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Accuracy of Sonography for Detection of Renal Stone Comparison with Non- Enhanced Computed Tomography

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Abstract: Introduction: *Renal or ureteric calculi are a common incidental finding on abdominal imaging. In most cases no definite cause is identified and the natural cumulative recurrence rate is reported to be 14% at 1 year, 35% at 5 years and 52% at 10 years. Many factors, including race, diet, occupation and water hardness have been implicated in stone formation. In most cases a definite cause is not identified but certain predisposing factors are recognized. Non enhanced helical computed tomography (CT) has become the primary imaging modality for evaluating acute flank pain and suspected renal stone disease. Ultrasound has an important role in the diagnosis and management of urinary tract stones but it has its limitations. The safety and ease of the ultrasound examination are unsurpassable, but its accuracy is modest. Reported sensitivities range from 37 to 64% for calculus detection and 74 to 85% for the detection of acute obstruction. Depending on its composition, a renal stone can be either sound transmitting or so reflective that only its near surface is seen as echogenic cap.*

Objectives: *To determine the sensitivity and specificity of ultrasonography (US) for detecting parenchymal and renal pelvis calculi and to establish the accuracy of US for determining the size and number of calculi, and to find the correlation between the accuracy of sonography with stone size.*

Patients & method: *This is a prospective study conducted from October 2015 to May 2016. Fifty patients (23 men and 27 women) with a mean age of 40 years (range, 19–69 years) selected from Consultant Clinic of Urology of Baghdad Teaching Hospital who had acute flank pain, hematuria or dysuria, and suspected renal stone. Ultrasound was performed by using Philips HD 11 EX equipped with (3.5 MHz) Convex Transducer with High Resolution Monitor and a Thermal Page Printer, Real Time B-Mode Gray Scale and the Examination consist of either dedicated Renal or Abdominal imaging. Non-Enhanced CT scans were performed with (4-chnannel multidetector spiral CT unit [Toshiba Aquilion , model TSX -101A] , 5.0 mm slices with 1.0 pitch , 5.0 mm collimation , 120 kv , (200-360) m As this was changed by the operator according to the patient size .*

Results: *Of the 50 patients, 36 (72 %) had a total 105 renal stones identified on Nonenhanced CT scans. Mean stone size (long axis) was 4.5 mm ± 0.5 with a range of (1.1 – 25 mm), Of these 36 patients, 20 (55 %) had multiple renal stones with mean stone size 3.8 mm ± 0.3 (size range 1.4 – 25 mm). Ultrasound demonstrate 50 of 105 renal stones identified on CT images, 16 stones in the Small size group (0.0-3.0mm), 19 stones in the Medium size group (3.1-7.0mm) and 15 stones in Large size group (>7.0mm).*

Conclusion: *US is of limited value for detecting renal stones.CT is the gold standard for assessing the size, number, and location of renal stones.*

Key words: *ultrasound (us), non- enhanced CT(CT), stone size, renal pelvis, calculi,indinavir.*

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I. Introduction:

In the UK, urolithiasis is responsible for 1.8 per 10000 hospital admissions. The incidence of this condition in the general population is 7 per 1000 (1) and similar figures have been reported from the USA (2). Renal or ureteric calculi are a common incidental finding on abdominal imaging. In most cases no definite cause is identified and the natural cumulative recurrence rate is reported to be 14% at 1 year, 35% at 5 years and 52% at 10 years (3). The overall lifetime risk is estimated as 35–65% with a male preponderance (M:F 2:1) and the peak age of onset is 20–30 years. Caucasian or Asian origin confers a higher risk.Calcium-containing calculi are commonest, composed mainly of pure calcium oxalate or calcium oxalate mixed with calcium phosphate. The majority of the remainder are so-called struvite or matrix stones composed of magnesium ammonium phosphate. Uric acid and cysteine stones account for less than 10% of all calculi. An organic matrix of mucoprotein, constituting 1–5% of the stone by weight, is present in all calculi (3).

Many factors, including race, diet, occupation and water hardness have been implicated in stone formation(4).Other stones, e.g. xanthine stones which may be related to a metabolic abnormality or indinavir stones (which are drug related due to use of protease inhibitors (indinavir) in the treatment of HIV infection.), are uncommon and account for less than 5% of all renal stones.In most cases a definite cause is not identified but certain predisposing factors are recognized. The incidence is higher in patients with an anatomical abnormality of the urinary tract and this may be related to urinary stasis(5).Renal impairment at presentation suggests the presence of a complicating factor, such as underlying renal disease or septicaemia. Rarely, renal failure may be secondary to bilateral obstructing calculi or an obstructing stone in a single functioning kidney.

Most normal adult kidneys have a maximum length of 10-12.5 cm, although substantial numbers of normal kidneys may be seen within the 9-13.5 cm range. Kidneys are roughly related to the patient's size and show some decrease in length with age (especially above 80 years). A difference of 2.0 cm or more between the two kidneys raises the possibility of unilateral disease. In young healthy adults cortical thickness is of the order of 2.5-3 cm at the poles and 1.5-2.0 cm elsewhere. This may decrease substantially with age and be associated with an increase in the central sinus fat. The normal renal parenchyma is of intermediate density, measuring between 30 and 60 HU. The renal sinus and perinephric fat are low density, around -10 to -50. (6)The earliest documentation of the Use of CT for diagnosing renal stones was published in 1995 (7). Nonenhanced helical computed tomography (CT) has become the primary imaging modality for evaluating acute flank pain and suspected renal stone disease.A major advantage of non-contrast CT is that (nearly) all stones are dense on CT. The primary limitation of CT is the small size of the stone rather than its attenuation. On soft tissue windows, **urinary calculi** appear as high-attenuation objects. **The single uncommon exception** is crystalline stones associated with the use of protease inhibitors (indinavir) in the treatment of HIV infection. These stones are low attenuation on CT but may cause ureteral obstruction.On CT, **calcium oxalate and calcium phosphate stones** are 800 to 1,000 H**U, struvite stones** are 330 to 900 HU, **cystine stones** are 200 to 880 HU depending on calcium content, and **uric acid stones** are 150 to 500 HU. High CT attenuation makes calculi easy to differentiate from other collecting system lesions, such as tumors, hematoma, fungus balls, or sloughed papilla, which are all usually <50 HU. (8)

Ultrasound has an important role in the diagnosis and management of urinary tract stones but it has its limitations. The safety and ease of the ultrasound examination are unsurpassable but its accuracy is modest. Reported sensitivities range from 37 to 64% for calculus detection and 74 to 85% for the detection of acute obstruction (9). Depending on its composition, a renal stone can be either sound transmitting or so reflective that only its near surface is seen as echogenic cap.

Objectives:

- To determine the sensitivity and specificity of ultrasonography (US) for detecting parenchymal and renal pelvis calculi and to establish the accuracy of US for determining the size and number of calculi.
- To find the correlation between the accuracy of sonography with stone size.

II. Patients & method:

This is a prospective study conducted from October 2015 to May 2016. Fifty patients (23 men and 27 women) with a mean age of 40 years (range, 19–69 years) selected from Consultant Clinic of Urology of Baghdad Teaching Hospital who had acute flank pain, hematuria or dysuria, and suspected renal stone. Informed consent was taken from each patient before doing the exam.

Females of Childbearing age were questioned about missed period to exclude any possibility of pregnancy.A specially designed questionnaire was used to collect information from patients. The patient selected from those undergoing Non Enhanced (Non-contrast) CT for suspected renal stones who also underwent sonographic examination performed by Experienced Radiologist within 72 hours preceding or following CT examination.Ultrasound was performed by using Philips HD 11 EX equipped with (3.5 MHz) Convex Transducer with High Resolution Monitor and a Thermal Page Printer, Real Time B-Mode Gray Scale and the Examination consist of either dedicated Renal or Abdominal imaging. US included evaluation of the kidney in multiple anatomical planes.All Echogenic foci regardless of size (with or without acoustic shadowing) that were seen in the renal pelvis, calices and parenchymal were diagnosed as renal stones. Because small stones may or may not cast an acoustic shadow (10,11,12).

Non-Enhanced CT scans were performed with (4-chnannel multidetector spiral CT unit [Toshiba Aquilion , model TSX -101A] , 5.0 mm slices with 1.0 pitch , 5.0 mm collimation , 120 kv , (200-360) mAs this was changed by the operator according to the patient size .With Images viewed [evaluations and measurements] on the stones at workstation [Toshiba Aquilion, model TSX -101A] at (Window Level = 35, Window Width = 200) & images reconstructed at 4.37 mm interval. On CT, except for vascular calcifications, all high-density foci in the renal pelvis, calyces and parenchyma were diagnosed as stones.Hydronephrosis if present in both modality, the patient was excluded from the study under the fact that the collecting system when distended by fluid, small stones that normally do not cast an acoustic shadow in tissues can produce an acoustic shadow when lying inside a fluid-filled cavity.(13)

Statistical analysis:

The Fisher exact test and Chi-square test were used to assess whether the accuracy of sonographic findings was influenced by stone size, location (right versus left kidney).The degree of correlation between the sizes of the renal stones as measured on sonography and CT was assessed using a Linear Regression Test.
A (p value) of less than 0.05 was considered statistically significant.

III. Results:

Of the 50 patients, 36 (72 %) had a total 105 renal stones identified on Non-enhanced CT scans shown in (Table 1). Mean stone size (long axis) was 4.5 mm ± 0.5 with a range of (1.1 – 25 mm), Of these 36 patients, 20 (55 %) had multiple renal stones with mean stone size 3.8 mm ± 0.3 (size range 1.4 – 25 mm)

Table 1 : Number of patients have Renal Stones on CT		
Renal Stone	Number of Patients	Percentage
(+) ve	36	72 %
(-) ve	14	28 %

Non enhanced CT showed thatof 105 renal stones, 59 stones in the Small size group (0.0-3.0mm), 27 stones in the Medium size group (3.1-7.0mm) and 19 stones in Large size group (>7.0mm) shown in (Table2).

Table 2: Number of Renal Stone according to Size group in CT		
Size Groups	**Number**	**%**
Small (0.0-3.0mm)	59	56 %
Medium (3.1-7.0mm)	27	26 %
Large (>7.0mm)	19	18 %

Ultrasound demonstrate 50 of 105 renal stones identified on CT images, 16 stones in the Small size group (0.0-3.0mm), 19 stones in the Medium size group (3.1-7.0mm) and 15 stones in Large size group (>7.0mm) shown in (Table 3). Forty-three (78%) calculi not visualized at US were less than 3.0 mm in size. The Mean renal Stones size detected with US was 6.8 mm ± 1.3. US demonstrate, 9 (45 %) of 20 patients had multiple renal stones with mean stone size 3.8 mm ± 0.3 (size range 1.4 – 25 mm) and demonstrated all calculi in (20%) of these patients. On sonographic examination, renal vascular calcifications were misinterpreted in 7 cases.

Table:3 Number of Renal Stone according to Size group in US		
Size Groups	**Number**	**%**
Small (0.0-3.0mm)	16	32 %
Medium (3.1-7.0mm)	19	38 %
Large (>7.0mm)	15	30 %

Ultrasound in comparison to CT (By Total 105 stone in Both Kindeys): Accuracy (48.2%) , Sensitivity (47.6%) , Specificity (50%) shown in (Table 4) .

Table 4: Detection of 105 Renal Stones				
	US Findings			
CT Findings		**+ve**	**-ve**	**Total**
	+ve	**50**	**55**	**105**
	-ve	**7**	**7**	**14**
	Total	**57**	**62**	**119**
Note : The sensitivity of US was 47.6% and The specificity was 50%				

The Sonographic Detection Rate of Renal Rtone (By Size of the Stone) : For The Right Kidney , Stone Size was not correlated with Detectability on Sonography , While For The Left Kidney , The results revealed a Significant Correlation between Stone Size and Detection Rate on Sonography (p < 0.05).table 5

Table 5: Sonographic Detectio Rates of Renal Stones by Stone Size for Right and Left Kidneys				
Stone Size(in mm)	Total	Detected (%)	Missed	P Value
Right Kidney				
Small (0.0-3.0mm)	29	10	19	>0.05
Medium (3.1-7.0mm)	13	9	4	
Large (>7.0mm)	9	8	1	
Left Kidney				
Small (0.0-3.0mm)	30	6	24	<0.05

Medium (3.1-7.0mm)	14	10	4	
Large (>7.0mm)	10	7	3	

IV. Discussion:

In most institutions non-enhanced multi-detector computed tomography (MDCT) is considered the gold standard technique to evaluate these patients because of its accuracy in the detection of stones as well as of other pathological conditions mimicking renal colic(14). It is also considered as the first imaging technique for the evaluation of patients with acute onset of flank pain by The American College of Radiology Appropriateness Criteria(15) On the other hand, ultrasound (US) is a safe, non-invasive and non-expensive technique able to evaluate patients with renal colic. However, its use remains controversial as it has good capability to identify dilatation of the excretory system even in non-experienced hands (16). However, it is now common practice to perform imaging studies in all patients with suspected renal colic admitted to the Emergency Department. This may be due to fear of missing a life-threatening condition mimicking this condition, such as rupture of an aortic aneurysm, ovarian torsion or appendicitis, or to the need for imaging confirmation of the cause of symptoms before deciding on whether a patient may be discharged. At present, additional strong indications for imaging are the desire of patients to know the cause of their symptoms and the fear of litigation. If not in all patients, immediate imaging modalities are necessary in patients without clinical improvement after treatment, in cases with fever or leukocytosis, or in some special circumstances (i.e., patients with a single kidney and/or renal failure); furthermore, imaging is also recommended in patients with remission of symptoms who do not eliminate the stone within a few days.(17)

Several studies have investigated the value of Sonography for detecting renal stones using CT as the reference standard (18,19,20)

Our Data Indicate that: -

1-Sonography is of limited value for diagnosing renal stones, due to:

The most important being the excellent contrast resolution of CT that allows discrimination of slight differences in attenuation within the renal pelvis and parenchyma. Helical CT enables acquisition of a volume of data that includes the entire kidney, thus allowing complete evaluation, whereas some portions of the kidney may not be visualized at US. Furthermore, CT is less dependent on factors such as patient body habitus and operator skill that are critical to US. Calculi may be missed at US because of a lack of acoustic shadowing that can occur with intervening tissue of different acoustic impedance. (21).

Ather et al (2004) (22) used CT to evaluate the diagnostic accuracy of Sonography for detecting renal stones and obstruction in patients with renal failure. These authors concluded that Sonography is highly sensitive and specific (81% and 100% , respectively) for detecting renal stones . We believe that this high sensitivity and specificity are related to the fact that all the kidneys examined were hydronephrotic. When the collecting system is distended by fluid, small stones that normally do not cast an acoustic shadow in tissues can produce an acoustic shadow when lying inside a fluid-filled cavity. (13) Patients with hydronephrosis were excluded from the study, because we felt that this condition might exaggerate the accuracy of sonography for detecting renal stones.

2- Sonographic Detection Rate of Renal Stone by Stone Size for Right and Left Kidney. Our study showed that, For the Right Kidneys, Stone size was not correlated with Detectability on Sonography. However, For the Left Kidney. The results revealed significant correlation between stone size and Detection Rate on Sonography ($p < 0.05$). Ulusan et al (2007) (23) agreed with our study.

3-Accurate Determination of Stone size. Our Study showed that, 45 (90%) of 50 renal stone on US are concordant with CT at Size Groups. Kanno et al.,2014.(19)stated that, the detection rate increased with stone size. Furthermore, stone sizes obtained by US were positively correlated with those obtained by CT. Importantly, stone size was only a factor that affected renal stone diagnosis using US.

4-Full Extent Stone Burden. Our Study showed that US was poor modality for demonstrating the Full Extent of Calculi burden. US depicted 9 (45%) of total 20 patients had multiple renal stones and in only 4 patients all renal stones depicted.

Renard-Penna et al.,2015(24) concluded that, CT is the preferred method for the evaluation and treatment planning of urolithiasis. CT radiation dose reduction can be achieved with low dose CT. However, conventional radiography and ultrasound are still recommended in the follow up of renal stones.

Conclusion: US is of limited value for detecting renal stones.CT is the gold standard for assessing the size, number, and location of renal stones.

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