Effects of the Dietary Fatty Acids on Manganese-enhanced Magnetic Resonance Imaging (MEMRI)

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Indroduction: Manganese (Mn^{2+}), a Ca^{2+} analogue, is able to enter cell through voltage-gated calcium channels; and its paramagnetic effect can be traced by magnetic resonance imaging (MRI)[1]. The manganese-enhanced MRI (MEMRI) enhancement of the brain is determined not only by the presence or absence the blood-brain barrier (BBB), but also the neuronal activity. Dietary supplementation of the omega-3 fatty acids (rich in fish oil) have been shown to have beneficial effects on the cardiovascular system[2] in human and animal models, but the effect on the central nervous system is not conclusive. MEMRI has been successfully used to study brain structures and activity, but the effect of the long-term dietary intervention on MEMRI is still unknown. We performed manganese-enhanced MRI (MEMRI) to evaluate the effects of different dietary fatty acids on murine brain's basal activity.

Methods: MEMRI with intravenous administration of $MnCl_2$ (63.2 mM, 5 µl/g) was performed in male C57BL/6 mice (7 - 8 months old), six months after maintenance on different fatty acid diets (N = 6 for 12% fish oil [FO], N = 5 for 5% FO, N=6 for 12% buttermilk [BM], N=6 for 5% BM) and on standard rodent chow diet (N=5) for control. Spin-echo T1-weighted imaging was performed with the following scanning parameters; TR = 600 msec, TE = 10 msec, matrix = 256 x 192, field of view = 25 x 25 mm, 1 average, 10 slices and 1 mm thickness. The time-course signal enhancement of the 4th ventricle, the anterior pituitary gland (AP), the arcuate hypothalamic nucleus (Arc), the periventricular hypothalamic nucleus (Pe), the ventromedial hypothalamic nucleus (VMH) and the paraventricular hypothalamic nucleus (PVN) were measured. $P < 0.05$ was considered statistically significant.

Results & Discussion: The body weights between different dietary groups and control showed no significant difference (ANOVA, P = 0.48). The time course enhancement of the 4th ventricle (P = 0.55) (Fig 1a), the Arc (P = 0.91) and the Pe (P = 0.14) revealed no difference. However, different dietary fatty acids modulated the MEMRI enhancements in the AP ($P < 0.0001$) and other hypothalamic nuclei. Mice fed on 12% and 5% BM diets had higher enhancement in the AP (Fig 1b) and the VMN (Fig 1c) compared to mice on the 12%, 5% FO diets and controls ($P < 0.001$). In PVN (Fig 1d), mice fed on high fat diets (12% BM and 12% FO) and normal chow diet revealed higher enhancement than mice on low fat diets (5% BM and 5% FO) (P = 0.0004). Since degeneration in integrity of the BBB[3] and the neuronal hyperactivities in diseased model[4], aged mice can display higher MEMRI enhancement than young mice. From this point of view, high BM diet containing large amount of saturated fatty acids seem to worsen the brain degeneration as compared to normal controls. Our findings also correlated with the age-related increase in the activity of the calcium channels at the AP, which has been documented previously[5]. The reasons why PVN behaves differently to other hypothalamic nuclei are still not clear. However, among these different diets, low FO diet might be relatively neuroprotective, showing the least enhancement.

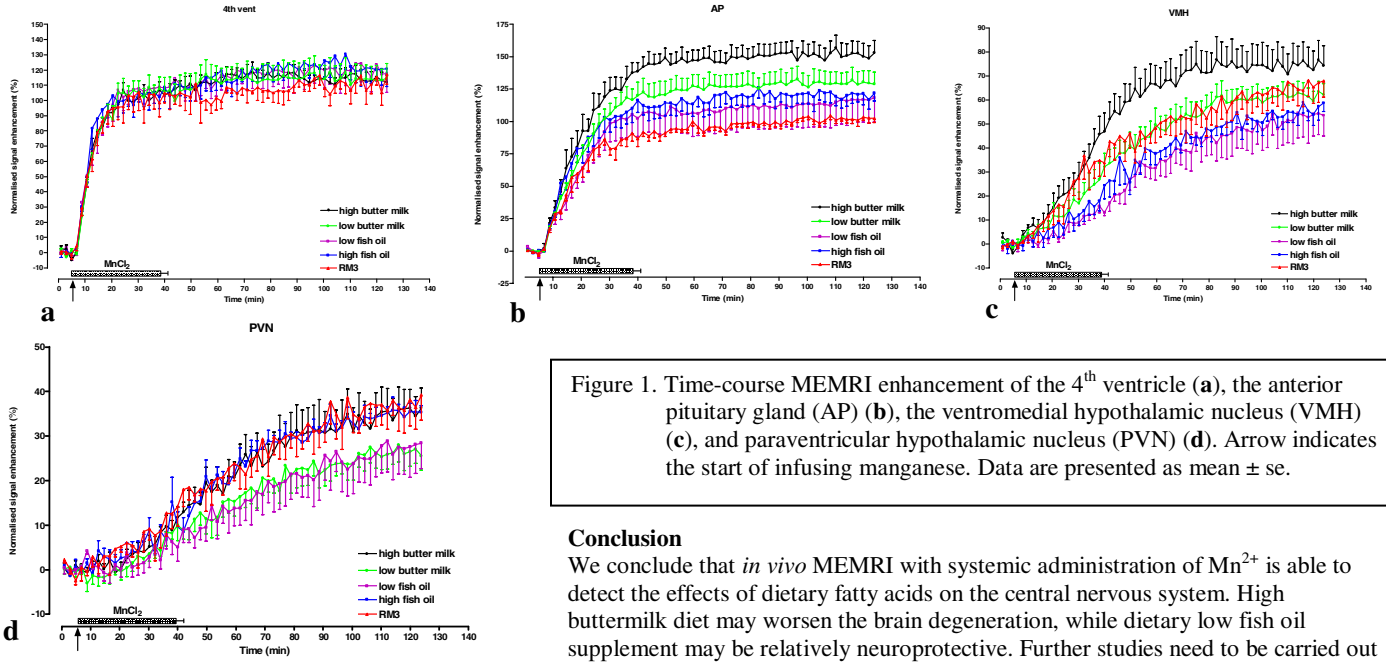

Figure 1. Time-course MEMRI enhancement of the 4th ventricle (**a**), the anterior pituitary gland (AP) (**b**), the ventromedial hypothalamic nucleus (VMH) (**c**), and paraventricular hypothalamic nucleus (PVN) (**d**). Arrow indicates the start of infusing manganese. Data are presented as mean ± se.

Conclusion

We conclude that *in vivo* MEMRI with systemic administration of Mn^{2+} is able to detect the effects of dietary fatty acids on the central nervous system. High buttermilk diet may worsen the brain degeneration, while dietary low fish oil supplement may be relatively neuroprotective. Further studies need to be carried out to verify these findings and assess the time-course of these changes.

References

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