Loss of renal diffusion anisotropy in Patients with Chronic Kidney Disease

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Introduction:

The measurement of the diffusion characteristics of the kidney could provide useful insights into the mechanisms of various renal diseases. The anisotropic diffusion properties in the kidneys is a result of structures like vessels, tubules and collecting ducts, which are oriented in a radial fashion. Diffusion tensor imaging (DTI) is a MR imaging technique that can be used to characterize the orientational properties of the diffusion process of water molecules (1,2), noticeably in the brain. Several studies successfully demonstrated the feasibility of DTI in kidney, which could visualize the renal microstructure (3,4). The purpose of the present study is to assess the changes in diffusion anisotropy in patients with chronic kidney diseases (CKD) using a 3 Tesla MR scanner.

Materials and Methods:

Six CKD patients (glomerular filtration rate range: 6–27 ml/min/1.73m^2) and six normal volunteers were recruited in this study, using a 3 Tesla MR scanner (Trio a TIM system, Siemens, Erlangen, Germany). Morphologic imaging included T2 and T1 weighted imaging for axial and coronal planes. DTI data were acquired using a single shot spin-echo echo-planar imaging sequence. Imaging parameters include: TR/TE =1600/78 ms, field of view = 250 mm. matrix size = 154 × 154. Nine contiguous coronal slices of 5-mm-thickness were obtained, with a b-value of 300 s/mm^2 and diffusion gradients along 12 non-collinear directions. A belt sensor was wrapped around the abdomen for the respiration-triggering. Regions of interest (ROI) were placed above the medulla and cortex of bilateral kidneys. Diffusion indices, including axial diffusivity ($\lambda_{\parallel} \equiv \lambda 1$), radial diffusivity ($\lambda_{\perp} \equiv (\lambda 2+\lambda 3)/2$), mean diffusivity ($MD = (\lambda 1+\lambda 2+\lambda 3)/3$) and fractional anisotropy (FA) were compared. Two-tailed student t-tests were used (p-values < 0.05 considered as statistically significant).

Results and Discussion:

Fig. 1 a and b show the maps of FA from a normal volunteer and a CKD patient, respectively. Significant reduction of diffusion anisotropy in medulla was noticed in patients. Fig. 2 plots the diffusion measures at the medulla. Both the increased $\lambda_{\perp}$ and the decreased FA were significant. The decreased FA can be attributed to an increase of radial diffusivity. A possible explanation might be the breakdown of the tubules, resulting in a dysfunction of the filtration process of water.

Conclusion:

DTI can detect the changes of diffusivities in patients with chronic kidney disease. The reduced anisotropy in medulla in CKD patients was attributed to the increased radial diffusivity ($\lambda_{\perp}$) when compared with normal subjects.

References: [1] Michaely HJ, et. al., Abdom Imaging 2007. [2] Muller MF, et.al., Radiology 1994. [3] Ries M, et.al., J Magn Reson Imaging 2001. [4] Kataoka, M., et al. J Magn Reson Imaging 2009.

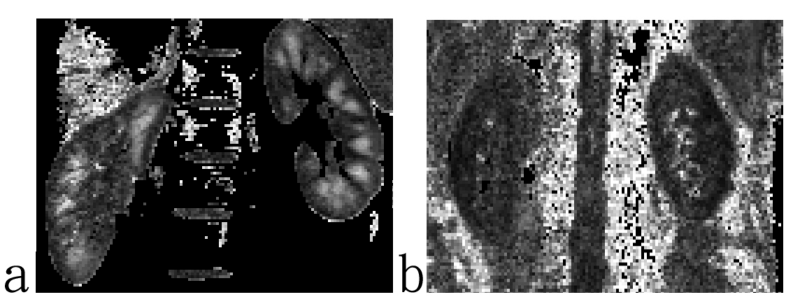

Fig 1. FA maps from a normal subject (a) and a CKD patient (b).

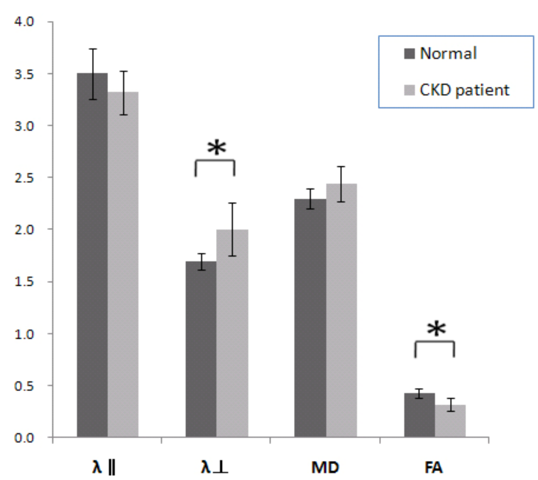

Fig 2. Diffusion measures at medulla in normal volunteers and CKD patients (* p<0.05)