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Original Article

Low Dose Computed Tomography in Diagnosis of Ureteric Calculus in Obese Patients

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Abstract

Background
Standard dose computed tomography is standard imaging modality in diagnosis of urolithiasis. The introduction of low dose techniques results in decrease radiation dose without significant change in image quality. However, the image quality of low dose computed tomography is affected by skin fold thickness and subcutaneous abdominal adipose tissue. The aim of this study to evaluate stone location, size, and density using low dose computed tomography compared with standard dose computed tomography in obese population.

Material and Methods
This non-randomized non-inferiority trial includes 120 patient having BMI ≥25kg/m^2 with acute ureteric colic. The low dose and standard dose computed tomography were performed accordingly. Effective radiation doses were calculated from dose-length product obtained from scan report using conversion factor of 0.015. The images were reconstructed using iterative reconstruction algorithm. Effective dose, number and size of stone, Hounsfield Unit value of stone and image quality was assessed.

Results
Stones were located in 69 (57.5%) in right and 51 (42.5%) in left ureter. There was no statistical difference in mean diameter, number and density of stones in low dose as compared with standard dose. The radiation dose was significantly lower with low dose. (3.68 mSv) The delineation of the ureter, outline of the stones and image quality in low dose was overall sufficient for diagnosis. No images of low dose scan were subjectively rated as non-diagnostics.

Conclusion
Low dose computed tomography with iterative reconstruction technique is as effective as standard dose in diagnosis of ureteric stones in obese patients with lower effective radiation dose.

Keywords: *Multidetector Computed Tomography, Obesity, Radiation, Urolithiasis*

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Introduction

Ureteric stones are common cause of acute flank pain. The prevalence of stone disease is around 1-8% globally [1]. The life time incidence of urolithiasis is 5-10% with 5-10 years recurrent rate of 50% [2].

Currently, Standard Dose Computed Tomography (SDCT) is considered as reference standard imaging modality in diagnosis of urolithiasis, despite having high radiation dose. The introduction of multi detector CT with low dose techniques results in lower radiation exposure without significant change in image quality [3]. The sensitivity and specificity of Low Dose Computed Tomography (LDCT) is equivalent to SDCT (96.6% and 94.9% vs 94% and 97%), whereas radiation exposure is nearly equal to that of plain radiograph KUB (0.5-1 mSv vs 0.97-1.9 mSv) [4]. In obese population the signal to noise ratio is low in LDCT that lowers the image quality thereby decreasing it's diagnostic accuracy [5]. Furthermore, the skin fold thickness and subcutaneous abdominal adipose tissue (SCAT) in South Asian population is high [6]. Abdominal obesity may further decrease the sensitivity of the LDCT.

The purpose of this study was to determine whether LDCT with iterative reconstruction algorithm can substitute SDCT to evaluate the size, location, and density of ureteric stones in obese patients.

Material and Methods

This non-randomized non-inferiority trial was conducted in the Department of Radiology, Nobel Medical College, Biratnagar, Nepal from 1st March 2019 to 29th February 2020. The sample size was calculated using formula, n= [z^2xpxq/m^2], where z is confidence level at 95% (standard value of 1.96), m is margin of error which is taken as 5% and p is the expected prevalence. Literature review shows the estimated prevalence of urolithiasis is approximately 1-8% [1]. Using the given parameters, the calculated sample size was 120. Using non probability purposive sampling method participants were recruited in this study. Patients of either sex, aged ≥18 years, having Body Mass Index (BMI) ≥ 25kg/m^2, (according to Asian-pacific classification) presented with abdominal pain in out-patient and emergency units who were referred for radiological assessment of urolithiasis were included in this study. The referral from attending physician was based on clinical or ultrasonogra-phical suspicion for urolithiasis. Pregnant women were excluded from this study. Institutional Review Committee (IRC) of Nobel Medical College, Biratnagar approved this study and required their informed consent for the enrollment in this study. In compliance with the study protocol authorized by IRC, all patients were made aware of additional radiation exposure of LDCT scan. Study participants were required to read and sign an IRC approved informed consent document. The collection, review, and storage of patient information including medical records and imaging was conducted according to the study protocol authorized by the IRC. (IRC number: 263/2019).

The study was conducted using a 128-multi-slice helical CT scanner (Siemens). The LDCT was performed using 4 x 2.5 mm collimation, pitch of 1.5, slice thickness 5mm, reconstruction interval 5mm, 120kVp and fixed tube current of 50mAs. Scans were performed in supine position taking the scan range from diaphragm to pubic symphysis. Images were reconstructed using iterative reconstruction algorithm. SDCT was performed using slice thickness of 5mm, pitch of 1.5, and reconstruction interval of 5mm, 120kVp and automatic tube current modulation ranging from 100-300mAs. Contrast medium was not used in any of these scans. Effective radiation doses were calculated from dose-length product (DLP) obtained from individual CT report using conversion factor of 0.015.

The acquired images were reviewed on picture archiving and communications system (Evensite) in axial, coronal and sagittal planes. The images were reviewed by two radiologists with 3 and 4 years of experience respectively. Both radiologists were required to report number, location, size and Hounsfield Unit values. The subjective evaluation of the image was done independently using 3-point scale given below. Over all image quality: 1. Not acceptable; 2. Acceptable; 3 Excellent. Delineation of ureter: 1. not possible; 2. Questionable; 3. Possible. Outline of the stones: 1. severely blurred; 2. slightly blurred; 3. not blurred. The findings of LDCT were further validated using SDCT images independently by each reviewer. Both reviewers brought their results for consensus development, where overall quality, delineation of ureter and outline of stone was examined for inter-observer reliability.

Data was tabulated and analyzed using SPSS version 20.0. The descriptive statistics was used to report frequency and percentage for categorical variables including sex, inter-observer scale and location of stones. Means and standard deviation were used to summarize continuous variable including age, BMI, stone size, density of stone and effective radiation dose. Paired sample t-test was used to compare the sample results of

LDCT and SDCT in each participant. The inter-observer agreement for image quality, delineation of the ureter and margin of the stone was examined using the kappa statistics. The results of the statistical tests were considered significant at *P*< 0.05.

Results

Of the 120 study participants, 74 (61.7%) were males and 46 (38.3%) were females. The age range was 18-72 years with mean age of 39.84±10.00years. The mean BMI was 29.08±1.5 (range 26.3–32.8). 69 (57.5%) participants had right ureteric stones and 51 (42.5%) had left ureteric stones. The location of the stones is shown in Table 1. Location of stones in ureter was found identical using LDCT and SDCT technique.

Table 1: Location of Stones in LDCT

Parameter	Right		Left	
Ureter	69 (57.5%)		51 (42.5%)	
	Upper third	7(5.8%)	Upper third	9(7.5%)
	Middle Third	21(17.5%)	Middle Third	14(11.7%)
	Lower Third	22 (18.4%)	Lower Third	17(14.1%)
	UV junction	19(15.8%)	UV junction	11(9.2%)

The mean diameter of the stone in LDCT was 6.03 ±1.25mm whereas the mean diameter of the stone in SDCT was 6.04, ±1.33mm. There was no statistical difference in mean diameter of stones in LDCT as compared with SDCT (*P* value = 0.651). The mean density of the stones in LDCT was 677.3, ±221.2 HU and in SDCT was 679.1, ±223.9 HU. There was no statistical difference in density of stones in LDCT compared to SDCT (*P value*= 0.062). The mean effective radiation dose in LDCT was 3.68±0.93 mSv and SDCT was 12.44±1.36 mSv. The mean difference of effective radiation dose was statistically significant with *P-value <0.001.* (Table 2) The sensitivity and specificity of LDCT was estimated to be 100%. No false negative or false positive cases were identified when comparing LDCT results with SDCT.

Table 2: Comparison of different finding of LDCT and SDCT

Parameter	Low Dose CT Range, Mean, SD	Standard Dose CT Range, Mean, SD	P-value
Effective Radiation dose (mSv)	1.95-5.89,3.68, ±0.93	9.2-15.5,12.44±1.36	0.001
Size of ureteric stone (mm)	3.1-8.6,6.03, ±1.25	3.0-9.6,6.04, ±1.33	0.651
Density of stone (HU)	181.3-1379,677.3, ±221.2	190.3-1480.0,679.1, ±223.9	0.062

89.2 % (n=107) patients had acceptable image quality in LDCT scans whereas 10.8% (n=13) had excellent image quality. (Figure: 1and 2) None of the images in LDCT were subjectively rated as nonacceptable by any of the reviewer. The delineation of the ureter in LDCT was possible in 96.7% (n=116) of cases. Only in 3.3% (n=4) of cases the delineation of ureter was questionable. Similarly, the outline of stone was well-defined or not blurred in 92.5 % (n=111) cases and outline was blurred in of 7.5 % (n=9) cases. The mean score for subjective evaluation of image is shown in Table 3. The inter-observer agreement was almost perfect for all three variables (κ =0.934for image quality, κ =0.835 for delineation of ureter and κ = 0.916for outline of stones).

Table 3: Image evaluation scores (Mean±SD) and inter-reviewer agreement (κ)

	Reviewer 1	Reviewer 2	P value
Image Quality	2.11±0.31	2.12±0.32	0.001
κ	0.934		
Delineation of ureter	2.97±0.18	2.94±0.23	0.001
κ	0.835		
Outline of stone	2.93±0.26	2.90±0.30	0.001
κ	0.916		

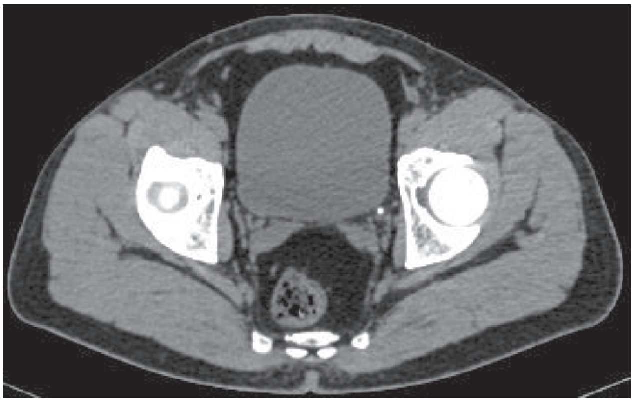

Figure 1: SDCT showing calculus at left UV junction

Figure 2: LDCT showing calculus at left UV junction

Discussion

For the past few years there is increased in incidence of renal and ureteric stones [7]. Similarly, the percentage of obese population is also increasing in similar trend [8]. This could be explained with changing life style and reduced physical activity. Some of the study shows that the incidence of the renal stones is higher in obese population [9, 10]. In this regard, this non-randomized non-inferiority trial was conducted in obese patients to evaluate size, location and density of ureteric stones.

NCCT of the renal tract is now accepted as the gold standard by European Association of Urology Guidelines for examination in suspected renal colic [11]. The advantage of CT is that most stones will be detected regardless of size, composition and location. The average effective dose in CT is almost three folds more than the conventional IVU. Different study shows an effective dose in IVU examination is about 2.6 mSv whereas the effective dose in SDCT is around 8–16 mSv [12, 13]. Also, there is tendency of stone to reoccur, patient may undergo CT many times so exposure to radiation is high [14]. Jin DH et al have studied the effect of reduced radiation protocols on the sensitivity and specificity of CT in detection of renal calculi. They suggested that decreasing the tube charge from 100 to 30 mAs results in similar detection of renal stones while reducing patient radiation exposure by as much as 70% [15]. Most of these Low dose CT studies had reported the estimated effective dose LDCT as 0.7–2.8 mSv [13, 16]. In this study range of effective radiation dose of LDCT was 1.95 – 5.89 mSv with mean 3.68mSv and SD of ±0.93 which is very much low as compared with the SDCT and is statistically significant (P-value=0.001). This finding is similar to the above mention studies. Range of effective radiation of standard dose CT in this study was 9.2-15.58, with mean 12.44mSv and SD of ±1.36 mSv.

Previous studies show no significant differences in detection of stones greater than 3 mm with low dose (−25% and−50%) examinations [17, 18]. Similarly, in this study there was no difference in size, density and number of stones in SDCT and LDCT. However, using LDCT in obese patients remains unclear. Some authors stated that LDCT is not applicable in patient with BMI > 31kg/m^2 [19]. Poletti et. al. study in patients with BMI < 30, the sensitivity of low-dose CT in detecting ureteric calculi of size < 3mm was 86% whereas the sensitivity for detecting calculi > 3 mm was 100% [20]. Previous studies showed LDCT less accurate than SDCT in detection of ureteric stones of less than 3mm [21]. However, in the present study, the sensitivity of LDCT in detecting the stones irrespective of the size is same as that of SDCT. This may be due to the use of the iterative reconstruction algorithm and tube current of 50mAs which results in better image quality (Figure 3 and 4) that allowed diagnostic accuracy of 100% with significant reduction of effective radiation dose. Most of the LDCT researches with low sensitivity used a fixed low tube current. Mohamed E. et al also used low dose CT in obese where variable tube current was used depending upon the body weight of the patient. Acceptable quality of image was obtained that allowed a diagnostic accuracy (100%) in their patients reducing the effective dose to half of the dose of SDCT[17].

Figure 3: SDCT in obese patient showing calculus at left proximal ureter

Figure 4: LDCT in obese patient showing calculus at left proximal ureter

Currently, researchers have compared the ultra-low dose and conventional CT protocol for detection of renal and ureteric calculi in cadaveric model. Using this ultra-low dose CT protocol, ureteric calculi was detected in a similar fashion to that of SDCT protocols. This protocol decrease the radiation dose up to 95% [22]. The limitation of this study is that relatively few patients were enrolled. Similarly, there were no very obese patients with BMI>35 kg/m2 and for this patient group different protocol may still be required. The present research revealed that the low dose CT using iterative reconstruction algorithm gave accurate results as compared to the standard dose CT in the detection of ureteral calculi in obese patients. This might be very useful in follow up of the patients where radiation dose could be minimized almost comparable to IVU.

Conclusions

The use of LDCT with iterative reconstruction algorithm for ureteric stone disease in obese patients showed significant reduction in effective radiation dose as compared to SDCT without compromising the parameters that help in detection of stones. So, LDCT should be considered as a replacement of SDCT in detection of urolithiasis.

Conflicts of interests: None

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