

The investigation of apparent diffusion coefficient in renal cortex and medulla during the cardiac cycle.

Masahiro Umeda¹, Toshihiro Higuchi², Yuki Mori³, Yoshichika Yoshioka⁴, Yasuharu Watanabe¹, Yuko Kawai¹, Tomokazu Murase², and Chuzo Tanaka²

¹Medical Informatics, Meiji University of Integrative Medicine, Nanantanshi, Kyoto, Japan, ²Neurosurgery, Meiji University of Integrative Medicine,

Nanantanshi, Kyoto, Japan, ³Immunology Frontier Center, Osaka University, Suita, Osaka, Japan, ⁴Immunology Frontier Research Center, Osaka University,

Suita, Osaka, Japan

Background

The apparent diffusion coefficient (ADC) of the kidney includes the perfusion effect as the intra voxel incoherent motion (IVIM) in the diffusion weighted image with low b value ($< 100 \text{ s/mm}^2$). Cheung introduced the blood pseudodiffusion coefficient (D_{pseudo}) and perfusion fraction for IVIM and reported that ADC of renal cortex without IVIM (D_{true}) was $1.5 \text{ mm}^2/\text{s}$ and total ADC was $2.2 \text{ mm}^2/\text{s}$ ⁽¹⁾. The diffusion weighted image (DWI) with high b value ($> 100 \text{ s/mm}^2$) may correspond to D_{true} . In this study, I measured ADCs of the renal cortex and medulla using DWI with low and high b value to investigate the flow effect during the cardiac cycle.

Material and Methods

Gradient and diffusion weighted MRIs of the mouse kidney were measured using a vertical bore 11.4 T magnet with Biospec spectrometer (Bruker Biospin GmbH). The mice (male CDF1, $n=5$) were fixed to the surface coil using 1.0 - 1.6% isoflurane. The needle electrodes were inserted into the front and hind paws for cardiac gating, and the balloon was located on the body for respiratory gating. The body temperature of the mouse was maintained by warm water circulating in a silicone tube. Model1025 (Small Animal Instruments, Inc.) was used to control acquisition as a trigger with a delay from the R- wave. ADC with low b values (0, 10, 40 and 100 s/mm^2) and ADC with high b values (100, 200, 500 and 800 s/mm^2) were calculated using axial DWIs with 1 mm slice thickness (TR/TE= 4000/33 ms; $\delta/\Delta= 2/10 \text{ ms}$; on X-axis; matrix = 96×96 ; FOV = $20 \times 20 \text{ mm}^2$; BW = 500 KHz; and an average of 8 DWIs) (Fig.1). The arterial blood flow speed were measure using a phase contrast method at 10 phases in a cardiac cycle. Unpaired 2-samples t -test was used to compare ADCs of the renal cortex and medulla with high b value values.

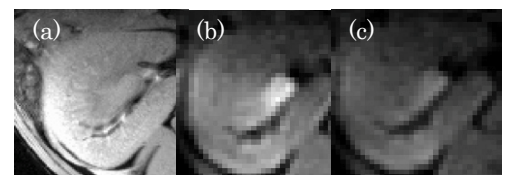


Fig. 1 Gradient echo image (a), DWI $b=0 \text{ s/mm}^2$ (b), DWI $b=200 \text{ s/mm}^2$ (c).

Results and Discussion

The maximum ADC of the renal cortex with low b value occurred 60 ms after the R- wave. The maximum renal arterial flow speed was occurred at the same time. However, the changes of ADC with high b value showed no peak at the same time during the cardiac cycle (Fig. 1). The differences between the ADCs of the cortex and the medulla were significant ($P < 0.01$) (Fig 2). The reported renal ADCs were higher than the ADCs with high b values obtained in our study. Our ADCs with high b values were less affected by the renal blood flow. Because the renal cortex and medulla are rich in water, the ADC may reflect water transport. The ADC of the renal cortex is reported to decrease with increasing arterial pressure ⁽²⁾; the slight change in ADC during the cardiac cycle (Fig.1) might be associated with changes in the renal arterial pressure during the cardiac cycle rather than with the flow. Moreover some studies have shown that the glomerular filtration rate is associated with the renal ADC ^(3,4). The observation of ADC changes during the cardiac cycle may yield insights into how renal function is influenced by renal arterial pressure.

In conclusion, the renal medulla ADC with high b values is larger than that of the renal cortex. The renal ADC with high b values was less influenced by renal blood flow.

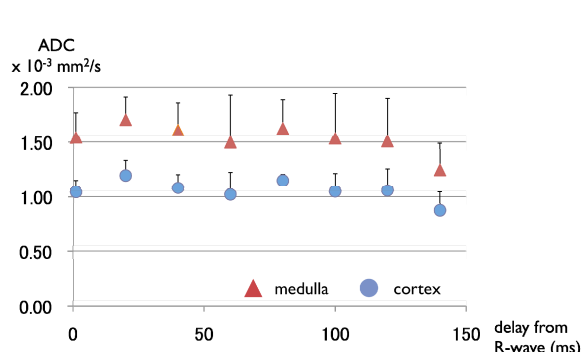


Fig.2 ADC changes of renal cortex and medulla during cardiac cycle.

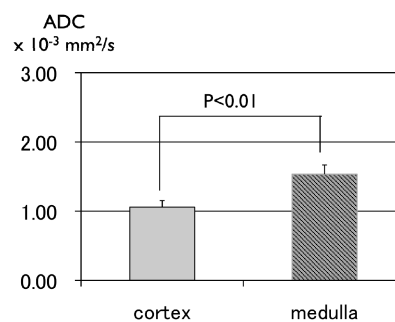


Fig.3 Time averaged ADC differences between renal cortex and medulla over cardiac cycle.

References

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