White matter abnormalities in male violent offenders with schizophrenia: A diffusion tensor imaging study using tract-based spatial statistics

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Target Audience: Those who are interested in microstructure of white matter in the brain from the neuroscience, psychiatry and forensic field.

Purpose: Violent criminal behavior causes much human suffering and is a costly social problem. There are many evidences that schizophrenia patients have an increased risk for aggression and violent behavior, including homicide. Schizophrenia has been characterized as a disorder of brain connectivity.[1] Using diffusion tensor imaging (DTI), it has shown that white matter integrity is disrupted in a number of different regions in individuals with schizophrenia, and some area have been associated with aggression and impulsivity[2,3]. Though a lot of studies had been carried out in the past years using DTI to explore the brain structural connectivity in schizophrenia, few articles had focus on the subgroup of patients with severe violence behavior. In the current study, we aim to perform a tentative study on white matter abnormalities in schizophrenia patients as violent offenders with diffusion tensor imaging using Tract Based Spatial Statistics (TBSS).

Method: 26 male violent offenders appraised as schizophrenia (VS) according to DSM-IV were recruited from the forensic psychiatry department (mean age = 36.7±10.9 years) and 33 age and handedness matched male healthy controls (HC)(mean age=35.6±11.1 years) were also recruited through advertisement. Modified Overt Aggression Scale (MOAS), WCST and Positive and Negative Syndrome Scale (PANSS) for schizophrenia were used for clinical evaluation in the violent schizophrenia group. Diffusion tensor images were acquired using a 3.0 T MR scanner employing a single-shot echo planar imaging sequence with 15 directions (repetition time=12,000 msec, echo time= 70.8 msec, slice thickness=3.0 mm, field of view=240×240 mm^2, voxel dimensions=1×1×3 mm^3, scan matrix=128×128, b value=1,000 sec/mm^2). Fractional anisotropy (FA) maps were generated from each individuals using FSL (FMRIB Software Library，Oxford) software. The parametric maps of FA were then registered to the 2×2×2 mm^3 MNI template using FLIRT program. By visual inspection, the registration was good enough so that nonlinear registration was not performed. Voxelwise statistical analysis of the FA data was carried out using Tract Based Spatial Statistics. The significance threshold for correlations was set at $p < 0.05$ (corrected for multiple comparisons) using threshold-free cluster-enhancement. Regions showing significant group differences were exacted to perform further correlation analysis with clinical scales.

Results: Compared with the healthy control group, the violent schizophrenia group demonstrated significant FA reductions in various brain regions including the bilateral acurate fasciculus (Fig.1A,B), genu and the body of corpus callosum(Fig.1C,D,E), bilateral corticospinal tract (Fig.1 F,G), bilateral uncinate fasciculus / inferior fronto-occipital fasciculus (Fig.1G) and right inferior longitudinal fasciculus(Fig.1H). The MOAS, PANSS, Wisconsin Card Sorting Test (WCST) Scales scores were exhibited in Table 1. Participants in VS group showed significant positive correlations of FA value in the genu of corpus callosum with WCST Total Correct number($r = 0.423$, $p = 0.039$) and WCST Total Errors ($r = -0.417$, $p = 0.042$), and FA value in left accurate fasciculus correlated with WCST Perseverative Error ($r = -0.416$, $p = 0.043$), FA value in left uncinate fasciculus / inferior fronto-occipital fasciculus correlated with WCST Nonperseverative Errors ($r = -0.455$, $p = 0.025$), FA in right corticospinal tract correlated negatively with PANSS-General score ($r = -0.523$, $p = 0.009$).

Discussion: Present study provides evidence of widespread cerebral connectivity disruption in schizophrenia patients with severe violent behavior shown as FA reduction in various brain regions. Moreover, for the first time we found significant correlation of several neuropsychiatric index for executive function correlate with FA values in several brain regions which support the role of executive function in this specific sub-group of schizophrenia patients.

Conclusion： In present study, Tract Based Spatial Statistics was carried out to reveal widespread brain structural connectivity abnormalities in the schizophrenia patients with severe violent behavior. The correlation between FA in several brain regions and WCST sub-Scales revealed the executive dysfunction may play an important role in the pathophysiology of violent schizophrenia patients other than impulsivity.

References: 1. Hoptman MJ, Antonius D., Current Opinion in Psychiatry 2011; 24(2): 100–106. 2. Hoptman MJ, Volavka J, Johnson G, et al. Biol Psychiatry 2002; 52:9-14. 3. Hoptman MJ, Ardekani BA, Butler PD, et al. Neuroreport 2004;15:2467-2470.

Scales	Score (Mean±SD)
WCST	
Total Correct	24.46±9.43
Categories Completed	2.00±1.02
Total Errors	23.46±9.13
Perseverative Errors	15.54±10.85
Nonperseverative Errors	7.92±4.57
PANSS	
General	38.04±3.77
Positive	30.46±5.46
Negative	27.46±5.63
Supplementary	11.54±3.52
MOAS	28.21±7.10

Table 1: WCST, PANSS and MOAS scores of violent schizophrenia patient.

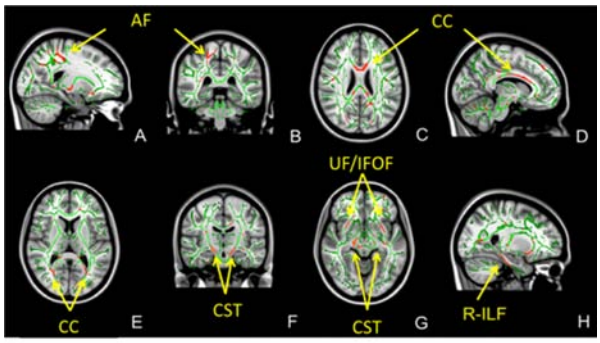

Fig.1: TBSS analysis reveals significant FA reduction regions in violent schizophrenia compared to healthy controls. AF: bilateral acurate fasciculus (A, B), CC: corpus callosum(C, D, E), CST: bilateral corticospinal tract(F, G), UF/ IFOF: bilateral uncinate fasciculus / inferior fronto-occipital fasciculus (G), R-ILF: right inferior longitudinal fasciculus (H).

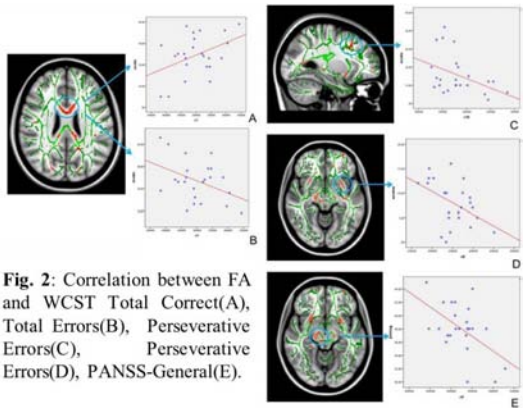

Fig. 2: Correlation between FA and WCST Total Correct(A), Total Errors(B), Perseverative Errors(C), Perseverative Errors(D), PANSS-General(E).