Original Article

The gap between ultrasonography and computed tomography in measuring the size of urinary calculi

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Abstract

Objective: Due to a lack of studies regarding the need for computed tomography (CT) in measuring the size of each urinary calculus before surgery, this study was conducted to elucidate the difference between ultrasonography (US) and CT in measuring the size of urinary stones. **Methods:** A retrospective review of 100 stones from 83 patients. Each urinary stone was measured using both US and CT; both measurements were then compared. **Results:** Of 83 patients, the mean age was 39.29 ± 23.76 years; 47 (56.62%) were male and 36 (43.37%) were female. Most of the urinary stones were <10 mm (50.0%) followed by 11–20 mm (42.0%), ($P < 0.001$). A cross-tabulation test revealed strong compatibility between US and CT in measuring the size of urinary stones (73.7% in stones <10 mm, 66.7% in stones 11–20 mm and 50% in stones >21 mm), ($P < 0.001$). Spearman's rho correlation test revealed strong compatibility between stone diameters measured by US and CT ($r = 0.755$), ($P = 0 < 0.001$). *T*-test for equality of means revealed no significant difference in the measured size using US and CT (mean = 11.80 ± 5.83 vs. 11.65 ± 6.59, respectively), mean difference = 0.15, and $P = 0.865$, 95% confidence interval: -1.584–1.884. **Conclusion:** No significant difference in measuring the size of urinary stones using US and CT. However, US may slightly overestimate small stones in some cases.

Keywords: Computed tomography, measurements, ultrasonography, urinary stones

Introduction

Urinary stones are a very common problem worldwide that affect about 12% of the population at some time in their life.[1] They affect males more than females and 50% of affected adults have a recurrence within 10 years following diagnosis.[1,2] Renal stones are formed in the renal calyces and pelvis. They form due to unknown etiology but are often thought to be initiated by mineral deposition on a nidus of the mucoprotein matrix. Predisposing factors for renal stone formation include familial tendency, metabolic syndrome, hot climates, recurrent dehydration, urinary tract abnormalities, and repeated urinary tract infections.[1,3] The most common type of urinary stones is calcium oxalate.[1,4] Ultrasonography (US) is the first-choice imaging modality for detecting urinary stones, but computed tomography (CT) is indicated in some cases, especially for nondetected ureteric stones.[5] The diagnosis of urinary stones is more rapid using low-dose CT.[6] US has high specificity for detecting kidney stones with moderate sensitivity apart from common false negative.[7] The sensitivity of US is low in stones with low-grade hydronephrosis or hydro calyces, and small stones (<3 mm).[8] The sensitivity of US increases with increasing stone size, but CT is still the gold standard for detecting urinary stones.[7,8] Measuring the stone size is an important point for

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planning management.[9] There have been doubts about the accuracy of US in measuring the size of urinary stones. US overestimates urinary stones, especially small calculi.[10] The size of renal stones is concordant in most cases, with differences of 1.5 ± 0.7 mm in some cases.[11]

This study was designed to compare the mean of the largest diameter of urinary stones measured by US and CT and to elucidate the difference between the two imaging modalities in measuring the size of urinary stones. Our question was: "is there a significant difference in measuring the size of the urinary stone by US and CT?" This study is important for urologists in preparing patients of the urinary stones for surgical intervention. We thesis that US and conventional X-rays of kidney, ureter, and bladder (KUB) are sufficient for most cases of urinary stones. However, CT can be used for further assessment only. This research recommended to avoid the unjustified using of CT in all cases of urinary calculi, firstly, to avoid unnecessary radiation exposure and its disastrous complications as a primary care procedure, and secondly to decrease economic expenses with no benefit medical investigations.

Patients and Methods

Study design

This cross-sectional retrospective study involved 83 patients with urinary stones. Inclusion criteria involved only patients with urinary stones and had available measurements for both US and CT KUB. Exclusion criteria involved (1) patients with urinary stones but no available both US and CT KUB examinations, and (2) patients with urinary stones but no available measurements.

Study parameters

Urinary stones in each patient involved in this study were measured using both US and CT KUB. A comparison of the largest diameters was done.

Procedure

In US, the largest diameter of each stone was measured using a 3.5 MHz curved transducer of US machine in the intercostal space of the flank. The largest diameter of the same stone was measured with CT KUB either on axial sections or coronal reconstruction. A comparison of the two measurements was done.

Statistical analysis

The collected data were analyzed using the "Statistical Package for Social Sciences", version 23 for Windows (Armonk, NY, USA: IBM Corp. 2015). Data are presented as frequency and percentage for continuous variables and mean ± standard deviation for descriptive variables. A *t*-test was done to determine any correlation between the measurements of US and CT. A cross-tabulation between the measurements of US imaging and CT was performed, and the Spearman's correlation coefficient was measured. A *P* value was used to explain the relationship between the different parameters, and it was assumed to be significant when it was <0.05.

Results

In total, 83 patients who underwent US imaging and CT KUB were included in this study. The mean age at diagnosis was 39.29 ± 23.76 years; 47 (56.62%) were male, and 36 (43.37%) were female. Urinary stones tend to affect middle-aged peoples ($P < 0.001$) [Figure 1].

Table 1 reveals that most of urinary stones tend to be <10 mm, followed by 11–20 mm ($P < 0.001$). US tends to overestimate urinary stone <10 mm and underestimate urinary stones >20 mm [Figure 2].

A cross-tabulation test revealed strong compatibility between measurements of stones using US and CT (73.7% in stones <10 mm, 66.7% in stones 11–20 mm and 50% in stones >21 mm), ($P < 0.001$) [Table 2].

The results revealed no significant difference in the mean of the measured stones between US and CT (mean of

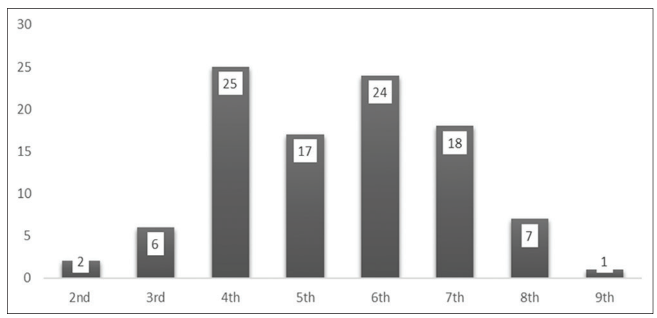

Figure 1: Distribution of the involved patients in age-decades revealed that urinary stones tend to affect middle age peoples ($P < 0.001$)

Table 1: The difference between computed tomography and ultrasonography measurements of urinary stones

Size of stone (mm)	US-measurements (%)	CT-measurements (%)
<10	50 (50.0)	57 (57.0)
11-20	42 (42.0)	33 (33.0)
21-30	08 (8.0)	10 (10.0)

US measured 50 stones <10 mm but CT measured 57 stone <10 mm. US tends to overestimate stones <10 mm in 12.28% of cases.US: Ultrasonography, CT: Computed tomography

Table 2: Cross-tabulation between computed tomography and ultrasonography measurements of urinary stones

CT measurements (mm)↓	US measurements (mm)			Total
	<10	11-20	21-30	
<10	42 (73.7%)	15 (26.3%)	0 (0.0%)	57
11-20	8 (24.2%)	22 (66.7%)	3 (9.1%)	33
21-30	0 (0.0%)	5 (50.0%)	5 (50.0%)	10
Total	50	42	8	100 (100.0%)

Strong compatibility between measurements using US and CT ($P<0.001$). US: Ultrasonography, CT: Computed tomography

US = 11.80 ± 5.83 vs. 11.65 ± 6.59 on CT KUB), (mean difference = 0.15 and P = 0.87) [Table 3].

T-test for equality of means revealed no significant difference in the measured size using US and CT (P = 0.865, 95% confidence interval: -1.584–1.884) [Table 4].

Spearman's rho correlation test revealed strong compatibility between US-measurements and CT measurements (r = 0.755), ($P = 0 < 0.001$) [Table 5].

Discussion

This study involved 100 urinary stones collected from 83 patients. The aim of the study was to elucidate the difference between US and CT in measuring the size of urinary stones. The results revealed no significant difference between the two imaging modalities in measuring stone size.

The patients involved in this study were between 30 and 70 years, and the age mean was 39.29 ± 23.76. This is consistent with Tyson *et al.*, who reported that urinary stones mostly affect patients between 31 and 60 years.[12] In this study, urinary stones were more prevalent in males (male: female = 1.3:1), this result is consistent with the findings of Tyson *et al.*, and Roudakova and Monga who reported 1.93:1 and 1.3:1 ratio of urinary stones between male and female respectively.[12,13]

The current study revealed that the majority of stone sizes were <10 mm, followed by 11–20 mm. This result is compatible with Alshoabi, who reported that 69.3% of renal stones were <10 mm and 25.7% were 11–20 mm.[14] In our study, we noticed that a lot of ureteric stones could not be detect by the US, but they were easily detected by CT. This result is consistent with Noble and Brown who reported that US cannot detect many ureteric stones.[15]

In this study, we found that US overestimates the small urinary stone sizes of <10 mm in some cases. This result is consistent with Dai *et al.*, who reported that US overestimates urinary stone sizes by 3.8 ± 2.4 mm compared with CT.[16] The result also compatible with Ganesan *et al.*, who reported that US significantly overestimates renal stone sizes of <10 mm.[17]

In this study, there was no significant difference between US and CT in measuring the size of urinary stones. This result is consistent with Ahmed *et al.* who reported that urinary stone size is usually the same for both US and CT.[8] The results are also consistent with Sade *et al.*, who reported that the diagnostic accuracy of US and low dose CT for the diagnosis of urolithiasis in pediatric patients, were 0.68 and 1, respectively.[18] However, this result was not consistent with the results of Dai *et al.*, who reported that the mean stone size was 6.8 ± 4 mm for CT and 10.3 ± 4.1 mm for US.[19]

Ultimately, using CT KUB in detecting and measuring urinary calculi is a balance between the benefits of the exam and the hazards of radiation exposure. US is a noninvasive, inexpensive, widely available imaging modality. It can achieve accurate diagnosis in most cases of acute and chronic renal obstruction without the need for radiation, as reported in a previous study by Nicolau *et al.*[20] Many methods can be used to improve the accuracy of US in measuring the size of urinary calculi, such as measuring the acoustic shadow of the stone, which is a good method for stone sizing in training operators, as reported by Dai *et al.*[19] Moreover, May *et al.* reported that the sizing of renal stones and the posterior acoustic shadow of the stone were similarly accurate with S-mode of US.[21]

Limitation of this study

This study was limited by its retrospective nature, which did not allow for the collection of a large sample size. Moreover, it was a single-center study.

Conclusion

Apart from the important role of CT in detecting small urinary calculi, especially those in the ureter, there was no significant difference between US and CT in measuring the size of urinary

Table 3: Independent-samples *t*-test				
Variables	*n*	Mean	SD	SEM
US	100	11.80	5.82749	0.58275
CT KUB	100	11.65	6.58645	0.65864

SD=Standard deviation; SEM=Standard error mean; US: Ultrasonography, CT: Computed tomography, KUB: Kidney, ureter, and bladder

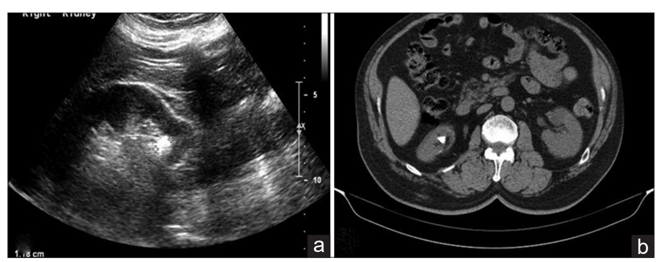

Figure 2: (a) Ultrasonography and (b) Computed tomography shows stone in the lower calyx of the right kidney that measured 11.8 mm with ultrasonography and 9 mm with computed tomography kidney, ureter and bladder

Table 4: T-test for equality of means

	t	df	Significant (two-tailed)	Mean difference	SEM	95% CI of the difference	
						Lower	Upper
Equal variances assumed	0.171	198	0.865	0.15	0.87944	−1.58426	1.88426
Equal variances not-assumed	0.171	195.105	0.865	0.15	0.87944	−1.58442	1.88442

t -test for equality of means revealed no significant difference in the measured size by US and CT (P =0865, 95% CI: -1.584-1.884). CI: Confidence interval, SEM: Standard error mean, US: Ultrasonography, CT: Computed tomography

Table 5: Correlation between measured size of stones using ultrasonography and computed tomography

	Diameter on US	Diameter on CT
Spearman's rho		
Diameter on US		
Correlation coefficient	1.000	0.755**
Significant (one-tailed)	.	0.000
Number *(n)*	100	100
Diameter on CT		
Correlation coefficient	0.755**	1.000
Significant (one-tailed)	0.000	.
Number *(n)*	100	100

**Spearman's correlation coefficient revealed strong compatibility between US measurements and CT measurements (r=0.755), (P=0<0.001). US: Ultrasonography, CT: Computed tomography

stones. US may slightly overestimate small urinary stones in some cases. US combined with conventional X-ray is sufficient for most cases of urinary stones. CT can be used for further assessment only.

Significance of this study

This study recommends to conserve the US and conventional X-rays for the diagnosis and management of urinary calculi and to reduce the overuse of CT, which will decrease radiation exposure, thereby preventing unnecessary procedures and reducing health-care costs.

Ethical approval

This study was approved by the Research Ethics Committee in college of applied medical sciences. The study was reviewed and approved by the Institutional Review Board, General Directorate of Health Affairs in Madinah, Saudi Arabia (No. H-03-M-084).

Declaration of patient consents

Patient consent was waived due to the retrospective nature of the study. However, confidentiality of all patient information was assured during and after the study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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