DIFFUSION TENSOR IMAGING INDICES IN A MODEL OF FOCAL ISCHEMIA IN RATS

U. Abo-Ramadan[1,2], M. pitkonen[2], E. Pedrono[2], I. Marinkovic[1,2], A. Durukan[1,2], and T. Tatlisumak[1,2]
[1]Dept of Neurology, Helsinki Uiversity Central Hospital, Helsinki, Finland, [2]Experimental MRI Laboratory, Biomedicum Helsinki, Helsinki, Finland

Introduction

Brain ischemia causes structural damage to the tissue that give rise to a loss of organization and structure at the cellular level. DTI indices (mean diffusivity [MD], fractional anisotropy [FA]) may enable a precise evaluation of tissue injuries caused by ischemic stroke (1). Recently, DTI indices (axial diffusivity [$\lambda_{\parallel}$], radial diffusivity [$\lambda_{\perp}$]) has been proposed to directly detect and characterize axonal injury and demyelination (2). In the present work, in a rat model of transient middle cerebral artery occlusion (MCAO) we measured the temporal evolution of the DTI indices from the hyperacute to chronic phase. Furthermore, we compared whether different brain regions have characteristic behaviour after transient ischemial. To our knowledge, there are no studies that have systematically followed the evolution of DTI parameters after ischemia over long periods with MR imaging.

Material and methods

MCAO was induced in Wistar rats (n = 9) by the intraluminal suture occlusion of the middle cerebral artery (MCA) for 90 min followed by reperfusion. The MRI measurements were repeatly performed (with a 4.7 T MR Scanner) at 2 and 3.5 hours, 1, 2, 3, and 4 days, 1, 2, 4, 6, and 8 weeks after the MCAO. Sham-operated rats were used as healthy controls (n = 8). Deep and subcortical white matter (WM) and cortical gray matter (GM) regions within the infarcts will be analyzed individually. DTI indices were acquired from multi-shot spin-echo echo-planar image (EPI) with 30 directions and b values of 0 and 1500 s/mm^2.

Result

MD decreased significantly, in the hyperacute phase in all measured tissues. In the acute phase, MD normalized at 2 to 3 days, and become higher than the normal in the subacute to chronic phase (Fig.1a). In the hyperacute phase, FA remained unchanged in all measured tissues. In the subacute and chronic phase, FA of the cortex depressed and remained significantly lower than the normal still at 8 weeks while subcortex and corpus callosum gradually increased from day 4, until becoming normalized at 4 and 6 weeks, respectively (Fig.1b). In the hyperacute phase, $\lambda_{\parallel}$ and $\lambda_{\perp}$ decreased significantly in all measured regions. In the acute to subacute phase $\lambda_{\parallel}$ and $\lambda_{\perp}$ of cortical and subcortical regions normalized and at 2 weeks both became significantly higher compared to the normal. In the corpus callosum, $\lambda_{\parallel}$ was normalized at 1 day and became higher than normal from 2 days until 8 weeks. $\lambda_{\perp}$ of corpus callosum was normalized from 2days until 4 weeks and then became higher than normal (Fig.1c,d).

Discussion

The study showed that, after transient MCAO, there are differences in the temporal evolution of DTI indices in different brain tissues. Differences in neuronal structure between WM and GM make it likely that the mechanism of ischemic injury and strategies for protection will vary. Thus DTI indices may allow separate evaluation of the treatment response of WM and GM to neuroprotective therapy. It seems that separate MD to $\lambda_{\parallel}$ and $\lambda_{\perp}$ give more detail information about tissue characterization as a function of time. DTI analysis of directional diffusivities could provide additional information to FA and MD, and may reflect more specifically the histological changes of reduced myelination and axonal injury.

References

1. Sotak CH et al. *NMR Biomed.* 2002;15:561–569 2. Song S. K. et al. Neuroimage. 2003;20:1714-1722.

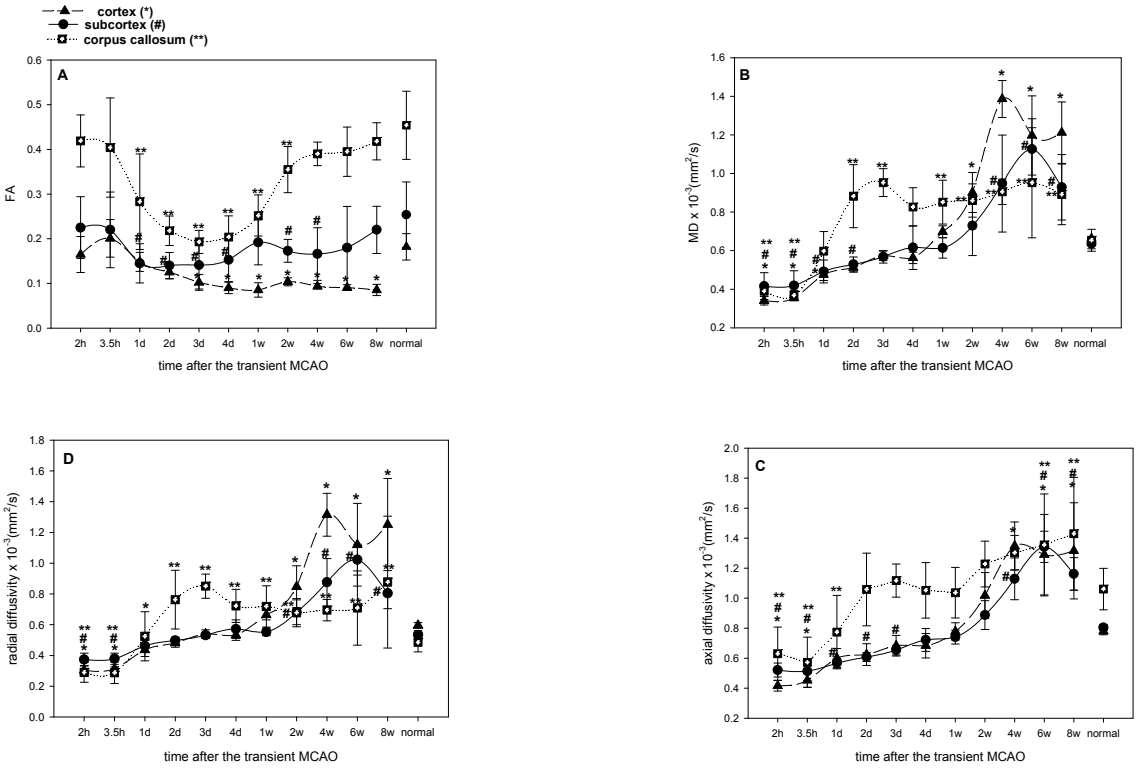

Fig 1. Each point is an average of the absolute values (n = 9) from the ischemic region (cortex, subcortex, and corpus callosum) and the normal presents the average of the healthy controls (n = 9). The evolution of the DTI indices; are presented over the 8 weeks observation period (2 hours – 8 weeks). Time points that are significantly different from the normal are marked in cortex (*), subcortex (#), and corpus callosum (**).