Simultaneous Measurement of Regional Cerebral Blood Flow Changes Using [15O]H2O-PET and Functional Near-Infrared Spectroscopy (fNIRS): A Pilot Study

VIII. 3. Simultaneous Measurement of Regional Cerebral Blood Flow Changes Using [^{15}O]H_2O-PET and Functional Near-Infrared Spectroscopy (fNIRS): A Pilot Study

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Introduction

We can use positron emission tomography (PET) as a methodology of functional neuroimaging to measure the cerebral metabolic rate of glucose (CMRglc), cerebral blood flow (CBF) and transmitter-receptor interaction, etc. (Fig. 1). In order to measure the CMRglc, a radioactive analogue of glucose, [^{18}F]fluorodeoxyglucose ([^{18}F]FDG) is used. In certain activated brain regions, the demand for glucose and oxygen may increase due to the increased regional brain energy metabolism, resulting in the dilatation of cerebral capillaries. This capillary dilatation can be observed as an increased regional CBF (rCBF). The rCBF can be measured using PET and radio-labeled water ([^{15}O]H_2O) (Fig. 1). Recently, however, other radiation-free methods such as functional magnetic resonance imaging (fMRI) and functional near-infrared light spectroscopy (fNIRS) have also been applied to the measurement of rCBF (Fig. 1). In addition, in the human brain, neurotransmitters can manifest their potent effects even with very small amounts. Activities of neurotransmitters can also manifest their effects even in very small amounts. It is not easy to visualize the actions of neurotransmitters in the living human brain without using a highly sensitive technique such as PET (Fig. 1)[1].

Though the PET method is still in active use for measuring CMRglc and for evaluating neurotransmission function, PET measurement of rCBF has been almost replaced by fMRI and fNIRS. The most important disadvantage of PET would be its low temporal resolution. Therefore, the combination of PET and fMRI or fNIRS would make sense[2-5].

Materials and Methods

One healthy volunteer man was scanned using both fNIRS and [^{15}O]H_2O PET for evaluation of regional cerebral blood flow changes. fNIRS device use here was OMM-3000 (Shimadzu Co., Ltd., Kyoto, Japan: Fig. 2) and PET scanner used here was SET-2400W (Shimadzu Co., Ltd., Kyoto, Japan). Three conditions such as 1) resting, 2) word generation task in which outputs were vocalized (Word Voice), and 3) not vocalized (Word Silent). Statistical examination was done using single subject conditions & covariates menu to produce the contrast "Word silent – resting" and "Word Voice – resting" for both fNIRS and PET data (Fig. 3).

Results

In the result of PET data, there was a trend for more activation in the left frontal region in both Word Silent and Word Voice tasks. However, in the results of fNIRS data, there was a trend for more activation of the left frontal region in Word Voice task, but not in Word Silent task. Rather prominent activation was observed in the right hemisphere of Word Silent task, that was finally judged as an artifact (Fig. 3).

Discussion

While some findings were commonly observed in the fNIRS and PET, the findings were not the same. It seemed to be reasonable that the left hemisphere demonstrated the trend for more activation in Word Voice task both in fNIRS and PET. Using the current system, it was hard to directly compare the location of statistical peaks in fNIRS and PET because the fNIRS images and PET images were normalized differently. For the better coregistration, a digitizer system should be introduced.

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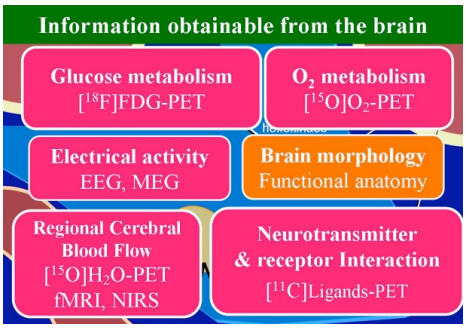

Figure 1. Information available from the living human brain. The most important energy resource of the human brain is glucose. Oxygen is necessary for glucose metabolism. These substances are supplied by the blood stream. Brain regions with increased activity are accompanied by increased regional cerebral blood flow. Information regarding glucose and oxygen metabolism can be obtained using PET. (Reproduced from the reference 1)

Figure 2. A NIRS device, OMM-3000 (Shimadzu, Co. Ltd., Kyoto, Japan), currently being used at CYRIC, Tohoku University.

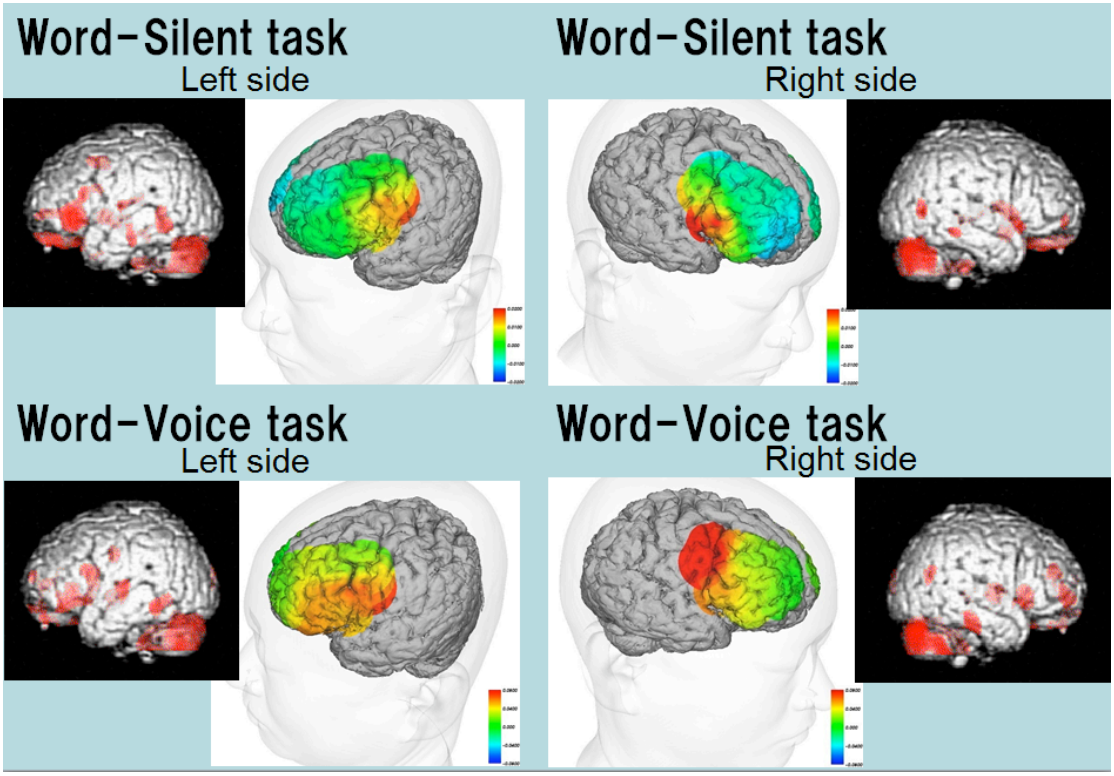

Figure 3. Regional activation pattern of NIRS and PET with $[^{15}O]H_2O$ in the left and right hemispheres (sides) of the brain separately.