Susceptibility Weighted Imaging: Microhemorrhage Prevalence and Prediction of Long Term Outcome in Pediatric Non-accidental Brain Trauma (NAT)

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Introduction: According to the U.S. Department of Health and Human Services, as of 2006, the rate of child abuse/neglect was 2.04 per 100,000 children in the general population. Two percent of these children died as a result of the abuse they sustained[1]. CT and MR imaging of the head often reveal subdural or subarachnoid hemorrhages, contusions and brain edema. MRI can also show areas of acute infarct on diffusion-weighted imaging (DWI) and parenchymal microhemorrhages (MH) with standard 2D gradient recalled echo (GRE) imaging. However, previous work has shown that susceptibility weighted imaging (SWI) depicts four to six times as many MH compared to standard T2* GRE imaging in children with accidental trauma[2]. This study was done to (1) determine the prevalence of parenchymal brain MH using SWI in children with NAT and (2) assess whether the presence of parenchymal MH resulted in improved prediction of long-term neurologic outcome.

Materials and Methods: A retrospective analysis of 118 pediatric NAT victims (mean age 8.2 ± 7.3 mo; range 1-32 mo) was performed with IRB approval from our institution. Imaging data was collected based on review of finalized reports of head CTs and MRIs from neuroradiologists and pediatric radiologists. The imaging findings were dichotomized into presence or absence of extra axial hemorrhages, contusions and MH. Clinical data was collected by a pediatric child abuse specialist and a pediatric neurology fellow. Long-term clinical outcomes were determined by a pediatric neurologist based on the Pediatric Cerebral Performance Category Scale (PCPCS). Patients were dichotomized into Good (normal, mild, moderate) and Poor (severe, vegetative, dead) groups. MH prevalence was determined using all subjects. Logistic regression was used to determine outcome prediction only in those patients with SWI and with follow-up outcomes at 6 months or greater (range: 6-95 months; mean: 32.5).

Results and Discussion: Of 118 NAT patients, 69% had MRI evidence and 56% had CT evidence of extra axial hemorrhage, 53% had retinal hemorrhages (unilateral or bilateral), 51% had skeletal fractures (other than skull fractures), 28% had skull fractures, 27% had brain MH on SWI and 8% had MRI evidence of contusion (Figure 1). Of the baseline 118 patients, 97 had SWI imaging. There were 26 patients (27%) with MH (14 patients had 6 month or greater follow-up). There were 71 patients without MH (36 patients with 6 months or greater follow up). Patients with MH had a significantly lower GCS score than patients without MH (8.2 vs 11.3; p=0.02). Patients with MH were 5.5 times more likely to have a poor outcome than patients without MH. A base model using logistic regression was constructed to assess predictive accuracy using patient age (in months) and initial GCS score. When presence of MH was added as a predictor to the base model, the predictive accuracy for those with poor outcome increased from 69.2% to 76.9% and for those with good outcome from 89.2% to 94.6% (Table 1). Retinal hemorrhage, CT findings and other MRI findings were not significantly associated with long term outcome and did not improve outcome prediction above presence of MH when included separately in the logistic regression model. The presence of retinal hemorrhages, which is routinely evaluated for as evidence of NAT, improved outcome prediction over the base model. However, the presence of MH on SWI further improved prediction of good outcome to achieve a combined overall predictive accuracy of 90%. Although extra-axial hemorrhage occurs more commonly after NAT (and is frequently of emergent surgical concern), our data suggest that the presence of parenchymal MH (as detected with SWI) may reflect diffuse axonal injury that contributes to a greater degree to long-term neurological disability.

Figure 1: Prevalence of Findings; n = 118

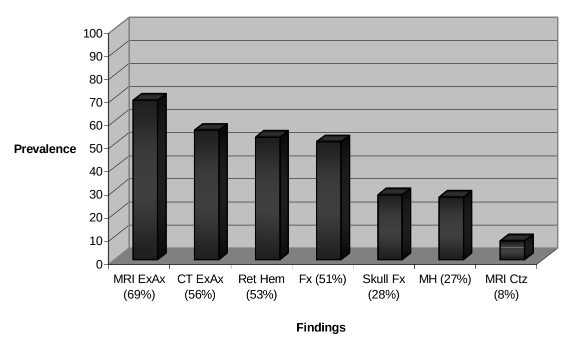

Table 1: **Logistic Regression Summary (n=50)**	Base Model = age(mo) +GCS			
Predictive Accuracy	Base Model	Base Model + Ret Hem	Base Model + MH	Base +Ret Hem + MH
Good Outcome (%)	89.2	91.9	94.6	94.6
Poor Outcome (%)	69.2	76.9	76.9	76.9
Overall (%)	84.0	88.0	90.0	90.0

Conclusions: The presence of intraparenchymal microhemorrhages seen on SWI is associated with and is more helpful in improving prediction of long-term outcome in pediatric patients after NAT than other radiologic findings or retinal hemorrhages.

References:

1U.S. Dept of Health and Human Serv., Admin. on Children,*Child Maltreatment 2006* (Washington, DC: U.S. Government Printing Office, 2008).
2Tong,K. et al. *Radiology* 2003; 227:332-9.