EVOLUTION OF BRAIN INJURY DURING THE FIRST WEEK AFTER PEDIATRIC RESPIRATORY +/- CARDIAC ARREST: SERIAL ADC CHANGES AND SELECTED CBV FINDINGS.

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Introduction: The time course of Apparent Diffusion Coefficient (ADC) changes and initial relative Cerebral Blood Volume (rCBV) changes in acute ischemic stroke have been well described with ADC and rCBV decreases documented within minutes of clinical onset and persisting for days in regions of necrosis. However, the time course of ADC changes and initial rCBV changes after respiratory arrest +/- cardiac arrest are not well documented. In this study, we describe the ADC evolution and rCBV findings in a collection of pediatric patients with known or presumed respiratory arrest +/- cardiac arrest. Based on the literature, we hypothesized that ADC patterns of involvement would fall into at least 2 main categories: primarily deep gray nuclei involvement with cardiac and respiratory arrest[1] or primarily white matter involvement with respiratory arrest.[2]

Methods: The study group consisted of 8 children (age range 3 - 32 months). Three had a history of choking or drowning, resulting in a respiratory followed by a cardiac arrest. Five had a clinical history of suspected trauma X syndrome complicated by seizures and a known (2) or highly suspected (3) respiratory arrest. Clinical charts were reviewed for outcomes. All patients underwent at least one clinical examination on a 1.5T Signa Scanner which included Diffusion Tensor Imaging (DTI) and in some cases dynamic contrast-enhanced spin-echo perfusion weighted imaging.[3,4] Seven patients underwent follow-up studies. The diffusion tensor images were eddy current corrected and processed to create ADC and LOWB maps.[3] Intrasubject data sets from consecutive examination dates were coregistered using FLIRT software. Regions of interest (ROIs) were drawn manually on the initial LOWB images and transferred to the ADC maps. Locations chosen for ROIs were thalamus, lentiform nucleus and centrum semiovale. For each ROI, the mean ADC value was calculated and compared to normal ADC values reported in the literature.[5] If multiple studies were available, the ADC values in each ROI were measured over time. Perfusion weighted imaging was performed within 7 days in 4 of 8 patients. Raw images were motion corrected and maps of rCBV were computed. ROIs were drawn in the same regions as in the ADC maps on the initial image and mean values calculated. ROIs were also drawn in the frontal and occipital cortex on the same slice as the thalamic and lentiform ROIs and the mean values calculated. The ratios of thalamus to cortex and lentiform to cortex rCBV were then calculated. Similarly, on the same slice as the centrum semiovale ROIs, we determined the mean fronto-parietal cortex rCBV and calculated the ratio of centrum to cortex rCBV. If MR studies greater than 2 weeks after admission were available, we assessed for the presence or absence of cerebral volume loss.

Results: 1) ADC Changes: The 8 patients could be divided into three groups according to the pattern of the ADC changes. i. In the first group of patients, the region most severely affected initially was the deep gray nuclei (thalamus, lentiform). The ADC values in the thalamus and the lentiform nucleus were lower than normal on the day of admission and dropped to even lower levels in the following days (Figure 1a,b). In the one patient with the latest time point (6 d after admission), decreases in centrum semiovale ADC were seen at the time brain death was declared. All 3 patients in this group had documented respiratory and cardiac arrests and all died within one week of admission. ii. The second group of patients had essentially normal scans or, in one of three, posterior ADC abnormalities on the day of admission, but progressed to marked ADC decreases in the white matter of the centrum semiovale. The ADC values rose to normal or above normal levels after the first week (Figure 1b,c). The values of the basal ganglia remained within normal range in this group of patients. All 3 patients in this group had known or highly suspected respiratory arrest with seizures and all survived. Two patients imaged more than 2 weeks after admission had marked diffuse volume loss (both gray and white matter). iii. The third group includes two patients for which we did not observe any remarkable change in either the deep gray nuclei or the white matter of the centrum semiovale. One of these patients had his second scan on day 23 after the insult and had marked volume loss. However, the other patient was imaged on the day of admission as well as on day 3 and 4. At 6 months volume loss was noted but was less marked than in other cases. Both of these patients had known or highly suspected respiratory arrest with seizures and both survived.

2) rCBV Changes: Two patients in group one had a perfusion study on the day of admission showing relative hyperperfusion in the thalamus and lentiform nucleus compared to the frontal and occipital cortex of the same slice (ratios from 1.55 to 2.35). These ratios are higher than expected for the age of the subjects.[6] Interestingly, perfusion imaging was repeated the next day on one of these patients and showed resolution of the relative hyperperfusion with both ratios close to 1 (Figure 2). The CBV maps of the 2 patients in the group two failed to show significant changes in rCBV in the basal ganglia or centrum semiovale compared to cortex. However, perfusion imaging in these cases did not take place on the day of admission as these studies appeared normal. In these two patients, perfusion imaging was performed on day 2 or 3 when the white matter ADC decreases were evident. No perfusion studies were obtained for patients in group 3.

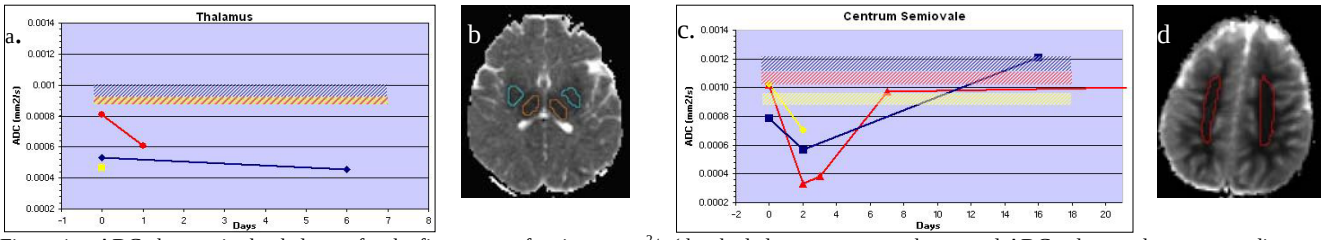

Figure 1 a. ADC changes in the thalamus for the first group of patients, mm^2/s (the shaded areas represent the normal ADC values at the corresponding age). b. ADC map of a first group patient on day of admission. c. ADC changes in the centrum semiovale for the second group of patients. d. ADC map of a second group patient on day 2 after insult.

Discussion: Our MRI findings suggest that children with suspected cerebral injuries secondary to respiratory +/- cardiac arrest should be scanned on the day of admission with diffusion weighted imaging, in order to detect early deep gray matter changes that portent a dismal prognosis. If these findings are normal, imaging should be repeated within the first 2-4 days after the insult, so that delayed white matter involvement can de detected. If the second scan is delayed after the first week, there is a high probability of missing the transient ADC decreases in the white matter. The relative hyperperfusion of the deep gray nuclei in cases with primarily deep gray nuclei injury suggests that rebound hyperperfusion plays a role in the progression of this type of injury. The case with multiple near normal studies in the first week but significant volume loss on follow-up suggests that not all forms of delayed cell death are accompanied by significant decreases in ADC during the first week.

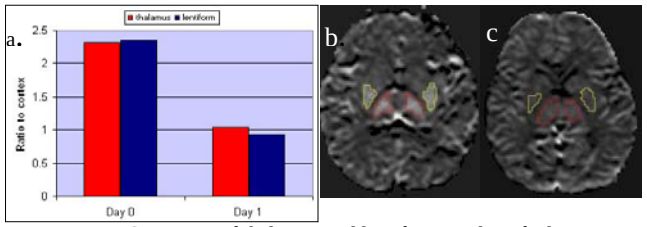

Figure 2. a. rCBV ratio of thalamus and lentiform on day of admission and one day later for patient in group one. b. rCBV map of same patient on day of admission and c. one day later.

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