IV. 3. Difference of Frontal Lobe Activity between Mental Task (Kraepelin Test) and General Exercise Task Detected with FDG Study

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Introduction

The tasked PET studies using $^{18}$F-fluorodeoxyglucose (FDG) has been reported under the various tasks. Greenberg et al.$^{1}$ reported that primary visual cortex activated during the simple visual stimulation. Mazziotto et al.$^{2}$ reported about the auditory stimulation. These studies aimed to detect the activity of the primary sensory cortex and the association cortex as the focus of high order brain function. But the role of the prefrontal cortex, so called "silent area", is still unknown. In our study, we wanted to make clear it.

Materials and Methods

Eight normal volunteers who gave informed written consent were studied. All were male, right handed, their ages ranged from 19 to 21 years old. Two tasks, the Kraepelin test and the general exercise task, were performed. The Kraepelin test consisted of reading a line of digits, adding in sequence, and writing the answers. Every minute the subject was instructed to go to the next line of digits. This task maintained the subject's intention. The general exercise task consisted of running and jumping on a sensor pad forced by family computer game (FAMILY TRAINER, Nintendo Co., Ltd.). Each task continued for 40-50 minutes.

10 minutes after beginning of task subject was injected with 2.1-3.8 mCi of $^{18}$F-fuluorodeoxyglucose (FDG), and 35-40 minutes after injection, scanning of activity in the tissues of brain was performed using a CTI 931/04 PET scanner. In our study data was not analysed as absolute CMRgic because arterial blood sampling was not performed. The relative activity was defined as the ratio of regional count and mean brain count. Regions of interest (ROIs) were generated in the cerebral cortical areas, 4, 6, 8, 9, 10, 11 described by Brodmann$^{3}$, putamen, and cerebellar cortex. To generate ROI we used $2 \times 2$ matrix printed out data of brain tissue radioactivity and morphological data obtained by Magnetic Resonance
Imaging CT at the same plane. The conceptual picture of cortical area of Brodmann is shown in Fig. 1.

Results

Regional brain tissue activity during general the exercise task is shown in Fig. 2. There was more activity in the areas 4, 6, putamen and cerebellum than in the other. No significant difference was observed between activity of left and right hemispheres. Regional brain tissue activity during the Kraeperin test is shown in Fig. 3. Activity of the left hemisphere was more than of the right hemisphere in the areas 4, 6. Difference of activity between the general exercise task and the Kraeperin test is shown in Fig. 4 (left hemisphere) and Fig. 5 (right hemisphere). In the areas 9, 10, 11, so called prefrontal cortex, more activity was observed during the Kraeperin test than during the general exercise task.

Discussion

Usual tasked studies using the FDG method have been limited because the tasks have to continue for 40-50 minutes and it is very difficult to make the subjects maintain his intention during then tasks. In our study two tasks such as the general exercise task and the Kraeperin test were selected. These tasks are able to maintain continuous intention of the subjects for 40-50 minutes.

The motion related regions such as the area 4 (motor area), the area 6 (premotor area), putamen and cerebellum had more activity than the other regions under the general exercise task. And the areas 4, 6 i.e. motion related cortex of the left hemisphere had more activity during the Kraeperin test than during the general exercise task. That fact means left motor area and premotor area were related with writing by the right hand. We believe our data support physiological and anatomical findings.

The prefrontal cortex, such as the areas 9, 10, 11 has been called "silent area". And its neurophysiological role has not been known clearly. But from clinical observation of patients with lobotomy or trauma in the frontal cortex, it is generally believed that the prefrontal cortex is related with higher mental function such as thinking, determination and will 4). In our study, we selected another task, the Kraeperin test, which induces activation of the prefrontal cortex. During the Kraeperin test areas, 9, 10, and 11 i.e. prefrontal cortex had more activity than during the general exercise task. This fact suggested that prefrontal cortex played an important role on reading and calculation which construct the Kraeperin test.

In summary, our results showed one aspect of the role of the prefrontal cortex and the motor cortex. While our tasks were complex, by selecting more elemental task, we would detect more locarized activity as the focus of the higher mental function with the FDG study.

References

Fig 1. The scheme of the cortical areas of Brodman.

Fig 2. Relative activity under the task of the general exercise. Relative activity is defined as the ratio of regional count and mean whole brain count. The box shows the average of brain activity in each area of the left hemisphere, and the circle shows of the right.

Fig 3. Relative activity under the task of Kaeperin test. The box shows each area of the left hemisphere, and the circle shows of the right.
Fig 4. and Fig 5. Relative activity under the task of general exercise vs Kraeperin test (Fig 4. right hemisphere, Fig 5. left). The box shows the activity of each subject under the task of Kraeperin test, and the circle shows under the task of general exercise.