

Comparison between Low-Dose CT and Ultrasound in Diagnosis of Renal and Ureteral Stones in Adults

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Abstract

Background: Non-contrast computed tomography of the kidneys, ureters, and bladder (CT KUB) is the examination of decision for renal colic when compared to ultrasonography; be that as it may, radiation presentation can be a worry.

Aim of Study: Comparison between low dose CT and ultrasound in diagnosis of renal and ureteral stones in adults.

Patients and Methods: This prospective study was conducted on fifty Egyptian adults meeting the inclusion criteria of having flank pain, suspected to have urinary tract calculi and recruited from Urology Department of Tanta University to Radiology Department at Tanta University Hospitals. All patients were applied to careful history taken, clinical and laboratory examination then underwent imaging studies which include renal ultrasound examination and MDCT-KUB using low dose protocol. Each depicted stone was documented whether it is renal or ureteric. All the stones were also defined as single or multiple, unilateral or bilateral and the maximum diameter of them. In case of upper urinary tract calculi reliable secondary signs of obstructing calculi were demonstrated. These include hydronephrosis, hydroureter, ipsilateral renal enlargement and ureter rim sign. The findings were confirmed by comparing to the previous standard CT scans that were done and detected in the medical records for 20 patients, ureteroscopy in 12 patients, percutaneous nephro lithotomy in 8 patients, medical treatment and more follow-up for 10 patients. The sensitivity, specificity and size accuracy of US was determined using low dose CT as the standard.

Results: Low dose CT showed number of renal and ureteral stones more than ultrasound with statistical significant p -value <0.001 with overall stones detected by ultrasound is 43 stones (5 ureteral and 38 renal) while low dose CT showed 96 stones (40 ureteral and 56 renal). The ultrasound missed 12 stones with 80% with mean size 4mm at ureterovesical junction and 10 stones with 83.8% with mean size 6mm at upper third of ureter. The ultrasound missed 100% of the ureteral stones in middle or distal ureter due to abdominal gases. The ultrasound overestimate the size in size group [4 to 10mm] by 3.3mm with statistically significant p -value detected. The ultrasound sensitivity, specificity, accuracy for renal stones detection were 67.8%, 100% and 81.2% respectively

when compared to low dose CT and the ultrasound sensitivity, specificity, accuracy for ureteral stones detection were 6.90%, 100% and 43.75% respectively when compared to low dose.

Conclusion: Low dose CT shows up as preferred imaging modality for urolithiasis over ultrasound because of its high sensitivity and accuracy in identifying renal and ureteral stones.

Key Words: Urolithiasis – Ultrasonography – Low dose CT.

Introduction

UROLITHIASIS is a standout amongst the most widely recognized issue of urinary tract. Imaging is significant for the analysis of acute and chronic urinary stones. Ultrasonography might be a satisfactory introductory examination in numerous cases, particularly in patients known to have a background marked by stones and in patients where radiation ought to be kept away from (e.g., pregnancy and children) [1]. In grown-ups, Unenhanced Multidetector (CT) has a high sensitivity (95%-96%) and specificity (97%-100%) for the conclusion of urinary stones, which was higher than intravenous urography or KUB. Be that as it may, concerning radiation dose, unenhanced CT has a higher danger of radiation peril than IVU or KUB, which may be a primary restriction of this examination. Exposure to limited quantities of radiation can cause malignant growth, particularly in younger patients [2].

Given the way that urinary stone is chronic in nature and requires continue imaging normally utilizing CDCT, there might be a generous radiation dose during a person's lifetime. In this manner, there is a requirement for a precise analytic imaging tool with negligible radiation presentation. A meta analysis demonstrates the radiation portion for

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urinary stone CT acquisitions can be securely diminished beneath 3mSv without influencing the analytic exactness of stone recognition [2]. These days, the American Urological Association gives no reasonable recommendation [3], however the current rules of the American College of Radiology just as the European Association of Urology prompt utilizing low-dose CT in patients with intense infection and doubt of urinary stone [4,5].

Patients and Methods

This prospective study was carried out on 50 Egyptian patients, clinically suspected to have urinary tract calculi referred from Urology Department and out clinics to the Department of Diagnostic Radiology Department in Tanta University hospitals for multi-slice CT examination from March 2017 to January 2019.

The commonest affected age group in our study was 41 to 60 years old as 20 patients were between 41 and 60 years old with 40% with mean age 49 years old. The male patients were 34 with 68.0% while the female patients were 16 with 32% with mean of 30.2.

Inclusion criteria were: Adult patients with flank pain and suspected to have urinary tract calculi while exclusion criteria were: Pregnancy, age younger than 16 years old, body mass index >40 and inability to obtain informed consent.

An informed consent was obtained from all participants in this research after full explanation of the benefits and risks of the procedure. The participants in this study with flank pain and ordered to do renal CT scan were subjected to careful history was taken, clinical examination, laboratory investigations including: CBC, urine analysis (for detection of crystals, hematuria and urine pH) then underwent imaging studies which include renal ultrasound examination and MDCT-KUB using low dose protocol.

The patients were told to prepare themselves carefully for the ultrasound scan by abstaining from food for the last 6 hours with continuous taking their drugs and ultrasound scan was carried out with the patient in supine position and additional scans in the lateral decubitus and prone were useful in some situations. Each depicted stone was documented whether it is renal or uretric, single or multiple, unilateral or bilateral and the maximum diameter of them.

Then MDCT-KUB using low dose is done without IV or oral contrast with fasting 8 hours prior

the examination and full urinary bladder. Patients were placed in the supine position, head first with arm elevated above the head, with scanning range from T12 vertebra to the edge of pubic symphysis. Then the scans were performed with a 128-section multidetector CT scanner (Optima HD 128-section; GE Healthcare), automatic tube current modulation scanning was used (a tube current range of 10-400 mA) modified to be from 26mA to 50mA according to the body mass index of the patient, with noise index setting 25 in LDCT, and some other scanning parameters were as following: Gantry rotation time, 0.5 second; section thickness, 5mm; pitch, 1.375, reconstruction interval 2.5mm and table speed 17.5mm per rotation.

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp).

Results

The most common clinical presentation of the studied patients was flank pain as it appear in 46 patients with 92%, followed by dysurea which appear in 12 patients with 24%, hematuria which have the same percentage as dysurea.

The overall stones detected by ultrasound is 43 stones (5 ureteral and 38 renal) while low dose CT showed 96 stones (40 ureteral and 56 renal). Low dose CT showed number of renal stones more than ultrasound with statistical significant p -value <0.001. Also low dose CT showed number of ureteral stones more than ultrasound with statistical significant p -value <0.001. The number of stones increased with the body mass index in ultrasound and low dose CT. The most common site for the detected ureteral stone was urterovesical (15 stones with 30%).

The ultrasound overestimated the size in size group [0 to 4mm] by 1.8mm with no statistically significant p -value detected, overestimated the size in size group [4 to 10mm] by 3.3mm with statistically significant p -value detected and overestimated the size in size group [$>$ 10mm] by 1.5mm with no statistically significant p -value detected. We found that stones classified as 5-10mm by US had the highest probability (45%) of having the management recommendation changed when a CT was performed.

The ultrasound sensitivity, specificity, accuracy for renal stones detection were 67.8%, 100% and 81.2% respectively when compared to low dose

CT and the ultrasound sensitivity, specificity, accuracy for ureteral stones detection were 6.90%, 100% and 43.75% respectively when compared to low dose CT.

Discussion

The aim of this study was to compare between the ultrasound and low dose CT in detecting urinary stones in adult patients.

Low dose CT appears as better imaging modality for urolithiasis than ultrasound due to its high sensitivity and accuracy in detecting renal and ureteral stones. Also it shows more accuracy in measuring stone size with reducing radiation exposure significantly than standard dose CT and cost acceptability as shown in Fig. (1). This study was conducted on fifty patients with commonest affected age group was 41 to 60 years old as 20 patients were between 41 and 60 years old with 40% which is approximately agree with (Vahlen-sieck EW, et al., 1982) [6] who studied a total of 10,130 individuals aged over 18 were interviewed to find out the incidence and prevalence of urolithiasis found that stone prevalence increased from 1.28% to 6.79% with increasing age. The male affection in our study was (34 patients) representing 68% which was more common than females (16 patients) representing 32%. This is agree with (Shirazi F, et al., 2009) [7] who studied 161 patients with findings show that 66.5% of patients were male.

The most common clinical presentation of the studied patients was flank pain as it appear in 46 patients with 92%. This agrees with (Spivacow FR, et al., 2010) [8] who studied a total of 160 patients and found that the most frequent form of presentation was renal colic (72%). Nadeem M, et al., 2012 [9] studied 1550 patients and also stated that flank pain is the most common clinical presentation of urolithiasis.

In our study the overall stones detected by ultrasound is 43 stones (5 ureteral and 38 renal) while low dose CT showed 96 stones (40 ureteral and 56 renal) as shown in (Table 1). This agree with (Oner S, et al., 2004) [10] who studied 29 patients and found that CT detected 57 stones (45 renal and 12 ureteral) while US detected 34 stones. Ganesan V, et al., 2017 [11] also studied 486 patients with both ultrasound and CT scans showed that CT detected a significantly greater number of stones: 299 vs. 184 on US ($p < 0.001$).

Table (1): Descriptive analysis of the studied cases according to number of stones (n=50).

	US	Low dose CT
<i>Number of ureteral stones:</i>		
Min.-max.	0.0-1.0	0.0-3.0
Mean ± SD.	0.80±0.27	0.80±0.70
Total	5.0	40.0
<i>Number of kidney stones:</i>		
Min.-max.	0.0-3.0	0.0-5.0
Mean ± SD.	0.76±0.96	1.12±1.29
Total	38.0	56.0
<i>Number of ureteral & kidney stones:</i>		
Min.-max.	0.0-3.0	1.0-5.0
Mean ± SD.	0.84±0.93	1.92±1.21
Total	43.0	96.0

Low dose CT showed number of renal stones more than ultrasound with statistical significant p -value < 0.001 . This agree with (Ather MH, et al., 2004) [12] who studied 864 patients which had un-enhanced helical CT for evaluation of the urinary tract with out of these 34 patients had both UHCT and US, UHCT identified renal stones in 21 (62%), whereas 17 of these were identified on US. Also (Oner S, et al., 2004) [10] studied 29 patients with spiral CT showed 45 stones in 28 kidneys while US was able to localize 31 stones (68,9%, 31/45) in 21 kidneys.

Low dose CT showed number of ureteral stones more than ultrasound with statistical significant p -value < 0.001 . This agree with (Oner S, et al., 2004) [10] who studied 29 patients and found that ultrasound could identify 3 stones (25%) in 11 ureters while CT showed 12 stones in 11 ureter and difference between US and CT rates of renal and ureteral stone detection was significant (chi-square, $p < 0.05$). Also this agree with (Ather MH, et al., 2004) [12] who studied 864 patients which had UHCT for evaluation of the urinary tract with out of these 22 patients with ureteric stone, on UHCT, US could only identify 10. Twelve patients with ureteric stones identified on UHCT were missed on US.

In the current study we found that the number of stones increased with the body mass index in ultrasound and low dose CT as shown in Fig. (2). This is agree with (Shrivastava SK, et al., 2016) [13] who studied a total of 100 patients who underwent open surgical procedures for urolithiasis and found that 68% of subjects had BMI more than normal supporting the evidence that renal stone disease is more common in higher BMI patients.

The most common site for the detected ureteral stone was uterovesical (15 stones with 30%) then proximal ureter (12 stones with 24%) then distal ureter (8 stones with 16%) then middle ureter (5 stones with 10%). This approximately

agrees with (Souza LR, et al., 2007) [14] who studied 52 consecutive patients and found that the locations of the calculi were: UVJ (47%), proximal (30%), distal (18%) and mid-ureteral (5%).

Table (2): Stone size measured by ultrasonography compared with CT.

Size (mm)	Size on CT	Size on US	Difference US-CT	Z	p
0-4	2.5 (3.0-8.0)	5.5 (2.0-3.4)	2.5 (-1.0-3.4)	1.857	0.063
5-10	8.0 (7.5-11.5)	9 (6.0-10.0)	6.0 (-1.0-8.0)	3.335*	0.001 *
>10	14.0 (9.0-20.0)	15 (12.0-19.3)	11.50 (-1.5-13.8)	1.536	0.124

Stones were grouped, based on the longest axis diameter, into three categories according to clinical relevance in management: <4mm (where observation would probably be recommended), 5-10mm (where shockwave lithotripsy would probably be recommended) or >10mm (where an endoscopic approach would probably be recommended). These groupings were based on previously reported practice patterns [15]. Analyses of size of stones on US were calculated using CT as the standard reference. In our study we found that ultrasound overestimate the size in size group [0 to 4mm] by 1.8mm with no statistically significant *p*-value detected. The ultrasound overestimate the size in size group [4 to 10mm] by 3.3mm with statistically significant *p*-value detected. Also we found that the ultrasound overestimate the size in size group [≥ 10 mm] by 1.5mm with no statistically significant *p*-value detected as shown in (Table 2). This agree with (Ganesan V, et al., 2017) [11] at two points and disagree at one point as they studied 486 patients with both ultrasound and CT scans showed that US overestimated stone sizes for size groups 0-4mm and 5-10mm with statistically significant *p*-value ($p < 0.001$). There was no significant difference for stones >10mm. Also, (Sternberg KM, et al., 2016) [16] who studied 155 patients received both a renal US and NCCT within 1 day stated that US overestimated stone size by 2.2mm ($p < 0.001$).

Because stone size measurements affect counseling decisions, we found that stones classified as 5-10mm by US had the highest probability

(45%) of having the management recommendation changed when a CT was performed. This agree with Ganesan V, et al., 2017 [11] who studied 486 patients and found that stones classified as 5-10mm by US had the highest probability (43%) of having the management recommendation changed when a CT was performed.

A wide range of sensitivities and specificities for ultrasonography have been reported, probably owing to variations in technique, body habitus, patient population and reference standards. Imaging stones in the renal pelvis and in the ureter also present different challenges as it is difficult to image the length of an undilated ureter owing to interference by bowel gas and increased penetration depth. In this study the ultrasound sensitivity, specificity, accuracy for renal stones detection were 67.8%, 100% and 81.2% respectively when compared to low dose CT. This agrees with (Ather MH, et al., 2004) [12] who studied 864 patients stated that US is sensitive and specific for renal stones, 81 % and 100%. Also (Sharma S, et al., 2018) [17] who studied 136 patients and stated that ultrasound sensitivity is 80-84% and ultrasound specificity is 50-53%. This study showed that the ultrasound sensitivity, specificity, accuracy for ureteral stones detection were 6.90%, 100% and 43.75% respectively when compared to low dose CT. This approximately agrees with (Souza LR, et al., 2007) [14] who studied 52 consecutive patients and found that US presented sensitivity of 22% and specificity of 100%.

Table (3): Agreement (sensitivity, specificity and accuracy) for number of kidney and ureteral stones (n=96).

	Sensitivity	Specificity	PPV	NPV	Accuracy
US/number of kidney	67.86	100.0	100.0	68.97	81.25
US/ureteral stones	6.90	100.0	100.0	41.30	43.75

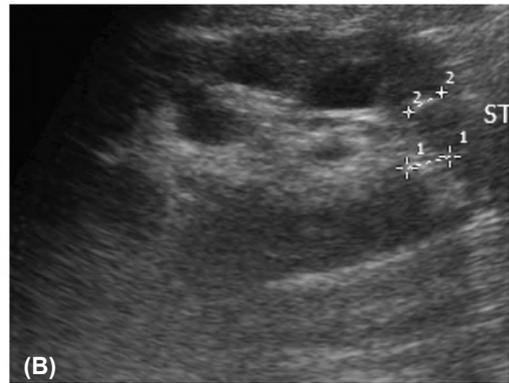
Conclusion:

Low dose CT appears is better imaging modality for urolithiasis than ultrasound due to its high sensitivity and accuracy in detecting

renal and ureteral stones. Also it shows more accuracy in measuring stone size with reducing radiation exposure significantly and cost acceptability.



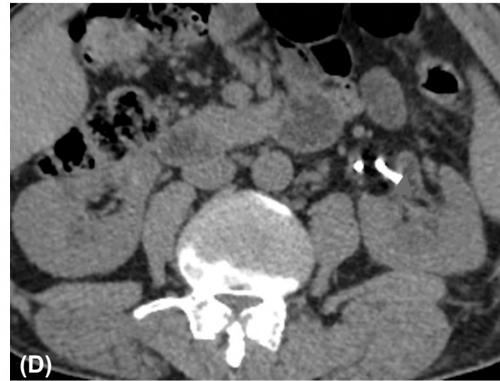
Ultrasound of right kidney



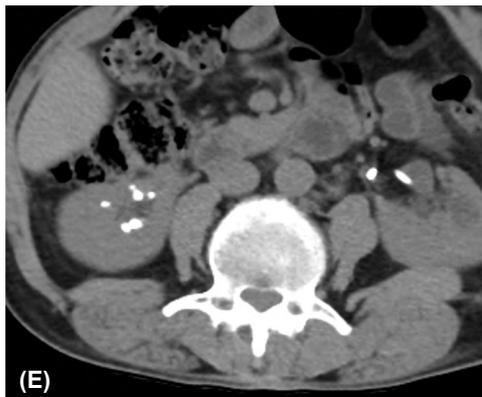
Ultrasound of left kidney



Axial non-contrast standard dose (160ma)
CT reformatted by MPR



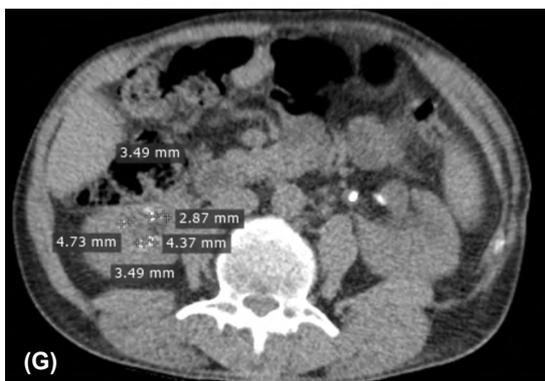
Axial non-contrast low dose (26ma)
CT reformatted by MPR



Axial non-contrast standard dose (160ma)
CT reformatted by MPR

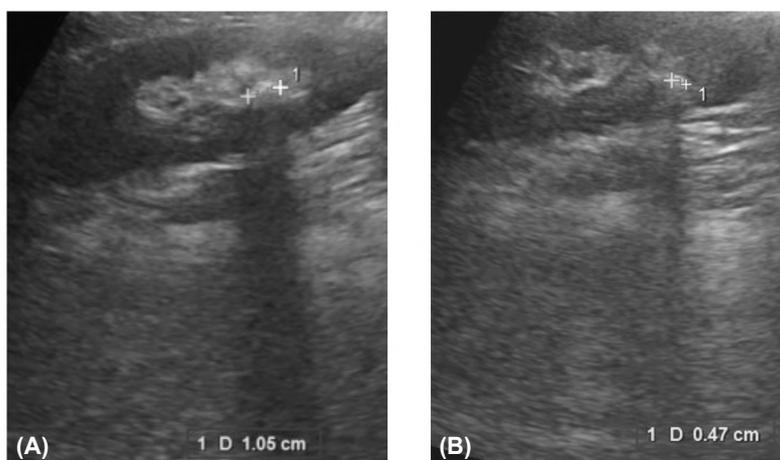


Axial non-contrast low dose (26ma)
CT reformatted by MPR



Axial non-contrast low dose (26ma) CT reformatted by MPR

Fig. (1): A male patient aged 57 years old weighted 80kg, with left renal J-stent and previous standard CT presented clinically with bilateral flank pain more pronounced in right side and hematuria. (A) Shows two hyper-echoic stones measuring 7mm and 6mm with mild hydronephrosis in right kidney. (B) Shows hyper-echoic J-stent with mild hydronephrosis in left kidney. (C,D) Show left renal J-stent with standard and low dose CT. (E,F) Show five hyper-dense stones in right kidney in standard with the same at low dose CT. (G) Shows the measurements of stones in low dose CT [2.8, 3.4, 3.5, 4.3, 4.7mm].



Ultrasound of right kidney



Curved coronal non-contrast standard dose (300ma) CT reformatted by MPR

Curved coronal non-contrast low dose (36ma) CT reformatted by MPR

Fig . (2): A Female patient aged 56 years old weighted 113kg, have previous standard CT, presented clinically with right flank pain. (A&B) Show two hyper-echoic stones measuring 10 and 4 mm in right kidney. (C&D) Show two hyper-dense stones measuring 11 and 5mm in standard (300ma) CT and low dose (36ma) CT.

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مقارنة بين الأشعة المقطعية منخفضة الجرعة والموجات فوق الصوتية في تشخيص حصوات الكلى والحالب في البالغين

تعتبر حصوات الكلى والحالب مشكلة سريرية متكررة، والتي قد تؤدي إلى حالات طارئة. قد تتأثر معدلات الإصابة وانتشار الحصى الكلى بالعوامل الوراثية والغذائية والبيئية وتميل إلى التكرار تتوفر طرق مختلفة لأخصائي الأشعة لتقييم مرضى المغص الكلوي الحاد. يعتبر التصوير بالموجات فوق الصوتية وسيلة للتصوير غير مكلفة نسبياً يمكن الوصول إليها والتي تأتي من دون التعرض لخطر الإشعاعات المؤينة الناجمة عن التصوير المقطعي وعلى الرغم من ذلك فإن استخدام الموجات فوق الصوتية لتوجيه عملية إتخاذ القرار السريري للحصوات المتبقية والتي بدون أعراض والموجودة في الحالب محدود بسبب الحساسية المنخفضة وعدم القدرة على قياس الحجم بدقة. نتيجة لذلك، قد يتم توجيه شخص واحد من بين كل خمسة مرضى بشكل غير مناسب عند استخدام الموجات فوق الصوتية وحدها. أما التصوير بالأشعة المقطعية بدون صبغة فهو حساس للغاية للكشف عن الحصوات. وقد وجد أن الجرعة الإشعاعية والتكلفة لفحوصات الأشعة المقطعية المتعددة تشكل مصدر قلق كبير ولا يمكن تبريرها. تمت دراسة العديد من بروتوكولات الجرعة المنخفضة والجرعة الفائقة الإنخفاض ووجد أنه يمكن إجراء أشعة مقطعية منخفضة الجرعة للمجرى البولي في وقت قصير، دون الحاجة إلى أي إعداد الأمعاء، بتكلفة أقل بكثير بالمقارنة مع الأشعة المقطعية التقليدية كما أن توفر معلومات دقيقة فيما يتعلق بحجم الحصوات والموقع والكثافة والعلامات المباشرة وغير المباشرة لإنسداد المجرى البولي وحتى تشخيص الحالات غير المسالك البولية.