ORIGINAL ARTICLE

Unenhanced Multi-Detector Low-Dose vs Standard-Dose Computed Tomography in Patients Having Urinary Tract Calculi. A Practical Approach in Optimizing Patient's Dose, Experience at Jinnah Postgraduate Medical Center, Karachi

Marya Hameed[1], Ameet Jesrani[2], Sehrish Mehreen[2], Naveed Ahmed[1], Tariq Mahmood[1]

ABSTRACT

Objective: This study is designed to assess the diagnostic accuracy of Low-dose unenhanced multidetector computed tomography (MDCT) in patients with suspected urinary tract calculi taking Standard-dose unenhanced MDCT as gold standard.

Methods: The cross-sectional study was conducted from July to December 2016 among patients with suspected urinary tract calculi. The patients underwent unenhanced low-dose MDCT scan with reconstruction slice thickness, 7.0 mm; pitch= 1.00; tube potential 120kV; and tube chargeper gantry rotation, 25-50 mAs, followed by standard-dose computed tomography (CT) scan. Diagnostic accuracy of unenhanced low dose multi-detector computed tomography was calculated taking standard dose MDCT as gold standard.

Results: Out of total 50 adult patients, 32 (64%) were males and 18 (36%) were females.The mean age of the patients was 50 ± 11 years.The diagnostic accuracy of Low dose CT showed 100% sensitivity when compared with Unenhanced Standard dose CT in diagnosing urinary tract calculi, indirect signs of obstruction and adjacent organs. However, a difference was observed in blood vessels within the renal sinus which were seen in 48 kidneys in low dose CT and 49 in standard dose CT (True positive 96%, true negative 100%).

Conclusion: Low dose MDCT can be effectively used for the evaluation of urinary tract calculi with significantly decrease radiation dose to the patients compared with standard dose CT. This is due to the improvements in CT technology which allow isotropic resolution with faster scan coverage in a single, short breath-hold, and high diagnostic performance.

Keywords: Unenhanced Low-dose and Standard-dose CT, Urinary tract calculi, Optimized Radiation dose.

How to cite this article: Hameed M, Jesrani A, Mehreen S, Ahmed N, Mahmood T. Unenhanced multi-detector low-dose vs standard-dose computed tomography In Patients having urinary tract calculi. A practical approach in optimizing patient's dose, experience at Jinnah postgraduate medical center, Karachi. J Dow Uni Health Sci 2018; 12(2): 33-37.

1. Department of Radiology, Jinnah Postgraduate Medical Center, Karachi, Pakistan.
2. Department of Radiology, Sindh Institute of Urology and Transplantation, Karachi, Pakistan.

Correspondence:
Dr. Ameet Jesrani
Department of Radiology, Sindh Institute of Urology and Transplantation, Karachi, Pakistan.
Email: ameet.jesrani@yahoo.com

INTRODUCTION

Urolithiasis frequently affects young adults. Clinical manifestations depend on the location and size of the stone. Recently, unenhanced computed tomography (CT) with a thin section and multi-detector has been increasingly used for renal colic patients because it provides a rapid and accurate examination.[1] CT has high sensitivity and specificity for the detection of ureteral stones

even in obese patients.[2, 3] Because of this reason now it is recommended by many authors for the diagnosis of urinary tract calculi in patients with suspected renal colic.[4,5]

Abdominal radiograph and ultrasonography have some limitations (bowel gases, bowel feces, subjective)but CT can accurately reveal the accurate size and location of the stone which is helpful in selecting the most appropriate therapeutic approach.[6-9]Renal stones tend to recur, and the recurrence rate is about 50%.[10] In general, 50% of patients with recurrence have one recurrent episode, whereas more than 10%have multiple recurrences.[11,12]

The repeated use of unenhanced CT for imaging patients with renal colic creates a risk of high radiation exposure on standard-dose CT. This raises an ethical concern about radiation dose to the patient.[13,14]With the widespread use of unenhanced CT for the diagnosis of ureter stones, radiation exposure has become a major concern. Although the risk induced by an individual unenhanced CT scan is minute, the lifetime cumulative effect from a large number of exposures might confer a risk for cancer in young ureter stone patients who have multiple recurrences.[15]Therefore, the "as low as reasonably achievable" (ALARA) principle is used to achieve the lowest radiation dose possible during unenhanced CT examinations while maintaining optimal image quality.[16] This study was conducted with the aim to determine the diagnostic accuracy of Low-dose CT scan for detection of ureteric and renal calculi with their indirect signs and application of results of Low-dose technique reduces the radiation burden to patients in future.

METHODS

The cross-sectional study was conducted from July to December 2016. A total of 50 adult patients (32 males and 18 females) with clinically suspected urinary tract calculi referred from emergency department were consecutively included. Those patients who had diverticulitis, appendicitis, pelvic inflammatory disease, tubo-ovarian abscess was excluded. The approval of Institutional Research & ethical Committee was obtained prior conducting of the study *(IRB/2016-GENL/18371/JPMC)*. Moreover, informed consent was also taken from all the participants after explaining the pros and cons of the study.

The sample size was calculated by using sensitivity and specificity of Low dose CT scan for diagnosis of urinary tract calculi. Unenhanced Low-dose MDCT scan was performed, sections were taken from lung bases to pelvis. A contiguous sections of 7mm were taken with table speed of 5mm/sec (pitch=1), 120Kv, and 25-50 milliampere second (mAs), followed by the Standard dose CT scan with the parameters of reconstruction slice thickness 7.0mm, pitch=1.00, tube potential, 120kV, and tube charge per gantry rotation, 100-250 mAs 100 CT scans were interpreted and reviewed independently using a clinical work station for the characterization of urinary tract calculi, indirect signs of calculi (Pelviureteric junction obstruction, renal enlargement, cortical thinning), peri-ureteral stranding with mural thickening and coincidence rate of both were calculated.Patient's bio-data, duration of presenting complains and CT findings were recorded on the proforma. The comparison of Low dose with Standard dose CT was conducted by consultant radiologists having more than 5 years of experience.

Data compilation and analysis were done using Statistical Package and Social Sciences (SPSS) version 21. Mean and Standard deviation (SD) was calculated for age whereas frequency and percentages were calculated for gender, site of calculi with direct and indirect signs of obstruction, standard and low-dose CT techniques were calculated. Diagnostic accuracy of Low dose CT was measured by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) taking Standard dose CT findings as gold standard.

RESULTS

The mean age of the patients was 50 ± 11 years.Majority of the patients were males (n=32, 64%) and 18 (36%) were females. On low dose CT, distribution of calculi in kidneys and ureters was 9 (18%) in renal calyces, 11 (22%) in renal pelvis, 8 (16%) in both calyces and pelvis, while 12 (24%) in ureter.Moreover, renal enlargement was observed in 22 (44%), hydronephrosis and

hydroureter in 27 (54%), perirenal organs with immediate relations in 30 (60%) whereas Blood vessels within renal sinus was observed in 48 (96%) patients. The diagnostic accuracy of Low dose CT showed 100% sensitivity when compared with Unenhanced Standard dose CT in diagnosing urinary tract calculi, indirect signs of obstruction and adjacent organs. However, a difference was observed in blood vessels within the renal sinus which were seen in 48 kidneys in low dose CT and 49 in standard dose CT (Sensitivity 98%, specificity 100%, PPV 100%, and NPV 50%) (Table 1). Site of calculi in urinary tract along with direct and indirect signs of obstruction are shown in figures 1 and 2.

Table 1: Conditions of low-dose CT for detecting direct and indirect signs of a renal or ureteral calculus, as compared with standard-dose CT (Reference Standard).

	LOW-DOSE	STANDARD-DOSE	SENSITIVITY	SPECIFICITY
Distribution of calculi				
Renal calyces	09	09	100%	100%
Renal pelvis	11	11	100%	100%
Renal calyces +pelvis	08	08	100%	100%
Ureteric roximal+mid+distal)	12	12	100%	100%
Renal Enlargement	22	22	100%	100%
Hydronephrosis and Hydroureter	27	27	100%	100%
Perirenal organs with immediate relations	30	30	100%	100%
Blood vessels within renal sinus	48	49	98%	100
CT: Computed Tomography				

Fig 1(a): Axial image Low-dose CT scan, showing Calculus and mild Hydronephrosis.

Fig 1(b): Axial image Standard-dose CT scan showing Calculus and mild Hydronephrosis.

Fig 2(a): Reformatted coronal images, showing ureteric Calculi causing gross Hydronephrosis and Perinephric fat stranding.

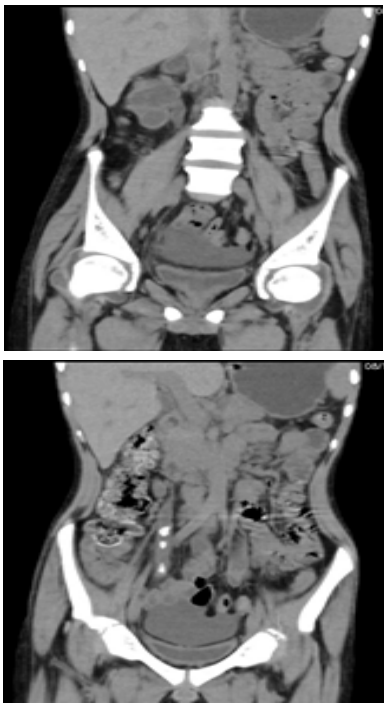

Fig 2(b): Reformatted coronal images showing ureteric Calculi causing gross Hydronephrosis and Perinephric fat stranding

DISCUSSION

In patients with suspected urinary tract calculi, CT is now becoming the initial and most appropriate investigation of choice because of its high sensitivity and specificity. We have compared Low dose unenhanced MDCT with the standard dose unenhanced CT and the results showed that low dose unenhanced CT can accurately diagnose urinary tract calculi and associated findings, using a low tube charge current, hence less radiation dose to the patient. It has been reported that patients with suspected renal colic may undergo low dose CT protocols as screening purpose, because of substantial reduction of tube charge current or an increase in the pitch.[17-19]

Clinical and ex-vivo porcine phantom studies have been done to evaluate radiation dose in low-dose MDCT with tube charge current (25-50 mAs), and radiation dose in abdominal radiography.[20] Significant reduction (50%) in dose of radiation is achieved by using Low dose MDCT, compared with initial abdominal radiograph and subsequent standard-dose CT, Moreover, sensitivities and specificities of low-dose MDCT and standard dose CT are close to each other in diagnosing ureteral stones. There are some concerns regarding use of Low-dose CT scan especially in overweight patients, also its role in alternate diagnosis which can mimic ureteric and renal calculi like colitis and appendicitis.[20] This is why low-dose CT protocols using 25-50 mAs are not yet universally accepted for the initial investigation of patients admitted with suspected renal colic.

Tube current charge is expressed in milliampere, which is the number of x-ray photons produced and has a direct linear relationship with radiation dose. Tube current is inversely proportional toimage noise which implies that if tube current is halved, there is 50% reduction in radiation dose and about a 40% increase in image noise.[21]

Radiation dose also depends on the tube potential, which is the energy of the photons and is represented as peak kilo voltage. Change in radiation dose is proportional to the square of the change in applied tube potential. A smaller change in tube potential, for example, from 140 to 120 kVp, leads to a larger decrease in radiation dose by about 35% to 40%.[22]

No I/V or oral contrast is used so further reducing radiation dose to the patient. But on the other hand evaluation of ischemia/ inflammation of bowel and accurate diagnosis of mass lesions in abdomen and pelvis are very limited.

Few studies have been done in the past on comparison of low dose versus standard dose CT for detecting renal calculi. A study done by Poletti et al in 2007 published in American Journal of Roentgenology, the result was 95% sensitivity and 97% specificity in diagnosing urinary tract calculi, while there was 96% sensitivity and 100% specificity for the detection of indirect signs of renal calculi.[23] But our study shows 100 sensitivity and specificity for both the diagnosis of calculi and indirect signs. Our 100% result proved that Low dose CT protocols can be considered as the primary imaging modality for patients with suspected urinary tract calculi.

The findings of this study could be observed in the light of limitation that the sample size of this study was small. More studies with larger sample size are recommended. Moreover, in our study we failed to find out the non-obstructing calculi of 1 to 2 mm in ureters on Low dose CT scan.

CONCLUSION

The study revealed that low-dose unenhanced MDCT is a preferred alternative of standard dose CT for the evaluation of suspected urinary tract calculi as proved by statistically significant accurately detected urinary tract calculi and its associated signs with comparatively lower radiation exposure to the patients.

REFERENCES

1. Fulgham PF, Assimos DG, Pearle MS, Preminger GM. Clinical effectiveness protocols for imaging in the management of ureteral calculous disease: AUA technology assessment. J Urol 2013;189:1203–13.
2. Mahesh M. MDCT physics: the basics—technology, image quality and radiation dose. Philadelphia, Pa: Lippincott Williams & Wilkins; 2009.
3. Heneghan JP, McGuire KA, Leder RA, DeLong DM, Yoshizumi T, Nelson RC. Helical CT for nephrolithiasis and ureterolithiasis: comparison of

conventional and reduced radiation-dose techniques. Radiology 2003; 229:575–80.

4. Dalrymple NC, Verga M, Anderson KR. The value of unenhanced helical computerized tomography in the management of acute flank pain. J Urol 1998; 159:735-40.
5. 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.
6. Vieweg J, Teh C, Freed K. Unenhanced helical computerized tomography for the evaluation of patients with acute flank pain. J Urol 1998; 160:679-84.
7. Miller OF, Kane CJ. Time to stone passage for observed ureteral calculi: a guide for patient education. J Urol 1999; 162:688-90.
8. Teichman JM. Clinical practice: acute renal colic from ureteral calculus. N Engl J Med 2004; 350:684-93.
9. 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. AJR Am J Roentgenol 2000; 175:1689-95.
10. Kobayashi T, Nishizawa K, Watanabe J, Ogura K. Clinical characteristics of ureteral calculi detected by nonenhanced computerized tomography after unclear results of plain radiography and ultrasonography. J Urol 2003; 170:799-802.
11. Hamm M, Knopfle E, Wartenberg S, Wawroschek F, Weckermann D, Harzmann R. Low dose unenhanced helical computerized tomography for the evaluation of acute flank pain. J Urol 2002; 167:1687-91.
12. Kim BS, Hwang IK, Choi YW. Low-dose and standard -dose unenhanced helical computed tomography for the assessment of acute renal colic: prospective comparative study. Acta Radiol 2005; 46:756-63.
13. Miller OF, Kane CJ. Time to stone passage for observed ureteral calculi: a guide for patient education. J Urol 1999; 162:688-90.
14. Tamm EP, Silverman PM, Shuman WP. Evaluation of the patient with flank pain and possible ureteral calculus. Radiology 2003; 228:319-29.
15. Chung JD, Kim TH, Myung SC, Moon YT, Kim KD, Chang IH. Influence of overweight on 24-hour urine chemistry studies and recurrent urolithiasis in children. Korean J Urol 2012;53:268–74.
16. Fulgham PF, Assimos DG, Pearle MS, Preminger GM. Clinical effectiveness protocols for imaging in the management of ureteral calculous disease: AUA technology assessment. J Urol. 2013;189:1203–13.
17. 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.
18. 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.
19. Meagher T, Sukumar VP, Collingwood J. Low dose computed tomography in suspected acute renal colic. Clin Radiol 2001; 56:873-6.
20. Ahn S LOCAT group. LOCAT (low-dose computed tomography for appendicitis trial) comparing clinical outcomes following low- vs standard-dose computed tomography as the first-line imaging test in adolescents and young adults with suspected acute appendicitis: study protocol for a randomized controlled trial. Trials 2014;15:28.
21. Mulkens TH, Daineffe S, De WijngaertR, Bellinck P, Leonard A, Smet G, Termote JL. Urinary stone disease: comparison of standard-dose and low-dose with 4D MDCT tube current modulation. Am J Roentgenol 2007;188:553-62.
22. Smith RC, Verga M, McCarthy S, Rosenfield AT. Diagnosis of acute flank pain: value of unenhanced helical CT. AJR Am J Roentgenol 1996; 166:97-101
23. Choi SY, Lee SY, Chi BH, Kim JW, Kim TH, Chang IH. Urbanization may affect the incidence of urolithiasis in South Korea. Springer Plus 2016;5:1891