Quantitative Apparent Diffusion Coefficient Values and T2 Relaxation Rates in Term Neonates with Suspected Hypoxic Ischemic Injury

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Introduction:

MR Diffusion weighted imaging (DWI) and T2 weighted imaging have been shown to be useful for the detection of hypoxic ischemic injury (HI) in neonatal patients. Apparent diffusion coefficient values (ADC) and R2 (R2 = 1/T2) relaxation rates provide a quantitative measure of tissue characteristics beyond simple image contrast. Previous work in an animal model (kittens) has demonstrated a correlation the ADC and R2 parameters during brain maturation[1]. Here we extend upon these initial observations in animals and report on the relationship between ADC and R2 values in human term infants following HI (> 12 days after birth). In the neonatal population motion and anatomical size are issues, which make DWI techniques problematic. Whereas, T2 imaging techniques are considerably less sensitive to motion and generally provide better spatial resolution. This is first study to compare ADC and R2 values in human neonates and the first report of quantitative R2 measurements in neonatal ischemic injury.

Methods:

MR studies were performed on a 3.0T IMRIS MRI system designed for infant or head only adult studies. DWI was performed using an 8-segment spin-echo EPI acquisition, with diffusion weighting (b=600 s/mm^2) in three orthogonal directions. Using a recently described velocity compensated diffusion sequence; motion artifacts in the multi segment acquisition were reduced.[2] Imaging parameters for DWI included: (10 slices, 128x128 matrix size, TE = 135ms, bandwidth = 100kHz, FOV = 160mm, TR = 10 R-R cardiac intervals, acquisition time = 2.5 minutes). A log-linear least squares regression was performed for each diffusion direction and averaged to create a trace apparent diffusion coefficient (tADC) map.

R2 measurements were also performed with an 8-segment spin-echo EPI acquisition with 3 echo times (TE = 57ms, 150ms and 250ms). Imaging parameters included: (10 slices, 128x128 matrix size, bandwidth = 100kHz, FOV = 160mm, TR = 3.4s, acquisition time = 1.8 minutes). A log-linear regression was performed to obtain R2 maps.

Three newborn infants with suspected HI were imaged at 12-15 days after birth, all born at 37 weeks gestational age. Informed parental consent was obtained for all patients. Infants imaged in this project were part of a study approved by the research ethics board. Criteria for study inclusion were: umbilical pH <7.10; gestational age of 37-42 weeks; cardio-respiratory instability. R2 and ADC measurements were collected from 6 regions of interest (ROI) in frontal white matter (FWM), posterior white matter (PWM), frontal gray matter (FGM), posterior gray matter (PGM), intravascular border zone white matter (IVBWM) and the basal ganglia (BG). Correlation coefficients were generated for the R2 and ADC values measured in all 6 ROI using the linear regression analysis provided by SPSS (v10.0).

Results:

The tADC and the R2 maps for one of the infants with severe HI are presented in figure 1. The T2 and tADC values in the six regions for the three infants are shown in figure 2. The correlation between the tADC values and the R2 relaxation rates are illustrated in figure 3. A significant correlation was observed between measured ADC and R2 values. ($r = 0.931$, $p<0.001$) The linear regression was performed on all 6 ROI. The regression parameters, slope and intercept, were found to be –213.99 mm^2 and 2.554×10^{-3}mm^2/s, respectively.

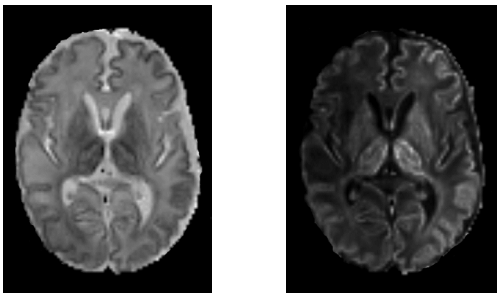
Discussion:

The result of the significant correlation observed between the ADC and R2 measurements collected show that following HI both diffusion and T2 imaging techniques provide similar information, for these infants who were imaged > 12 days after birth, after the immediate effects of the hypoxic ischemic insult have taken place. The previously published study of brain maturation in kittens also demonstrated a significant correlation between R2 and ADC values throughout normal maturation.[1] Additionally we show that the R2 and ADC values are correlated even following ischemic injury. This study demonstrates the potential of quantitative measurements of R2 as a marker of brain injury following HI.

REFERENCES:

1. Baratti, et al, *Radiology*, **210**:133-142 (1999)
2. Winter JD, et al, *Proc ISMRM* **2937** (2003)

Financial Support from the Canadian Foundation for Innovation (CFI), Innovative Magnetic Resonance Imaging Systems (IMRIS), the Ontario Research and Development Challenge Fund (ORDCF), and Multi-Magnetics Inc (MMI) are gratefully acknowledged.



(a) (b)

Figure 1. ADC map (a) and R2 map (b) of a term infant with severe HI.

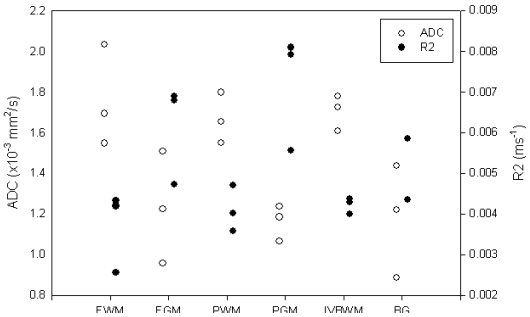


Figure 2. Interregional and inter-subject variability in the ADC and R2 values measured in term infants.

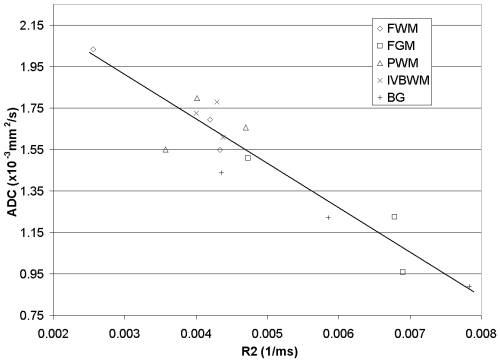


Figure 3. Plot illustrating the significant correlation observed between the ADC and R2 values obtained in various brain ROI