

Pediatric and adult global hypoxic-ischemic injury evaluated by diffusion-weighted imaging and MR spectroscopy

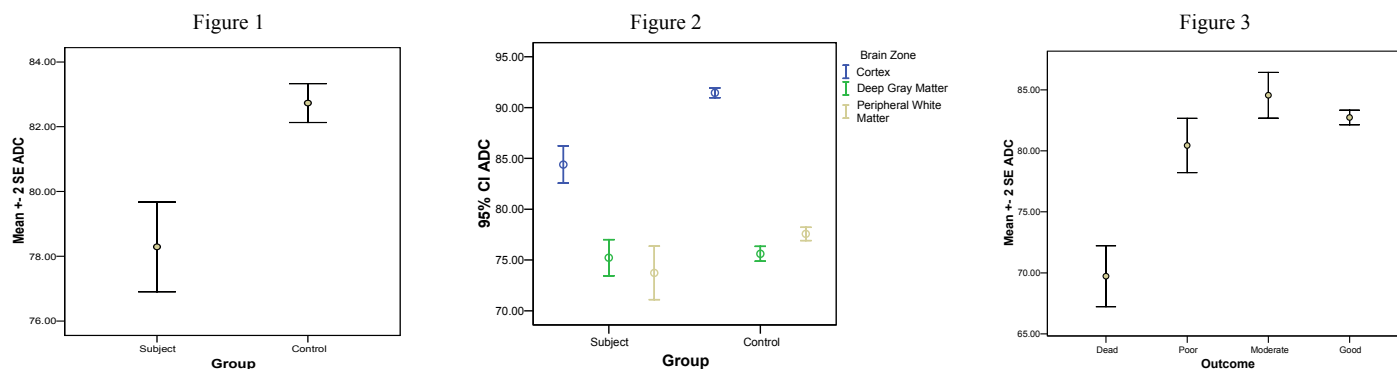
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Introduction: Diffusion weighted imaging (DWI) has been established as an important tool in the diagnosis of acute infarction, but has been less studied in the setting of global hypoxic-ischemic injury. Studies have been performed on animal models of hypoxia, as well as neonatal/perinatal asphyxia. However, there are only a few small DWI studies of hypoxic injury in the non-neonatal population¹ with only recent evaluation of objective ADC measures²⁻⁴. There are even fewer studies that combine DWI and MRS evaluation in this setting. The purpose of this study was to evaluate the ability of DWI to assess brain injury after hypoxic injury, in a larger sample of patients. Specifically, apparent diffusion coefficient (ADC) values were measured in pre-selected brain regions to determine if there was a correlation with patient outcomes. Comparison with MR spectroscopy data was also performed.

Method: Eligible patients were retrospectively studied over a 4 year period at our institution. 56 patients (aged 3 months to 80 years old) were imaged in a 1.5 T MRI scanner after a hypoxic-ischemic event, and compared to 45 control subjects. Infants who suffered perinatal hypoxia were not included in this study population. ADC values were measured in specific brain regions that included right and left frontal cortex, frontal white matter, parietal cortex, parietal white matter, temporal cortex, temporal white matter, occipital cortex, occipital white matter, caudate nuclei, lentiform nuclei and thalami. These were further grouped into three brain zones: cortex, peripheral white matter and deep gray nuclei. A single mean averaged ADC value was also calculated from all brain regions for each patient. ADC values were compared using univariate analysis or pairwise comparisons with post-hoc testing, and differences were considered significant at $p \leq 0.05$. Proton MR spectroscopy was performed on a subset of the patients. Four patients had repeat MRI/MRS studies. Patient outcomes were divided into four categories: dead ($n=15$), poor ($n=27$), moderate ($n=13$) or normal ($n=0$).

Results: There was no significant difference in mean averaged ADC values of the brain when comparing male to female subjects. There was also no significant difference when comparing right to left cerebral hemispheres, due to the global nature of the injury. The mean averaged ADC value of the patient group was significantly lower than the control group (Fig. 1). Evaluation of the ADC values in specific brain zones showed higher ADC values in the cortex compared to the white matter or deep gray nuclei for both patients and controls. However, there was significantly lower ADC values in the cortex of the patients compared to the controls (Fig. 2). The mean averaged ADC value of the patients who died were significantly lower than those with moderate or poor outcomes (Fig. 3). The ADC values of each of the three brain zones were also significantly lower in the group of patients that died, compared to all other outcome groups. Several patterns of diffusion restriction were observed, some predominantly involving the white matter, while others predominantly involved the gray matter. Follow-up studies in a small subgroup of patients showed temporal changes in diffusion abnormalities. When available, MR spectroscopy data showed decreased N-acetyl-aspartate (NAA) and elevated lactate in areas of brain injury. There was an inverse relationship between ADC values and the presence of lactate. Decreased NAA was also correlated with decreased diffusion.



Discussion: Diffusion restriction occurs after global hypoxic-ischemic injury, the degree of which may be predictive of outcome. In our study population, those patients with the greatest degree of diffusion restriction were most likely to die. MRS data provides additional information that supports DWI findings. Although there were regional differences in normal diffusion, all brain regions were susceptible to injury. Different patterns of injury are probably related to differences in mechanisms, varying degrees of hypoxia, and/or susceptibility related to age. Temporal changes in diffusion after injury are also important, which can affect the evaluation of ADC data. Although further research is necessary, these preliminary results suggest the ability of diffusion-weighted imaging to predict mortality after hypoxic-ischemic injury.

References:

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