Brain Tissue Decomposition and its effects on Diffusion Tensor Images

H. E. D'Arceuil[1], and A. J. de Crespigny[1]

[1]Radiology, Martinos Center, Massachusetts General Hospital, Charlestown, MA, United States

Introduction: There have been numerous studies demonstrating high resolution diffusion tensor imaging in fixed animal brain tissues (typically rodents or monkeys), but relatively few studies involving human brain tissues. While animal tissues are generally fixed pre-mortem, this is not possible for human tissue, therefore there is always some delay between death and tissue fixation. Soon after somatic death, brain tissues undergo self-destruction (autolysis) in tandem with bacterial degradation which also facilitates tissue decomposition. Chemical fixation arrests autolysis and bacterial decomposition and stabilizes the cellular and tissue constituents. Depending on the elapsed time between death and tissue fixation, the postmortem interval (PMI), tissue decomposition will most likely adversely affect the tissue diffusion properties. We studied the effects that the PMI has on the diffusion properties of rodent brain.

Methods: Adult male CD1 mice (n=8) were euthanized and the brains were left in the skulls and kept at 4^0C. The skulls were placed in formalin at the following PMIs; 0, 1, 4 and 14 days. After 18 days of fixation, the skulls were removed from the formalin and placed in a 1mM GdDTPA solution of phosphate buffered saline for a further 14 days at 4^0C. For scanning, the skulls were immersed in Fomblin (susceptibility matching liquid) in sealed plastic tubes. 3D DTI scans were acquired on a 4.7T Bruker scanner, using a 3 cm solenoid coil. DTI data were processed using MRVision (Winchester, MA) to generate apparent diffusion coefficient (ADC) and fractional anisotropy (FA) maps. Tractography was performed using DTIstudio (Jiang/Mori, Johns Hopkins University)and tracts displayed using Amira software. Regional ADC and FA data (corpus callosum, basal ganglia, cerebral cortex, hippocampus CA1-3, fimbria) were modeled using a linear mixed effect model with FA and ADC as free variables and time as an ordinal variable, followed by a 2 tailed student's T-test.

Results and Discussion: When all PMIs were considered the regional FA and ADC of gray and white matter decreased significantly with time ($p<0.05$), figure 1. If time 0 was removed from the model, subsequent changes in FA in basal ganglia, cerebral cortex and fimbria ceased to be significant, while ADC and FA of the other regions decreased further. DTI tractography showed a decrease in the number and coherence of reconstructed fiber pathways between PMIs 0 and 14, Fig 2. Elapsed time between death and tissue fixation has a major effect upon the diffusion properties of brain tissue, and should be born in mind when interpreting fixed brain DTI.

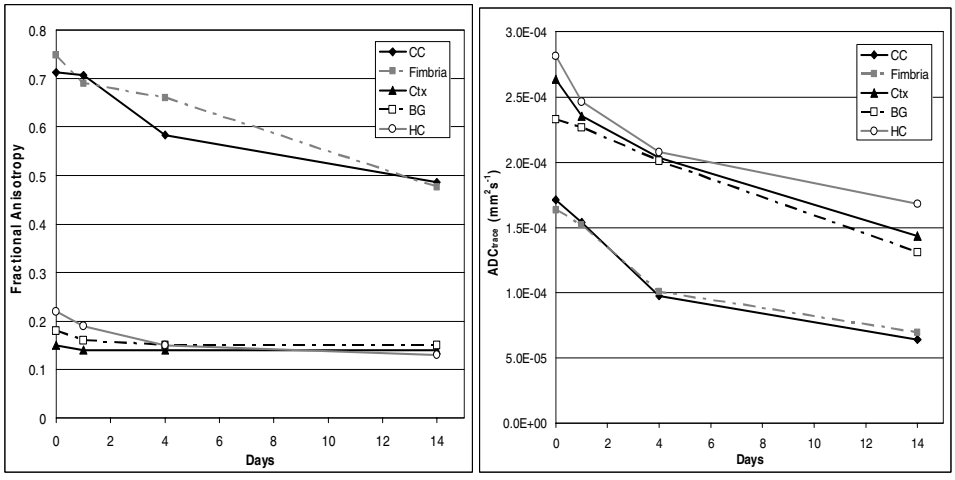

Figure 1: Regional FA (left) and ADC (right) with increasing PMI.

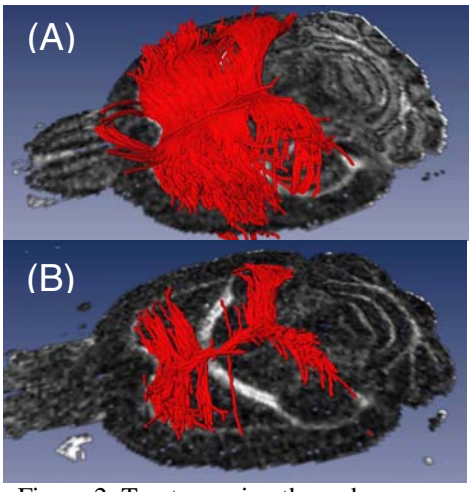

Figure 2: Tracts passing through corpus callosum at PMI 0 (A) and 14 (B) days.

Acknowledgements: We are very grateful to George Dai and Joe Mandeville, and for financial support from NIH/NCRR: P41RR14075, 1S10RR016811, NIBIB: EB00790 and the MIND Institute.