Functional Evaluation of Transplanted Kidneys with Reduced Field of View Diffusion-weighted Imaging at 3 T

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INTRODUCTION: Diffusion-weighted imaging (DWI) in human transplantation was regarded as a promising indicator of graft dysfunction. By applying the intravoxel incoherent motion (IVIM) theory, fitting the bi-exponential model with a number of b-values yielded the apparent diffusion coefficient (ADC_T), the "perfusion fraction" (F_P), and the "perfusion-free" diffusion (ADC_D)(1). Saritas et al proposed a reduced field of view single-shot diffusion-weighted echo-planar imaging (rFOV ss-DWEPI) method to provide images with higher in-plane resolution without the need for a longer readout time(2). In this study, we performed DWI using rFOV ss-EPI with multi-b values in renal allografts to determine whether diffusion parameters vary in different estimated glomerular filtration rate (eGFR) levels and correlate with clinical indicators.

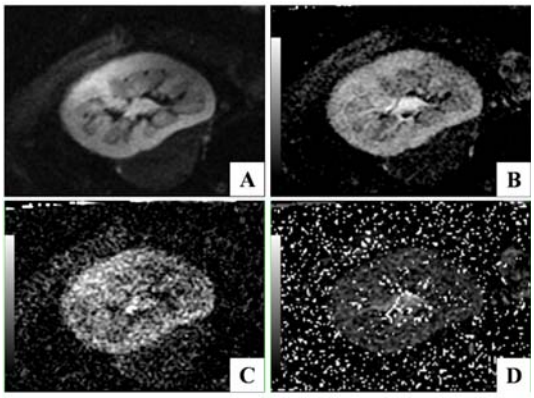

Fig 1. DWI images and parameter maps

METHODS: From March 2014 to October 2014, 18 patients with eGFR≥60 ml/min/1.73m^2 (Group 1), 20 patients with eGFR equal or more than 30 and below 60 ml/min/1.73m^2 (Group 2) and 8 patients with eGFR<30 ml/min/1.73m^2 (Group 3) were included in the study. Multi-b rFOV DWI (b=0, 10, 30, 50, 100, 150, 200, 400, 600, 800, 1000) was performed in 46 renal allograft recipients and ADC_T, ADC_D and F_P values were calculated.

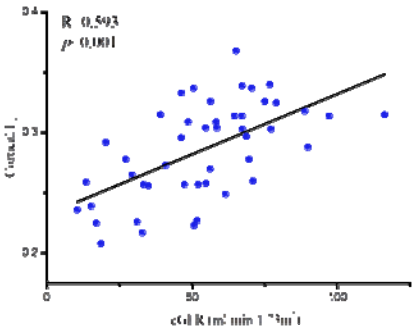

Fig 2. Correlation between cortical F_P and eGFR

RESULTS: The DWI images and parameter maps are shown in Fig 1. (A: DW image obtained with a b value of 10 s/mm^2, B: ADC_T map, C: ADC_D map, D: F_P map). Cortical ADC_T and F_P differed significantly among eGFR levels (p<0.02 and p<0.001 respectively). In cortex, ADC_T (mm^2/s) in Group 1 (1.64±0.14) and 2 (1.58±0.18) were significantly higher than Group 3 (1.44±0.11) (p<0.05), and the differences in F_P values between each two groups (Group 1: 0.31±0.03, Group 2: 0.28±0.04, Group 3: 0.25±0.03) were statistically significant (p<0.05). Medullary F_P in Group 1 (0.29±0.06) was significantly higher than Group 3 (0.24±0.06) (p<0.05). ADC_D values in both cortex and medulla remained stable among groups. When using 0.276 as the cutoff value, cortical F_P had a sensitivity of 88.89% and specificity of 60.73% for predicting normal and mildly decreased renal function (eGFR≥60 ml/min/1.73m^2). Cortical ADC_T (r=0.385, p=0.008) and F_P (r=0.593, p<0.001) and medullary F_P (r=0.404, p=0.005) showed a positive and significant correlation with eGFR(Fig 2).

DISCUSSION AND CONCLUSION: In our study, F_P seems to hold the best diagnostic performance among all determined diffusion parameters to evaluate kidney transplantation recipients at different stages. According to the IVIM theory, F_P measures the fractional volume of capillary blood flowing in each voxel(3). Heusch et al reported a significant correlation between renal allograft perfusion assessed by arterial spin-labeling perfusion measurements and F_P derived from bi-exponential DWI measurements, confirming F_P as a reliable indicator of perfusion(4). As interstitial fibrosis are generated in kidneys with impaired function, the microcirculation of blood in capillaries would be decreasing, leading to the lower F_P values in DWI. In conclusion, the present investigation demonstrates that multi-b rFOV DWI is a promising new technique for functional evaluation of renal allografts.

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