Intravoxel Incoherent Motion (IVIM) in Evaluation of Ischemic Acute Kidney Injury Animal Model

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Target audience: Radiologists and nephrologists

Purpose: Ischemic acute kidney injury (AKI) is relatively common among hospitalized patients with high morbidity and mortality. AKI is characterized by a rapid decline in kidney function within a few hours to a few days, accompanied by the underlining tissue changes of injury under biopsy. Imaging examination is rarely utilized as the limited diagnostic value for AKI. Intravoxel incoherent motion (IVIM) [1] MRI is a novel and noninvasive imaging method to provide functional data and is sensitive for detecting in vivo tissue injury as in AKI. We herein test if the IVIM is a potential tool for the detection and monitoring of reperfusion-related injury on an ischemic AKI model.

Methods: A total of 6 rats with ischemic AKI model by artery clamping for 45 minutes followed by reperfusion were examined at 3T scanner (Achieva 3.0T TX, Philips, Best, The Netherlands) using a single-shot echo-planar diffusion-weighted pulse sequence with six b-values ranging from 0 to 800s/mm^2. The IVIM parameters as diffusion coefficient (D), perfusion fraction (f) and pseudodiffusion coefficient (D*) were calculated over 72 hours using the bi-exponential model.

Results: $D_{0.5h}$ and $f_{0.5h}$ values of outer stripe of the outer medulla at 0.5 hours after reperfusion were significantly lower when compared with the normal controls [mean±SD] (1.24±0.90×10^{-3}mm^2/s *versus* 1.35±0.16×10^{-3}mm^2/s, 9.08±1.32% *versus* 15.64±6.55%, respectively, $P_{D,f}$ <0.01). On the contrary the $D^*_{0.5h}$ values were much higher than that of normal controls (30.04±15.55×10^{-3}mm^2/s *versus* 18.63±5.30×10^{-3}mm^2/s, P_{D^*} <0.01). D values reached highest level at 8 hours (1.57±0.16×10^{-3}mm^2/s) and then decreased to nearly normal level at 72 hours (1.39±0.07×10^{-3}mm^2/s), while both f values and D* values gradually restored to normal levels(16.04±4.37% and 17.30±5.77×10^{-3}mm^2/s, respectively) (Figure 1) within 24 hours.

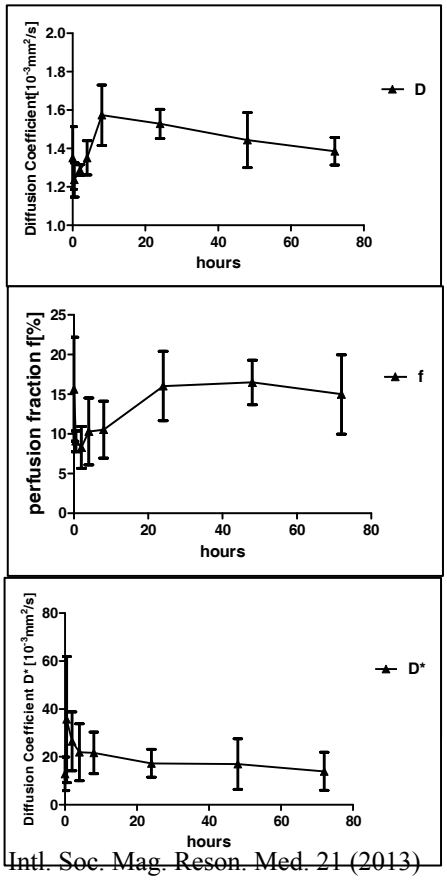

Figure 1: The time curves showing D (top), f (middle) and D* (bottom)

Discussion: IVIM is a sensitive tool for characterizing the random microscopic motion of water molecules by applying additional field gradients. Combined effects of water diffusion and capillary blood perfusion in injured tissues can be detected with MR diffusion imaging. Our research showed tissue changes triggered by reperfusion injury altered IVIM parameters D, f and D* as previously reported [2]. The oscillation of D, which mostly contributed by the mobility of extracellular water caused by ischemia/reperfusion (I/R) injury-related edema [3], revealed the gradual recovery of the renal parenchyma in 72 hours. The high curvature of f and D*curve reflected the relatively quick restoration of microvascular perfusion.

Conclusion: IVIM parameters varied closely to the progress of ischemia/reperfusion (I/R) of the kidney. IVIM could be potentially utilized for the detection of the ischemic in the early stage and monitoring the recovering process.

Reference:

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