Development of multinuclear/multichannel MRI system at ultra-high field for the elucidation of metabolic mechanism underlying human brain function

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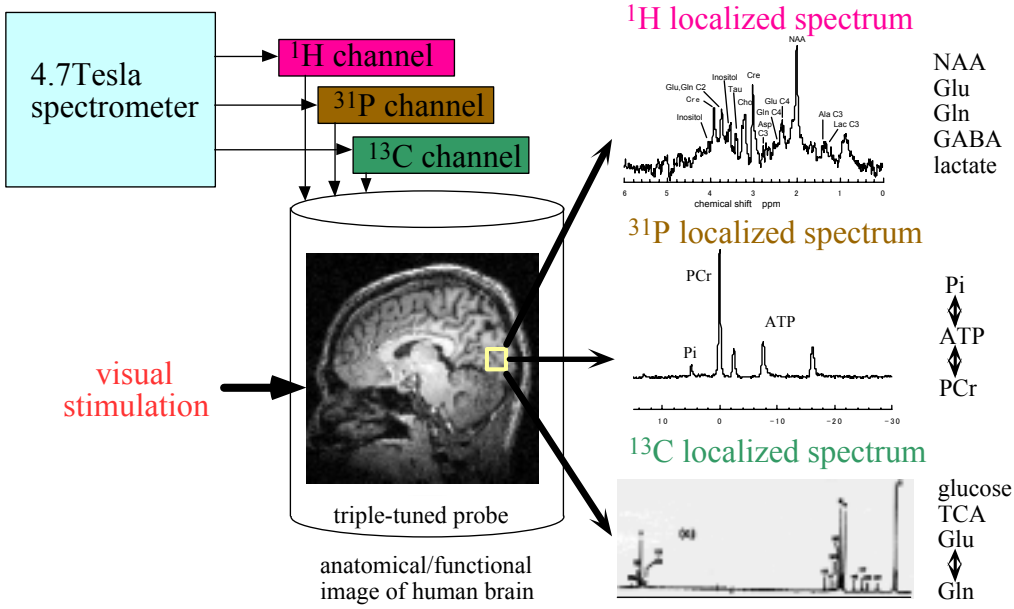

Introduction

The fMRI technique exploited a way to map the human brain function noninvasively. As a next step it is of great interest to see the metabolic process underlying the brain function. In the present work we propose a development of a multinuclear/multichannel MRI system at 4.7Tesla to allow us to observe neurotransmitters, energy metabolism, and glucose utilization at the same time on a human brain region where the activation occurs in the event related manner.

Method

We are developing a MRI spectrometer equipped with three transmit/receive channel based on a 4.7Tesla ultra-high field wholebody magnet. In this work we construct a triple-tuned MRI probe which enables us to observe 1H, 31P, and 13C resonances. We also have to construct a multiple channel localized spectroscopy pulse sequence for a single voxel for the above three nuclei. Techniques for localized spectroscopy on single nucleus for 1H or 31P have rather been established. Thus, we use a STEAM method with an ultra-short echo time for 1H, and ISIS for 31P measurements. We need to develop a new technique for 13C localized spectroscopy. We also have to develop a new method combining above three nuclei measurements into one sequence to make it possible to observe three nuclei spectrum at the same time. The merit of this method is that we can observe the metabolic change in the activated brain voxel from three different viewpoints, neurotransmitters, energy, and carbon fuel without extending the measurement time compared with a single nucleus measurement. Difficulty is in avoiding the overlapping of gradient pulses for the spatial localization in each nucleus, and in eliminating the internuclei interaction of spins.

Goal of the project

1. High sensitive 1H, 31P, and 13C spatially-localized spectroscopy at ultra-high field.
2. Simultaneous observation of neurotransmitters, energy metabolism, and glucose utilization on an activated area in human brain.
3. Temporal resolution down to one minute for the brain metabolic change in the event related manner.

Further challenges

1.Further improvement in sensitivity by developing small receive-only coil for signal reception.
2.Further refinement in the temporal resolution down to sub-second for some kinds of brain functions by a gating technique.
3.Selection of specific metabolic pathways by systematic resurrection of interaction between spins, or magnetic/isotopic labeling techniques.