ACCURACY OF ULTRASONOGRAPHY COMPARED TO UNENHANCED HELICAL COMPUTERIZED TOMOGRAPHY IN SCREENING OF SMALL KIDNEY STONES IN A COMMUNITY

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ABSTRACT

OBJECTIVE: To determine the sensitivity and specificity of ultrasonography for screening of small kidney stone by comparison with unenhanced helical computerized helical tomography (UHCT). Our community in the North-Easthern part of Thailand have a prevalence of kidney stone which is the main public health problem. Our ultrasonography (US) survey found a prevalence of hyperechoic (HYF) with or without acoustic shadowing mimicing with small kidney stones (KS). Since small stone is relatively easy to manage but difficult to be diagnosed. It will be most beneficial to study this project in order to be able to manage the kidney stones in the epidermic area since the stones are still small and easier to be managed.

METHOD: Participants were 164 subjects (328 kidneys) randomly sampled from our community survey, with and without HYF in 118 and 210 kidneys, respectively. Within 48 hours, the subjects were transferred to the university hospital for UHCT by the radiologists.

RESULT: By comparison with UHCT, the sensitivity and specificity of US in screening for KS was 81.1% and 72.7%. The respective sensitivity and specificity of microhematuria and micropyuria were 53.7% and 57.9%, and 36.6% and 52.9%.

CONCLUSION: The screening of small kidney stones by US in community had moderate sensitivity and specificity.

Key words: hyperechoic foci, small kidney stone, unenhanced helical computed tomography, microhematuria, micropyuria

HYF = Hyperechoic Foci
KS = Kidney Stones
HYF = Hyperechoic Foci
UHCT = Unenhanced Helical Computerized Tomography

INTRODUCTION

Kidney stones (KS) are a common health problem among the rural community of Northeast Thailand. The prevalence of KS vary, particularly when different diagnostic techniques are employed. In a survey of known stone cases, confirmed by plain radiography (KUB) in an area of Khon Kaen province, the prevalence was 0.38%.[1] Using ultrasonography (US) in two community surveys, the prevalence was 9%[2] and 16%,[3] vs. 5% by KUB.[4] These differences may partly reflect the difference in sampling techniques

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and/or the real situation in the studied communities, or the accuracy of the technique (s) used. All of these surveys might not be able to detect the small kidney stone.

Stone size is the crucial factor in determining the accuracy of US where the diagnosis of stones >5 mm has the accepted accuracy.[5,6] However, all of these previous studies were hospital-based using high quality equipment in an optimally-controlled environment; mostly, on cases with radio-opaque stones.[5,6] Unenhanced helical computed tomography (UHCT) is highly sensitive in detecting ureteral stone. The UHCT has replaced emergency urography and became the modality of choice for imaging patients with ureteral colic.[7-9] Our study was designed to determine the sensitivity and specificity of US in screening of KS in community level done by a general practitioner. UHCT was used as the gold standard.

UHCT = Unenhanced Helical Computed Tomography

MATERIALS AND METHODS

Sampling Method and Estimation of Sample Size

To answer the question about sensitivity and specificity of US as compare to the UHCT, we made the assumption that the sensitivity and specificity was 0.75 and 0.65, respectively. When we allowed the 0.10 difference, the sample size for detection of the sensitivity and specificity was 73 and 88 kidneys, so we needed at least 88 normal kidneys (or 44 negative subjects) and 88 positive kidneys to enrolled in the study. We decided to use 100 subjects with HYF and 64 normal subjects in this study.

Free kidney stone checking, by a mobile ultrasound unit, was announced about one week in advance by local health volunteers. During the 20-month study period (2003-2005), participating subjects were underwent US examination. From the result of US, we performed the simple random sampled 5-6 subjects whose HYF size not over10.0 mm and 3-4 normal subjects for each village. These subjects were sent for UHCT in the university hospital within 48 hours after screening by US. The radiologist was blind for the US result.

US Examination and Criteria for Hyperechoic Foci (HYF)

After the interview and urinalysis, the subjects were examined for the presence of significant HYF by an US machine curved phased array transducers, with frequencies ranging from 3.0- 4.0 MHz.(Fukuda Denchi, UF4000, 256 grey scale). Multiple anatomic approaches were used in the imaging of kidneys (from the supine and decubitus views, both transverse and longitudinal planes). Standard views of the kidneys using the liver and spleen as acoustic windows were also employed. Performing each US examination lasted about 8-10 minutes. Due to time constraint, we did not count the number of multiple stones. Only the longest diameter of the largest stone or HYF was measured and recorded for comparison with the results of other methods. The significant HYF or KS by US in our study were demonstrated as the characteristic highly echogenic foci with or without acoustic shadowing. If it appeared without acoustic shadowing, it was diagnosed as a HYF when it met all of the criteria, namely: 1) the focus was denser than normal vascular or collecting tissues, and 2) was in an unusual place when compared with the distribution of vascular or collecting tissues, and 3) showed some calyectasis or chronic inflammation such as the scar of the nearby tissues.

Urinalysis

The participants were tested for urine abnormalities after the interview. A spot urine sample was collected from each subject and tested with a urine strip for the presence of red blood cells (microhematuria) and white blood cells (micropyuria), which were read by a reflectance photometer (Urilux-S). Urine collection in female who were in (or less than 48 hours after) the menstruation period was omitted.

UHCT Examinations

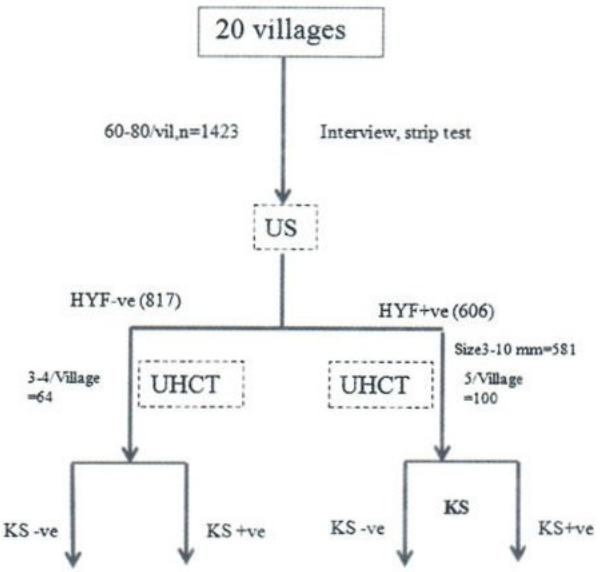
Within an interval of 48 hours after the US

examination, the participating subjects were transferred to the university hospital for UHCT examination. The radiologist who performed UHCT was blinded for the US results. The UHCT examinations were performed with a helical CT scanner (Toshiba, model Exvision). The exposure settings were 120 kVp and mAs 200. Helical data acquisition consisted of 5 mm thick sections with 3 mm reconstruction.

RESULTS

A total of 1,423 subjects from 20 rural villages were enrolled in the field survey. 1,423 subjects underwent US examination with 581 subjects had the HYF size not over 10.0 mm (Details of the survey would be in another report). From the result of US, we performed the simple random sampled 100 and 64 subjects with and without HYF, respectively, to undergo the UHCT exam (Fig.1). Of the 164 subjects (328 kidneys) enrolled in the study, 78.1% of them were females, 86.6% were ?40 years old. There were 118(36%) kidneys contained significant HYF by US, 88 (74.6%) of which had the longest diameters between 2.1-5.0 mm and 25 (21.2%) of them were between 5.1-7.5 mm (Table 1). The acoustic shadow could not detect for HYF size less than 7.5 mm.

Fig. 1 Details of patients enrolled in the study



KS=kidney stone; HYF=Hyperechoic foci;
UHCT= unenhanced helical computed tomography

Table 1 Characteristic of subjects participated in the study and stone sizes by US

Variables		Number	Percent
Sex	Male	49	29.9
	Female	115	70.1
Age	<40	22	13.4
(years)	40-49	45	27.4
	50-59	58	35.4
	≥60	39	23.8
HYF sizes (US)	2.1 - 5.0 mm	88	†74.6
	5.1 - 7.5 mm	25	†21.2
	7.6 -10.0 mm	5	†4.2
Total kidney with significant HYF		118	36.0
No. of kidney without HYF		210	64.0

US, ultrasonography; HYF, Hyperechoic focus(foci); †, Percent distribution from total kidney with HYF

The positive KS by US (or the significant HYF) were 118 (36%) kidneys, while the positive KS by UHCT were 53(16.2%). Both US and UHCT demonstrated stones in 43 kidneys, and neither could find stone in 200 kidneys. For the positive stones (significant HYF) by US (118 kidneys), UHCT demonstrated stones in 36.4% (43 kidneys). For the negative stone by US (210kidneys), UHCT find stone in 4.8 % (10 kidneys) (Table 2).

The average size of HYF and KS measured by US and by UHCT [mean (SD)] were 4.8(1.4) and 4.4(3.2) mm, respectively (data no showed). The average size discrepancy of HYF and KS by UHCT in our study was 0.6 4.3 mm, of which US was slightly larger. The distribution of stones by size as measured by US and UHCT were different as shown in Table 3.

Table 4 shows the percentage positive for stones by UHCT from the US positive. Percent of stone positive by UHCT were significantly increased (p-value<0.05 Chi square for trend) with the increase in sizes of the HYF, i.e., 29.5% for the smallest (2.1-5.0 mm), 48% for the small (5.1-7.5 mm) and 100% for the mid-size (7.6-10.0 mm) (Table 4).

Accuracy of Each Method

Using UHCT as gold standard, the sensitivity and specificity for stone detection by US and urine findings are shown in Table 5. From 118 positive kidney by US, 53 subjects were confirmed as positive KS by UHCT. The kidneys with normal US was 210 of which 10 kidneys was positive by UHCT.

For HYF size 2.1-10mm, the sensitivity and specificity for US were 72.2% and 76.3%. When microhematuria and micropyuria was used as screening methods, both sensitivity (53.7% and 36.6 %) and specificity (57.9% and 52.9%) were lower than US.

Based on a stone prevalence of 16.1% by UHCT [positive kidneys (53)/total kidneys (328) x 100, Table 2] in our study, the positive predictive values (PPV) for HYF, the presence of RBC and WBC in urine were 36.4%, 30.1% and 20.8%, respectively.

The respective negative predictive values (NPV) for HYF, and the presence of microhematuria and micropyuria were 95.2%, 78.7% and 71.1%. The presence of pyuria and hematuria in urine had 56.8% and 48.8% accuracy in predicting the existence of KS, both were lower than the HYF (74.1%). Compared with other methods, the micropyuria or microhematuria, the HYF by US had the higher sensitivity (81.1%), accuracy (74.1%), NPV (95.2%) but the PPV was quite low(36.4%), however, the interpretation of HYF as small kidney stone were to be improved.

Table 2 Diagnosis of kidney stone by the methods of US, and urine findings as compared to UHCT

Method (Number)	Result	UHCT		Total (%)
		Pos (%)	Neg (%)	
US† (n=328)	Pos	43(81.1)	75(27.3)	118(36)
	Neg	10(18.8)	200(72.7)	210(64)
	Total	53(100)	275(100)	328
Microhematuria‡ (n=162)	Pos	22(53.7)	51(42.1)	73(45.1)
	Neg	19(46.3)	70(57.9)	89(54.9)
Micropyuria‡ (n=162)	Pos	15(36.6)	57(47.1)	72(44.4)
	Neg	26(63.4)	64(52.9)	90(55.6)

US, ultrasonography ; RBC, urine red blood cells ; WBC, White blood cells;
UHCT, Unenhanced helical computerized tomography;
† Number of total kidneys(328);
‡ Number of total subjects was 164 but 2 subjects being in menstruation period.

Table 3 Numbers of stones by sizes as estimated by US and UHCT

Stone size by UHCT (mm)	Size of HYF by US (mm)					
	2.1-5.0 R(L)	5.1-7.5 R(L)	7.6-10.0 R(L)	US positive R(L)	US negative R(L)	Total R(L)
≤2	9(4)	2(1)	0(0)	11(5)	5(1)	16(6)
2.1-5.0	4(5)	1(1)	0(1)	5(7)	2(2)	7(9)
5.1-7.5	0(1)	1(0)	1(1)	2(2)	0(0)	2(2)
7.6-10.0	1(2)	1(1)	0(0)	2(3)	0(0)	2(3)
>10	0(0)	4(0)	0(2)	4(2)	0(0)	4(2)
UHCT positive	14(12)	9(3)	1(4)	24(19)	7(3)	31(22)
UHCT negative	37(25)	7(6)	0(0)	44(31)	89(111)	133(142)
Total kidney	51(37)	16(9)	1(4)	68(50)	96(114)	164(164)

US, Ultrasonography ;UHCT, Unenhanced helical computed tomography;
HYF, Hyperechoic foci ; R, right kidney ; L, left kidney ;

Table 4 Percentage of stone detection by UHCT in kidneys with positive and negative HYF by US

No. of kidney with HYF(US)	Size of HYF by US (mm)	No. of kidney with stone by UHCT	% Detected by UHCT*
88	2.1-5.0	26	29.5
25	5.1-7.5	12	48.0
5	7.6-10.0	5	100.0
118	Total detect	53	44.9
210	Not detected	10	4.8

UHCT, Unenhanced helical computerized tomography;
HYF, Hyperechoic foci; US, Ultrasonography ;
* p-value<0.05 (Chi square for trend)

Table 5 Sensitivity , Specificity, PPV , NPV and Accuracy of detection of KS by US , urine findings when the gold standard was UHCT

Method	**Sens (%)**	**Spec (%)**	**PPV (%)**	**NPV (%)**	**Acc (%)**
US (HYF=2.1-10.0mm)	81.1	72.7	36.4	95.2	74.1
Micro-hematuria	53.7	57.9	30.1	78.7	56.8
Micro-pyuria	36.6	52.9	20.8	71.1	48.8

KS, Kidney stone; Sens, Sensitivity; Spec, Specificity; PPV, Positive predictive value ; NPV, Negative predictive value; Accu, Accuracy; HYF, Hyperechoic foci(focus); US, Ultrasonography; UHCT, Unenhanced Helical Computed Tomography

DISCUSSION

Summary of Main Findings

About 30% and 50% of the HYF of the sizes 3-5.0 and 5.1-7.5mm, respectively, was confirmed by UHCT as kidney stones, while the false negative by US in KS not larger than 10 mm was 5%. Ultrasonography can be used as screening test for small kidney stone in patient with suspected nephrolithiasis with the awareness of the moderate sensitivity (72-81%) and specificity (72.7-76.3%). The US scanning by multiple anatomical approaches, the significant HYF in this studied was fulfilled with the 3 criteria: denser, unusual place, and nearby calyectasis.

Where This Fits with Other Literature

The present study found the ability of US to detect stones depends upon stone size as described by Middleton.[5] In reported literature the sensitivity of US is reported to be 96 % for kidney stones and the specificity is 100% for stones larger than 5 mm [5, 12]. Vrtiska and coworker[6] reported the sensitivity of US was as high as 98% in radiopaque stone patients who had undergone ESWL when compared abdominal radiographs and renal tomograms. Ather MH[12] reported that when compared US with UHCT in the patients with serum creatinine ≥1.8 mg/dl, the

sensitive and specific for kidney stones was 81 and 100%, respectively. US is highly sensitive and specific for renal stones in patients with renal failure, it lacks sensitivity for ureteric calculi particularly when they are in the middle ureter. In patients with acute flank pain diagnosed for the presence of ureteric stones in previous reports the sensitivity of US varies between 37 and 64 %.[14-16]

In our study, for detection of the KS not larger than 10 mm, US had sensitivity and specificity of 81 and 72%.

Some investigators reported that stone sizes were overestimated by US in 22% of all detected stones. Middleton[5] described that the causes of the difference may be opaque uric acid mantle or proteinaceous matrix around the central radiopaque nidus. In our study the mean (SD) of the size discrepancy of HYF and KS by UHCT was 0.6 (0.3) mm, of which US was slightly larger (data not shown).

The HYF detected by US but were not diagnosed as stones by UHCT might be the renal sludge, pericalyceal fat, crystal laden calyceal sub-mucosal plaques, milk of calcium or uric acid in the calyceal diverticula or arterial calcification as mentioned earlier by Vrtiska.[6]

Strengths and Limitations

This is the first attempt in Thailand to study the reliability of the screening small kidney stones with simple available machine by a general practitioner who had 5 year- experience in US scanning. The result of the study, performed in the practical environment in rural community, can be applied to the actual circumstances. This study based on the facts that radiologist is extremely rare and does not work in the remote communities. However, if the US screener was a radiologist with a new generation US, the study result might be more attractive.

Because of time limitation and a large numbers of participants in the field survey, the position of the largest stones in this study were not definitely located, so the difference in stone size by US and UHCT may due to measuring different stones in cases of multiple stones.

Implications

Screening for small KS is crucial for effective control. The treatments of large KS by surgical removal or shockwave lithotripsy (SWL) have a high rate of recurrence, which increases with age and observation time. The average recurrence rate is 30- 40 %.[17,18] Since small stones can pass spontaneously, the earlier the diagnosis the easier and more successful stone management, by promoting the passage of stones.[11,12] The presence study revealed that the US had a positive predictive value of 36.4%, which is quite low but it is better than the urine strip exam for screening of small KS in the community.

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