Cine Magnetic Resonance (MR) Urography for the Evaluation of the Upper Urinary Tract Function

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INTRODUCTION
The ureters conduct urine from the kidney to the bladder by means of peristalsis. Several techniques are available for the assessment of ureteral function including cinefluoroscopic monitoring of the opacified ureter, ureteral pressure recording. To our knowledge, MR imaging has never been used for this purpose. Therefore, we conducted this study to assess the upper urinary tract function using a novel MR technique, namely cine magnetic resonance urography.

MATERIALS AND METHODS
The study consisted of two parts: phantom and clinical studies. In both studies, MR images were acquired using a 1.0T clinical unit (Signa Horizon, GE, Milwaukee) or a 1.5T clinical unit (ExcelArt/pianissimo, Toshiba, Tokyo, Japan). Heavily T2-weighted coronal images of the abdomen with fat suppression were obtained using a single-shot half-Fourier fast spin echo sequence. The imaging parameters were as follows: effective TE of 1000 to 1200 millisecond, acquisition matrix of 256×256. The field of view was 32~35×32~35 cm and a slice thickness 50 mm.

1) Phantom study
The phantom study was performed in order to evaluate the correlation between urine volume and signal intensity. Syringes filled with saline (0~10 ml) were used as the phantom. MR images were obtained using the above-mentioned parameters. The relationship between signal intensity and the region of interest (ROI) and the saline volume was assessed by means of a linear regression analysis.

2) Clinical study
Five asymptomatic volunteers, 4 men and 1 woman (age 28~41), were included. Coronal images of the abdomen, mentioned above, were obtained every 10 seconds with an intermittent breath holding during each acquisition of the image. These images were observed in the form of the cine loop and this technique was herein named cine MR urography. Two sets of consecutive images were acquired: the 30 consecutive images for 5 minutes before intravenous injection of furosemide and the 30 consecutive images immediately after the injection. To eliminate the bright signals of fluid in the gastrointestinal tract, an oral negative contrast material (ferric ammonium citrate) was given to all subjects 20 to 30 minutes before the examination. ROIs were selected to the renal pelvis, the proximal ureter, and the distal ureter bilaterally. Six ROIs were excluded from the analysis because incomplete suppression of the signals from the gastrointestinal tract overlay the signals from the urinary tract. Therefore, a total of 24 ROIs was available for further analysis. A time-intensity curve was generated in each ROI. An abrupt increase of signal intensity in ROI, which are defined as a urine bolus, was counted by the inspection of the time-intensity curve. The frequency and amplitude of the urine bolus were evaluated.

RESULTS
1) Phantom study
There is a significant correlation between saline volume and its signal intensity (Signa Horizon: r = 0.998, n = 20, p < 0.0001, ExcelArt/pianissimo: r = 0.993, n = 31, p < 0.0001) (Fig. 1).

2) Clinical study (Fig. 2)
In all ROIs, four to nine time urine bolus (mean 6.4 times) were observed during 5 minutes (one set) before the intravenous injection of furosemide. After furosemide injection, the mean value of signal intensity was increased in 22 ROIs (92%). In 21 ROIs (88%), the urine bolus also became more frequent, 5- to 12-time urine bolus (mean 9.1) during one set, than those before furosemide injection. The amplitude of the urine bolus also became two to ten times larger in 21 ROI (88%) than that before injection.

DISCUSSION
Previous reports using other modalities such as cinefluoroscopy show that there is a considerable fluctuation in the frequency of the peristaltic waves in the ureter and 1-to 10-time ureteral peristalsis usually occurs per minute in the dehydrated or normally hydrated human [1-3]. The frequency of urine bolus in our volunteers coincided with the normal range mentioned by previous reports. It was also reported that administration of diuretics produces an increase in the rate of peristalsis and amplitude of the peristaltic wave. In our study, an increase in the frequency and amplitude of the urine bolus were noticed after intravenous injection of furosemide. Therefore, it seems to us that the urine bolus and its change on MR urography indicate the abrupt change in the urine volume due to the peristaltic waves. Because there is a close correlation between saline volume and its signal intensity in the phantom study, we conclude that the amplitude of the urine bolus correlate to the change of urine volume in the ureter, and we also emphasize that this type of information could not be obtained in the previous study.

CONCLUSION
Cine MR urography is useful for the evaluation of an upper urinary tract function. The dynamic change of the urine volume can be obtained using this technique.

REFERENCES
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