. Am J Psychiatry 2005;162(8):1461-1472. Thompson PM, et al. J Neuroscience 2005;24(26):6028-6036.