Assessment of renal allograft perfusion and diffusion using renal ASL and IVIM

Tao Ren[1], Hua Li Chen[1], Li Pan Zuo[2], Thorsten Feiweier[3], Niels Oesingmann[4], and Wen Shen[1]

[1]Department of Radiology, Tianjin First Center Hospital, Tianjin, Tianjin, China, [2]Siemens Healthcare, MR Collaborations NE Asia, Beijing, China, [3]Siemens Healthcare, Erlangen, Germany, [4]Siemens HC, New York, United States

Purpose: Allograft perfusion and diffusion are strongly correlated with long-term graft survival for transplant recipients[1]. With advances of MR technology, renal arterial spin labeling (ASL) and intravoxel incoherent motion(IVIM) have been successfully applied in the kidney and show high potential in detecting changes of renal function in patients with renal mass[2]. The purpose of the presented study was to assess the clinical evaluation of perfusion and diffusion parameters derived from ASL and IVIM in allografts at the early stage after kidney transplantation.

Methods: 32 renal allograft recipients 1 month after transplantation and 16 age-matched healthy volunteers were involved and examined using a 3T MR scanner (MAGNETOM Trio,a Tim system, Siemens AG, Erlangen, Germany). Patients were divided into two groups according to the estimated glomerular filtration rate (eGFR): patients with good allograft function (eGFR $\geq$60 ml/min/1.73m^2, n=22), and patients with impaired allograft function (eGFR<60 ml/min/1.73m^2, n=10). Sagittal-oblique ASL was performed using a prototype flow- sensitive alternating inversion recovery (FAIR) trueFISP sequence of 2.3×2.3×5.0 mm^3 voxel size, TE/TR 2.24/4.48 ms, and flip angle 70 degrees. 12 perfusion images (ΔM) with a TI of 1200 ms, and 1 M_0 image without inversion were acquired. T_1 mapping of the same slice was performed using a modified look-locker inversion-recovery (MOLLI) sequence of the same resolution. The renal blood flow (RBF) was then calculated using a Matlab(Mathworks,Natick,MA) in order to compute $RBF = \lambda\times\Delta M(TI)\times\exp(TI/T_1)/(2\times TI\times M_0)$, in which λ is 80 ml/100g and TI is 1200 ms. IVIM imaging was acquired using a prototype sequence with voxel size of 1.8×1.8×5.0 mm^3, TE/TR of 72.4/1600 ms, and 11 b values of 0, 10, 20, 40, 60, 100, 150, 200, 300, 500, and 700 s/mm^2 on 3 gradient directions. To separate the perfusion and diffusion, a bi-exponential fit was used to calculate the perfusion fraction (PF), Dfast and Dslow. For quantification, ASL- derived RBF and IVIM- derived Dfast, Dslow and PF in hand-drawn ROIs were compared between the three groups by one-way ANOVA with Bonferroni test.

Results and Discussion: Fig.1shows image examples of RBF, Dfast, Dslow and PF of kidneys in a healthy volunteer, a patient with good allograft function, and a patient with impaired allograft function. Statistical analysis showed that all parameters in the right and left renal cortices had no differences in the healthy group (*P* >0.05). Fig. 2 shows the statistical results of the parameters in renal cortex. For IVIM, Dslow and PF were higher in the healthy group than in patients with impaired allograft function, and both were higher in patients with good allograft function than with impaired allograft function(*P* <0.05). Dfast had no statistical difference between the three groups. For ASL, RBF was higher in the healthy group than in patients with kidney transplantation, and it was higher in patients with good allograft function than with impaired allograft function (*P* <0.001). However, the differences between groups were higher in RBF than in Dslow and PF.

Conclusion: IVIM and ASL were able to provide perfusion and diffusion information in healthy volunteers and subjects with transplanted kidneys for monitoring renal function noninvasively. Compared with IVIM, perfusion information provided by ASL was more sensitive to evaluate the renal function.

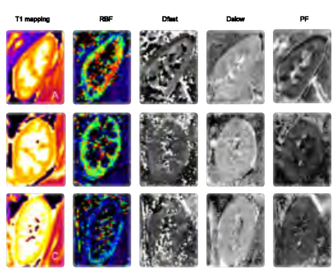

Fig.1 Image examples of RBF, Dfast, Dslow and PF of renals in a healthy volunteer(A), a patient with good allograft function(B), and a patient with impaired allograft function(C).

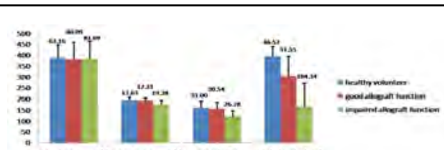

Fig.2 shows differences of cortex Dfast, Dslow,PF and RBF in all subjects. Dfast showed no difference between groups, Dslow and PF were higher in the healthy group than in patients with impaired allograft function, and both were higher in patients with good allograft function than with impaired allograft function(*P* <0.05). RBF was higher in the healthy group than in patients with kidney transplantation, and it was higher in patients with good allograft function than with impaired allograft function (*P* <0.001).

References: 1. Wenjun F, Pan-Li Zuo, Wen Shen. Assessment of renal allograft function early after transplantation with diffusion tensor imaging.ISMRM.2014.

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