Initial application of diffusional kurtosis imaging (DKI) in brain development of preterm infants and evaluation of DKI in hypoxic-ischemic encephalopathy

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Introduction and Purpose：Hypoxic-ischemic encephalopathy (HIE) is a major cause of pediatric mortality and morbidity, especially for preterm infants. Previous studies focus on the ability and sensitivity of DTI to detect microstructural abnormalities of white matter lesions due to HI injury in neonatal brain [1], which is limited for gray matter. Recently, a new diffusion imaging technique, DKI, has been introduced and is increasingly used for human brain studies. DKI characterizes non-Gaussian water diffusion and is not limited to anisotropic environments. Hence, it can provide more information than DTI, especially its sensitivity to white matter and gray matter may be of importance in the examination of the early hypoxic-ischemic injury [2]. Our purpose was to observe correlations of DKI parameters with the postmenstrual age (PMA), and compare these parameters between preterm infants at TEA and term infants.

Materials and Methods: Conventional magnetic resonance imaging and DKI were performed in 36 preterm infants（21 preterm infants at term-equivalent age）and 15 term controls. Among them, 21 preterm infants (15 infants before TEA, 6 at TEA) and all the term controls had normal brain MRI performance and normal physical and neurologic examination, while the left 15 infants had typical MRI performance from hypoxic-ischemic injury. All the MRI acquisitions were performed on a 3.0T MRI scanner (GE Signa HDxt 3.0T). DKI series acquired two b_0 images and diffusion weighted images at b values 1250 and 2500 s/mm^2 with same 25 gradient directions for each of them. The values of FA, MD, $D_{/\!/}$, $D_{\perp}$, MK(mean kurtosis), $K_{/\!/}$(axial kurtosis) and $K_{\perp}$ (radial kurtosis) from the lentiform nucleus(LN), the ventrolateral thalamus(VLM), the posterior limb of internal capsule (PLIC), the corona radiate(CR), the frontal, parietal and occipital white matter (FWM,PWM,OWM correspondingly) were obtained. The relationship between these values and PMA was analyzed by Pearson's correlation analysis. The median of the parameters between the preterm infants at TEA and term infants was compared by independent samples t-test.

Results: Different levels of correlations existed between PMA and the values of FA, MD, $D_{\perp}$, MK, $K_{/\!/}$, $K_{\perp}$ from the selected ROIs. In general, PMA was positively correlated with FA, MK, $K_{/\!/}$ and $K_{\perp}$ values, while negatively correlated with MD, $D_{/\!/}$ and $D_{\perp}$ values. Among these parameters, MD from the CR(r=-0.829), $D_{\perp}$ from the FWM(r=-0.691), the OWM(r=-0.835), the PWM(r=-0.82) and the LN(r=-0.811), MK from the PLIC(r=-0.872) and the VLM(r=-0.801) had the highest correlation with the PMA. In addition, MD, $D_{/\!/}$ values from the CR(Fig.2), FA values from the LN, MD, $D_{\perp}$ values from the OWM, FA, MD, $D_{/\!/}$, $D_{\perp}$values from the FWM and the PWM were significantly different between the preterm infants at TEA and the term controls.

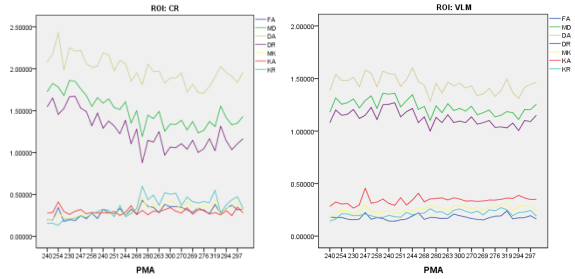

Fig.1. PMA was positively correlated with FA, MK and $K_{\perp}$ value，but negatively correlated with MD value, $D_{/\!/}$ value and $D_{\perp}$ value in CR and VLM. Da, Ka stand for $D_{/\!/}$, $K_{/\!/}$, Dr, Kr stand for $D_{\perp}$, $K_{\perp}$.

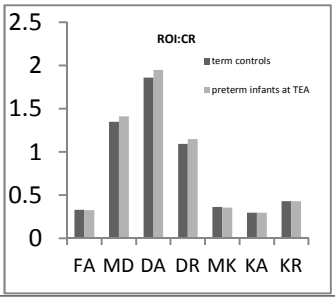

Fig.2. MD, $D_{/\!/}$ values of preterm infants at TEA were significantly higher than the term controls in CR. Da, Ka stand for $D_{/\!/}$, $K_{/\!/}$, Dr, Kr stand for $D_{\perp}$, $K_{\perp}$.

Conclusion: The DKI-derived measures at both white matter and grey matter showed high correlation with the postmenstrual age. FA, MD, $D_{/\!/}$ and $D_{\perp}$ values could effectively differentiate the preterm infants group from the term infants group. Therefore, DKI is a promising tool to detect the abnormality of HIE.

References: [1] O. Brissaud, et al. AJNR Am J Neuroradiol, vol., 2010. 31:282-287.

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