Optimizing Diffusion Weighted Imaging in Neonatal Vascular Territory Injuries.

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Introduction: Diffusion-weighted imaging (DWI) has been widely used to assess acute cerebral injury, but studies for the determination of the optimum value for the diffusion sensitivity factor, b, have mainly been performed in adult stroke patients.[1,2] In neonatal brain, it has been suggested that the optimum b value to image ischemic injury is around 800s/mm^2.[3] We studied the effects of varying the b factor during DWI assessment of neonatal focal ischemic brain injury.

Methods: The study group consisted of 8 neonates who presented with focal seizures within the first few days of life and a focal vascular territory abnormality on DWI. All patients underwent clinical examination on a 1.5T Signa Scanner which included multiple Diffusion Weighted Imaging (DWI) scans, each with a different b value.[4] The sequence parameters were: TR =7500ms, TE = min for chosen maximum b value, b = 0 and at least 2 of 500, 700, 1000, 1500 or 2000 s/mm^2, single shot, FOV 200x200mm, matrix 128x128, 4 to 5mm thick, slice gap 0-1mm, NEX =3. The diffusion tensor images were eddy current corrected and processed to create DWI and ADC maps. Intra-subject data sets at different b values were co-registered using FLIRT software. The lesion was outlined manually on all DWI images using Analyze 5.0. A Region of interest (ROI) was also drawn in the normal tissue of the cerebellar hemisphere. The cerebellum was chosen for a normal ROI as it was not involved in any case and therefore served as a control ROI. The average DWI signal intensity (S) was determined in each ROI at all b values. ΔS was calculated as the difference in signal between DWI lesion and normal cerebellar tissue. The signal-to-noise ratio (SNR) was defined as S/σ, S being the signal intensity of the lesion and σ represented noise as calculated from an ROI placed in an area in the air surrounding the head that was free of artifact. The contrast-to-noise ratio (CNR) was defined as $\Delta S/\sigma$. The lesion was also outlined on each ADC map generated from the DWI at each b value. The mean ADC was recorded and the size of the ROI created was compared to the size of ROI of the corresponding DWI map.

Results: DWI maps: In all patients, noise remained approximately the same at all b values. SNR dropped with increasing b values. ΔS and CNR increased when b increased from 500 or 700 to 1000 s/mm^2 and then dropped with further increase of b to 1500 and 2000 s/mm^2. (Figure 1) The size of the lesion on the DWI maps decreased with increasing b values.
ADC maps: The size of the lesion on the ADC maps was the same at all b values and smaller than the lesion outlined on the corresponding DWI maps. This difference between ADC and DWI lesion volume was more pronounced at b = 700 s/mm^2 and almost nonexistent at b = 1500 s/mm^2. (Figure 2) The observed ADC values were lower at higher b values for both normal tissue and areas of infarction.

Discussion: At a b = 1000s/mm^2, CNR is highest and SNR, although lower than at 700s/mm^2, is still acceptable. T2 shine through effects are lower at a b = 1000s/mm^2 than at 700s/mm^2 and therefore the lesion size on the DWI map is closer to the ADC size. Although DWI lesion size was closer to ADC size at a b = 1500s/mm^2, the lower SNR and CNR made this b value less favorable. In conclusion if a single b value is used to image focal ischemic injuries in neonates, a b value of 1000s/mm^2 is recommended. Also given changes in ADC that occur with b, the b value of the acquired data should be reported when providing quantitative ADC data.

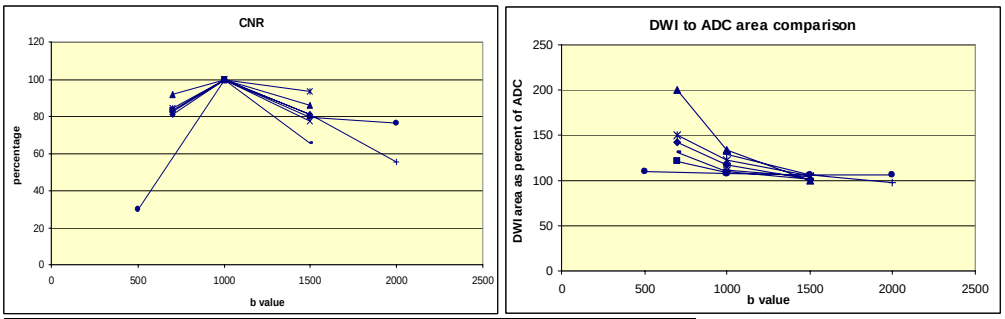

Figure 1: a. CNR at different b values presented as percentage of CNR at b =1000s/mm^2.
b. Size of the lesion on the DWI maps at different b values presented as percentage of size on corresponding ADC map.

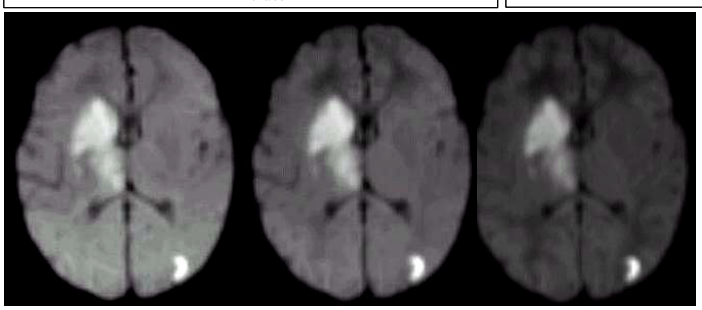

Figure 2: Newborn DWI images at b values of 700 (left), 1000 (middle) and 1500 (right) s/mm^2.

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