

A Comparison between Low Dose and Standard Dose Computed Tomography Scan in Detection of Urolithiasis

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Abstract

Background: Computed tomography (CT) (standard and low-dose CT [LDCT] scan) has become the reference technique in medical imaging for urinary calculi, to diagnose, plan treatment, and explore differential diagnosis of renal colic. **Objective:** This study was done to compare the low-dose nonenhanced CT scan with standard dose CT scan in the detection of urolithiasis. **Materials and Methods:** Cross-sectional study conducted from 2017 to 2018 in Al-Hilla teaching general hospital on 60 patients undergone unenhanced (native) spectral detector CT (SDCT) and LDCT, the patients were scanned by Siemens CT system, 64 slice using automated tube current modulation, all CT scan were performed without oral or intravenous contrast. **Results:** This study showed that 93 stones detected by SDCT scan and 89 stones detected by LDCT scan, mean age of patients 44.2 ± 7.3 and mean of body mass index 26.3 ± 3.1 , male constitute 56.6% (34) and female 43.4% (26). In 46.6% of patients had stone in the left side and 53.4% show stone in right side, most of patients presented solitary stone which appear 73.4%, 11.6% of patients had double stone, 5% had triple stone, 6.6% had four stones, and 3.45% had 5 or more stone at investigation, 10.8% of stones lie in ureter, 7.6% of stones in renal pelvis, 13.9% in upper calyx, 28% in lower calyx, and 39.7% lie in middle calyx, according to size of stones 11.9% of stones had size <3 mm, 35.4% of stones range 3–5 mm, 34.5% size range 6–10 mm, 12.9% 11–15 mm in size, 3.25 of stones had size range 16–20 mm and only 2.1% of stone had size >20 mm. In standard CT scan, the current mean was 283.2 while in LDCT scan the mean was 126.1 mA, sensitivity is (93%) and specificity (100%) of LDCT in reference SDCT. **Conclusion:** LDCT scans provide effective methods of identifying and evaluating urinary tract stones, high diagnostic accuracy, sensitivity, and specificity are maintained despite significant radiation dose reduction compared to standard dose CT.

Keywords: Computed tomography, low-dose computed tomography scan, standard dose computed tomography scan, urolithiasis

INTRODUCTION

Computed tomography (CT) is recommended by several authors at present as the initial diagnostic imaging technique in patients with suspected renal colic because of its high sensitivity and specificity for the detection of stone.^[1-4]

The initial use of CT reveals the presence of a stone, its size and location,^[5] these give us a useful information for selecting the most appropriate therapeutic approach.^[6]

However, because renal colic frequently affects young adults, with a recurrence rate of about 50%,^[7] the systematic use of CT at a patient's admission raises an ethical concern about the dose of radiation administered.^[8,9]

Many authors have reported that low-dose CT (LDCT) protocols, the term LDCT scan refers to radiation dose of CT scans where compared to a “normal” or “standard”

dose scan, the image quality has been modified to reduce the exposure dose while preserving the diagnostic performance,^[10] low-dose CT is suitable for urolithiasis and renal colic because of the good spontaneous contrast between most urinary stones that are spontaneously hyper attenuating (between 200 and 2800 HU)^[11] and the soft tissues that surround them, thus even if the dose reduction is substantial, the naturally high contrast between urinary stones and the surrounding soft tissues prevents too much deterioration of the contrast-to-noise ratio while preserving good diagnostic performance.^[12]

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The methods to minimize dose in CT depend on both behavioral factors (independent of the CT equipment) and technological factors (some of which depend on how recent the CT equipment is), the behavioral factors are the level of awareness of the medical and paramedical teams, the principles of substitution and justification, as well as limiting the scan coverage area, the technological factors include reduction of the tube current and voltage, automatic tube current modulation, and iterative reconstructions.^[13]

MATERIALS AND METHODS

A cross-sectional study which approved by Local Ethical Committee and patients informed about the study and acquired their consent to undergo additional CT scans. It conducted from November 2017 to July 2018 on 60 patients with a male–female ratio 34:26, age range 18–62 years, in the CT unit of the radiological department of Al-Hilla teaching general hospital in Al- Hilla city, Babylon governorate, Iraq.

Those patients had a history of urinary stone and referred from consultant clinic of urology, patients with documented urinary stone by spectral detector CT (SDCT) were included; additionally; body mass index (BMI) was calculated by dividing weight in kilograms by height in meters square, using the formula: $BMI = \text{Weight (in kg)} / \text{Height}^2 \text{ (in meters)} = \text{kg}^2$, less 18 consider underweight, 18–24.9 normal weight, overweight if BMI is 25–29.5 kg/m^2 , obese if BMI >30.

The patients were scanned by Siemens CT system, 64 slice using automated tube current modulation, all CT scan were performed without oral or intravenous contrast.

Scan started from diaphragm to lower symphysis pubis with standard CT dose first done to patients, after detection of stone in patient then undergo LDCT in a limited area (only the site of stone). In SDCT, tube voltage of 100 kV and tube current time product of mean in all patients of 283.2 mAs are shown in Figure 1a. While in LDCT, tube voltage of 80 kV and tube current time product of mean 126.1 mAs are shown in Figure 1b.

RESULTS

A cross-sectional study enrolled 60 patients had renal colic symptoms and signs and had a urinary stone that detected

in standard dose CT, mean of age is 44.2 ± 7.3 and mean of BMI is 26.3 ± 3.1 , male constitute 56.6% (34) and female 43.4% (26).

About 65% of the patient in the age group of 40–59 years, 26% in the age group of 20–39 years, 6.6% of them had age less of 20 years and 1.4% with age more than 59 years.

Table 1 reveal 46.6% of patients had stone in the left side and 53.4% show stone in the right side, solitary stone which appears 73.4%, 11.6% of patients had double stones, 5% had triple stones, 6.6% had four stones, and 3.45 of the patients had 5 or more stones.

Other results for the location of stones for 93 stones reveal 10.8% of stone located in ureter, 7.6% of stones in renal pelvis, 13.9% in upper calyx, 28% in lower calyx, and 39.7% in middle calyx as shown in Table 2.

In Table 3, appeared stone size in mm, which is as follow 11.9% of stone had size <3 mm, 35.4% of stone range 3–5 mm, 34.5% of stone size range 6–10 mm, 12.9% for 11–15 mm in size, 3.25% of stones had size range 16–20 mm, and only 2.1% of stone had size >20 mm.

Table 1: Side and number of the renal stones

Variables	Patients, n (%)
Side	
Left	28 (46.6)
Right	32 (53.4)
Number of stone	
One	44 (73.4)
Two	7 (11.6)
Three	3 (5)
Four	4 (6.6)
≥5	2 (3.4)

Table 2: Location of the renal stones

Location of stone	n (%)
Ureter	10 (10.8)
Renal pelvis	7 (7.6)
Upper calyx	13 (13.9)
Lower calyx	26 (28)
Middle calyx	37 (39.7)
Total	93

Table 3: Size of the renal stones

Stone size (mm)	Stone, n (%)
<3	11 (11.9)
3–5	33 (35.4)
6–10	32 (34.5)
11–15	12 (12.9)
16–20	3 (3.2)
20<	2 (2.1)
Total of stone	93

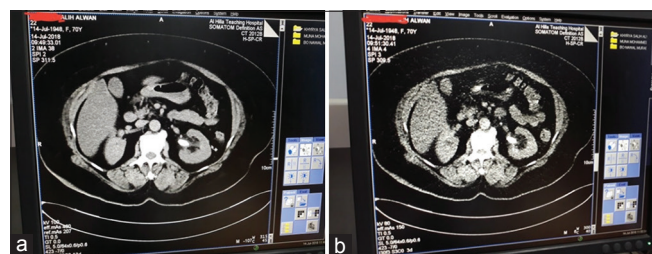


Figure 1: Appearance of renal pelvis stone. (a) Stone appeared by spectral detector computed tomography (100 kV, 460 mAs). (b) The same stone appeared by low dose computed tomography (80 kV, 150 mAs)

In Table 4, there was significant difference in tube current between two procedures in standard CT scan the current mean was 283.2 while in LDCT scan the mean 126.1 mA. Other finding there was no statistical difference in diameter of stone between two procedures which demonstrated stone diameter is 7 mm in both, it also revealed highly reduction in dose of radiation appear between two procedures and comparison between LDCT and standard dose CT in stone detection, this revealed sensitivity (93%) and specificity (100%) of LDCT in reference standard dose CT.

Table 5 shows the only difference in diagnosis of stones of size less 3 mm between two procedures that located in ureter.

In Table 6, most of the stone that cannot seen by LDCT which are in a patient with BMI more than 30.

Table 4: Comparison of finding between standard dose computed tomography and low dose computed tomography

	Mean (range)		P
	SDCT	LDCT	
Tube current (mA)	283.2 (113-498)	126.1 (78-188)	0.001
Diameter of stone (mm)	6.8 (2-35)	6.9 (2-35)	0.3
Stone density (HU)	470.1 (125-1223)	512.9 (142-1234)	0.9
Radiation dose (kv)	100	80	0.004
Sensitivity (%)		93	
Specificity (%)		100	

SDCT: Standard dose computed tomography, LDCT: Low dose computed tomography

Table 5: Stone detection regarding size and site in both standard dose computed tomography and low dose computed tomography

Stones	SDCT	LDCT
n	93	89
Size		
<3	11	7
≥3	82	82
Site		
Renal	83	83
Ureteric	10	6
Total of stone	93	89

SDCT: Standard dose computed tomography, LDCT: Low dose computed tomography

Table 6: Comparison between standard dose computed tomography and low dose computed tomography stone finding in regarded to body mass index

	BMI		Total
	<30	30≤	
SDCT	76	17	93
LDCT	75	14	89

SDCT: Standard dose computed tomography, LDCT: Low dose computed tomography

DISCUSSION

LDCT has become the standard for diagnosing urolithiasis with various protocols and LD settings resulting in a different radiation exposure.^[14,15]

In our study, the mean age was 44.2 ± 7.3 and most patients in age groups 40–59 years, similar to study in the USA by Moore *et al.*^[16] in 2015 reported mean of age 44 ± 2.6 , Poletti *et al.*^[17] reported in 2006 age range from 19 to 80 years and mean age 45 ± 5.1 , Park *et al.*^[18] reported mean patient age was 49.9 years (range 19–77 years) while other study Patients had mean age of 33.01 ± 10 years (range 19–62 years)^[19] and by Fracchia *et al.*^[20] reported 53 years mean age.

Male to female ratio in study equal to 1.3:1, as male constitute 56.6% of sample, other studies reported high male percentage Hamm *et al.* had 74%,^[21] Fracchia *et al.* reported 69%,^[20] and Moore *et al.*^[16] study recorded male predominant as constitute 52% of sample.

Other result of the study the mean BMI was 26.3 ± 3 and 3.3% had underweight, 46.6% had normal weight, 28% had overweight and 21.1% presented as obese. In a study by Poletti *et al.*^[17] reported 9% of patients had a BMI <18.5, 54% had BMI between 18.5 and 24.9, 27% had BMI between 25 and 29.9, and 10% had BMI >30. A study in Indian patients reported mean BMI of 24.26,^[19] study by Park *et al.*^[18] reported mean BMI was 24.9 kg/m² and by Moore *et al.*^[16] mean BMI was 29.1 ± 7.8 .

Mulkens *et al.*^[22] confirmed that LDCT with automatic tube current modulation provides excellent diagnostic performance in all patients with suspected renal colic, including overweight and obese patients.

Niemann *et al.*^[23] stated that the effects of CT dose reduction in obese patients remain unclear. With the current use of automatic tube-current modulation techniques, concepts of absolute effective dose reduction are difficult to apply in all patients because of differences in the BMI of patients.

In a study by Abou El-Ghar *et al.*^[24] they were used variable tube current to obtain half of the radiation dose from the automated dose generated at SDCT, and they modified the dose according to body weight, and this yielded an acceptable image quality that allowed a high diagnostic accuracy (100%).

Our result reveal 10.8% of stone located in ureter, 7.6% of stone lie at renal pelvis, 13.9% in upper calyx, 28% in lower calyx, 39.7% lie in middle calyx, other study reported stone location as 50% of the stones were located in the kidney, 30% within the distal ureter, and 20% within the proximal ureter^[25] other study by William Sohn demonstrated that ureteral stones were presented in 38 (36%) of 106 patients.^[26]

Zilberman^[27] 2011 revealed the most frequent location for stone detection was the kidney (58.5%), followed by the distal ureter (21.7%) and upper ureter (13.2%).

Our result demonstrates a significant difference in tube current between two procedures in standard CT scan the current mean

was 283.2 while in LDCT scan the mean 126.1 mA, which appear low dose of radiation 80 kV in compared to SDCT 100 kV. These coincide with a study by Heneghan *et al.*^[28] which show CT performed with a reduced tube current of 100 mA resulted in an approximately 25%–42% reduction in dose for the patient when compared with the dose of standard protocol, without a significant change in accuracy. Spielmann *et al.*^[29] reported excellent visualization of stones, even with significant reduction in the tube current (mA range, 170–20) and approximately 75% decrease in radiation dose. Indeed, many stones were visualized even at a mA as low as 20.

Other investigators used modulated changeable low dose of tube current according to gender and weight of the patient, Abou El-Ghar *et al.*^[24] used variable tube current to obtain half of the radiation dose from the automated dose generated at SDCT, they modified the dose according to body weight, and this yielded an acceptable image quality that allowed a high diagnostic accuracy (100%).

Our result reveals sensitivity and specificity of LDCT in reference SDCT 93%, 100% respectively. Many researchers reported high sensitivity and specificity of LDCT in diagnosis renal and ureteric stone, a study by Niemann *et al.*^[23] reported sensitivity of 96.6% and specificity of 94.9% and study by Moore *et al.*^[16] yielding a sensitivity of the reduced-dose protocols 90.3% and 99% specificity.

In another study by Tack D had found low-dose CT using a tube charge current of 30 mAs achieved a sensitivity between 89.5% and 94.7% and a specificity between 94.1% and 100% for detecting ureteral calculi.

Some researcher found the low-dose CT achieved an excellent coincidence sensitivity (100%) and specificity (100%).^[30,31]

Poletti *et al.*^[17] reported on a comparison of CT findings in 125 patients presenting with urinary colic who underwent both low dose and conventional dose CT. They reported an overall 98% sensitivity and 100% specificity of LDCT scans compared with conventional scans.

There were many factors affect the efficacy of LDCT such as size of stone and weight of patients. In our study few stones not diagnosed by LDCT which are size <3 mm, these may effect of sensitivity and specificity, these coincide with the result of study by Rob *et al.*^[32] which reported sensitivity and specificity were lower when diagnosing stones <3 mm in size.

Other authors conclude low efficacy LDCT with increase weight of patients, for examples, Poletti *et al.*^[17] showed that BMI <30 had a sensitivity of 95% and a specificity of 97%, the sensitivity and specificity for patients with a BMI of >30 was 50% and 89%, respectively.

Mulkens *et al.*^[22] found that the 25 patients with a BMI >30 had a sensitivity and specificity of 100%. The sensitivity was lower for overweight patients (BMI of 20–29.9 kg/m²) at 97%.

The same result appears when comparing the diameter of stone in both procedures in LDCT 6.8 mm and in SDCT

6.9 mm, similar to the result of other study Kwon *et al.*^[31] Sohn *et al.*^[26] reported that no significant difference was found in the measurement of stone size between the LDCT and SDCT scans in patients who underwent both CT scans.

CONCLUSION

LDCT scan provides effective methods of identifying and evaluating urinary tract stones. High diagnostic accuracy, sensitivity, and specificity are maintained despite significant radiation dose reduction compared to standard dose CT.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Dalrymple NC, Verga M, Anderson KR, Bove P, Covey AM, Rosenfield AT, *et al.* The value of unenhanced helical computerized tomography in the management of acute flank pain. *J Urol* 1998;159:735-40.
2. Boulay I, Holtz P, Foley WD, White B, Begun FP. Ureteral calculi: Diagnostic efficacy of helical CT and implications for treatment of patients. *AJR Am J Roentgenol* 1999;172:1485-90.
3. Teichman JM. Clinical practice. Acute renal colic from ureteral calculus. *N Engl J Med* 2004;350:684-93.
4. Abramson S, Walders N, Applegate KE, Gilkeson RC, Robbin MR. Impact in the emergency department of unenhanced CT on diagnostic confidence and therapeutic efficacy in patients with suspected renal colic: A prospective survey 2000 ARRS president's award. American Roentgen Ray Society. *AJR Am J Roentgenol* 2000;175:1689-95.
5. Vieweg J, Teh C, Freed K, Leder RA, Smith RH, Nelson RH, *et al.* Unenhanced helical computerized tomography for the evaluation of patients with acute flank pain. *J Urol* 1998;160:679-84.
6. Miller OF, Kane CJ. Time to stone passage for observed ureteral calculi: A guide for patient education. *J Urol* 1999;162:688-90.
7. Sierakowski R, Finlayson B, Landes RR, Finlayson CD, Sierakowski N. The frequency of urolithiasis in hospital discharge diagnoses in the United States. *Invest Urol* 1978;15:438-41.
8. Tamm EP, Silverman PM, Shuman WP. Evaluation of the patient with flank pain and possible ureteral calculus. *Radiology* 2003;228:319-29.
9. Katz SI, Saluja S, Brink JA, Forman HP. Radiation dose associated with unenhanced CT for suspected renal colic: Impact of repetitive studies. *AJR Am J Roentgenol* 2006;186:1120-4.
10. Keyzer C, Tack D. Dose optimization and reduction in MDCT of the abdomen. In: Tack D, Genevois PA, Kalra M, editors. *Radiation Dose from Multidetector CT*. Berlin Heidelberg: Springer-Verlag; 2012. p. 369-87.
11. Kambadakone AR, Eisner BH, Catalano OA, Sahani DV. New and evolving concepts in the imaging and management of urolithiasis: Urologists' perspective. *Radiographics* 2010;30:603-23.
12. Sung MK, Singh S, Kalra MK. Current status of low dose multi-detector CT in the urinary tract. *World J Radiol* 2011;3:256-65.
13. Gervaise A, Gervaise-Henry C, Pernin M, Naulet P, Junca-Laplace C, Lapiere-Combes M. How to perform low-dose computed tomography for renal colic in clinical practice. *Diagn Interv Imaging* 2016;97:393-400.
14. Karmazyn B, Frush DP, Applegate KE, Maxfield C, Cohen MD, Jones RP, *et al.* CT with a computer-simulated dose reduction technique for detection of pediatric nephroureterolithiasis: Comparison of standard and reduced radiation doses. *AJR Am J Roentgenol* 2009;192:143-9.
15. Paulson EK, Weaver C, Ho LM, Martin L, Li J, Darsie J, *et al.* Conventional and reduced radiation dose of 16-MDCT for detection of nephrolithiasis and ureterolithiasis. *AJR Am J Roentgenol*

- 2008;190:151-7.
16. Moore CL, Daniels B, Ghita M, Gunabushanam G, Luty S, Molinaro AM, *et al.* Accuracy of reduced-dose computed tomography for ureteral stones in emergency department patients. *Ann Emerg Med* 2015;65:189-98.e2.
17. Poletti PA, Platon A, Rutschmann OT, Schmidlin FR, Iselin CE, Becker CD, *et al.* Low-dose versus standard-dose CT protocol in patients with clinically suspected renal colic. *AJR Am J Roentgenol* 2007;188:927-33.
18. Park SB, Kim YS, Lee JB, Park HJ. Knowledge-based iterative model reconstruction (IMR) algorithm in ultralow-dose CT for evaluation of urolithiasis: Evaluation of radiation dose reduction, image quality, and diagnostic performance. *Abdom Imaging* 2015;40:3137-46.
19. Sharma S, Chaudhari R, Rawal K, Khant S. Low dose computed tomography KUB region for management of urolithiasis in Indian scenario. *Int Surg J* 2018;5:638-42.
20. Fracchia JA, Panagopoulos G, Katz RJ, Armenakas N, Sosa RE, DeCorato DR. Adequacy of low dose computed tomography in patients presenting with acute urinary colic. *J Endourol* 2012;26:1242-6.
21. Hamm M, Knopfle E, Wartenberg S, Wawroschek F, Weckermann D, Harzmann R, *et al.* Low dose unenhanced helical computerized tomography for the evaluation of acute flank pain. *J Urol* 2002;167:1687-91.
22. Mulkens TH, Daineffe S, De Wijngaert R, Bellinck P, Leonard A, Smet G, *et al.* Urinary stone disease: Comparison of standard-dose and low-dose with 4D MDCT tube current modulation. *AJR Am J Roentgenol* 2007;188:553-62.
23. Niemann T, Kollmann T, Bongartz G. Diagnostic performance of low-dose CT for the detection of urolithiasis: A meta-analysis. *AJR Am J Roentgenol* 2008;191:396-401.
24. Abou El-Ghar ME, Shokeir AA, Refaie HF, El-Nahas AR. Low-dose unenhanced computed tomography for diagnosing stone disease in obese patients. *Arab J Urol* 2012;10:279-83.
25. Tack D, Sourtzi S, Delpierre I, de Maertelaer V, Gevenois PA. Low-dose unenhanced multidetector CT of patients with suspected renal colic. *AJR Am J Roentgenol* 2003;180:305-11.
26. Sohn W, Clayman RV, Lee JY, Cohen A, Mucksavage P. Low-dose and standard computed tomography scans yield equivalent stone measurements. *Urology* 2013;81:231-4.
27. Zilberman DE, Tsivian M, Lipkin ME, Ferrandino MN, Frush DP, Paulson EK, *et al.* Low dose computerized tomography for detection of urolithiasis – its effectiveness in the setting of the urology clinic. *J Urol* 2011;185:910-4.
28. Heneghan JP, McGuire KA, Leder RA, DeLong DM, Yoshizumi T, Nelson RC, *et al.* Helical CT for nephrolithiasis and ureterolithiasis: Comparison of conventional and reduced radiation-dose techniques. *Radiology* 2003;229:575-80.
29. Spielmann AL, Heneghan JP, Lee LJ, Yoshizumi T, Nelson RC. Decreasing the radiation dose for renal stone CT: A feasibility study of single- and multidetector CT. *AJR Am J Roentgenol* 2002;178:1058-62.
30. Licheng J, Yidong F, Ping W, Keqiang Y, Xueting W, Yingchen Z, *et al.* Unenhanced low-dose versus standard-dose CT localization in patients with upper urinary calculi for minimally invasive percutaneous nephrolithotomy (MPCNL). *Indian J Med Res* 2014;139:386-92.
31. Kwon JK, Chang IH, Moon YT, Lee JB, Park HJ, Park SB, *et al.* Usefulness of low-dose nonenhanced computed tomography with iterative reconstruction for evaluation of urolithiasis: Diagnostic performance and agreement between the urologist and the radiologist. *Urology* 2015;85:531-8.
32. Rob S, Bryant T, Wilson I, Somani BK. Ultra-low-dose, low-dose, and standard-dose CT of the kidney, ureters, and bladder: Is there a difference? Results from a systematic review of the literature *Clin Radiol* 2016;72:11-5.

