

The additively deactivated regions during a motor task in intracranial tumor patients show modulations of functional connectivity within the default mode network

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Introduction: The default mode network (DMN) region is compatible with task-induced deactivation regions in the study of functional imaging data based on signal changes compared to a baseline (1). Although there have not been enough studies dealing with motor tasks based deactivation, a previous study using motor task fMRI first described interhemispheric control of motor action as involving deactivation to prevent interference from the opposite hemisphere (2). A previous study described the detailed deactivated regions with respect to motor tasks and their functional connectivities based on normal human brain (3). Nonetheless, there is still a lack of knowledge in the understanding of deactivations identities and roles during a task-induced BOLD fMRI study. Furthermore, only a few studies investigated alterations of the default mode network or deactivations in patients with intracranial lesions. Therefore, in this study, we investigated the alterations of the motor deactivation regions in patients with intracranial lesions compared with the normal status of brain. Therefore, we hypothesized that an intracranial lesion would cause changes in a task-induced deactivation region compared with the default mode network, and these changes are associated with changes in functional connectivity or plasticity.

Materials and Methods: Pre-operative fMRI examinations with only the motor task obtained from 27 patients with intracranial lesions were analyzed. Mean age was 57.3 years (range 15~78 years). Language, memory, and sensory tasks were not analyzed for this study because there could be multiple influencing factors in those tasks according to intracranial lesions. BOLD fMRI during a motor task were obtained from 27 intracranial lesion patients (mean age, 57.3 years; range 15~78 years) who had various kinds of brain tumors. Statistical Parametric Mapping 2 software (SPM2, Wellcome Department of Cognitive Neurology, London, UK) was used for post-processing of fMRI data. The BOLD fMRI data for each patient were evaluated to obtain activation or deactivation regions. The distinctive deactivation regions from intracranial lesion patients were evaluated by comparing to the literature reports.

Results : In response to the non-dominant (left-hand) motor task, there were widespread deactivations of the left postcentral gyrus, bilateral anterior cingulate gyri as well as right posterior cingulate, precuneus and middle temporal gyrus in most patients. Similar deactivations were observed in response to the dominant (right-hand) motor task, including areas in the bilateral posterior cingulate, left temporal lobe and cuneus as well as right pre- and postcentral gyri, and precuneus. However, there were 10 patients who exhibited additive motor task-induced deactivated regions: one cavernous hemangioma (25%), 2 meningiomas (33.3%), 1 hemangiopericytoma (100%), 5 GBM (45.5%), and 1 metastatic brain tumor (50%). There was no connection in the lesion side and the motor task side. However, there was a tendency of additive task-induced deactivated regions occurring at left motor task in GBM patients to an appreciable extent. Globus pallidus, lateral occipital gyrus, fusiform gyrus, and caudate nucleus were markedly deactivated and claustrum, precentral gyrus, and midbrain were also demonstrated for deactivated regions. Caudate nucleus was distinctively deactivated in 2 GBM patients. Two meningioma patients and 2 GBM patients demonstrated additive deactivated regions in the lateral occipital gyrus.

Discussions: Motor task fMRI analysis delineated functional changes in brain networks in patients with intracranial diseases. In the line with a previous fMRI study of the motor task-based deactivation, we were able to identify motor task-induced deactivations. They clarified ipsilateral (to the task) postcentral gyrus connectivity with the ipsilateral primary motor cortex for both hands, and found that motor deactivation was likely a motor-specific process with no relation to basal ganglia circuit deactivation. Consequently, motor task specific deactivation and their representative regions were included in our study. We found several unique motor task-induced deactivated regions which do not occur to normal brains. Among the result of additive deactivated regions, the locations which appeared often were caudate nucleus, globus pallidus, lateral occipital gyrus, and fusiform gyrus.

Conclusion: The findings of the present study show, for the first time, that intracranial lesions altered motor-task deactivated regions. The additive deactivated regions in intracranial lesion patients provide preliminary evidence that a variable degree of structural changes modulates functional connectivity within the default mode network. It will be important to compare structurally changed brain with neuropsychiatric disorders which had been investigated extensively to enhance our understanding in human brain functional connectivity.

References: 1. Mayer JS, et al. Hum Brain Mapp 2010; 31 (1):126-139. 2. Allison JD, et al. Neurology 2000; 54 (1):135-142. 3. Marchand WR, et al. Neuroimage 2007;38 (3):538-548.

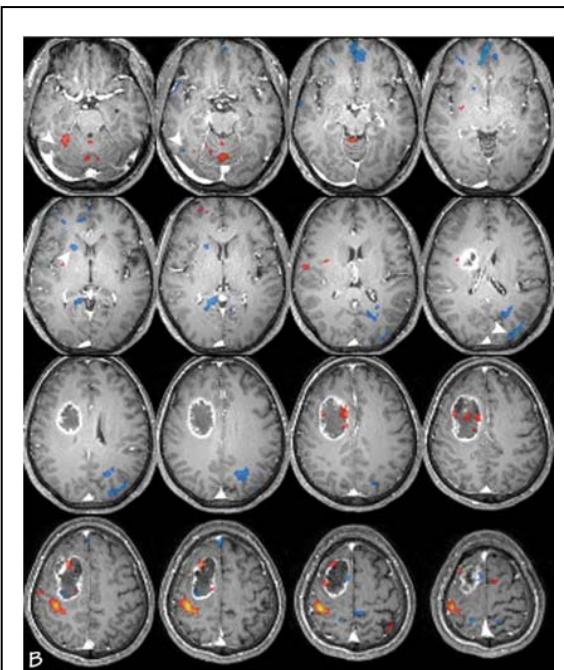


Figure. fMRI (56/F) with glioblastoma (case 7). Axial fMRI series during left hand motor task showing activation (orange) and deactivation (light-blue) regions. Arrowheads denote the distinctive deactivated regions.