Assessing renal ischemia/reperfusion injury in mice using time-dependent BOLD and DTI at 9.4T

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INTRODUCTION

In our current study, we investigated the regional functional/pathophysiologic changes in renal IR-injured mice using in vivo 9.4T BOLD and DTI and assessed any correlations between these MR techniques. We hypothesize from our findings on BOLD/DTI imaging that the outer renal medulla is the most sensitive to renal IR injury and that BOLD and DTI correlate with each other.

MATERIALS & METHODS

Both kidney arteries of all mice were exposed and cross-clamped for 40 minutes under anesthesia. Reperfusion was initiated before MRI acquisition by releasing the clamps as the incisions were being sutured. All MR experiments were performed using a 9.4T/160mm MRI scanner and quadrature volume coil. The T2* was measured using multi-gradient echo multislice (MGEMS) sequencing using the following parameters: TR = 120 ms, TE = 2.47–25.5 ms, 10 echoes total, flip angle = 30°, averages = 20. DTI was performed using spin echo sequencing with Jones6. DTI parameters included the following: TR/TE = 2500/31.3 ms, slice thickness = 1.2 mm, averages = 4, gradient amplitude = 16.4 G/cm, duration = 4 ms, separation = 10 ms, target b value = 300 sec/mm2, and 6 directions. DTI images were acquired at the same geometric positions as T2w and T2* imaging.

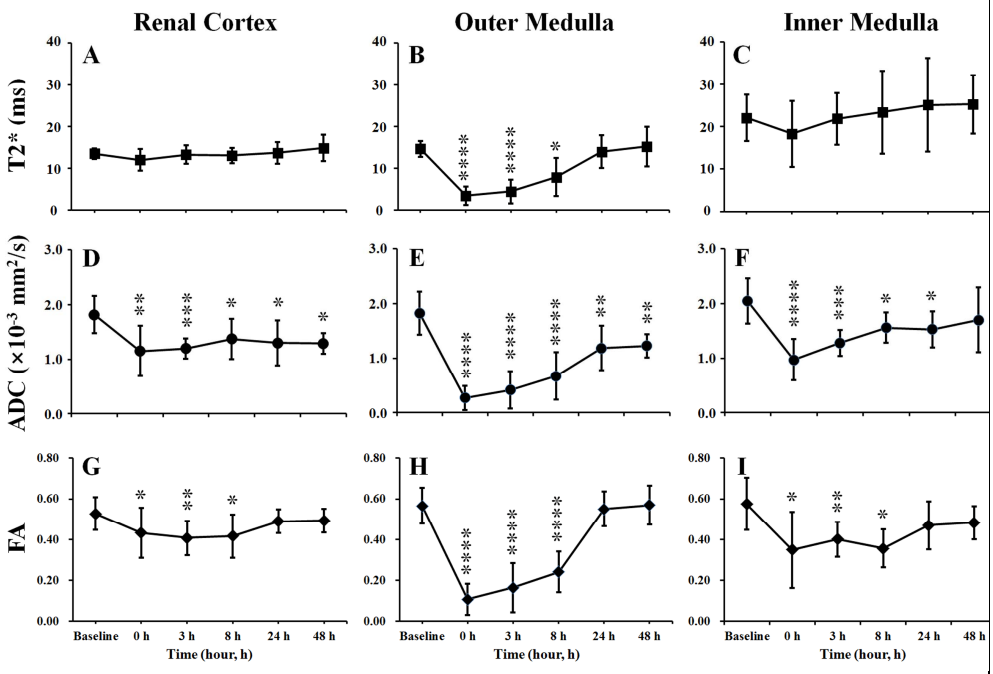

Figure 1. Plot showing the means of the T2*/ADC/FA values vs time for 8 mice and the three examined ROIs covering the CO, OM, and IM (error bars indicate standard deviations). Statistically significant differences are indicated accordingly: *p < 0.05; **p < 0.01; ***p < 0.001; ****p < 0.0001.

RESULTS & DISCUSSION

Absolute quantification was performed with 8 metabolites (Gln, compared with baseline, the T2* values in the outer medulla (OM) were significantly lower ($p < 0.05$) immediately after IR injury (i.e., 0 hours) and then gradually increased within 48 hours. According to the DTI results, the ADC values in the three renal regions were significantly lower at 0 hours, and then gradually increased within 48 hours (except in the IM). The FA values of all three renal regions decreased at 0 hours, and then gradually increased by 8 hours after IR injury. The BOLD and DTI correlations were not significant in the CO or IM. However, significantly positive correlations were found between the baseline and time-dependent data obtained from the OM of IR-injured kidneys. Our current findings suggest that MRI could be used to obtain pathophysiological data from separate renal compartments in IR-injured mice. Hence, BOLD and DTI may also provide functional and pathophysiological data on the allograft status following kidney transplant without the need to use a contrast agent.

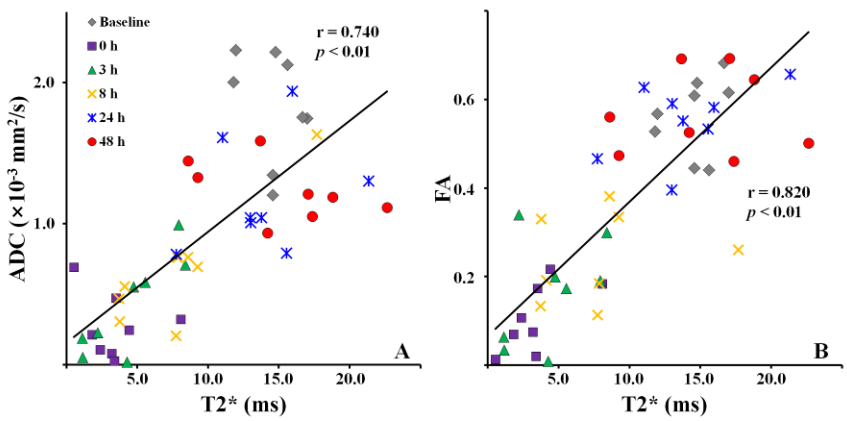

Figure 2.Correlations between BOLD (T2*) and DTI (ADC/FA) values are shown. T2* ADC and T2*-FA were only significantly correlated in the OM. (a): Y = 0.078X + 0.000; (b): Y = 30.32X + 0.065.