Determining the Efficacy of Ultrasonography for the Detection of Ureteral Stone

Toru Kanno, Masashi Kubota, Hiromasa Sakamoto, Ryuichi Nishiyama, Takashi Okada, Yoshihito Higashi, and Hitoshi Yamada

OBJECTIVE To assess the efficacy of ultrasonography (US) for the detection of ureteral stone using non—contrast-enhanced computed tomography (NCCT) as a standard reference.

MATERIALS AND METHODS From January 2009 to September 2011, 428 patients underwent both NCCT and US on the same day. The sensitivity and specificity of US to detect ureteral stone was evaluated. The detection rates using US imaging were examined according to location and stone size. The sizes of stones determined in the longest axis of NCCT and US were compared. We also performed group classification based on size to examine whether stone sizes measured by NCCT and US were similar. Moreover, the factors that may affect the detection of ureteral stone by US were analyzed.

RESULTS Out of 856 ureters, NCCT could detect 171 stones in 169 patients, whereas US could detect 98 stones, yielding a sensitivity of 57.3% and a specificity of 97.5%. Expectedly, detection rate of US increased with stone size but was lower for distal ureter. With hydronephrosis, the sensitivity of US improved from 57.3% to 81.3%. Stone sizes measured by US correlated positively with those by computed tomography, and were concordant with those of NCCT in 68 of 98 patients (69.4%). Interestingly, stone size and the presence of hydronephrosis were factors that independently affected ureteral stone detection by US.

CONCLUSION These results indicate that US may be useful as an initial imaging modality for detecting ureteral stone. UROLOGY 84: 533—537, 2014.

Urinary tract stone is a very common disease that can cause renal colic and needs urgent care. Therefore, imaging for urinary stones, particularly for ureteral stones, is critical both in emergent department and in urological department.[1-3] Because of its high sensitivity and specificity, non—contrast-enhanced computed tomography (NCCT) is generally accepted as the gold standard among the commonly used imaging modalities for suspected urinary stone.[1,2] However, with growing concerns about health effects of cumulative radiation exposure, overutilization of NCCT is becoming a serious public health issue.[4,5] Therefore, it is desirable to explore alternative approaches. In this respect, ultrasonography (US) is a very attractive modality as it is radiation free and inexpensive. However, the effectiveness of US for renal colic and suspected urinary stone is yet to be established. We have recently reported the efficacy of US for the detection of renal stone in 428 patients.[6] The objective of this study, therefore, was to determine the efficacy of US for detecting ureteral stone in the same cohort.

Financial Disclosure: *The authors declare that they have no relevant financial interests.*

From the Department of Urology, Ijinkai Takeda General Hospital, Kyoto, Japan; and the Department of Urology, Kyoto University Graduate School of Medicine, Kyoto, Japan

Reprint requests: Toru Kanno, Ph.D., M.D., Department of Urology, Ijinkai Takeda General Hospital, 28-1 Moriminami-cho, Ishida Fushimi-ku, Kyoto 601-1495, Japan. E-mail: t.kan@kuhp.kyoto-u.ac.jp

Submitted: February 14, 2014, accepted (with revisions): April 26, 2014

MATERIALS AND METHODS

This study was approved by institutional review board, and informed consent was obtained from patients. We reviewed our database of patients who underwent both NCCT and US imaging on the same day from January 2009 to September 2011 as previously described.[6] Indications for imaging included symptoms such as acute flank pain or hematuria. Although new patients routinely received US for the screening of urinary tract at our institution, we also performed NCCT for patients with acute flank pain and suspected urolithiasis to get information such as mean stone density and skin-to-stone-distance, except for patients who received NCCT in other hospital and were referred to our institution. As a result, most patients with acute flank pain received both NCCT and US. Patients with solitary kidney or urinary diversion were excluded from this study. Clinical data about age, body mass index, sex, stone location, and stone size were retrospectively collected.

NCCT (Aquilion ONE 640, Toshiba, Tustin, CA) was performed from the upper abdomen to the pelvis with images reconstructed at 1- or 2-mm intervals. US was performed using gray scale sonography (SSA 550A, Toshiba) with a 3.5-MHz convex transducer. NCCT and US examinations were reviewed in a blind retrospective manner, and US images were reviewed without reference to NCCT findings. Stone size was defined using longest axis of NCCT and US. The sensitivity of

http://dx.doi.org/10.1016/j.urology.2014.04.047
0090-4295/14

Table 1. Detection of ureteral stone in 428 patients

	US Findings		
CT Findings	Positive	Negative	Total
Positive	98	73	171
Negative	17	668	685
Total	115	741	856

CT, computed tomography; US, ultrasonography.

Table 2. US detection according to stone site and stone size

	Total No. of Calculi	Detected	Sensitivity (%)
Stone site			
Proximal ureter	85	58	68.2
Mid ureter	15	11	73.3
Distal ureter	71	29	40.8
Calculi size at CT (mm)			
0.1-5.0	55	17	30.9
5.1-10.0	89	57	64.0
10.1-20.0	20	18	90.0
>20.1	7	6	85.7
Total	171	98	57.3

No., number; other abbreviations as in Table 1.

US was calculated using NCCT as the standard reference. Stones were classified according to size in groups of 0-5.0 mm, 5.1-10.0 mm, and >10.1 mm. The sensitivity and specificity of detecting ureteral stones were calculated by examining the correlation between US and NCCT findings in each ureter. Stone density and skin-to stone distance were measured by NCCT as described previously.[7]

Statistical Analysis

A standard statistical software program was used. The chi square or Fisher exact test was used to determine any significant differences in the normal data between the 2 groups. The 2-tailed Student *t* test was used to analyze differences in continuous variables. P values of <.05 were considered significant.

RESULTS

To assess the efficacy of US for the detection of ureteral stone, we first compared NCCT and US findings and calculated the sensitivity of US (Table 1). Of 856 ureters (428 patients), NCCT could identify 171 stones in 169 patients. On the other hand, US could detect 98 ureteral stones identified by NCCT, yielding a sensitivity and specificity of 57.3% and 97.5%, respectively.

Next, the detection rate of ureteral stones by US was categorized according to location and stone size (Table 2). The detection sensitivity in the distal ureter was found to be lower than in other sites. Expectedly, the detection rate was found to increase with stone size. For stones >5 mm, which are considered clinically important, the sensitivity was high at 69.8% (81 of 116) compared with 30.9% for small stone <5 mm. We also analyzed the association between the presence or absence of hydronephrosis and detection rate (Table 3). Of 171 stones confirmed by NCCT, US depicted 130 hydronephroses. As expected, US detected 89 of 130 ureteral stones with hydronephrosis as opposed to only 9 of 41 ureteral stones without hydronephrosis. This indicates that the detection of ureteral stone without ureteral obstruction by US is very difficult. Overall, the sensitivity of US improved from 57.3% to 81.3%.

Table 3. The relationship between hydronephrosis and US findings

	US Findings		
Hydronephrosis	Positive	Negative	Total
Positive	89	41	130
Negative	9	32	41
Total	98	73	171

Abbreviations as in Table 1.

To investigate the accuracy of the stone size measurement by US, we compared stone sizes measured by both NCCT and US (Supplementary Fig. 1). Stone sizes measured by US strongly correlated with those by computed tomography (CT) (Supplementary Fig. 1; Pearson correlation coefficient, 0.7733; P <.001). Furthermore, we classified stone sizes into 3 groups (0-5.0 mm, 5.1-10.0 mm, and >10.1 mm), and examined whether stone sizes measured separately by NCCT and US would fit in the same group (Supplementary Table 1). Remarkably, similarity in stone group size was 68 of 98 (69.4%).

To determine the primary factor that affects the detection of ureteral stone by US, a bivariate analysis was carried out on the detection rate (Table 4). The stone size, stone site, the presence of hydronephrosis, and stone density of stone were associated with the detection by US. We then further performed multivariate analysis to determine the factors that independently affected the detection of ureteral stone and found these to be stone size and the presence of hydronephrosis (Supplementary Table 2).

COMMENT

The European Association of Urology guideline recommends NCCT as the first line of investigation for suspected urinary stone in the adult population.[2] Indeed, it was recently reported that there was a 10-fold increase in the use of CT scan for patients with suspected urinary stone between 1996 and 2007.[5] However, with a growing concern about cumulative radiation exposure, overuse of CT has a big public health issue.[4,5] Although the radiation exposure of plain radiography of the kidneys, ureters, and bladder is low (0.5-1 mSv), that of NCCT is high (0.5-1 mSv).[2] For this reason, alternative imaging modality may attract attention for the diagnosis of renal colic. Low-dose NCCT (0.97-1.9 mSv) may be useful, but radiation-free imaging is desirable because patients with urinary stones have to receive multiple imaging sessions. In this respect, US is a very attractive imaging modality as it is radiation-free and inexpensive.

However, compared with NCCT, the main problem with US detection of ureteral stone is that the reported sensitivity of US was much lower. The sensitivity and specificity of US for the detection of ureteral stone varied