High-field MR Imaging Reveals an Acute Impact on Brain Function in Survivors of the Wenchuan Earthquake in China

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Introduction

In the afternoon of May 12, 2008, a devastating earthquake, measuring 8.0 on the Richter scale, occurred in the Sichuan Province of China where 45 million people were directly affected. A significant proportion of them (about 20%) [1] are likely to develop stress related disorders such as PTSD. Given the serious and persistent impact of these highly prevalent psychiatric disorders, it is vital to develop a better understanding of the alterations of cerebral function evident in the early stages of adaptation to trauma; this in turn may lead to a better understanding of post-traumatic responses and the development of more effective interventions. However, to date, no studies yet identify the alterations of cerebral function at early stage after trauma. The present study aims to apply resting state fMRI to examine both regional cerebral function and functional integration in physically healthy trauma survivors shortly after the massive earthquake.

Method

Forty-four healthy survivors and 32 age, sex, height, weight, handedness and years of education matched controls were recruited, and were scanned using a gradient-echo echo-planar imaging (EPI) sequence on a 3T MR imaging system (EXCITE, General Electric, Milwaukee, USA). Levels of anxiety and depression were evaluated using the Self-Rating Depression Scale (SDS) and the Self-Rating Anxiety Scale (SAS) in survivors. Amplitude of low-frequency (0.01–0.8 Hz) fluctuations (ALFF) of the blood oxygenation level-dependent (BOLD) signal, which is thought to reflect spontaneous neural activity [2], was used to characterize regional functional alteration. The corresponding ALFF were subsequently extracted from all survivors and input into SPSS13.0 along with SAS and SDS scores. The Pearson correlation coefficient was used in exploratory analyses to estimate the relationships between the averaged ALFF values in these regions of interest and SAS/SDS scores with a statistical threshold of $P < 0.05$ (two tailed). Subsequently, using the areas with ALFF alteration as seeds, a method based on the seed-voxel correlation approach was used to examine the relationship of the symptoms and the functional connectivity. This approach included following steps: (1) Obtaining seed reference by averaging the fMRI time series of all voxels within the areas with ALFF alteration; (2) Temporally bandpass filtering (0.01–0.08 Hz) for each time series; (3) Correlation analysis of the seed reference with the rest of the brain in a voxel-wise manner using the realigned images, and subsequently individual relativity value (r-value) map was produced, and (4) the correlation coefficients were transformed to z-values using the Fisher r-to-z transformation to improve normality prior to averaging data across subjects. Individual z-values in each voxel were compared across groups using a two-sample t-test in SPM2 with statistical inferences being made at $p < 0.05$ (after correction for multiple comparisons).

Results

Significant increased ALFF were observed in the left prefrontal cortex, the left precentral gyrus, bilateral insula, caudate and left putamen. ($p<0.05$ after correction for multiple comparisons) (Figure 1). Meanwhile, the ALFF in left putamen, right amygdala, right caudate and right hippocampus had a significant positive correlation with SAS and SDS scores ($p<0.05$) (figure 1). The combined analysis of survivors and controls showed a significantly positive association among seed regions as revealed by functional connectivity analysis, mainly involving the bilateral amygdala, hippocampus, caudate, putamen, insula, parahippocampus, prefrontal cortex, cingulate cortex and cerebellum ($p<0.05$ after family wise error correction for multiple comparisons) (figure 2). However, comparison of the two groups revealed that survivors had decreased functional connectivity compared to controls within a distributed network that included the bilateral amygdala, hippocampus, caudate, putamen, insula, cingulate cortex and cerebellum ($p<0.05$ after correction for multiple comparisons) (figure 2).

Discussion

Current study demonstrated for the first time that survivors show hyperactivity and decreased functional connectivity in prefrontal-limbic and striatal brain systems shortly after the massively traumatic sequelae of the earthquake. Particularly, it may indicate that trauma victims have a reduced ability to shift, at least in part, brain activity to default mode which is a recognized model for an optimal resting state of brain activity.

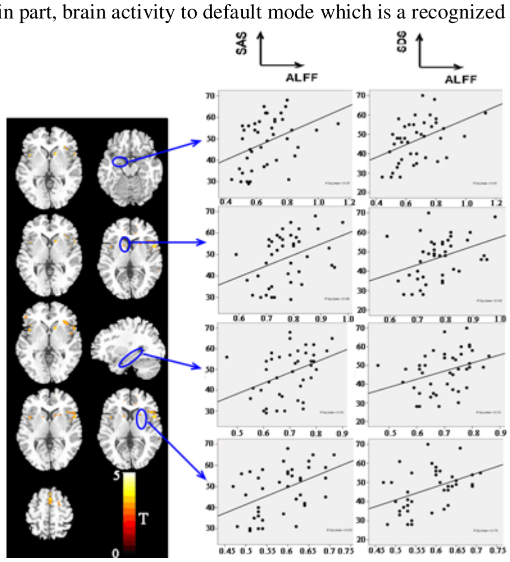

Figure 1. Regions showing increased ALFF in survivors (red areas) compared to controls ($p<0.05$ corrected). Scatter plot figures show significant positive correlations between regional ALFF (the structure in blue circle) and the Self-Rating Depression Scale (SDS) scores and the Self-Rating Anxiety Scale (SAS) scores in survivor group ($p<0.05$).

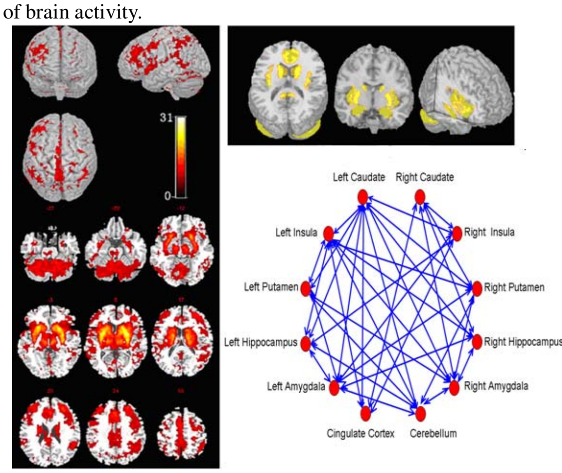

Figure 2 Left: Regions (red areas) showing significant functional connectivity in the within-group analysis of all subjects. Positive functional connectivity was observed mainly involving bilateral amygdala, hippocampus, caudate, putamen, insula, parahippocampus, prefrontal cortex, cingulate cortex and cerebellum ($p<0.05$, corrected for multiple comparisons). Right: Regions showing decreased functional connectivity (blue arrows) involving these areas (yellow areas above) in the survivor group compared to the control group ($p<0.05$, corrected for multiple comparisons).

References

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