Quantitative Measurement of Deep Medullary Venous in Susceptibility Weighted Imaging: Comparison of Hypoxic-ischemic and Normal Neonates

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Target audience
MR physicists and pediatric neurologists.

Purpose
Hypoxic-ischemic encephalopathy (HIE) represents a major pattern of neonatal brain injury and increase level of deoxygenated blood. The susceptibility-weighted imaging (SWI) is particularly sensitive in detecting intravascular deoxygenated blood alterations [1]. Minimal intensity projection (mIP) based on the magnitude images of SWI is helpful to reveal small veins in neonatal brain. In some previous SWI studies, the dilated veins in the brain were often found in HIE neonates [2], Moreover, the HIE neonates with prominence of deep medullary veins were believed to be associated with poor outcomes at later stage [3]. However, whether the volume of cerebral small veins differs between the HIE and normal neonates is still unknown. Therefore, this study aims to evaluate the prominence of deep medullary veins in neonatal brain by a quantitative method for predicting degree of injury after HIE.

Methods
This study was approved by the local institutional review board. The neonates were all sedated (oral chloral hydrate, 50 mg/kg) before MRI scanning. 7 normal neonates as control were with mean postmenstrual ages (PMA) of 40±4 weeks (range of 35–44 weeks) and 20 HIE neonates with mean PMA of 39±2 weeks (range of 35–43 weeks). There were no significant differences in body temperature between two groups during the MRI examination. All images were obtained using a 3.0T MR system (Signa HDxT, General Electric Medical System, Milwaukee, WI, USA) with 8-channel head coil. A 3D gradient-echo sequence (Enhanced T2* weighted angiography - ESowan) was performed with TR=51 ms, number of echoes=8, TE =6–60ms, FA=20°, slice/gap=2mm/0mm, NEX=0.69. FOV= 18×18×cm² and matrix=384×256. The phases were low-pass filtered to remove background inhomogeneity. During post-processing by SPIN software (Signal Processing in Nmri, version 2131), the neonatal mIP images are typically reconstructed with a low effective mIP thickness of 8mm. For each subject, two axial slices were selected: (i) a slice #1 tangential to the roof of the lateral ventricles; (ii) a slice #2 through the lateral ventricles parallel to the first slice, in which the deep medullary veins could be shown more clearly. For the quantification of the deep medullary veins, we developed bilateral region of interest (ROI)-based analysis in the centrum semiovale in slice #1 [3] (see Fig. 1 A), deep white matter (WM) of frontal lobe (ROI-2, see Fig. 1 B) and temporal-occipital junction in slice #2 [4] (ROI-3, see Fig. 1 B).

Results
To accurately extract deep medullary veins in mIP images exactly, different thresholds were evaluated (Fig. 2 A–C). Appropriate thresholds were determined according to the effects of veins segmentation. In this study, the optimal thresholds for deep medullary veins in centrum semiovale and periventricle regions were set to 25% and 22%, respectively. In all neonatal brain, the deep medullary veins in defined regions showed no significant difference between the two hemispheres by the paired-sample t-test. The differences in venous prominence were segmented with using thresholds of 25% for A and 22% for B and C, which were highlighted in red color.

Discussion and Conclusion
The mIP images of deep medullary veins in SWI, which is highly sensitive to deoxygenated venous blood, highlights the cerebral small vessels as very subtle hypointense branches lying in the WM. In this study, we quantitatively measured the deep medullary venous prominence in ROIs by a threshold segmentation method. In different brain regions, we found increased prominence of deep medullary veins in HIE when compared to normal group as indicated by VRR. The increased VRR values could be interpreted by the degree of increased area of veins in ROIs. The prominence of deep medullary venous is influenced by various factors that include the increased venous concentration of deoxyhaemoglobin, venous stasis/thrombosis, and venous dilatation due to adenosine release [1,2,4]. The present study suggests that VRR can be a potential marker for assessing the degree of hypoxia in neonates with HIE. The proposed quantitative method may be valuable for clinically assessing the prominence of cerebral small veins for predicting degree of injury after HIE.

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References