

Physiological brain temperature change is detectable by MRS

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Introduction: The body temperature is one of the basic physical parameters affecting several body functions, such as metabolism, activity, pH and chemical reactions. The noninvasive accurate monitoring of the temperatures at deep regions, such as brain and liver, is desirable. It is reasonable that the brain temperature changes by physiological actions, such as sleeping, exercise, functional stimulation, drinking, eating, and so on. However, the brain temperature change at physiological conditions was reported scarcely [1,2]. Here we tried to examine whether the dynamic human brain temperature change is detectable or not by NMR. It is supposed that the sensitivity better than 0.1 °C is necessary [1,2]. We used the same approach of Cady et al. [3] and Corbett et al. [4,5] to detect the brain temperature change because the effect of the field drift and fluctuation, the main factor worsening the accuracy, should be excluded and the method using frequency may be rather accurate than the other noninvasive methods at physiological conditions.

Methods: ¹H-NMR spectroscopy was performed at 3.0 T (General Electric: Signa Excite HD 3T) on normal adult volunteers using PRESS without water suppression. We used 2 inch original surface coil to obtain spectra with high S/N ratio. Voxel size was 2cmx2cmx2cm. TR/TE were 3000ms/144ms. The NMR spectrum was analyzed every 6 sec by our homebuilt soft. We estimated the brain temperature by using the magnetic resonance chemical shift of water protons relative to acetyl protons of N-acetylaspartate as the temperature probe [3-5]. The temperatures of esophagus and axilla were also measured simultaneously. Volunteers drunk cold (500mL, 1 °C) or warm (500mL, 53 °C) water using a straw in a magnet. ¹H-NMR spectra were obtained successively during drinking and also pre- and post-drinking periods. The brain temperature was also measured under a light exercise such as a knee flexion of 1Hz.

Results: The standard deviation (SD) of our temperature measurements was 0.028 °C for a phantom solution. The SD became large a little for a human brain and also depended on the site of measurements (Fig. 1) and the task. Brain temperatures fell transiently about 0.5 °C by drinking of cold water (Fig. 1. Left). After the end of drinking, the brain temperature rose gradually. Brain temperatures rose about 0.4 °C by drinking of warm water. These brain temperature changes were transient and larger than that caused by heat loss and gain of cold and warm waters. The temperature changes of axilla were equivalent to the loss and gain caused by cold and warm waters. These results show that the human brain temperature is affected easily by the arterial blood which is cooled or warmed at the pharynx and neck. The brain temperature rose monotonously about 0.5 °C by 30min exercise and fell gradually after the end of exercise (Fig. 1. Right). This brain temperature change was larger and faster than that of esophagus. These results indicate that the temperature change started immediately by the task and that the heat balance in the brain changes during exercise.

Conclusions: We could detect the dynamic change of human brain temperature noninvasively using ¹H-NMR spectroscopy. Our results show that the human brain temperature changes dynamically even at physiological conditions and by physiological tasks. Moreover the temperature change of human brain was larger than that of esophagus and axilla. This indicates that the brain temperature is affected easily by the blood flowing into the brain and also that the temperature of this blood is easily affected by foods and drinks. We can easily change the brain temperature of about 0.5 °C by drinking or light exercise.

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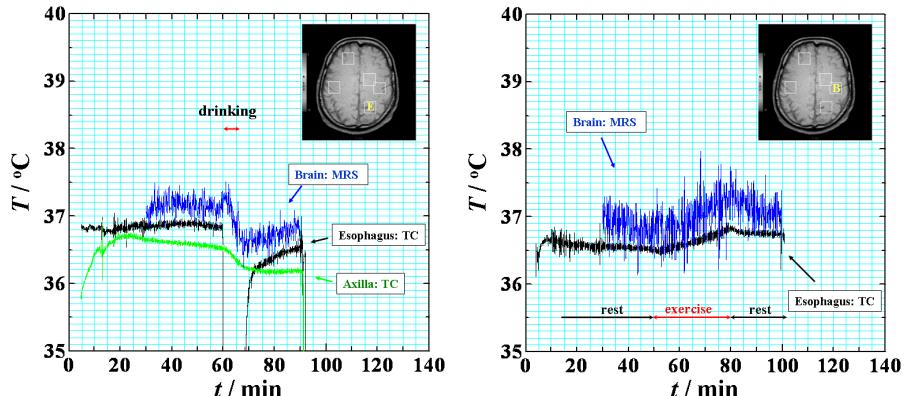


Figure 1. Left: Brain temperature change by drinking of cold water.
Right: Brain temperature change by light exercise.