Effects of 24hr of Total Sleep Deprivation on Resting CBF Differs in High-vulnerable and Low-vulnerable Adults

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Introduction Sleep deprivation (SD) can induce significant deficits in multiple neurocognitive functions (1). Recent studies using the Psychomotor Vigilance Test (PVT) and other cognitive tasks have consistently reported large inter-individual differences in responses to SD and suggested a trait-like differential vulnerability to SD (2). Using arterial spin labeling (ASL) perfusion fMRI, the present study measured and compared resting CBF patterns in high-vulnerable and low-vulnerable individuals before and after 24hr of total sleep deprivation (TSD), aimed to examine the effects of 24hr SD on the resting CBF and differentiate the neurobiological underpinning for inter-individual differences in SD susceptibility.

Methods A total of 20 healthy adults (including 10 high-vulnerable and 10 low-vulnerable subjects, matched by age and gender) participated in the study. The subjects were scanned on a Siemens 3 T Trio scanner at a resting state without any tasks before and after 24hr of TSD using a pseudo-continuous ASL sequence (3) to acquire the perfusion data with the following parameters: TR = 4s, TE =17s, Labeling time = 1.8s, Delay time = 1s, FOV = 22 x 22 cm, matrix = 64 x 64, 16 axial slices, 6mm thickness and 2 mm gap. Data were analyzed by SPM2. Perfusion weighted image series were then generated by pair-wise subtraction of the label and control images, followed by conversion to absolute CBF image. One mean resting CBF image was generated for each individual subject before and after TSD, respectively. Global CBF values were calculated and compared. Whole brain voxel-wise analysis using general linear modeling (GLM) was also conducted.

Results Global CBF showed no changes after 24hr of TSD, and no differences between high-vulnerable (HV) and low-vulnerable (LV) groups (Fig.1, all $p > 0.4$). However, SPM voxel-wise analyses showed significantly differential influences of SD on resting CBF patterns in HV and LV subjects. Specifically, SD induced robust regional CBF changes in HV subjects, including CBF increases in multiple occipital, temporal, parietal and frontal regions, and CBF decreases in right basal ganglia (Fig.2, top). In contrast, SD induced much less regional CBF changes in LV subjects, including CBF increases in small regions in right occipital cortex, middle cingulate cortex, and left sensorimotor cortex (Fig.2, middle). Direct comparisons between the two groups confirmed the greater effects of SD on resting CBF in HV than LV subjects (Fig.2, bottom).

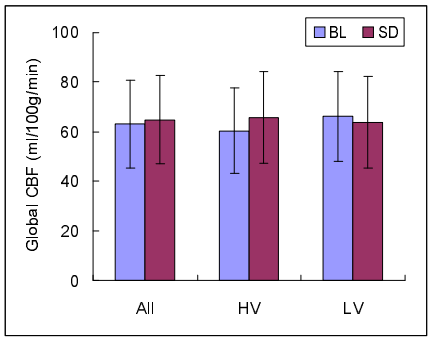

Fig.1 Effects of SD on global CBF.

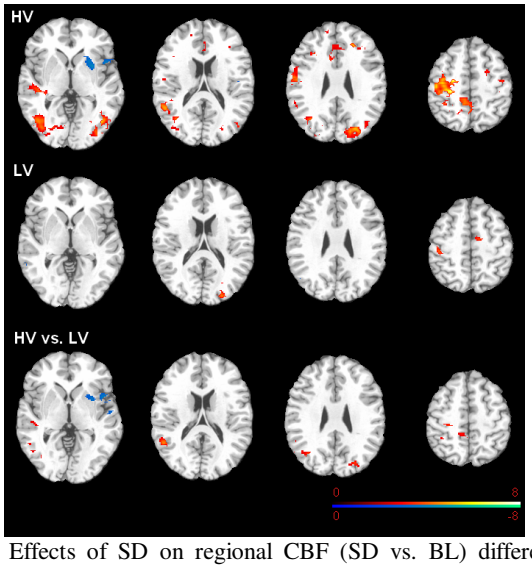

Fig2. Effects of SD on regional CBF (SD vs. BL) differed in high-vulnerable (top) and low-vulnerable (middle) subjects.

Discussions and Conclusions Inconsistent to the PET study reporting significant global CMRglu deduction after 24hr of TSD (4) and ASL study showing significant global CBF decrease after 48hr SD (5), our results showed no differences in global CBF. This finding suggests that global CBF is more resistant to short-time TSD. However, 24hr of TSD significantly altered resting CBF in widespread cortical regions in HV subjects but affected much less regions in LV subjects, indicating that differential effects of sleep deprivation on resting CBF may underlie the trait-like inter-individual differences in sleep deprivation vulnerability.

References

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