CORRELATION BETWEEN RENAL CORTICAL THICKNESS AND ESTIMATED GLOMERULAR FILTRATION RATE (eGFR): EVALUATION BY NON-CONTRAST-ENHANCED STEADY-STATE FREE PRECESSION (SSFP) MRI WITH SPATIALLY SELECTIVE IR PULSE

Purpose: Chronic kidney disease (CKD) is divided into five stages, the last of which is called end-stage renal disease (ESRD) and is the time when dialysis or transplant is necessary to stay alive. In recent years, ESRD patients have continued to increase in number; thus, diagnosis and evaluation of CKD is particularly important. Renal volume and maximal renal length are reportedly correlated with renal function, with atrophy of the renal cortex being particularly dominant, but few imaging studies have been conducted. This is primarily because The obfuscation of corticomedullary differentiation in non-contrast-enhanced MRI has been observed in patients with renal insufficiency, causing difficulty in precise measurement of renal cortical thickness and volume. Evaluation of corticomedullary differentiation of the kidney is possible using contrast-enhanced MRI, but it carries the risk of nephrogenic systemic fibrosis (NSF). Therefore, evaluation of renal function using contrast media is unsuitable. Our preliminary study showed that distinct renal corticomedullary differentiation can be observed by non-contrast-enhanced steady-state free precession (SSFP) MRI with an optimal inversion recovery (IR) time using a spatially selective IR pulse placed on the kidney in young adults, as differences in T1 values between the renal cortex and the medulla are emphasized in the acquired images. In the present study, we measured renal cortical thickness by clearly depicting renal corticomedullary differentiation using non-contrast-enhanced SSFP MRI with a spatially selective IR pulse, and investigated the correlation between renal cortical thickness and estimated glomerular filtration rate (eGFR).

Materials and Methods: This study included a total of 35 patients (20 men, 15 women; mean age, 55 years; age range, 28-84 years) who did not have chronic liver or kidney disease, hypertension or other vascular diseases. All patients underwent non-contrast-enhanced SSFP MRI with spatially selective IR pulse. Imaging parameters were as follows: TR/TE=4.2/2.1 ms; number of acquisitions = 1; flip angle = 90°; slice thickness = 7 mm; field-of-view = 400 × 400 mm2; and acquisition matrix = 256 × 256. A series of topographically identical SSFP sequences with Time-SLIP were performed using various inversion times (TI) (700, 800, 900, 1000, 1100, 1200, 1300, 1400 and 1500 ms). Signal intensity (SI) of the renal cortex and medulla were measured using the region-of-interest (ROI) to calculate the renal corticomedullary contrast ratio (SI cortex/SI medulla). Next, optimal TI values for best visualization of corticomedullary differentiation were determined based on a series of SSFP images with variable TI. In addition, using the optimal TI, maximal renal length and minimal renal cortical thickness were measured. eGFR was calculated using the Japanese equation as follows: $eGFR = 194 \times Scr^{-1.094} \times Age^{-0.287}$ (for females, ×0.739). For statistical analysis, Spearman's correlation test, Kruskal-Wallis test, and Mann-Whitney test were used.

Result: Mean eGFR was 83.0 mL/min/1.73 m^2 (range,60.9 – 123.2 mL/min/1.73 m^2). Renal corticomedullary differentiation was clearly depicted in all patients. Mean minimal renal cortical thickness was 4.6 mm (range, 2.5 – 6.9 mm). Mean maximal renal length was 102 mm (range, 87 – 124 mm). Changes in minimal renal cortical thickness with reductions in eGFR are shown in Figure 1.There was a positive correlation between minimal renal cortical thickness and eGFR (P= 0.019). However, there were no significant correlations between maximal renal length and eGFR (P= 0.161).

Conclusion: Morphological changes associated with reductions in renal function are thought to be characterized by atrophy of nephrons, the basic functional and structural unit, and fibrosis. In the present study, we found using the above imaging method that renal cortical thickness decreases based on renal function with higher sensitivity than maximal renal length. Because the volume ratio of individual neurons is significantly higher in the cortex than the renal medulla, these results were attributed to the substantial effects of morphological changes.

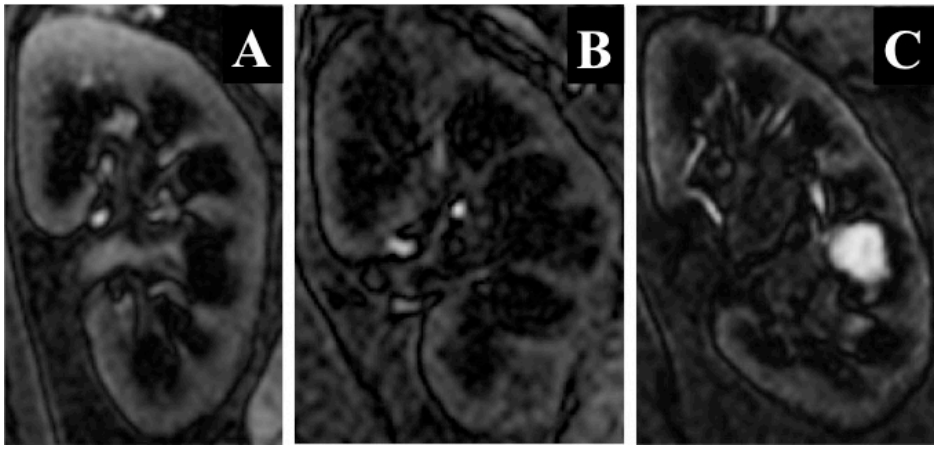

Figure1.
(A) male, eGFR= 109.8 mL/min/1.73 m^2,
(B) male, eGFR= 79.4 mL/min/1.73 m^2,
(C) male, eGFR= 66.4 mL/min/1.73 m^2.

SSFP MRI with a spatially selective IR pulse obtained from three patients with different eGFR values. Minimal renal cortical thickness in patients with low eGFR was shorter than that in patients with high eGFR.