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ORIGINAL PAPER

Comparison of conventional radiography combined with ultrasonography versus nonenhanced helical computed tomography in evaluation of patients with renal colic

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Abstract The aim of this study is to determine whether kidneys ureters bladder X-ray (KUB) film combined with ultrasound (US) can be effectively used in evaluation of renal colic and miss stones with clinically significant size identified on nonenhanced computed tomography (NECT) in patients with urolithiasis. This retrospective study evaluated the clinical and radiological records of 300 patients at our institution undergoing KUB and/or US and/or NECT for the evaluation of renal colic from June 2007 to December 2010. Of patients with negative findings on KUB and/or US, 22 had renal stones on NECT (mean size 4.4 mm, range 3–8), 3 had lower ureteral stone (mean size 3.3 mm, range 2–5). In patients with isolated suspicious renal ectasia without stone image, two had renal stone on NECT (mean size 4 mm, range 2–6), 5 had upper ureteral stone (mean size 4.4 mm, range 4–6), 7 had middle ureteral stone (mean size 3.7 mm, range 3–4) and 14 had lower ureteral stone (mean size 4 mm, range 2–6). The cost-effective and almost radiation-free combination of KUB and US should be preferred for diagnosis of urolithiasis, as it detects most of the ureteral and renal calculi which are clinically significant.

Keywords KUB · Ultrasound · NECT · Urolithiasis

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Introduction

Patients with renal colic typically present with radiating acute colicky flank pain with or without hematuria. Unfortunately, the clinical findings are nonspecific with potential mimickers including, but not limited to, pyelonephritis, appendicitis, pelvic inflammatory disease, tubo-ovarian abscess, and inflammatory bowel disease. Imaging modalities for assessing patients with acute flank pain are conventional radiography of kidneys ureters bladder (KUB), ultrasonography, excretory urography, unenhanced helical computed tomography (NECT). Studies in the past decade have shown NECT to be highly sensitive and specific in demonstrating kidney and ureteric calculi [1, 2].

Despite these benefits, however, there is growing concern that CT is being overused, and it is estimated that 1.5–2.0% of all cancers in the United States may now be attributable to the radiation from CT examinations [3]. Prior to the acceptance of CT, US was accepted as a low-risk, noninvasive, inexpensive and widely available method with a reasonable sensitivity and specificity for the depiction urinary calculi and acute obstruction [4–6]. Several studies suggested US to be used effectively in screening for urolithiasis [7, 8]. NECT is time consuming, costly, exposes patients to cumulative radiation when repeated frequently in the diagnosis and follow-up for urolithiasis patient [9–12]. Previous studies suggested that the combination of KUB and US through demonstration of calculi or pyelocaliectasis is very useful [12, 13].

In this retrospective study, our aim was to evaluate the diagnostic accuracy of combined use of KUB and US versus NECT in renal and ureteral stones and to discuss the findings.

Patients and methods

This is a retrospective evaluation of clinical and imaging records of patients with acute renal colic at our institution. In the period from June 2007 to December 2010 the clinical and radiological records of 300 patients in Maltepe University Hospital with acute flank pain were reviewed. Patients were excluded from the study if they had received treatment or passed their stone in the interval between KUB and/or US and NECT, or if they presented with pyelonephritis, sepsis, impaired renal function and in case of pregnancy. The database of patients at our Emergency Department of the University Hospital undergoing abdominal KUB, US and/or NECT, with a suspicion of urolithiasis and who were confirmed to have urolithiasis or no other disease were reviewed. KUB, US and NECT imaging were conducted at our institution in the time period of less than 15 days apart. All stones were confirmed clinically (history of spontaneous passage), or via treatment with ureteroscopy, percutaneous nephrolithotomy and extracorporeal shock wave lithotripsy. Some patients have been diagnosed normal or nonurolithiasis disease with KUB and/or US, some only with NECT. When the diagnosis is suspicious, NECT was added to KUB and/or US. When KUB and/or US revealed no stone, stone status was confirmed on follow-up course for at least 6 months with clinical findings.

Imaging protocols

All patients underwent NECT using one of two machines. Either a Aquilion 64 64-detector row (Toshiba Medical Sysytem, Tokyo, Japan) with 0.5-mm section thickness and then 3-mm reformat or a Philips Mx 8000 two-detector row (Philips Medical Systems, Eindhoven, The Netherlands) with 3-mm section thickness were used, depending on availability and departmental workload. NECT was carried out through both kidneys to the bladder base in one breath-hold without the use of oral or intravenous contrast material. Patients were placed in supine position with full urinary bladder at the time of the NECT. All subjects were examined by B-mode ultrasound using a commercially available US scanner (MyLab70 XVision; Esaote Biomedica, Genoa, Italy). Ultrasound was done using 3.75 MHz convex probe. All ultrasounds were seen and reported after being reviewed by a radiologist. Secondary signs of obstruction, like hydronephrosis, hydroureter, nephromegaly, perinephric and periureteric stranding were also noted. KUB were done at the accepted standard of 77 kV using a AGFA direct view CR 35-X. The relevant radiological and clinical records of all the patients were analyzed, the presence of UL and hydronephrosis were noted in KUB/US versus NECT.

Primary data analysis

Data were analyzed using commercially available software (statistical package for social sciences version 16.0). The sensitivity, specificity and positive predictive value (PPV) were calculated.

Results

Our review of records revealed that 300 patients had imaging modalities for urolithiasis evaluation. Mean age was 46 years (range 21–79 years). 56% of patients were males. 98 out of 300 patients, stone disease were diagnosed only with KUB and/or US. 55 were diagnosed with only NECT (Table 1). In 147 cases KUB and/or US were performed prior to NECT (Table 2). Of the patients with negative findings on KUB and/or US, 22 had renal stones on NECT (mean size 4.4 mm, range 3–8), 3 had lower ureteral stone (mean size 3.3 mm, range 2–5). Detailed evaluation of these missed 22 stones in kidney revealed that 20 stones were missed by KUB without US (mean size 4.5 mm, range 3–8), 2 stones were missed by KUB combined with US (mean size 3.5 mm, range 3–4). Considering clinically significant stones (accepted as >5 mm) only 5 stones, all of which were renal stones (mean size 6.6 mm, range 6–8), escaped notice via KUB without accompanying ultrasound. Out of 59 patients with renal stone image in KUB and/or US, 4 had no stone (one of them had 20-mm radioopaque image on KUB without US), 47 had renal stone (mean size 11.3 mm, range 2–40), 6 had upper ureteral Stone (mean size 9.5 mm with range 5–14) were found to be intrepreted by KUB without US as upper ureteral stones, one had middle ureteral stone (5 mm), and the other had lower ureteral stone (6 mm) missed by US although ectasia with renal stone suggested a suspected stone in the ureter. Of ten patients with upper ureteral stone image in KUB and/or US, two had renal stone (both were

Table 1 Imaging modalities used to identify stones in patients with clinical suspicion of urolithiasis

Imaging modality	KUB	US	KUB + US	KUB + NECT	US + NECT	KUB + US + NECT	NECT	Total
Number (%)	2 (0.67%)	17 (5.7%)	79 (26.3%)	52 (17.7%)	20 (6.7%)	75 (24.7%)	55 (18.3%)	300 (100%)

KUB kidney ureters bladder X-ray, *US* ultrasound, *NECT* nonenhanced computed tomography

Table 2 The stones' mean size and location on NECT correlated with KUB and/or US findings

KUB and/or US	NECT					
	Normal	Renal stone	Upper ureteral stone	Middle ureteral stone	Lower ureteral stone	Total
Normal	6	22 (4.4 mm)	–	–	3 (3.3 mm)	31
Renal stone	4	47 (11.3 mm)	6 (9.5 mm)	1 (5 mm)	1 (6 mm)	59
Upper ureteral stone	–	2 (8 mm)	7 (6.4 mm)	1 (11 mm)	–	10
Middle ureteral stone	–	–	–	1 (8 mm)	–	1
Lower ureteral stone	–	–	–	–	17 (6.7 mm)	17
Only ectasia in US	1	2 (4 mm)	5 (4.4 mm)	7 (3.7 mm)	14 (4 mm)	29
Total	11	74	18	10	32	147

KUB kidney ureter bladder X-ray, *US* ultrasound, *NECT* nonenhanced computed tomography

8 mm in size), seven had upper ureteral stone (mean size 6.4 mm, range 4–10) and the other had middle ureteral stone (11 mm) on NECT. In one patient with middle ureteral stone in KUB and/or US, NECT confirmed the diagnosis (8 mm). Of 17 patients with positive image for lower ureteral stone on KUB and/or US, NECT confirmed the diagnosis (mean size 6.7 mm range 4–10). In patients with isolated suspicious renal ectasia without stone image, two had renal stone on NECT (mean size 4 mm, range 2–6), 5 had upper ureteral stone (mean size 4.4 mm, range 4–6), 7 had middle ureteral stone (mean size 3.7 mm, range 3–4) and 14 had lower ureteral stone (mean size 4 mm, range 2–6).

According to the presence of suggestive or definitive urolithiasis findings; the sensitivity, specificity and positive predictive value (PPV) were 61.2% [Confidence interval (CI), 54.3–67.8%]; 50% (CI, 25.4–74.6%) and 95% respectively for KUB alone and 98.3% (CI, 95.2–99.4%); 80% (CI, 49–94.3%); 98.9%, respectively, for US alone. The overall sensitivity, specificity PPV of KUB combined with US were 97.9% (CI, 94.1–99.3%); 66.7% (CI, 35.4–87.9%) and 97.9% respectively. In order to compare the efficacy of NECT versus KUB combined with US, seventy-five patients who underwent all of the imaging modalities were also evaluated. One patient with no evidence of UL either in the KUB combined with US, nor in NECT, passed 3 mm stone. The sensitivity, specificity and PPV were found to be 95.7% (CI, 88.0–98.5%); 66.7% (CI, 30.0–90.3%) and 97.0% for KUB combined with US and 98.6% (CI, 92.2–99.7%); 100% (CI, 0.61–100%) and 100% for NECT, respectively. The positive stone status suggested by both KUB and US was not confirmed with NECT in two particular cases. In the first, US displayed grade II hydronephrosis with no opacity in KUB, however, due to the rapidly subsiding renal colic symptoms and absence of microscopic hematuria, NECT was performed and UL was not shown. In the second, the presence of a 10 mm opacity in the renal location in KUB without ectasia in US suggested the presence of UL, but the persistence of intemperate symptoms led to NECT evaluation ruling out UL.

The distribution of location and size of stones on both KUB and/or US and NECT is shown in Table 2.

Discussion

The order of imaging methods for the diagnosis of UL varies according to clinical practice of each center; KUB and intravenous urography, using US to monitor the evolution of hydronephrosis; association of KUB or urography with US; only NECT; NECT and other imaging methods if US is negative [14–16]. Since NECT was reported to be superior to KUB and/or US in demonstrating urolithiasis, many centers have been using it as the initial diagnostic tool in urolithiasis [1, 2]. In several studies sensitivity and specificity of NECT in the diagnosis of ureteral calculi were found to be approximately 99 and 98%, respectively [17, 18]. However, this greater degree of accuracy may not always be necessary. Since urolithiasis is usually a self-limited disease that can be managed conservatively [19]. Spontaneous passage of a stone is likely when stone size is less than 5 mm and the necessity of determining the precise size and location of a stone has not reached consensus [20]. The complication rate from conservative management has been observed to be as low as 7% when symptoms last less than 4 weeks [21].

In accordance with the above cited reports, our patients with negative findings on KUB and/or US, only three had lower ureteral stone on NECT and mean size of the stones was 3.3 mm (range 2–5). Five clinically significant stones missed in KUB were all in kidney in NECT (mean size 6.6 mm, range 6–8). It was highly possible that US would display stone image in all of these kidneys. In patients with isolated suspicious renal ectasia or hydronephrosis without stone image, NECT detected 5 upper ureteral stones (mean size 4.4 mm, range 4–6), 7 middle ureteral stones (mean size 3.7 mm, range 3–4) and 14 lower ureteral stone (mean size 4 mm, range 2–6).

Beside the information in favor of NECT examination in the diagnosis of urolithiasis patients, NECT scan's radiation issue is worth mentioning. In many articles it was cited that cumulative radiation exposure to patients is significant and likely to be a public health problem in the future [22–24]. Patients with a history of recurrent ureterolithiasis appear to be among those at greatest risk for excessive radiation from diagnostic imaging [25].

Additionally, the economic burden of NECT compared to other diagnostic modalities in the follow up of urinary tract stones was also mentioned in one study [26]. Although the sensitivity of US with or without KUB was inferior to NECT for diagnosing ureteral stones, several series suggest not only that NECT may be avoided in patients with no signs of urolithiasis on KUB and US but also that US can be safely employed when combined with KUB [4, 14]. When there is no stone image in US, the complete or partial obstruction of the ureter causing dilation above the level of obstruction suggests the presence of stone. Therefore, urolithiasis may be suspected upon identification of hydroureteronephrosis, especially when accompanied by renal colic. However, many authors claimed to date that regular gray scale US is not accurate in minimally dilated obstruction, such as with partially obstructing ureteral stone. In one series, 4–5% of patients with obstruction showed minimal or no upper tract dilatation [27]. However the opposite point of view reported that the absence of dilation suggests insignificant stone disease and hydronephrosis was present in all patients who required intervention [14]. In a recent study which reported the role of US in the diagnosis of urolithiasis, if hydronephrosis and hydroureter were present without stone image, the scrupulous ultrasonographers tried to track the hydroureter from the kidney downstream for as long as they could [28]. If no calculus was identified, they continued to track the ureterovesical junction and the distal ureter and identified most of the ureteral calculi at this level. If no calculus was identified there either, they tried to view the middle ureter, trying to displace the intestinal gas by compression of the region with the transducer or changing the position by placing the patients in lateral position on the opposite side of the colic and they found successfully 11 stones in the middle ureter among 217 patients with urolithiasis [28]. Although US is successful in urolithiasis imaging in the hand of experienced operators and even suspicious ectasia in kidney combined with KUB and clinical symptoms suggests ureteral stone, it is certain that NECT is the definitive test in the evaluation of urolithiasis due to its high accuracy rate. However, a dominant role for US in limiting NECT imaging appears warranted considering its cumulative radiation exposure, higher cost and availability. There are several limitations of this study; it is a retrospective analysis of urolithiasis patients, there is no concensus about the size of the clinically insignificant stones and additionally the precise diagnosis of urolithiasis on ultrasound imaging is extremely dependent on operator's experience and attention.

Conclusion

The combination of KUB and/or US in the diagnosis is highly sensitive and specific for urolithiasis, but it lacks sensitivity for ureteral calculi particularly when they are in the middle ureter. Even the addition of KUB to US misses about 1/5 of ureteral stones; however, as spontaneous passage of these small ureteral stones is very likely, these urinary stones escaped notice on KUB and/or US imaging impose insignificant clinical burden. Therefore, we recommend using NECT only if the clinical signs and symptoms of a patient with suspected ureterolithiasis are disproportionate in the presence of negative or suspicious findings on KUB and/or US. We believe that the cost effective combination of KUB and US should be preferred for urolithiasis diagnosis, as it detects most of the ureteral and renal calculi, thus the cumulative irradiation of NECT in urolithiasis patients for the diagnosis and follow-up of new and recurrent stones will be avoided.

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