Imaging of Electroacupuncture Stimulation in the Hippocampus using Manganese-enhanced MRI

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Introduction

The hippocampus is highly involved in the memory and learning process, and is known as a brain area, which is closely connected to dementia and mental diseases. Manganese chloride ($MnCl_2$) alters the magnetic resonance (MR) signal intensity by changing the longitudinal relaxation time. Manganese can enter the ventricles via the choroid plexus within a few minutes after systemic administration and can enhance hippocampal formations in one day. This imaging method is referred to as Manganese-enhanced Magnetic Resonance Imaging (MEMRI) [1][2]. Recently, various reports have demonstrated that electroacupuncture (EA) has the potential to increase brain cell metabolism (see e.g. [3]). The aim of this study was to investigate feasibility of hippocampal imaging in rats using MEMRI after electrical somatosensory stimulation by EA.

Materials and Methods

Male Wistar rats (310 g - 360 g, n = 12) were randomly divided into two groups: a control group without stimulation (NS, n = 6) and an electroacupuncture group (n = 6). All animals were infused with 50 mM $MnCl_2$ solution ($MnCl_2$-$4H_2O$, Sigma, USA) from the tail vein (50 mg/kg, 2.0 ml/hour) under 2.0 % isoflurane anesthesia mixed with O_2 and air. After the infusion, animals were conscious and kept in the plastic cage. For the EA group, five hours after $MnCl_2$ infusion, two acupuncture electrodes were placed on the right side of the posterior region of the neck and stabbed 10 mm into the skin under isoflurane anesthesia (2.0 - 2.5%) using facemask. The electrodes were connected to a stimulator. The stimulation parameters were: frequency = 2 Hz and 20 Hz, alternating every two minutes, current = 50 - 80 mA, duration = 1 ms. Stimulation was conducted for 60 minutes. After the stimulation, the animals were re-anesthetized with 2.0 % isoflurane mixed with O_2 and air, intubated, and ventilated. MRI measurements were performed immediately after stimulation (EA group) and 24 hours after $MnCl_2$ administration (NS and EA group) with a 4.7 Tesla scanner interfaced with a Bruker Paravision console (Bruker Medical GmbH, Germany). The animals were placed in a volume coil (Litz coil, Doty Scientific, Inc., USA). Coronal and horizontal slices of T_1-weighted MRI were acquired using a conventional spin-echo sequence. Imaging parameters were: pulse repetition time (TR) = 177 ms, echo time (TE) = 9.5 ms, slice thickness (ST) = 1.2 mm, field of view (FOV) = 32 mm, and matrix size = 256 x 256. StatView 5.0.1 (SAS, US) was employed for statistical evaluation of possible signal enhancement.

Results

Figure 1 depicts the MEMRIs, for both experimental groups (NS and EA). Figure 1A and B show the results for the experiment without stimulation six hours after initiation of $MnCl_2$ administration. Although signal enhancement was observed in the fimbria of the hippocampus and its periphery, no enhancement was detected in the hippocampal CA1 and Dentate Gyrus (DG). In contrast, enhancement of CA1 (black arrow) or DG (white arrow) can be seen in the images of the EA group obtained at the same time (Fig. 1C and D). Equivalent enhancement can be observed in the NS group in the images acquired after 24 hours. The statistical results displayed in Fig.2 confirm the findings.

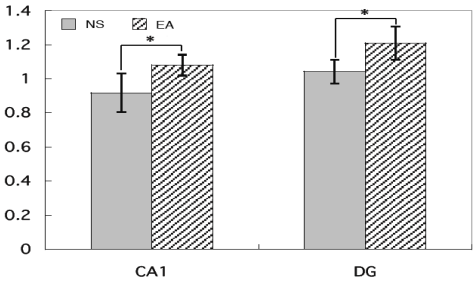

Fig.2: Statistical comparison of signal intensity in CA1 and DG, NS vs. EA.

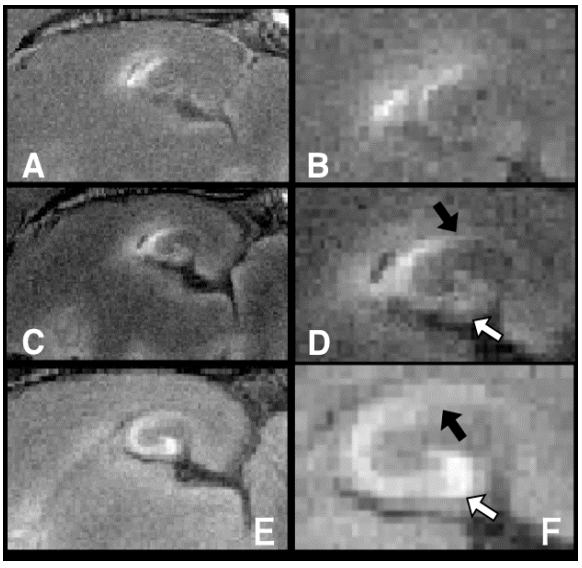

Fig.1: MEMRIs: top: NS group after six hours, center: EA group after six hours, bottom: NS group after 24 hours

Discussion

Typically, without stimulation, the hippocampal regions CA1 and DG are earliest enhanced 12 hours after $MnCl_2$ administration (data not shown). In this study these regions were successfully imaged in the EA group six hours after systemic $MnCl_2$ administration using MEMRI. This is presumably due to the accelerated uptake of $MnCl_2$ as a consequence of increased metabolic activity of the hippocampal cells. We therefore suggest MEMRI as an *in vivo* imaging technique that does not only supply morphological information but also information on the metabolic activity of pyramidal cells.

References

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