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COMPARISON BETWEEN LOW AND STANDARD DOSES OF CT IN URETERIC STONE

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Abstract:

Background: Urolithiasis is approximate to11% of men and 7% of women.1 Helical CT scan has now become the “gold standard” for diagnosing both renal and ureteric calculi.2 Reducing the tube charge from 100 to 30 MAs led to comparable detection of the stones while reducing radiation exposure by up to 70%.3

Aim of the study: This study conducted a comparison between low and standard doses of CT technology in the diagnosis of ureterolithiasis. The use of low-dose parameters has been shown to reduce radiation exposure while maintaining diagnostic accuracy in most patients

Patients and method: An observational and prospective study conducted on 120 patients, 72 males and 48 females, aged between (19 -50) years, who attended the kidney and urinary tract Diseases Consultation Clinic in Al-Hussien Teaching Hospital during the period from June 2023 to January 2024 in Al Nasiriyah City, Thi-Qar Province, Iraq. All patients suffered from ureterolithiasis and who underwent both SDCT and LDCT, respectively in the same day, was performed via Revolution EVO, GE Healthcare, Japan, without intravenous or oral contrast.

Results: The mean age of patients in this study was 30.8±9.42 years, the mean weight of patients was 81.03±11.11 kg, the mean height was 164.97±7.82 cm, and lastly, the mean BMI was 29.89±4.59 kg/m2. Most of the patients in this study had only one stone (50%), and 60% of those had stones at the distal ureter, 19% at the mid ureter, and 21% at the proximal ureter. Finally, most of the patients had stones on the left side of the body (67%). There was highly significant difference in Total Effective Dose between both protocols, it was 13.39 ± 1.04 mSv in SDCT compared to 1.34 ± 0.44 mSv in LDCT, with a p-value less than 0.001.

Conclusion: A significantly decreased dosage index protocol may not be a perfect examination, but it could be a viable substitute for SDCT scans for evaluating suspected stones, especially in younger patients who are improbable to have other medical conditions and who need follow up.

Recommendations: There is an urgent need for more studies from various Iraqi governorates, with a larger sample size, to confirm the results of this study, and may reduce the number of patients who undergo standard radiation dose.

Keywords: *Urolithiasis. Helical CT- scan, Ureteric Stone, Low and Standard Doses of CT-scan.*

Introduction

Introduction: Urolithiasis is approximate to affect 11% of men and 7% of women[1]. Renal stones account for over 87% of all urinary calculi[4]. About 10% occurring in the urinary bladder.[5] Typically, renal calculi can spontaneously move via the urinary system without intervention.[6] Nevertheless, when the size of the stone reaches ≥ 7 mm, it frequently requires urologic intervention to be passed. Stones of ≤5 mm typically can pass spontaneously.[7] Nevertheless, due to individual anatomical differences, certain patients may have trouble in passing what is considered a little stone. [8]

Stone occurrence is relatively rare before age 20 years but peaks in incidence between 40 and 60 years, caused by higher urinary peak flow rates, which decreases to 15 ml/s compared to 35 ml/s in second decade of life.[9] The Stone score is a clinical decision rule used to categorize patients with suspected ureterolithiasis.[10] The Stone score alone is insufficient to definitively identify or rule out the presence of stones or exclude medically significant conditions.[11] Although the STONE score may not eliminate the need for CT imaging in all patients, it can serve as a useful tool for involving patients in the decision-making process regarding imaging options. [12]

Ureteral stones can be evaluated with X-rays, ultrasound, computed tomography (CT), or magnetic resonance imaging (MRI).[13] Helical CT has now become the "gold standard" for diagnosing both renal and ureteric calculi, thanks to its high sensitivity (95%) and specificity (98%).[14] Noncontract computed tomography (CT) is recommended for diagnosis in patients with acute flank pain and suspected renal or ureteral stones.[15] CT can detect and measure ureteral stones with a sensitivity and specificity of 98% to 100% regardless of size or stone composition In addition CT can help determine the type of stone and the difficulties during lithotripsy.[16] CT scans may diagnose other conditions causing the patient's symptoms if they are not caused by urolithiasis.[16] Nonetheless, CT imaging exposes patients to radiation. Several studies have highlighted significant radiation exposure in patients with urolithiasis, both at initial presentation and during follow-up.[17]

This has led many to advocate the use of low-dose CT imaging to treat stones.[18] The use of low-dose parameters has been shown to reduce radiation exposure while maintaining diagnostic accuracy in most patients.[19] However, this method requires more accurate detection of small stones (i.e., <3 mm) and needs to be performed in patients with a body mass index (BMI) >30 kg/m2[19].[20] This problem can be partially addressed by increasing the ratio of radiation dose to BMI while maintaining lower total radiation exposure than with standard-dose CT. [20] Technological advances have led to the recent development of ultra-low-dose CT, where the radiation exposure is close to that of X-rays. Although further research is needed, early literature shows promise. [21]

Patients who are at moderate or high risk of experiencing a stone emergency or having a clinically significant alternative diagnosis should get an unenhanced computed tomography (CT) scan.

Patients who have a minimal probability of experiencing a stone emergency or having a clinically significant alternative diagnosis should undergo ultrasonography.[22]

As a result, unenhanced CT scans have a high level of accuracy in identifying urinary tract stones (sensitivity of 97% and specificity of 96%). [23]The location and size of the ureteric calculi are the primary factors used to choose the specific clinical therapy approach. [24]

Multi-detector computed tomography (MDCT) has been suggested as a method for diagnosing ureteric calculi.[25] For common CT protocols, the average radiation dose is between 12.4 and 16.1 mSv.[24] For excretory urography, the average radiation dose is 3 mSv.[22] It is important to note that there is no minimum point of radiation dose in diagnostic imaging protocols that does not carry a risk of cancer development.[26] Ferrandino et al. found that patients with urinary calculi had a high cumulative effective radiation dose due to CT scanning during short-term follow-up. [26]

Researchers have suggested using reduced radiation-dose CT (RDCT) has comparable performance to standard-dose CT (SDCT) protocols to minimize radiation exposure for evaluating urolithiasis.[27]Multiple authors have recognized that employing LDCT approaches can be utilized for screening individuals who are suspected to have a colic.[28] In recent times, there have been clinical and ex vivo study investigations that have assessed a low-dose MDCT protocol ($\leq$ 30 mAs), which results in a radiation dose comparable to that of abdominal radiography.[26] In addition, LDCT has the potential to reach similar levels of sensitivity and specificity as SDCT in detecting ureteral stones.[28]

The effective dose (EDOs) is proportional related to the overall amount of radiation received during an imaging scan. While most of the studies have focused on the LDCT accuracy, very few data have been studied the differences in stone size, skin-to-stone distance (SSD), and Hounsfield units (HU) might show up on LDCT compared to SDCT, which are the 3 critical elements for management. [29] However, if the exact path of the ureter is not known, LDCT scans might make it harder to tell the difference between ureteral stones and calcifications close to the ureter, like pelvic phleboliths.[28] There are also special issues concerning the use of LDCT in overweight patients and its ability to accurately show other alternate diagnoses, which explains why LDCT protocols utilizing $\leq$ 30 mAs have not yet received widespread approval in the suspected renal colic condition.[29]

In addition to that, there are no reports on the sensitivity of CT urography for detecting Ureterolithiasis in our city and to our knowledge, this is the first report to highlight its utility for this purpose. Since these scans include the pelvis and, therefore, the lower urogenital tract, we reason that s, when present, should be readily visible on all CT-urograms[29]. This study conducted a comparison between low and standard doses of CT protocol in the diagnosis of ureterolithiasis. As far as we know, the regional investigation of how reducing CT doses affects the tracing of the ureter has not been conducted yet.[30]

Methodology: An observational, and prospective study conducted on 120 patients, 72 males and 48 females, aged between 19 and 50 years, who attended the kidney and urinary tract Diseases Consultation Clinic in Al-Hussien Teaching Hospital during the period from June 2023 to January 2024 in Al Nasiriyah City, Thi-Qar Province, Iraq. The study was conducted to compare low and standard doses of CT technology via Revolution EVO, GE Healthcare, Japan in patients with ureterolithiasis for Comparison between Low and Standard Doses of CT in Ureteric Stone. **Inclusion Criteria:** All patients, regardless of gender or age, who suffered from ureterolithiasis were able to participate and complete the CT examination. They give a written informed consent form to participate in the clinical study. **Exclusion Criteria:** the patients who had inconstant with inclusion criteria. Those with an alternative diagnosis for reported symptoms or immune compromised patient and patient with malignancy. Those who did not complete the entire information sheet for this investigation.

Using Microsoft 365 Excel 2024 and SPSS (IBM version 26.0), the data were analysed. In this study, results were provided as mean ± SD and frequencies as percentages. The Chi-square test, and ANOVA test were used to compare distributed groups. Probability levels less than 0.05 were deemed physiologically significant, and p-values less than 0.01 were deemed extremely significant.

Results: The mean age of patients in this study was 30.8±9.42 years, the mean weight of patients was 81.03±11.11 kg, the mean height was 164.97±7.82 cm, and lastly, the mean BMI was 29.89±4.59 kg/m2. All variables were significantly_different among patients, with p-values of 0.000.

Most of the patients in this study had only one stone (50%), and 60% of those had stones at the distal ureter, 19% at the mid ureter, and 21% at the proximal ureter. Finally, most of the patients had stones on the left side of the body (67%).

As presented in the Table 2, the mean craniocaudal diameter of stone in this study was 5.63±1.65 mm, based on the SDCT, compared to 5.74±1.45 mm in LDCT. While the anteroposterior diameter was 5.15±0.43 mm by SDCT, compared to 5.77±0.85 mm in LDCT, Lastly, the transverse diameter was 6.4±0.9 mm, and 6.40±0.91 mm, respectively. All of the 3 diameters were not significantly different between the two protocols (SDCT & LDCT), with p-values more than 0.05. The density of the stone in this study was 777±81.09 HU, based on the SDCT, compared to 865.6±81.2 HU in LDCT. While there was no significant difference in the density of the stones based on the protocols with a p-value more than 0.05.

The mean radiation dose in the low protocol was 100±0.001 kV, while it was 118.18±6.03 kV in the standard protocol, and it is statistically different among both with a p-value less than 0.001. Also, the tube current in the low protocol was 75±0.001 mA compared to 187.73±37.39 mA, and it is statistically different among both with a p-value less than 0.001. There was highly significant difference in Total Effective Dose between both protocols, it was 13.39 ± 1.04 mSv in SDCT compared to 1.34 ± 0.44 mSv in LDCT, with a p-value less than 0.001. The LDCT was the most significant protocols to detect the urolithiasis compared to SDCT, as measured by the area under the curve (AUC). The paired comparison analysis revealed that the AUC values of the LDCT was significantly lower than SDCT. This suggests that this protocol is the most precise predictors of stones in individuals who have urolithiasis. Most of the patients in this study had moderate hydronephrosis (50%), without perinephric stranding (50%), and without renal atrophy (50%).

Discussion:

This study represents the one of the first studies and knowledge that examines the use of LDCT & SDCT techniques for imaging individuals with suspected urolithiasis. The LDCT scan is suitable for the follow up ureteric stone in many patients who have a high symptom caused by other factors and it can be the most effective method for assessing the inevitability of intervention in the patients. [31]

The mean BMI was 29.89±4.59 kg/m2. These results compared to another study by Moore, Christopher, et al.[32] that involved patients with average age 44 years, found that most of the patients were males (52%), and (58.7%) had the high BMI, the mean BMI was 33.0 kg/m2. Numerous studies have already indicated that LDCT can decrease the radiation dose by 70%–95% with minimal decrease in diagnostic accuracy. [32]

Most of these studies have looked at how well LDCT can detect and diagnose urolithiasis. However, not many have looked at whether LDCT can be used to find out basic information about the stone and where it is located, like its size, volume, density, and SSD, which is needed to plan effective appropriate stone therapy. [33]

The present study suggests that all these parameters can be accurately assessed using LDCT in our patients. This result was agreed with another by Moore, Christopher et al. which reported that the stone parameters were similar between the standard CT and LDCT protocols, and the correlation in their measurements between observers and between modalities was reliable.[34] This implies the reliable use of LDCT in planning stone therapies. [35]

A similar study using 14 human cadaveric ureters showed that an ULDCT (7.5 mAs) radiation method, which is comparable to KUB, may be able to find distal ureter stones with a rate that is comparable to that of SDCT protocols.[36]

The most significant protocols to detect the urolithiasis compared to SDCT. Another study by Moore, Christopher, et al. in the USA also has shown that a CT protocol for patients of diverse BMIs with a mean dose reduction of 84% is moderately sensitive (90.2%) and highly specific (99.0%) for ureteral stone, with near-perfect sensitivity for larger stones that may require intervention.[37]

Although the sample size of the study conducted by Moore, Christopher, et al. [60], was limited, the LDCT scan successfully identified almost all patients who needed intervention. This finding can be viewed as the most accurate and reliable reason to have a CT scan. Out of the patients who finally received a urologic intervention, 26 out of 27 anomalies (96.3%) were detected on the LDCT scan.[38]

In this study had only one stone (50%), and 60% of those had stones at the distal ureter, 19% at the mid ureter, and 21% at the proximal ureter. Finally, most of the patients had stones on the left side of the body (67%). Another study by Moore, Christopher, et al. found, by SDCT, 50% of the stones were in the kidney 30% within the distal ureter, and 20% within the proximal ureter, while by LDCT, 30% were kidney stones, 40% in the distal ureter, 20% in the proximal ureter, and 10% in the mid-ureter.[39]

This study's findings were continent with other by Moore, Christopher, et al. [60] which reported there were no significant differences were found between the LDCT and SDCT in the stone characterization or density.

A previous study conducted by Moore, Christopher, et al. has already shown that the use of LDCT scan can decrease the radiation by over 70% while maintaining high diagnostic accuracy. Another study by Moore, Christopher, et a reported that the predicted average of EDose was 1.6 mSv, which is 86% lower than the present national mean effective dose of roughly 11.2 mSv. The SDCT scan had an EDose of around 12.6 mSv, which is somewhat over the national average.[40]

This study indicates that implementing a high-BMI protocol is a practical approach to include all patients while effectively reducing the dosage.[39] The only American study on the LDCT, included 50 patients who weighed less than 90.7 kg, demonstrated an accuracy rate of 94% for detecting ureterolithiasis, while also obtaining a reduction in radiation dose ranging from 25% to 42%. Unlike other studies, this research did not exclude patients with high BMI. Additionally, we were able to achieve a significant reduction in dosage while keeping a high level of accuracy.

Table: 1 The Statistical analysis of Age, Height, Weight, and BMI

Variables	N	Minimum	Maximum	Mean	SD	SEM	t	Sig.
Age (years)	120	19	50	30.80	9.42	0.86	35.825	0.000
Weight (kg)	120	51	99	81.03	11.11	1.01	79.922	0.000
Height (cm)	120	150	195	164.97	7.82	0.71	231.263	0.000
BMI (kg/m2)	120	19	43	29.89	4.59	0.42	71.423	0.000

Table: 2 Characteristics of Stone

Variables		Frequency	Percent
Number of stone	1	96	80%
	2	20	17%
	3	4	3%
Distal Ureter (%)			60%
Mid Ureter (%)			19%
Proximal Ureter (%)			21%
Side of the stone	Right	40	33%
	Left	80	67%
Total		120	100%

Table 3: The measurements of stone composition in both CT scan protocols

Variables	SDCT	LDCT	P-value
Craniocaudal diameter (mm)	5.63±1.65	5.74±1.45	0.89
Anteroposterior diameter (mm)	5.15±0.43	5.77±0.85	0.7
Transverse diameter (mm)	6.05±0.82	6.40±0.91	0.745
Density (HU)	775.4±77.9	865.6±81.2	0.5
Tube current (mA)	187.73±37.39	75.0±0.01	<0.001
Radiation dose (kv)	118.182±6.03	100±0.01	<0.001
CTDI vol (mGy)	15.93 ± 0	1.96 ± 0	<0.001
DLP (mGy-cm)	836.79 ± 65.11	83.76 ± 27.66	<0.001
Total Effective Dose (mSv)	13.39 ± 1.04	1.34 ± 0.44	<0.001

Table 4: Area under the curve of the study's protocols

Protocols	Sensitivity	Specificity	AUC	P	95% CI	
LDCT	0.908	0.742	0.820	<0.001	0.772	0.867
SDCT	0.978	0.638	0.933	<0.001	0.759	0.868

Image 1; Computed tomography scans of a patient (Standard Radiation Dose; 120Kv, 199mA).

Image 2; Image from computed tomography scans of a patient (Low Radiation Dose).

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