CORTICOMEDULLARY DIFFERENTIATION OF THE KIDNEY WITH NON-CONTRAST-ENHANCED MR IMAGING WITH TIME-SPATIAL LABELING INVERSION PULSE: COMPARISON OF IMAGING WITH FAST ASYMMETRIC SPIN ECHO AND STEADY-STATE FREE-PRECESSION SEQUENCES

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Purpose: In recent years, it has been reported that renal cortical volume or cortical thickness was a good predictor for the progression of chronic renal diseases. Therefore, it is important to clearly visualize the renal corticomedullary junction by MR imaging for the measurement of renal cortical thickness. However, loss of corticomedullary differentiation in non-contrast-enhanced MR imaging has been observed in renal insufficiency, secondary to a variety of etiologies, including glomerulonephritis, acute tubular necrosis, obstructive hydronephrosis and end-stage chronic renal failure because of prolonged T1 relaxation due to cortical edema, preventing proper measurement of renal cortical thickness or volume. Non-contrast-enhanced MR imaging with time-spatial labeling inversion pulse (Time-SLIP), which can saturate the signals of the target tissue, can be applied to visualize the corticomedullary differentiation since the differences in T1 values between the cortex and the medulla could be accentuated by using an optimal inversion recovery time. In Time-SLIP technique, better contrast between the renal cortex and the medulla will be dependent on imaging sequences. Fast asymmetric spin echo (FASE) and steady-state free-precession (SSFP) MR sequences may be appropriate for this purpose. However, there has been no report comparing these two different MR sequences directly in the visualization of the renal corticomedullary differentiation. The purpose of this study was to compare the two different MR sequences, FASE and SSFP combined with Time-SLIP, for the better visualization of corticomedullary differentiation in the normal kidney.

Materials and Methods: We included a total of 17 patients (15 men, 2 women; mean age, 33 years; range, 28-49 years) who underwent abdominal MR imaging including a non-contrast-enhanced FASE and SSFP sequences with Time-SLIP. All patients had no history of renal disease, hypertension, or other vascular diseases. FASE sequence was conducted with the following parameters: TR/TE=7000/30msec, slices thickness = 7mm, field-of-view = 400 mm^2, acquisition matrix = 256 x 256, flip angle = 90°, and receiver bandwidth 651 Hz/pixel. The imaging parameters of SSFP sequence were TR/TE=4.2/2.1msec, slices thickness = 7mm, field-of-view = 400 mm^2, acquisition matrix = 256 x 256, flip angle = 90°, and receiver bandwidth 250k Hz/pixel. In the Time-SLIP examination, a spatially selective inversion labeling pulse was placed on the both kidney. A series of topographically identical FASE and SSFP sequences with Time-SLIP were performed to observe the signal changes of the labeled renal cortex and medulla using various inversion recovery times (TIs); 500-1800 msec in increments of 100 msec. The signal intensity (SI) of the renal cortex and medulla were measured using region-of-interest (ROI). Corticomedullary contrast ratio (SI cortex/SI medulla) was calculated to determine the optimal TI for the visualization of renal coriticomedullary junction. Then, the corticomedullary contrast ratio was compared between Time-SLIP FASE and SSFP images obtained with optimal TI. Additionally, as the qualitative analysis, the visibility of coriticomedullary differentiation and overall image quality in Time-SLIP FASE and SSFP images with optimal TI was visually categorized as one of four grades (1=poor; 2=fair; 3=good; 4=excellent).

Results: In FASE with Time-SLIP, corticomedullary contrast ratio was highest in TI of 1000 msec in 8 subjects (47%), followed by TI of 1100 msec in 4 (24%), TI of 1200 msec in 4 (24%) and TI of 1300 msec in 1 (5%). In SSFP with Time-SLIP, corticomedullary contrast ratio was highest in TI of 1100 msec in 7 subjects (41%), followed by TI of 1200 msec in 6 (35%), TI of 1000 msec in 2 (12%) and TI of 1300 msec in 1 (6%) and TI of 1400 msec in 1 (6%). The mean corticomedullary contrast ratio of FASE with Time-SLIP (7.86 +/- 1.68) was significantly higher (p=0.009) than those of SSFP with Time-SLIP (5.97 +/- 1.93). Conversely, the visibility of corticomedullary differentiation and overall image quality was significantly better (p = 0.005) in SSFP images with Time-SLIP (averaged grade=3.94) than in FASE images with Time-SLIP (averaged grade=3.47), indicating better delineation of corticomedullary junction in SSFP with Time-SLIP.

Conclusions: Both FASE and SSFP MR imaging with Time-SLIP can be used to visualize the renal corticomedullary differentiation in normal kidneys without using contrast agents. SSFP sequence with Time-SLIP may be preferable for the measurement of renal cortical thickness or volume because of good visualization of corticomedullary junction and high image quality although FASE sequence with Time-SLIP had high corticomedullary contrast ratio.

a) Coronal SSFP image with Time-SLIP (TI=1100msec), b) FASE image with Time-SLIP (TI=1000msec) in the same patient. FASE images had high corticomedullary contrast ratio, whereas, SSFP images had good visualization of corticomedullary differentiation and high image quality.