Vein Quantification of SWI in Infants with Hypoxic-Ischemic Encephalopathy (HIE)

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Introduction: Conventional MRI is an important imaging technique for abnormal neonatal brains. However, it is still not very sensitive to hypoxia-ischemia injuries (HIE). The use of SWI can give additional information about the varying amounts of deoxyhemoglobin in cerebral veins. This is a reflection of cerebral metabolic stress and can be correlated to poor clinical outcomes. The work sought to develop a quantified method of determining the amount of visible deoxyhemoglobin and to correlate this with clinical outcome.

Materials and methods: A total of 29 subjects were studied, all SWI images were acquired at 1.5T with a resolution of 0.5x1.0x2.0 mm^3. Imaging parameters were TR=57ms, TE=40ms, FA=20°, BW=78Hz/pixel, matrix of 512x160x32, and TA = 4:25. Standard SWI processing with the high pass filtered phase image was performed. Qualitative scores based on venous visibility were assigned by an experience radiologist on a prominence of vein (POV) scale ranging from 1 to 7 (Figure 1) although this study didn't contain any subjects scored above 5. Quantitative scores were calculated using two different thresholding techniques to mark the veins. In the first method a manual threshold was chosen for each slice to best mark the veins. In the second method an automated local thresholding algorithm was run where the threshold was set to 2.5 standard deviations below the mean calculated for a local ROI (40x40x5) centered on the voxel of interest. The percent of marked veins was calculated for each technique. To compare with the qualitative method and due to the limited number of subjects the quantitative scores were grouped into four bins for comparison (Figure 4). The Pediatric Cerebral Performance Category Scale (PCPS) was used as a long term clinical outcome score ranging from 1 (normal) to 6 (death).

Results: The qualitative vein scores indicated poor clinical outcomes for subjects with low and high scores which correspond to abnormally low or high levels of deoxyhemoglobin. The quantitative results mimicked this trend with slightly more variance. Scores in the intermediate categories indicate normal levels of deoxyhemoglobin and had good clinical outcome.

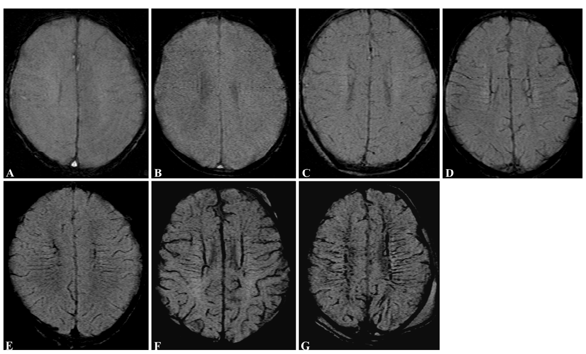

Figure 1. A through G show example images demonstrating qualitative POV scores ranging from 1 (A) to 7 (G).

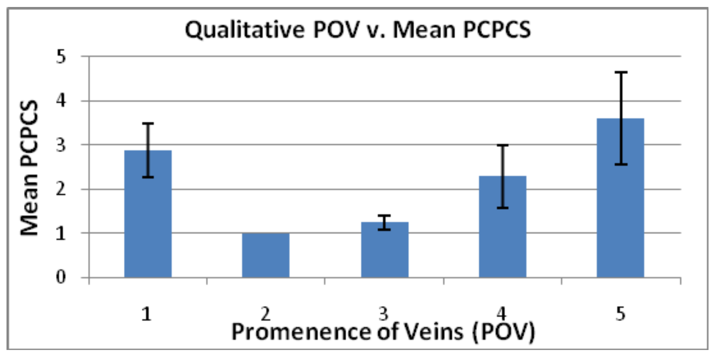

Figure 2. Low and high POV scores indicate abnormal levels of deoxyhemoglobin and correspond to poor clinical outcomes.

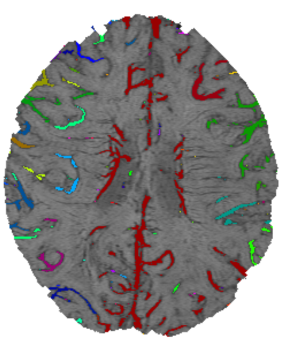

Figure 3. Example slices showing results of manual thresholding. Colors indicate vessels connected in 3D.

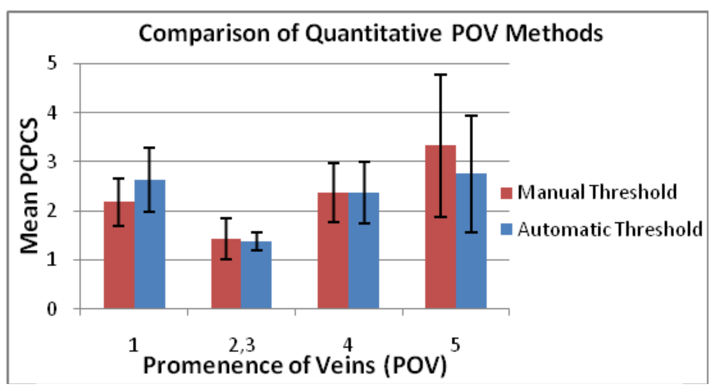

Figure 4. Comparison of two quantitative POV measures, both methods show the same trend as the qualitative measure.

Discussion and Conclusion: While the quantitative methods currently show more variance than the qualitative score, they hold promise for more robustly defining a POV or deoxyhemoglobin score. The qualitative scores are difficult to reliably define, especially near the boundaries, and require an experienced radiologist. While this initial analysis performed global measurements refinements such as more targeted local measurement would likely yield better results with decreased variance.