Evaluation of the Accuracy of Low Dose CT in the Detection of Urolithiasis in Comparison to Standard Dose CT

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Received *for publication January 20, 2020;* ***Accepted*** *February 14, 2020;* ***Published*** *on line March 14, 2020.*

doi: 10.21608/aimj.2020.22462.1082

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Radiology
Urology

Abstract

Objective: This study aims to evaluate the sensitivity, specificity, and accuracy of low dose CT in the detection of urolithiasis in comparison with standard-dose CT as a reference test.
Materials and Methods: This prospective randomized study was conducted on 30 patients with suspected renal colic undergone standard and low dose CT from September 2018 to September 2019 at AL-Zahraa University Hospital. The patients were scanned by the Toshiba CT system, 160 slices using automated tube current modulation; the computed tomography was performed without oral or intravenous contrast.
Results: This study enrolled 30 patients who had renal colic symptoms and signs and had a urinary stone that detected in standard-dose CT, the mean of age was (43.83±11.45). The male percentage was (56.7%) while the female percentage was (43.3%). This study was revealed that 55 stones were detected by SDCT and 53 stones were detected by LDCT, so there was a statistically significant agreement between the two modalities in the detection of urolithiasis with Kappa value of (0.868) and p-value(<0.001**). The mean current tube was (416.0±79.1) and (135.2±25.7) in SDCT and LDCT respectively. The radiation dose was (120 and 80) in SDCT &LDCT respectively. Sensitivity was (96.4%) and specificity was (100%) in LDCT.
Conclusion: This study revealed that LDCT was an effective technique in the detection of urolithiasis with high sensitivity and specificity despite a significant reduction in radiation dose exposure to SDCT

Keyords: CT; Low Dose; Standard Dose; Effectiveness; Urolithiasis;

Disclosure: *The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.*
Authorship: *All authors have a substantial contributions to the article*

INTRODUCTION

Renal colic is a common situation affecting 1 in 1,000 persons per year[1]. Non-contrast computed tomography scan of the kidney, ureter, and bladder (CT KUB) is the investigation of choice for patients with suspected urolithiasis, and it is recommended by the European Association of Urology and the American Urological Association [2, 3.]
The usage of non-contrast computed tomography reveals the presence of a stone, its size, location, density and the presence of hydronephrosis[4]; it gives us information for selecting the appropriate therapeutic approach.[5]. However, renal colic affects frequently adults with a high incidence of recurrence about 50%[6.]The regular usage of SDCT increases the ethical concern about the exposure dose of radiation [7,8].

Today, there is an improvement in computed tomography technique that has marked a decrease in the exposure dose and allowed the provision of clear images. Low-dose CT (LDCT) is a method that has been developed to reduce the exposure dose associated with the examination, and is mainly performed for lung cancer screening [9, 10.] LDCT is recommended as an examination for urinary tract stones [11, 12]. Our study aims to evaluate the sensitivity, specificity, and accuracy of LDCT in the detection of urolithiasis compared to SDCT as a reference test.

MATERIALS AND METHODS

A prospective randomized study approved by the Local Ethical Committee and patients informed about the study and acquired their consent to undergo additional CT scans. It is conducted from September 2018 to September 2019 on 30 patients with the mean age (43.83±11.45) which done in the CT unit of the radiological department of Al-Zahraa University Hospital.
The patients had a history of urinary stone and referred from the consultant clinic of urology, patients with documented urinary stone by SDCT were included. The patients were scanned by the Toshiba CT system, 160 slices using automated tube current modulation; all CT scans were done without oral or intravenous contrast. CT scan started from the diaphragm to lower symphysis pubis with standard- dose CT has first done to patients, and then after detection of stone the patient was undergone LDCT in a limited area (only the site of stone). In SDCT, tube voltage of 120 kV and tube current- time product of mean in all patients of the mean (416.0±79.1) is shown in Figure (1,2,3 a). While in

LDCT, tube voltage of 80 kV and tube current- time product of mean (135.2±25.7) mAs is shown in Figure (1,2,3 b).

Fig. 1: (A, B): CT of the urinary tract revealed left renal lower calyceal stone. (a) Stone appeared by standard dose Computed tomography (120 kV, 420 mAs). (b) The same stone appeared by low dose computed tomography (80 kV, 130 mAs)

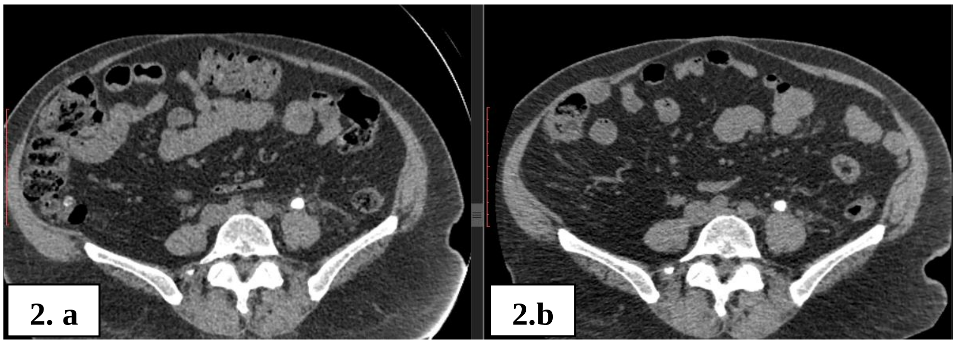

Fig. 2: (A, B): CT of the urinary tract revealed left lower Ureteric stone. (a) Stone appeared by standard dose computed tomography (120 kV, 420 mAs). (b) The same stone appeared by low dose computed tomography (80 kV, 130 mAs).

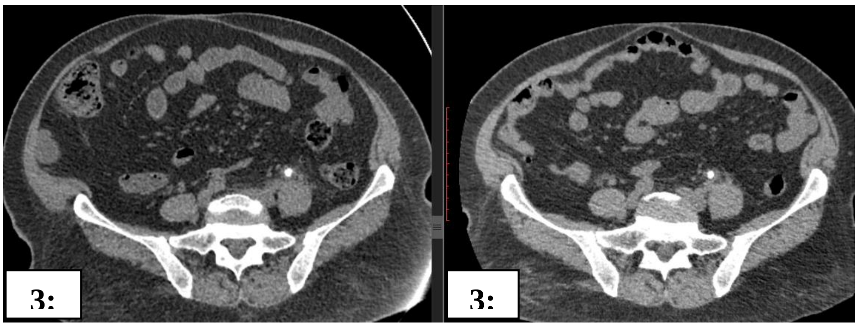

Fig.3: (A, B): CT of the urinary tract revealed left lower Ureteric stone. (a) Stone appeared by standard dose computed tomography (120 kV, 420 mAs). (b) The same stone appeared by low dose computed tomography (80 kV, 130 mAs).

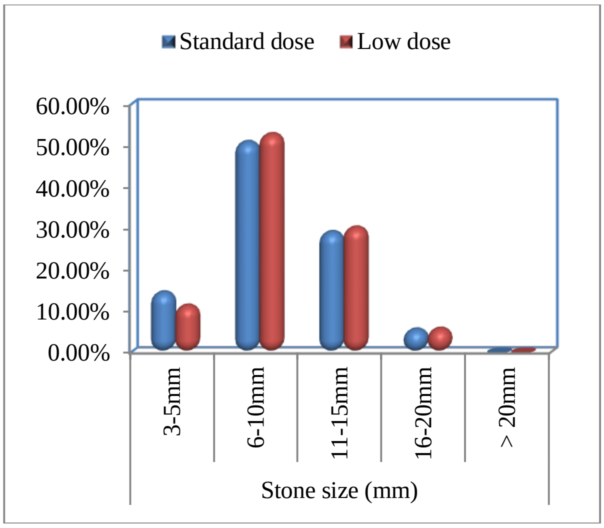

Fig. 4: Bar chart between standard and low dose according to stone size (mm).

Statistical analysis: Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage. Independent-samples t test using to compare two means. Kappa measure of agreement between standard dose and low dose in detecting the level of stone. *A value of:* 0 – 0.20 indicates slight agreement; 0.21– 0.40, fair agreement; 0.41– 0.60, moderate agreement; 0.61– 0.80, substantial agreement; and 0.81–1.00, almost perfect agreement. The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, P-value ≤0.05 was considered significant, P-value ≤0.001 was considered as highly significant, and P-value >0.05 was considered insignificant.

RESULTS

A prospective randomized study included 30 patients who had renal colic and a stone was detected in the urinary tract in standard- dose CT. General Character of patients showed in (table1).

Demographic data	Total (n=30)
Age (years)	
Range	22-a63
Mean ±SD	43.83±11.45
Gender	
Male	17 (56.7%)
Female	13 (43.3%)

Table 1: Demographic data distribution of the study group. This table shows that the ranged age 22-63 with mean 43.83 regarding age, while the male (56.7%) and female (43.3%) of sex.

Stone distribution	No.	%
Renal stone	**25**	**45.5%**
Upper calyx		
Left	**4**	**7.3%**
Middle		
LT	**5**	**9.1%**
RT	**1**	**1.8%**
Lower		
LT	**8**	**14.5%**
RT	**4**	**7.3%**
Pelvis		
RT	**3**	**5.5%**
Ureteric	**30**	**54.5%**
Right		
Lower	**11**	**20%**
Mid	**4**	**7.3%**
Left		
Lower	**7**	**12.7%**
Mid	**8**	**14.5%**
Bladder		
Mural		
0	**0**	**0.0%**
Luminal		
0	**0**	**0.0%**
Total	**55**	**100.0%**

Table 2: Stone distribution of the study group. Renal stones were 25 (LT:17 and RT:8)(45.5%) and Ureteral stones were 30(LT:15 and RT:15)(54.5%).

one size (mm)	Standard	Low dose
3-5mm	8 (14.5%)	6 (11.3%)
6-10mm	28 (50.9%)	28 (52.8%)
11-15mm	16 (29.1%)	16 (30.2%)
16-20mm	3 (5.5%)	3 (5.7%)
> 20mm	0 (0.0%)	0 (0.0%)
Total stones	55 (100.0%)	53 (100.0%)
Kappa test	0.868	
p-value	<0.001**	

Table 3: Comparison between standard and low dose according to stone size (mm).*Using: Kappa test; **p-value <0.001 HS.* Statistical analysis of these results showed significant agreement between the two modalities in the detection of stone. Comparison of standard and low dose a yielded weighted Kappa value of 0.868

	Standard	Low dose	t-test	p-value
Tube current (mAs)				
Range	170-560	81-191	12.862	**<0.001****
Mean±SD	416.0±79.1	135.2±25.7		
Diameter of stone (mm)				
Range	5-20	5-20	0.921	0.482
Mean±SD	7.3±1.4	7.5±1.31		
Stone density (HU)				
Range	120-1444	120-1297	1.482	0.097
Mean±SD	726.20±424.70	676.58±404.55		
Radiation dose (KV)				
Mean	120	80	17.914	**<0.001****
Sensitivity		96.4%		
Specificity		100.0%		

Table 4: Comparison of finding between standard doses Computed tomography and low dose computed tomography.
*Using: Independent Sample t-test; p-value >0.05 NS: Using: Independent Sample t-test; p-value >0.05 NS: **p-value <0.001 HS*

There was a significant difference in tube current between two procedures in SDCT scan the mean of tube current was (416.0±79.1) mAs, while in LDCT scan the mean was (135.2±25.7) mAs. There was no statistically significant difference in diameter and density of stone between the two procedures (P=0.482) and (P=0.097) respectively. Also, there was a statistically significant difference in radiation dose between two procedures (kV) (P<0.001). The sensitivity of LDCT was (96.4%) and specificity was (100%) in comparison with SDCT.

DISCUSSION

Urolithiasis affects a wide range of age groups from adults to elderly patients. In the U.S., the incidence of recurrence of urinary calculi was 75% which needs treatment and follow-up for a long time [13, 14]. Multiple recent studies demonstrated the effectiveness of low dose CT in the detection of urinary stones [15, 16, 17].

In our study, the mean age was (43.83±11.45) and the age range from (22-63) years, which is nearly similar to Moore et al[18].in 2005 reported mean of age(44± 2.6), and Poletti et al[11].reported in 2006 age range from (19-80) years and mean age(45±5.1), while Fracchia et al[19] reported 53 years mean age.

In our study, the male constitutes (56.7%), while in other reported studies revealed high male incidence Hamm et al 74%.[20], and Moore et al[18] recorded 52% of male incidence.

Our study revealed 45.5% of stones were located in the kidney, while 54.5% of stones were presented in the ureter, which is nearly similar to the study reported stone location as 50% in the kidney and 30% within the distal ureter and 20% located in the proximal ureter[21], while another study by William Sohn detected that ureteral stones were demonstrated in 38 (36%) of 106 patients[16].

In this study, there was a statistical significant difference between the two procedures in tube current and radiation dose, in SDCT the tube current mean was (416.0±79.1mA)and the radiation dose was 120(KV), while in LDCT, the tube current mean was (135.2±25.7 mA) and the radiation dose was 80 (KV)(P<0.001),which agree with a study demonstrated by Heneghan et al[22].That detected CT done with a reduced tube current of 100 mA resulted in an approximately 25%-42% reduction in dose when compared with the SDCT, without a significant change in the accuracy. Spielmann et al[23].recorded excellent detection of stones, even with significant reductions in the tube current (range 170-20 mA) and nearly 75% reduced in radiation dose. Indeed, many stones were visualized at a mA as low as 20.

Our study demonstrated that the sensitivity and specificity of LDCT in relation to SDCT as a reference test was (96.4%) and (100%) respectively, our results were similar to study by Niemann et al[24].that revealed sensitivity of 96% & specificity of 94.9%, and another study by Moore et al[18]. detected a sensitivity of the reduced protocols 90.3% and 99% specificity. Some studied revealed 100% sensitivity and specificity of low dose CT [15, 25].

Several factors may affect the accuracy of LDCT, such as the size of stone. In our study some small stones < 3mm were not detected by LDCT which may affect the sensitivity and specificity of LDCT, these agree with the results of a study by Rob et al[26], which reported lower sensitivity and specificity in the diagnosis of stones<3mm.

In our study, there was no statistically significant difference in the diameter of stones between the two procedures (p=0.482), which agree with the results of Kwon et al[15]. And Sohn et al[16]. Revealed that no difference in the measurement of stones between LDCT and SDCT. In our study there is no significant difference in the attenuation values of stones detected in LDCT compared to that in SDCT, this agrees with a study by Alsyoufet al [27], reported similar attenuation values of stones detected in LDCT (regarding stone composition) compared with Conventional/standard-dose CT with only a slight increase in variability. A study by Sohn et al[16]supported this observation.

CONCLUSION

This study revealed that LDCT was an effective technique in the detection of urolithiasis with high sensitivity and specificity despite significant reduction in radiation dose exposure in to SDCT.

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