JEMTAC
Journal of Emergency Medicine Trauma & Acute Care
A PEER REVIEWED JOURNAL

OPEN ACCESS

Research article

Emergency unenhanced multi-slice computed tomography in suspected urinary calculi—with dose reduction method (care dose 4D)

Syed Nabir*, Vajjala Ravi Kumar

Department of Radiology, HGH, Hamad Medical Corporation, Doha, Qatar
*Email: snabir@hotmail.com

ABSTRACT

Objectives: To assess urinary calculi and the secondary signs of obstruction, in patients referred from the accident and emergency department, by unenhanced computed tomography examination and to review the radiation dose the patients received with the use of automatic dose modulation technique, care dose 4D.

Material and methods: Medical records of unenhanced multi-slice computed tomography (MSCT) examinations for 114 patients referred to the emergency department for analysis of suspected urinary calculi were reviewed retrospectively. Their treatment involved automatic tube current modulation, a dose reduction method (care dose 4D), in Hamad General Hospital. The cases were analyzed for the presence of stones, size, site, density and the secondary signs of obstruction, namely hydronephrosis, hydroureter, perinephric fat stranding, peri-ureteric fat stranding and renal enlargement. A search for alternate diagnosis was made if no stone was found. The final diagnosis was noted from the discharge summary in medical records. The radiation dose, Computed Tomographic Dose Index volume (CTDI) and Dose Length Product (DLP) in each patient was recorded from patient protocol.

Results: Of 114 patients referred to CT scan for suspected urinary calculi, between March and June 2008, urinary calculi were noted in 75.4%. An alternate diagnosis was offered to 5.3% and a diagnosis of normal was given to 19.3%. The size of stones detected varied from 2 mm – 35 mm. Density of stones varied from 110 – 1250 hounsfield units (HU). Solitary stones were seen in 54.4% of cases observed and multiple stones in 22%. Renal stones were observed in 6.1% of cases, urteric stones in 26.3%, vesico-uretric junction stones in 18.4%, multiple sites in 23.7%. Hydronephrosis was seen in 68% of cases, hydroureter in 63%, perinephric fat stranding in 51%, periureteral fat stranding in 34%, ureteric rim sign in 28% and renomegaly in 24%.

Time interval between onset of symptoms to imaging varied from 4 to 12 hours. The radiation dose, CTDI, ranged from 6.5 – 15.8 mGy and DLP from 257 to 918 mGy/cm with the use of automatic tube current modulation, care dose 4D. Final diagnosis and MSCT diagnosis were in concordance in 86 (75% of) patients of renal calculi and alternate diagnosis in 6 (5.3%) of patients and normal in rest of the patients.

Conclusion: In clinically-suspected urinary calculi, unenhanced MSCT of abdomen with the use of care dose 4D, an automatic tube current modulation technique, is a fast and reliable investigation in an emergency setting to detect stones and secondary signs of obstruction. It offers alternate diagnosis with substantial reduction in radiation dose—both the computed tomography dose index (CTDI) and dose length product (DLP).

Keywords: Urinary calculi, MSCT, automatic dose modulation

http://dx.doi.org/10.5339/jemtac.2012.15

Submitted: 28 July 2009
Accepted: 12 June 2012

QSCIENCE.com
Member of Qatar Foundation

Cite this article as: Nabir S, Ravi Kumar V. Emergency unenhanced multi-slice computed tomography in suspected urinary calculi—with dose reduction method (care dose 4D), *Journal of Emergency Medicine, Trauma & Acute Care* 2012:15 http://dx.doi.org/10.5339/jemtac.2012.15

INTRODUCTION

Urolithiasis is a common problem in patients presenting to emergency departments. Detection and precise localization of stones are essential in diagnosis and choice of therapy in urinary calculi. Imaging modalities used in the case of suspected urinary calculi include abdominal radiography, ultrasonography, excretory urography or unenhanced computed tomography.[1] There has been a shift toward unenhanced helical/spiral CT examination in evaluation of acute flank pain replacing abdominal radiograph, excretory urography and ultrasonography as the modality of choice since the publication of an article by Smith et al. comparing unenhanced CT with IVU in acute flank pain.[2–10]

With the availability of multislice computed tomography units (MSCT), the emergency evaluation of urolithiasis is done by unenhanced CT in adults, as it is a quick and rapid method of evaluation. As the radiation dose for the most commonly used CT techniques is higher than that for IVU,[1] various radiation-reducing techniques are used routinely. One such technique is automated tube current dose modulation technique, care dose- 4D where, in both z-axis and xy axis tube, current modulation is implemented.[11,12]

AIMS AND OBJECTIVES

To assess urinary calculi and the secondary signs of obstruction in emergency patients with acute renal colic evaluated with multislice computed tomography using the automatic tube current modulation technique care dose 4D.

MATERIAL AND METHODS

Unenhanced multislice computed tomographic examinations of 114 patients referred from the emergency department were retrospectively reviewed. The radiology department in Hamad General Hospital has two MSCT units (16 –slice and 64-slice MSCT units, Siemens, Germany). Standard protocols used are given in Table 1.

Table 1. Standard protocols.

Parameters	74 kg 16 slice	76 kg 64 slice
kV	120	120
Effective/ref mAs	90 /160 Eff mAs/ Ref mAs	93/160
Care Dose 4D	Tube current modulation technique, Seimens,	
Slice thickness	8 mm	8 mm
Detector configuration	1616x 0.75,	64x0.6
Pitch	0.75	pitch 1.4
Rotation time	05 seconds	0.5
Scan time	27.2 seconds	9.73 seconds
CTDL volume	7.12 mGy	7.19 mGy
DLP	372 mGy/cm	350 mGy/cm

The care dose 4D is an automatic real-time tube current modulation for dose reduction. Radiation dose is noted from patient protocol with details of kV, mAs, CTDI vol and DLP.

At workstation, images were reconstructed at 1.5 mm slice thickness with increments of 1 mm in axial plane and these thin slices were used for 3D processing to generate MPR/MIP images in axial, saggital and coronal planes and evaluated interactively. In accordance with prior publications, imaging analysis is done for detection and localization of stones and the secondary signs of obstruction.[5,6]

In the absence of any detectable stone, the possibility of alternative diagnosis was considered. The two radiologists involved in this study reviewed images and results from plain abdominal radiograph, sonography, intravenous urography. The final diagnosis was noted as per discharge summary in medical records. The data obtained was subjected to standard statistical analysis.[13–17] The radiation dose data (CTDI and DLP) from patient protocol were stratified based on weight of patient, MSCT unit used (64/16 slice) and reviewed.

RESULTS

Of 114 patients, 99 (86.8%) were males and 15 (13.2%) females between the ages of 15 and 75 years, patients within the age group of 21 to 40 years forming the majority (68.4%). Nationalities most commonly involved being Indians (23.7%) and Egyptians (21%) among others (Table 2).

Table 2. Demographics.

		Number/(%)
Age	15–20	4(3.5)
	21–40	78(68.4)
	41–60	28(24.6)
	>61 < 75	4(3.5)
Gender	Male	99(86.8)
	Female	15(13.2)
Nationality	Indian	27(23.7)
	Egyptian	21(18.4)
	Qatari	11(9.6)
	Nepali	10(8.8)
	Pakistani	8(7.0)
	Others	37(32.5)

Urinary calculi were detected in 86 patients (75.4%), no abnormality in 22 patients (19.3%) and alternate diagnosis in 6 patients (5.3%) (Table 3). Solitary stone were seen in 62(54.4%) and multiple stones in 25 patients (22%).

Table 3. Alternate diagnosis.

Appendicitis with appendicolith	1
Ovarian cyst	1
Complicated renal cyst	1
Gall bladder Stone	1
Cystic lesion in sacrum, metastasis from ca lung	1
Abdominal aortic aneurysm	1

Table 4. Number, site, side, size and density of stones.

	Category	Num (%)
Number	Solitary	62(54.4)
	Multiple stones	25(22.)
	No stones	27(23.6)
Site	Renal	7(6.1)
	Urethra	30(26.3)
	Ves Ureteric junc.	21(18.4)
	Urinary bladder	2(1.8)
	Multiple sites	27(23.7)
Side	Right	34(30.7)
	Left	32(28.1)
	Bilateral	20(17.5)
Size	< 5 mm	32(28.8)
	6–9 mm	29(26.1)
	10 mm–35 mm	25(21.4)
Density	> 300 HU	58
	< 300 HU	28

Ureteric stones were seen in 30 patients (26.3%), vescico-uretic junction stones in 21 (18.4%) and renal stones in 7 (6.1%). Stones in multiple sites were found in 27 (23.7%) of cases and urinary bladder stones in 2 (1.8%). Right-sided stones were seen in 30.7%, left sided in 28.1% and bilateral in 17.5%.

The size of stones varied from 2 mm to 35 mm. Stones less than 5 mm were observed in 32 (28.8%) cases, stones between 6 and 9 mm were seen in 29 (26.1%) cases, and stones 10–35 mm appeared in

Table 5. Time interval and secondary signs of obstruction.

		114 PTS (%)	86 PTS (%)
Time interval	>6hrs	74(64.9)	74(88.3%)
	<6hrs	40(35.1)	12(13.9%)
Dilatation of calyceal system	Present	78(68%)	78(90.6%)
	Absent	36(32%)	8(9.4%)
Dilatation of ureter	Present	72(63%)	72(83.7%)
	Absent	42(37%)	14(16.2%)
Perinephric fat stranding/fluid	Present	58(51%)	58(67.4%)
	Absent	56(49%)	28(32.5%)
Periuretric fat stranding/rim sign	Present	39(34%)	39(45.3%)
	Absent	75(66%)	49(56.9%)
Renomegaly	Present	32(28%)	32(37.2%)
	Absent	82(72%)	50(58.1%)

25 (21.4%) cases (Table 4). Densities ranged from 110 HU to 1250 HU. Stones with CT value of 300 HU or more were seen in 59 patients, and 28 patients had stones of less than 300 HU. MSCT was performed in 35.1% of patients in less than 6 hours and in 64.9% of cases it took between 6 and 12 hours.

The secondary signs observed were hydronephrosis 68%, hydroureter 63%, pernephric fat stranding 51%, periuretric fat stranding 34%, renomegaly 28% and rim sign 28% (Table 5).

Table 6. Radiation dose CTDI and DLP in 114 patients.

Variable	Category	No (%)
MDCT	64-MDCT	67(58.8)
	16-MDCT	47(41.2)
Body weight	50–80	55(48.2)
	81–99	57(50)
	>100 kg upto115 kg	2(1.8)
CTDI(radiation dose)	5.0 to 7.5 mGY	55(48.2)
	7.6–9.9	57(50)
	>10 mGy–15.0	2(1.8)
Dose Length Product (DLP)	250–500	45(40.6)
	501–780	55(48.2)
	>780 mGy/cm	14(12.6)

In this study, MSCT revealed presence of stones in 86 patients. Twenty-two patients were normal and six patients had alternate diagnosis. Final diagnosis at discharge was urinary calculus in all confirmed cases on MSCT, indicating 100% accuracy with no false positive or negative cases.

RADIATION DOSE CTDI AND DLP IN 114 PATIENTS

Computed tomography dose index ranged from 6.5-to15.0 mGy. DLP varied from 257 to 918 mGy with body weights between 55 kg and 115 kg (Table 6). The reference radiation dose values for abdomen as per European guidelines are CTDI 35 mGy and dose length product (DLP) 780 my/cm.

Computed tomography dose index was reduced by 16.7%, to 44.2%, with reference to recommended level of 35 mGy. However DLP exceeded the reference level of 780 mGy/cm in 12.6% of patients. This was achieved with imaging of 8 mm slice thickness, with reconstruction of thinner slices 1 mm to 1.5 mm and 3D MPR analysis.

DISCUSSION

Unenhanced multislice computed tomography (MSCT) has become the imaging modality of choice in the evaluation of patients with renal colic in adults, as it is a quick and rapid method of evaluation with multiplanar capability having a sensitivity of 94 to 100% and a specificity of 92 to 100%.[1,13–15,18]

DETECTION OF STONES

The detection of stones is due to the combined effect of size and density. In our series, 86 patients had stones, of which 32 were less than 5 mm, and 44 patients had stones > 5 mm with densities less than 300 HU in 28 of those patients. The stone size is an important consideration because 90% of stones

smaller than 4 mm and 50% of stones 4 to 7 mm in diameter will pass spontaneously. However, stones measuring 8 mm or more in diameter rarely pass spontaneously.

Density of stones varied from < 20 HU, as in uric acid stones, to > 450 HU, as in calcium oxalate stones. The detection threshold size of stones, with 50% probability of detection, varied from 0.81 mm to 1.3 mm depending on composition, with increased conspicuity of small calculi at higher kV and ma settings. Small uric acid calculi may be imperceptible, even with maximal CT technique, because of low density.[18] Overlap densities in stones at 120 kV can be reduced with 80 kV supplementary studies at the area of interest, which improves the assessment of chemical composition.[10] However, in this study composition analysis was not done.

Technical factors, i.e., slice thickness, kV and mAS and 3D processing, affect the detection of stones. If slice thickness is decreased, detectability improves. A slice thickness of 3 mm detects more precisely than one of 5 mm or 8 mm. However, in our study with 8 mm thick slices with reconstruction to 1.5 mm at 1 mm increments with the 3D MPR analysis, stones were detected in 86 of the 114 patients with no false negatives.

SECONDARY SIGNS DUE OBSTRUCTION AND TIME FACTOR

Secondary signs of obstruction are related to time interval between symptoms and MSCT examination. Of 86 patients with urinary calculi, 88% were evaluated six hours after clinical presentation and only 12% within six hours. The minimum interval was two hours and the maximum interval was 12 hours. The pelvicalyceal dilatation was seen in 90.6% of cases, dilation of ureter in 83.7%, perinepric fat stranding in 67.4% (Figure 1), periureteral fat stranding—rim sign 45.3% and renomegaly—in 37.2%.

Among cases observed, no examinations were performed sooner than two hours after admission. A study by Smith RC, et al.[5] showed that secondary signs start appearing from one to two hours after symptom onset, with progressive visibility by seven to eight hours in. The study noted that between one and two hours, ureteral dilatation was seen in 84% of cases, collecting system dilatation in 68% of cases, renomegaly in 40% of cases, periureteral stranding in 35% of cases (Figure 2), and perinephric stranding in 5% of cases (Figure 3).

The odds ratio for the frequency of the tissue-rim sign with stones versus tissue-rim with phleboliths was 31:1.[5] The mean size of the ureter on the asymptomatic side was 1.8 mm with a standard deviation (SD) of 0.9 mm. The mean size of the ureter on the obstructed side was 7 mm with an SD of 3.2 mm. In 96% of patients, the ureter diameter on the asymptomatic side was 3 mm or smaller.[19]

RADIATION DOSE

A CTDI of 35 mGy and DLP of 780 mGy/cm for routine abdomen, and a CTDI of 35 mGy and DLP of 520 mGy/cm for pelvis are recommended diagnostic reference levels as per European Guidelines.

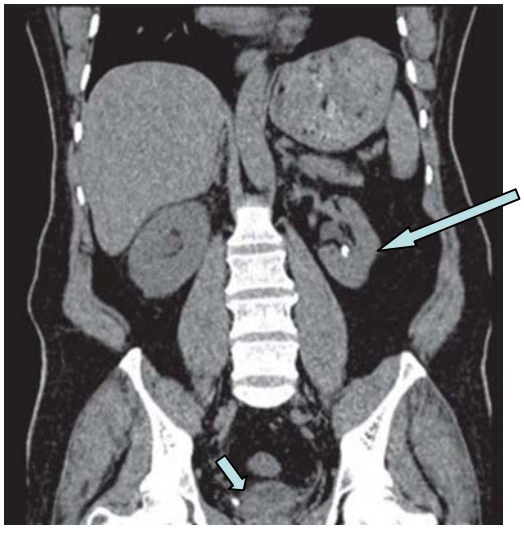

Figure 1. Unenhanced CT scan, coronal reformatted images show left renal calculus (long arrow) and right UV junction calculus (short arrow) with backpressure changes in right kidney.

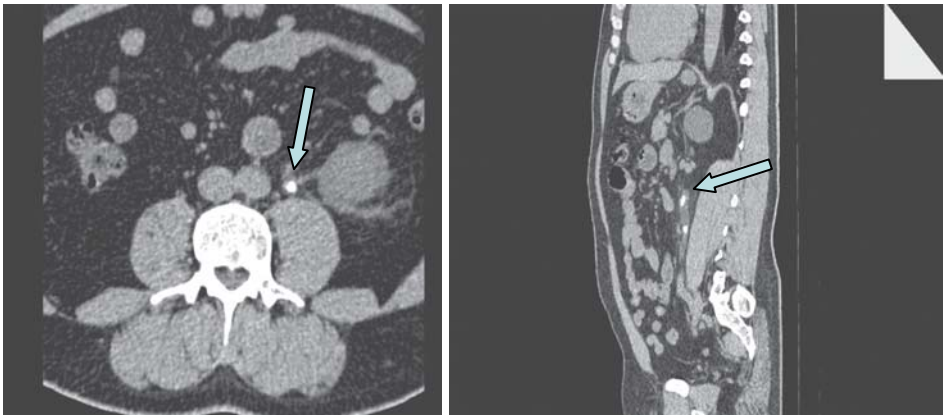

Figure 2. Axial (left) and saggital (right) reconstructed CT images showing right proximal ureteric calculi with rim sign (arrow). Periureteric and perinephric fat stranding demonstrated in axial image.

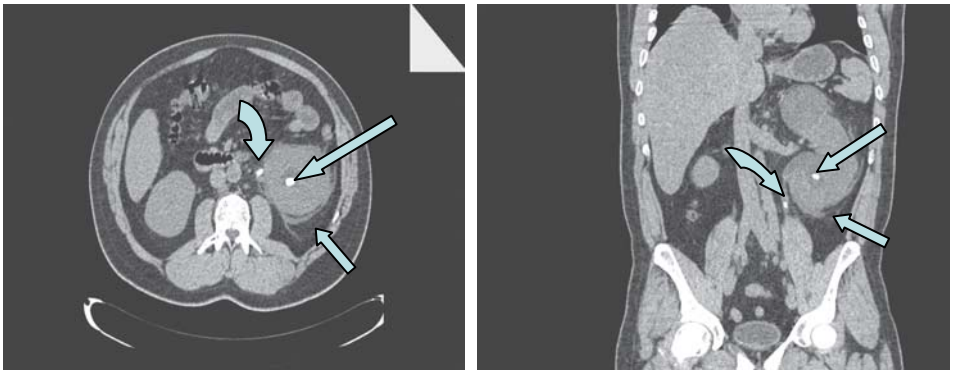

Figure 3. Unenhanced axial CT scan (left) and coronal (right) reconstruction CT images shows left renal enlargement, dilatation of left pyelocaliceal system and stranding of perirenal fat (short arrow) due to left proximal ureteric (curved arrow) and left renal calculi (long arrow).

Automated real-time mA adjustment with care dose 4D provides up to 66% dose reduction compared to fixed mA examinations for adults and children.[11,12,20]

In our study the CTDI ranged from 6.5 to 15 mGy with DLP from 257 to 918 mGy/cm. Though CTDI was reduced by 16.7%, to 44.2%, with reference to recommended level of 35 mGy, DLP exceeded 780 mGy in 12.6% of cases, with body weight between 90 and 115 kg.

One obese patient with a body weight of 110 kg was administered a CTDI of 15 mGy, and DLP of 918 was performed on 16-slice MSCT with care dose 4D. Another obese patient with a body weight of 115 kg was administered a 64 slice MSCT with CTDI of 11.5 mGy and DLP of 830 mGy/cm with care dose 4D. Though CTDI was substantially reduced, DLP remained above the reference levels. Recent studies comparing low dose MDCT techniques with standard dose techniques show the same high sensitivity and specificity.[11,12,16,17,21–23] However, our study was performed using standard dose technique.

CONCLUSION

Emergency unenhanced MSCT evaluation with care dose 4D in suspected urinary calculi is a fast and effective technique with offering practitioners the ability to reconstruct thin sections in multiple planes for the detection of stones with reduced radiation dose in most of the patients. However, the radiation dose received in obese patients is above the permissible limits. Hence radiation concerns are to be balanced with clinical situation in repeat examinations especially in patients with recurrent renal colic and follow-up cases.

REFERENCES

[1] Tamm EP, Silverman PM, Shuman WP. Evaluation of the patient with flank pain and possible ureteral calculus. *Radiology*. 2003;228:319–329.
[2] Smith R, Rosenfield AT, Choe KA, Essenmacher KR, Verga M, Glickman MG, Lange RC. Acute flank pain: Comparison of non-contrast-enenhanced CT and intravenous urography. *Radiology*. 1995;194:789–794.
[3] Smith RC, Vergam M, McCarthy S, Rosenfield AT. Diagnosis of acute flank pain-Value of unenhanced helical CT. *Am J Roentgenol*. 1996;166:97–101.
[4] Sheafor DH, Hertzberg BS, Freed KS, Carroll BA, Keogan MT, Paulson EK, DeLong DM, Nelson RC. Nonenhanced helical CT and US in the emergency evaluation of patients with renal colic: prospective comparison. *Radiology*. 2000;217:792–797.
[5] Smith RC, Verga M, Dalrymple N, McCarthy S, Rosenfield AT. Acute ureteral obstruction: value of secondary signs of helical unenhanced CT. *Am J Roentgenol*. 1996;167:1109–1113.
[6] Varanelli MJ, Coll DM, Levine JA, Rosenfield AT, Smith RC. Relationship between duration of pain and secondary signs of obstruction of the urinary tract on unenhanced helical CT. *Am J Roentgenol*. 2001;177:325–330.
[7] Catalano O. Suspected ureteral colic: Primary helical CT versus selective helical CT after unenhanced radiography and sonography. *Am J Roentgenol*. 2002;178:379–387.
[8] Abramson I, 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. *Am J Roentgenol*. 2000;175:1689–1695.
[9] Dalrymple NC, Casford B, Raiken DP, Elsass KD, Pagan RA. Pearls and pitfalls in diagnosis of urolithiasis with unenhenced helical CT. *Radiographics*. 2000;20:439–447.
[10] Zagoria RJ, Khatod EG, Chen MY. Abdominal radiography after CT reveals urinary calculus: A method to predict usefulness of abdominal radiography on basis of size and CT attenuation. *Am J Roentgenol*. 2001;176:1117–1122.
[11] Paulson EK, Weaver C, Ho LM, Martin L, Li J, Darsie J, Frush DP. Conventional and reduced radiation dose of 16- MDCT for detection of nephrolithiasis and ureterolithiasis. *Am J Roentgenol*. 2008;190(1):151–157.
[12] Katz SI, Saluja S, Brink JA, Forman HP. Radiation dose associated with unenhanced CT for suspected renal colic: Impact of Repetitive Studies. *Am J Roentgenol*. 2006;186:1120–1124.
[13] Kirpalani A, Khalili K, Lee S, Haider MA. Renal colic: Comparison of use and outcomes of unenhanced helical CT for emergency investigation in 1998 and 2002. *Radiology*. 2005;236:554–558.
[14] Memarsadeghi M, Heinz-Peer G, Helbich TH, Schaefer-Prokop C, Kramer G, Scharitzer M, Prokop M, Unenhanced MDCT in patients suspected of having urinary stone disease: Effect of section thickness on diagnosis. *Radiology*. 2005;235:530–536.
[15] Zagoria RJ. Retrospective view of diagnosis of acute flank pain: Value of unenhanced helical CT. *Am J Roentgenol*. 2006;187:603–604.
[16] Memarasadeghi M, Schaefer-Prokop C, Prokop M, Helbich TH, Seitz CC, Noebauer-Huhmann IM, Heinz-Peer G, Unenhanced MDCT in suspected urinary stone disease: Do coronal reformation improves diagnostic performance. *Am J Roentgenol*. 2007;189(2):1160–1164.
[17] Zangos S, Steenburg SD, Phillips KD, Kerl JM, Nguyen SA, Herzog C, Schoepf UJ, Vogl TJ, Costello P. Acute abdomen: Added diagnostic value of coronal reformation with 64-slice MDCT. *Acad Radiol*. 2007;14:19.
[18] Tublin ME, Murphy ME, Delong DM, Tessler FN, Kliewer MA. Conspicuity of renal calculi at unenhanced CT: Effects of calculus composition, size and CT technique. *Radiology*. 2002;225:91–96.
[19] Zelenko N, Coll D, Rosenfeld AT, Smith RC. Normal ureter size on unenhanced helical CT. *Am J Roentgenol*. 2004;182:1039–1041.
[20] Tracy TA, Yoshizumi TT, Toncheva GI, Nguyen G, Hurwitz LM, Nelson RC. Early first-trimester fetal radiation dose estimation in 16-MDCT without and with automated tube current modulation. *Am J Roentgenol*. 2008;860–864.
[21] Tack D, Sourtzis S, Delpierre I, de Maertelaer V, Gevenois PA. Low dose unenhanced MDCT of patients with suspected renal colic. *Am J Roentgenol*. 2003;180:305–311.
[22] Poletti PA, Platon A, Rutschmann OT, Schmidlin FR, Iselin CE, Becker CD. Low-dose versus standard-dose CT protocol in patients with clinically suspected renal colic. *Am J Roentgenol*. Apr. 2007;188:927–933.
[23] Niemann T, Kollmann T, Bongartz G. Diagnostic performance of Low-Dose CT for the detection of urolithiasis: A Meta-Analysis. *Am J Roentgenol*. 2008;191(2):396–401.