Manganese as an in vivo tract tracer for callosal connectivity

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Synopsis:

Manganese-enhanced MRI was used to monitor the callosal pathway, which connects the visual cortex of the two hemispheres of the brain. The area17 region of the visual cortex was used as the cite for manganese injection. The results demonstrate that manganese can be successfully transported across the corpus collusum, to the visual cortex of the contralateral side, which opens the door for utilizing manganese as a tract tracer for understanding the white matter pathology in diseased conditions. In addition, the visual pathway from the area17 of the visual cortex to the Lateral Geniculate Nucleus, through the optic tract was also observed.

Introduction:

Research on the neural connectivity has contributed greatly for the better understanding of the brain structure and functions. The two brain hemispheres are interconnected by corpus collusum, whose function is to allow one hemisphere to control and inhibit homologous areas in the other hemisphere [1]. The pathogenesis of prominent white matter diseases like Multiple sclerosis, Acute disseminated encephalomyelitis and Herpes simplex encephalomyelitis contains lesions in the corpus collusum. An ideal methodology has to be developed for the evaluation of the damage occurring to the white matter regions, especially to the corpus collusum during diseased conditions. Many attempts have been made for the quantitative analysis of establishing neuronal connections, including histological sections. As the *in vitro* techniques is available only at one time point, development of an *in vivo* method of analysis will be of immense potential. An *in vivo* technique called manganese enhanced MRI has been proved to be an ideal methodology for tract tracing studies in living subjects [2]. The perception of vision is carried out by a continuous complex processes depending on the communication between two visual cortices of the two hemispheres of the brain. The connection is relayed through the callosal pathway along the corpus callosum [3]. In the present study, area17 region in the visual cortex was used as the site of injection for delineating the callosal pathway through the white matter tracts.

Materials and Methods:

Experiments were carried out in 12 SD rats (200g-300g). An isotonic solution of $MnCl_2$ was prepared (1.0Mm, 0.05 micro liter) and was intra injected (Bregma = -6.3, Lateral 4.4, Depth 1.4) to the site of injection (area17) using a 26' gauge needle (Hamilton, USA). The animals were anesthetized using 5% isoflurane and the anesthetization (1.5%) was maintained throughout the experiment. The body temperature and the respiratory rate of the animals was monitored and maintained at 37^0 c and 30-40/min respectively throughout the experiment. All MRI experiments were performed on an Avance 9.4T system (Bruker, Germany). Axial images were obtained by using FOV = 2.56 cm, slice thickness = 1 mm and matrix = 256 * 256 before and after 24 hours of intra injection. T2WI were acquired with TR = 4000ms, Effective TE = 52.7ms,NEX = 6 and Echo train length = 8. T1WI images were obtained with TR = 800 ms, TE = 5.5 ms and NEX = 6. All data analyses were performed using MR vision (MR Vision Co., Menlo Park, CA).

Results:

Even though a lot of papers have described about the transport of manganese through neurons, very few is found to be dealing with the contralateral transportation of manganese through the white matter tracts. We observed significant signal enhancement in the contra lateral side of the visual cortex after 24 hours of manganese intra injection in all of our experimental animals (Figure A). A noticeable increase in the signal intensity of the white matter tract (corpus collusum) was also observed. In the literatures using manganese as tract tracer, has often described the visual pathway from the eyes to the Lateral Geniculate Nucleus but most of them failed in establishing the connection between the visual cortex and the LGN. In our studies we observed significant signal enhancement in the LGN in all of our experimental animals (as shown in Figure B). The enhancement was persistent even after 48 hours of intra injection. The quantitative analyses of the enhancements are shown in Figure C.

Discussion:

The results from our studies prove that Manganese could be successfully transported from the area17 of the visual cortex to the contralateral side through the white matter tract. This opens the door for further studies in this field for using manganese as an effective tract tracer for the better understanding of the white matter pathology especially in diseased conditions of the white matter tracts. Our study also has proved that the area17 region of the visual cortex is actively connected to the LGN and further studies are needed for a better description of the visual pathway from the eye to the visual cortex via LGN [4]. Our results demonstrate that manganese can effectively be utilized as an in vivo tract tracer for defining the neuronal pathways between the two hemispheres of the brain.

References:

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3.Housel et al., Brazilian journal of medical and biological research (2002) 35: 1441-1453.

4.Watanabe et al., Magnetic Resonance in Medicine (2001) 46:424 – 429.

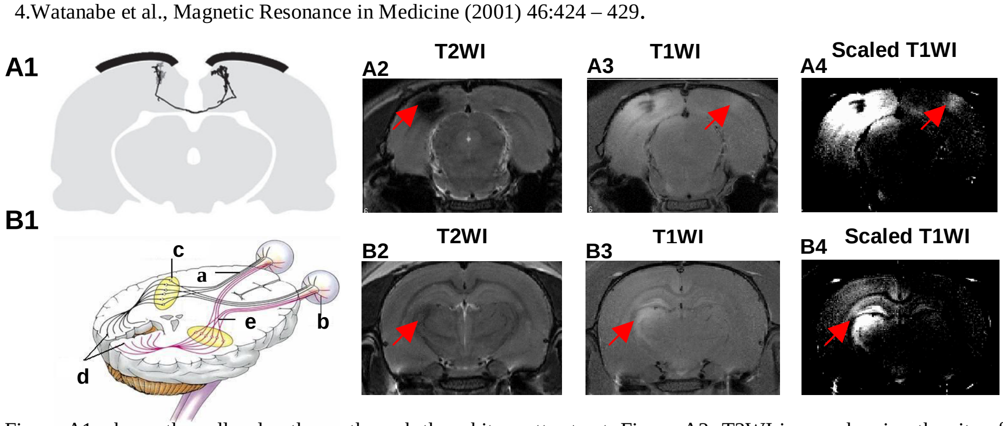

Figure A1: shows the callosal pathway through the white matter tract. Figure A2: T2WI image showing the site of injection (area17 in the visual cortex). Figure A3: T1WI image showing the enhancement in the contralateral side 24 hours after injection. Figure A4: T1WI image after scaling showing signal enhancement on the contralateral side 24 hours after injection.

Figure B1: describes the visual pathway from the visual cortex to the eyes through the LGN. (Figure B1a= optic nerve; B1b = eye; B1c = LGN; B1d = visual cortex; B1e = optic tract.)

Figure B2: shows the LGN region in the T2WI. Figure B3: T1WI showing significant signal enhancement in the LGN region 24 hours after intra injection. Figure B4: T1WI showing the signal enhancement in the LGN region after scaling.

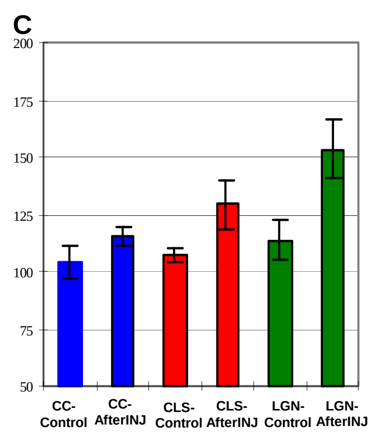

Figure C1: shows the average increase in the signal intensity in corpus collusum (CC), contralateral side visual cortex (CLS) and in the Lateral Geniculate Nucleus (LGN) 24 hours after intra injection, in comparison with their respective controls.