DOI: https://doi.org/10.70749/ijbr.v4i3.2972

INDUS JOURNAL OF BIOSCIENCE RESEARCH
https://ijbr.com.pk
ISSN: 2960-2793/ 2960-2807

# Diagnostic Accuracy of Low Dose CT-KUB and Conventional Computed Tomography in Detecting Renal and Ureteric Calculi in Paediatric Patients

Norina Iftikhar[1], Rida Fatima[1], Munazza Butt[2], Loqman Shah[3], Akhtar Javed[1], Syeda Kubra[1]

[1]Faculty of Allied Health Sciences, Superior University, Lahore, Punjab, Pakistan.
[2]University of Child Health Sciences and Children's Hospital, Lahore, Punjab, Pakistan.
[3]Department of Radiological Sciences & Medical Imaging Technology, Faculty of Allied Health Sciences, Northern University, Nowshera, Khyber Pukhtunkhwa, Pakistan.

## ARTICLE INFO

**Keywords:** Computed Tomography, Kidney, Urinary Bladder, Diagnostic Accuracy, Specificity, Sensitivity, Positive Predictive Value, Negative Predictive Value.

**Correspondence to:** Loqman Shah, Department of Radiological Sciences & Medical Imaging Technology, Faculty of Allied Health Sciences, Northern University, Nowshera, Khyber Pukhtunkhwa, Pakistan.
**Email:** loqmanshah001@gmail.com

**Declarations**

**Authors' Contribution**
All authors equally contributed to the study and approved the final manuscript

**Conflict of Interest:** No conflict of interest.

**Funding:** No funding received by the authors.

**Article History**
Received: 07-01-2026 Revised: 13-03-2026
Accepted: 21-03-2026 Published: 30-03-2026

## ABSTRACT

**Background:** Renal and ureteric calculi, also referred to as kidney stones, are becoming increasingly common in the pediatric population, especially in countries such as Pakistan. Timely and accurate diagnosis is very important in preventing complications through an early diagnosis. The gold standard for the diagnosis of urolithiasis is conventional CT-KUB (Computed Tomography of Kidneys, Ureters, and Bladder) because this method has a high specificity and sensitivity. Nonetheless, constant exposure to ionizing radiation among children is dangerous to their health. Thus, low dose CT-KUB protocols have been developed to lower the radiation dose while maintaining the diagnostic accuracy. **Objective:** To identify the diagnostic accuracy of low-dose CT-KUB in identifying renal and ureteric calculi in children using conventional Computed Tomography as a gold standard. **Methodology:** This cross-sectional analytical study was conducted at the Department of Radiology, University of Child Health Sciences and Children Hospital, Lahore. Non-probability consecutive sampling was used to sample 45 pediatric patients (1 day to 16years) with history of urinary stones. Following informed consent and clinical judgment, every patient was subjected to low dose CT-KUB (<3.5 mSv) and standard CT. The same radiologist interpreted the findings. The Sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy of low-dose CT-KUB will be determined by using SPSS version 26 by comparing the findings with those of conventional CT as the reference standard. **Results:** Diagnostic performance of low-dose CT-KUB was found to be highly preferable as compared to the conventional CT in children. The total diagnostic capability of LDCT was 93, sensitivity was 96, specificity was 95, positive predictive value was 96 and negative predictive value was 95. LDCT displayed a better correlation with the standard CT in determining the size of the stone, its number, and position within the pelvis as well as the ureter. **Conclusion:** CT-KUB at low doses is a reliable and precise method of imaging in identifying renal and ureteric calculi among children. It has a diagnostic accuracy that is similar to standard CT and has a much lower radiation exposure. Consequently, LDCT-KUB is a safe imaging method that can be suggested as a choice when making a diagnosis and following up on children with urolithiasis.

## INTRODUCTION

The kidneys are vital organs responsible for the excretion of water and metabolic waste products, thus playing a crucial role in maintaining the balance of electrolytes and water in the body. They have important endocrine functions, such as producing and releasing renin which regulates blood pressure, erythropoietin which aids in the formation of red blood cells and 1,25-di-hydroxycholecalciferol which is involved in vitamin D metabolism, among others(1). The kidneys are positioned behind the peritoneum on each side of the spine and are encased in fat tissue. They are bordered at the top by the upper edge of the 12th thoracic vertebra and extend downward to the third lumbar vertebra. Typically, the right kidney is located lower than the left because of its proximity to the liver, which is above it. The left kidney is slightly longer and narrower than the right and is positioned more towards the center. The long axis of each kidney is oriented anterolaterally, while the transverse axis is directed posteromedial, indicating that the anterior and posterior surfaces are anterolateral and posteromedial (2, 3). Each kidney is approximately 11 to

12 cm long, 6 cm wide, and 2.5 to 3 cm in anteroposterior (AP) dimension. The left kidney is about 1.5 cm longer than the right; however, it is uncommon for the right kidney to exceed the left by more than one cm (4, 5). The average weight is roughly 125-170 gram in men and 115-155 gram in women. The kidney is divided into 8-10 lobes, consisting of an outer cortex about one centimeter thick and a renal pyramid, whose apex (papilla) opens into a minor calyx (6). The kidney of fetuses and newborns normally consists of 12 lobules. These lobules merge in adults to form a smooth surface though remnants of lobulation can still be observed (7). The kidney hilum connects to the central renal sinus, which houses the renal pelvis, vessels and fat. Knowledge of this anatomical plane is essential in the renal pelvis surgery, particularly, open stone surgery (8, 9). In the renal sinus, the collecting tubules of the nephrons empty into the apex of the renal papillae, which empties into minor calyces, which are funnel shaped extensions of the upper urinary tract. These small calyces are combined with the surrounding calyces and become two or three bigger chambers called major calyces and these are emptied into the renal pelvis (10). The ureters are muscular tubes, each 25-30 cm long and they are the ones that carry the urine back to the urinary bladder by means of peristaltic contractions. They have thick walls and are thin in diameter and are continuous on the superior end with the renal pelvis (11, 12). The ureters run downward a little to the middle, anterior to the psoas major muscle, and enter the pelvic cavity, first passing laterally and then medially to empty at the base of the urinary bladder. The ureter has a typical diameter of about 3 mm, but is somewhat smaller in the area of the renal pelvis junction, at the rim of the lesser pelvis close to the medial border of the psoas major and where it crosses the wall of the urinary bladder which is the narrowest area. These are the most frequent locations where renal stones are impacted (13-15). Kidney stone disease, nephrolithiasis, renal calculus disease, or urolithiasis, is a type of crystallopathy, or a disease where crystals form in the body as a result of a disproportionate composition of urine, usually excessively minerals and inadequately hydrated. The result of this imbalance is a development of small crystals, which may accumulate to create hard structures referred to as calculi (stones) in the upper urinary tract, where they mostly occur in the kidneys (16, 17). Renal ureteric calculi, commonly referred to as kidney stones or urinary stones, are small, solid crystals that can form in the kidneys and descend through the ureter, the tube connecting the kidney to the bladder. Diagnosis is achieved through a combination of patient history, physical examination, and imaging tests such as Computed Tomography scans and ultrasounds. Urinalysis may also be employed to identify the cause of infection or hematuria (18). Approximately 50% of patients who experience one kidney stone are likely to develop another within the subsequent 10 years (19). In Pakistan, the prevalence of renal calculi in pediatric patients is estimated at 2-3%, which is relatively high compared to the global pediatric average, where the prevalence of kidney stones in the general population ranges from approximately 1-15%, varying by region, dietary patterns, climate, and healthcare facilities. In children, kidney stones present with a wide range of symptoms, which may vary based on the patient's age, the stone's location, and size. Younger children may exhibit nonspecific symptoms such as irritability, abdominal pain, nausea, and vomiting. Older children and adolescents are more likely to present with flank or back pain, painful urination (dysuria), increased urinary urgency or frequency, and fever if an infection occurs (20). The following investigations are conducted to detect renal and ureteric calculi; urinalysis and 24 hour urine collection to assess for crystals, pH, and metabolic disorders, renal function tests (RFTs) to evaluate kidney function, complete blood count (CBC) to identify infection or inflammation; urine culture and sensitivity (C/S) to rule out infection, X-ray KUB to detect radiopaque stones in children, ultrasound kidney-ureter-bladder (KUB) as a first line investigation in children to avoid harmful radiation and non-contrast CT KUB, which is considered the gold standard due to its high sensitivity and specificity (21). The management of renal and ureteric calculi encompasses; Conservative management involves hydration. Promote increased fluid consumption, Pain Management through NSAIDs or opioids for intense pain, Medical Expulsive Therapy including Alpha-blockers (e.g. tamsulosin to facilitate stone expulsion. Interventional Procedures include ESWL (Shock Wave Lithotripsy) is a non-invasive technique that splits stones into acceptable pieces. Ureteroscopy is an endoscopic extraction of calculi, may require stenting. Percutaneous-Nephrolithotomy is for substantial or intricate calculi. Prevention can be achieved through dietary modifications based on the kind of stone, such as low salt and low oxalate diets. Medications: Thiazides, citrate supplements, or allopurinol depending on metabolic background. Underlying Disorders to access congenital or metabolic reasons e.g., cystinuria, hypercalciuria) (22). Urinary stone diagnosis is commonly made by non-contrast-enhanced computed tomography of the kidneys, ureters, and bladder (CT KUB), which is considered the gold standard. These methods are essential for choosing a therapy strategy (21). Because of its excellent diagnostic accuracy, CT scanning is preferred by the American Urological Association (AUA) and the European Association of Urology (EAU) above other imaging modalities including X-ray and ultrasound. Compared to X-rays or ultrasounds, which could overlook tiny or radiolucent stones, this method is more dependable, detects problems and differential diagnoses, and evaluates stone composition using Hounsfield units. Because urolithiasis is recurring (50-70% recurrence within 10 years) and common in younger persons, frequent CT scans pose radiation concerns, according to ethical safety measures. Exposure to this ethical issue needs the development and assessment of low-dose CT (LDCT) protocols (22). Low-dose computed tomography (LDCT) offers great diagnostic accuracy with much lower radiation exposure than regular CT scans; it is a useful diagnostic technique for identifying renal and ureteric calculi in paediatric patients due to children are more radiosensitive than adults, this reduces the long-term

cancer risk linked to radiation (23). The main benefit is a significant radiation dose decrease up to 70-80% or more without sacrificing diagnostic performance. This is especially important for youngsters, who may need several imaging tests over their lives due to their extended life expectancy and increased risk of recurrence. According to studies, Low Dose Computed Tomography (LDCT) is equivalent to standard dose CT for this particular problem since it retains a high sensitivity (90-97%) and specificity (86-100%) for identifying the majority of clinically relevant stones. All forms of stone compositions, even those that are radiolucent not visible on normal X-rays, can be detected by quick LDCT scans. It is useful for providing precise anatomical information about the urinary system, which helps with treatment planning, especially prior to surgery (24). This study's primary goal was to compare the diagnostic accuracy of conventional CT with low dose CT KUB for the diagnosis of renal and ureteric calculi. Healthcare professionals will be able to make evidence-based judgements regarding when to utilize low-dose CT KUB and when conventional CT is necessary thanks to this study. Common urological disorders that produce severe pain and discomfort include renal and ureteric calculi. Since treatment options and choices may differ depending on the size, location, and makeup of the stones, prompts and accurate identification is essential for proper care. Optimizing patient care requires an understanding of the diagnostic accuracy of various imaging modalities.

### Problem Statement

Children are increasingly being diagnosed with renal and ureteric calculi, which require appropriate imaging in order to be treated promptly. Conventional CT-KUB is the gold standard, but it exposes kids to high levels of ionizing radiation, which can be dangerous over time. Children are particularly susceptible to radiation, and the majority of them need recurrent scans due to sickness recurrence. There is less radiation exposure with low dose CT-KUB, and its diagnostic accuracy in children is still in its infancy. Therefore, in order to have safer paediatric radiology, the quality of CT-KUB low dose diagnostic must be evaluated in relation to the standard CT-KUB.

### Objective

To assesses the diagnostic precision of low-dose CT-KUB by using conventional CT-KUB as the gold standard to identify renal and ureteric calculi in paediatric patients. Also find out if low dose CT-KUB can be a safe, dependable substitute for regular CT-KUB, meaning it can lower children's radiation exposure while maintaining the same degree of diagnostic performance.

## MATERIALS AND METHOD

In order to compare the diagnostic accuracy of low dose CT KUB with conventional CT in identifying renal and ureteric calculi in paediatric patients, a cross-sectional analytical study was carried out over a period of four to five months in the Department of Radiology at the University of Child Health Sciences and The Children's Hospital, Lahore. The sample size was determined using Cochran's formula ($n = Z\,2 \times p \times (1-p)\,/\,d\,2$) (n=Z 2×p× (1−p)/d 2), taking on the basis of prevalence ($p$) = 0.03(24), $Z$ = 1.96 Z=1.96, and $d$ = 0.05 d=0.05. A non-probability successive sampling method was used to select patients. Paediatric patients having a clinical history or suspicion of renal or ureteric calculi between the ages of one day and sixteen were eligible for inclusion; patients older than sixteen and those who had received extracorporeal shock wave lithotripsy (ESWL) were not. Ethical approval was obtained by the institutional review board and written informed permission by the parents or other legal guardians of all the participants. Minimization of radiation exposure was ensured through low-dose CT protocols less than 3.5 mSv without compromising diagnostic quality. Low-dose CT KUB and conventional CT of each subject was done on a Siemens 128-slice CT scanner. Prior to imaging, a thorough clinical history and physical examination were carried out, which included assessment of costovertebral angle discomfort, renal palpation, and evaluation for fever or oedema. One competent consultant radiologist was used to interpret all the CT scans to ensure consistency and the findings were recorded on a pre prepared proforma. SPSS version 26 was used to enter and analyze the data. Chi square test was use for seeing association between variables. Diagnostic Odd Ratio was use to see diagnostic accuracy between low-dose CT KUB and conventional CT (25).

## RESULTS

To determine the diagnostic accuracy of low-dose CT (LDCT) in comparison with conventional CT in the detection of renal and ureteric calculi in paediatric patients, this study was conducted over a period of four months (August-November 2025) in the Department of Radiology at the University of Child Health Sciences and The Children Hospital, Lahore. It was a cross-sectional study by observation involving 45 patients aged 16 years and above. Data were collected using a well-constructed, self-administered proforma with a 2-point scale that was dichotomous (present/absent). All the subjects underwent conventional CT as well as LDCT tests after obtaining informed consent of the attendants to the paediatric patients.. The presence, location, size, and quantity of renal and ureteric calculi were evaluated based on the imaging results. Sensitivity, specificity, positive predictive value, negative predictive value, and total accuracy were among the diagnostic performance metrics that were computed. In all 45 paediatric instances included in the study, calculi were successfully detected by both LDCT and conventional CT since all patients had previously verified renal or ureteric calculi on ultrasonography.

**Table 4.1**

*Patients division into Age groups*

| Age of patient | | | |
|---|---|---|---|
| | | Frequency | Percent |
| Valid | 1 day to 8years | 30 | 66.7 |
| | 9 years to 16years | 15 | 33.3 |
| | Total | 45 | 100.0 |

Table 4.1 shows that the majority of patients (66.7%, $n$ =

30) were between 1 day and 8 years, while 33.3% (*n* = 15) belonged to the 9-16 years age group. This indicates a higher prevalence of the studied condition among younger pediatric patients.

**Figure 4.1**

*Shows graphical representation of Age distribution*

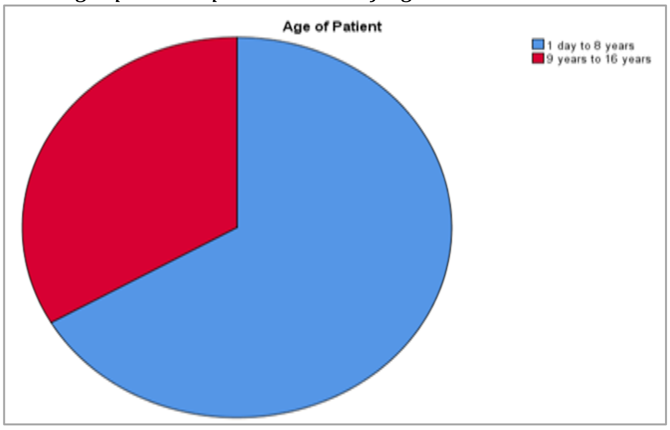


**Table 4.2**

*Frequency of Gender*

| Gender of Patient | | | |
|---|---|---|---|
| | | **Frequency** | **Percent** |
| **Valid** | Male | 28 | 62.2 |
| | Female | 17 | 37.8 |
| | Total | 45 | 100.0 |

Table 4.2 shows male patients constituted 62.2% (*n* = 28) of the study population whereas female patients accounted for 37.8% (*n* = 17). This male predominance suggests a higher occurrence of the condition in males compared to females within the sampled population.

**Figure 4.2**

*Shows Graphical representation of Gender distribution of patients*

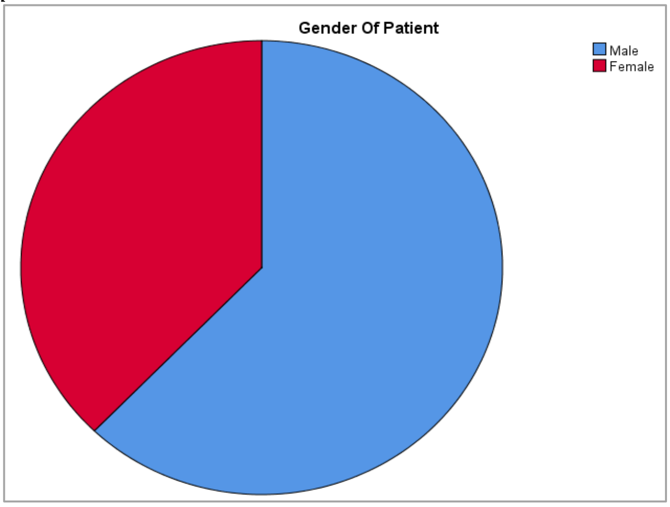


**Table 4.3**

*SOS in LDCT * SOS in Conventional CT Crosstabulation*

| Count | | | | |
|---|---|---|---|---|
| | | **SOS in Conventional CT** | | **Total** |
| | | **0.1mm to5mm** | **5.1mm to 1.5cm** | |
| SOS in LDCT | 0.1mm to 5mm | 23 | 2 | 25 |
| | 5.1mm to 1.5cm | 1 | 19 | 20 |
| Total | | 24 | 21 | 45 |

Table 4.3 shows 23 patients was true positive, 2 false positive, 1 false negative, 19 true negative out of 45 patients

Calculation of Sensitivity and Specificity:

**Table 4.4**

*Sensitivity*

| **Sensitivity:** |
|---|
| Sensitivity=TP/TP+FN×100 |
| =23/23+1*100 |
| =23/24*100= 95.8% |

Table 4.4 show 95.8 % sensitivity value indicates that LDCT is a good measure of stone size in clinically useful categories.

**Table 4.5**

*Specificity*

| **Specificity**: |
|---|
| Specificity=TN/TN+FP*100 |
| =19/19+2*100 |
| =19/21*100= 90.4% |

Table 4.5 show 90.4% specificity value indicates that Low dose CT KUB is reliable in ruling out stones when they are actually absent according to Conventional CT-KUB (gold standard)

**Table 4.6**

*Overall Accuracy*

| **Overall Accuracy:** |
|---|
| Accuracy=TP + TN/Total Population×100 |
| =23+19/45*100 |
| =42/45*100=93.3% |

Table 4.6 show Low-Dose CT-KUB is correctly identify 93.3% of pediatric patients regarding the presence or absence of stones of a particular size when compared with Conventional CT-KUB (gold standard).

**Table 4.7**

*Positive Predictive Value (PPV)*

| **Positive Predictive Value (PPV):** |
|---|
| PPV=TP/FP+TP*100 |
| =23/2+23*100 |
| =23/25*100= 92% |

Table 4.7 shows when Low-Dose CT-KUB detects a stone of a particular size; there is a 92% probability that the stone is truly present according to Conventional CT-KUB (gold standard).

**Table 4.8**

*Negative Predictive Value (PPV)*

| **Negative Predictive Value (NPV)** |
|---|
| =TN/TN+FN |
| =19/19+1*100 |
| =19/20*100=95% |

Table 4.8 shows When Low-Dose CT-KUB shows that a stone of a specific size is NOT present; there is a 95% probability that the patient truly does not have that stone according to Conventional CT-KUB (gold standard). Measures of stone size with LDCT demonstrated high in agreement with traditional CT results. In the case of 0.1mm -5 mm stones, 25 of them were detected by LDCT and 23 were identified by conventional CT. On the same note, in the LDCT of the 5.1mm to 1.5 cm stones, 20 cases were identified, and 19 cases corresponded to the results of conventional CT. This near accordance is an indication

that LDCT is a good measure of stone size in clinically useful categories. By using 2*2 contingency table, calculated diagnostic accuracy of LDCT as compared to conventional CT in detecting least size of renal and ureteric calculi is 93%, Sensitivity of LDCT is 95%, Specificity of LDCT is 90%, Positive predictive value of LDCT is 92%, Negative predictive value is 95%.

**Table 4.9**

*LOS in LDCT * LOS in Conventional CT Crosstabulation count*

| | | LOS in Conventional CT | | Total |
|---|---|---|---|---|
| | | Ureteric Calculi | Renal Calculi | |
| LOS in LDCT | Ureteric Calculi | 22 | 3 | 25 |
| | Renal Calculi | 1 | 19 | 20 |
| Total | | 23 | 22 | 45 |

Table 4.9 shows 22 patients was true positive, 3 false positive, 1 false negative, 19 true negative out of 45 patients Calculation of Sensitivity and Specificity:

**Table 4.10**

*Sensitivity*

| Sensitivity: |
|---|
| Sensitivity=TP/TP+FN×100 |
| =22/22+1*100 |
| =22/23*100= 95.6% |

Table 4.10 show 95.6 % sensitivity value indicates Low-Dose CT-KUB correctly identified 95.6% of pediatric patients who truly had stones at a specific anatomical location, as confirmed by Conventional CT-KUB (gold standard).

**Table 4.11**

*Specificity*

| **Specificity**: |
|---|
| Specificity=TN/TN+FP*100 |
| =19/19+3*100 |
| =19/22*100= 86.3% |

show 86.3% specificity value indicates that good but slightly lower ability of Low-Dose CT to correctly exclude Table 4.11 stones at a specific location.

**Table 4.12**

*Overall Accuracy*

| Overall Accuracy: |
|---|
| Accuracy=TP + TN/Total Population×100 |
| =22+19/45*100 |
| =41/45*100=91.1% |

Table 4.12 Overall diagnostic accuracy 91.1% shows high diagnostic agreement between Low-Dose CT and Conventional CT in identifying stone location.

**Table 4.13**

*Positive Predictive Value (PPV)*

| Positive Predictive Value (PPV): |
|---|
| PPV=TP/FP+TP*100 |
| =22/3+22*100 |
| =22/25*100= 88% |

Table 4.13 shows that there is 88% probability that the stone is truly present at that location according to Conventional CT-KUB (gold standard).

**Table 4.14**

*Negative Predictive Value (PPV)*

| Negative Predictive Value (NPV) |
|---|
| =TN/TN+FN |
| =19/19+1*100 |
| =19/20*100=95% |

Table 4.14 shows excellent reliability in ruling out stone location When assessing the location of stones, LDCT correctly detected 20 renal calculi, 19 of which were congruent with conventional CT results, and 25 ureteric calculi, 22 of which were verified by conventional CT. According to table 4.9, these results reveal that LDCT has a high diagnostic consistency with the standard imaging modality and is useful in accurately localizing stones inside the urinary system. Using a 2*2 table, the computed diagnostic accuracy of LDCT compared to conventional CT in identifying the precise location of renal and ureteric calculi is 91%, its sensitivity is 95%, its specificity is 86%, its positive predictive value is 88%, and its negative predictive value is 95%.

**Table 4.15**

*NOS in LDCT* NOS in Conventional CT Crosstabulation*

| Count | | NOS in Conventional CT | | Total |
|---|---|---|---|---|
| | | more than 1 stone | 1 stone | |
| NOS in LDCT | more than 1 stone | 23 | 2 | 25 |
| | 1 stone | 1 | 19 | 20 |
| Total | | 24 | 21 | 45 |

Table 4.15 shows 23 patients was true positive, 2 false positive, 1 false negative, 19 true negative out of 45 patients Calculation of Sensitivity and Specificity:

**Table 4.16**

*Sensitivity*

| Sensitivity: |
|---|
| Sensitivity=TP/TP+FN×100 |
| =23/23+1*100 |
| =23/24*100= 95.8% |

Table 4.16 show 95.8 % sensitivity value indicates that **e**xcellent ability of Low-Dose CT-KUB to detect the correct number of stones.

**Table 4.17**

*Specificity*

| **Specificity**: |
|---|
| Specificity=TN/TN+FP*100 |
| =19/19+2*100 |
| =19/21*100= 90.4% |

Table 4.17 shows 90.4% specificity value indicates that Low dose CT KUB has high reliability in ruling out extra stones.

**Table 4.18**

*Overall Accuracy*

| Overall Accuracy: |
|---|
| Accuracy=TP + TN/Total Population×100 |
| =23+19/45*100 |
| =42/45*100=93.3% |

Table 4.18 Overall diagnostic accuracy 93.3% indicates high diagnostic agreement between Low-Dose CT and Conventional CT in detecting the correct number of stone

**Table 4.19**

*Positive Predictive Value (PPV)*

| Positive Predictive Value (PPV): |
|---|
| PPV=TP/FP+TP*100 |
| =23/2+23*100 |
| =23/25*100= 92% |

Table 4.19 shows high reliability when Low-Dose CT detects stones as compared to conventional CT.

**Table 4.20**

*Negative Predictive Value (PPV)*

| Negative Predictive Value (NPV) |
|---|
| =TN/TN+FN |
| =19/19+1*100 |
| =19/20*100=95% |

Table 4.20: Shows excellent reliability of low dose CT KUB in ruling out stones.

A good degree of agreement was found when comparing the stone number between LDCT and traditional CT. While single stones were found in 20 patients, with 19 cases supported by conventional CT results, LDCT found multiple stones in 25 patients, with 23 cases verified by conventional CT. As indicated in table 4.15, this further demonstrates the accuracy with which LDCT can determine stone burden. Using a 2*2 table, it was determined that LDCT had a diagnostic accuracy of 93.3% when compared to conventional CT in identifying the precise number of renal and ureteric calculi. Its sensitivity was 96%, its specificity was 90%, its positive predictive value was 92%, and its negative predictive value was 95%.

## DISCUSSION

In the comparison of the number of stones found in LDCT and conventional CT, it was found to have a high level of agreement. Although LDCT revealed many stones in 25 patients and 23 of them were proved by conventional CT data, 20 patients had single stones that were revealed by LDCT and 19 of them were proved by conventional CT data. This also depicts the effectiveness of LDCT in detection of stone burden as it is observed in table 4.15. Diagnostic accuracy of LCCT was found to be 93.3 percent in estimating the precise number of renal and ureteric calculi when compared to conventional CT (2 x 2 contingency table). Its positive predictive value was 92, its negative predictive value was 95, its sensitivity was 96 and its specificity was 90. The results of the current study indicate that the LDCT-KUB is a high-quality diagnostic test with the sensitivity, specificity, and diagnostic accuracy of the test being similar to the traditional CT-KUB. The findings suggest that a reduced dose of radiation does not have any significant effect on both the quality of the picture and the confidence in the diagnostic result in the cases of assessing paediatric urolithiasis. Consequently, LDCT-KUB appears to be a better and safer alternative imaging procedure that can be reliably used to determine the presence of renal and ureteral calculi and reduces any possible radiation risks in the long run. This justifies the increasing movement by recommending low-dose CT to be used on routine basis in children suspected to have a urinary tract stone. Renal and ureteric calculi are comparatively more common in early childhood, as evidenced by the fact that the majority of patients (66.7) in the current study were in the younger age category of paediatric, younger than 1 day to 8 years old. This observation means that paediatric urolithiasis can develop in infancy and early childhood in addition to children and teenagers. However, a number of variables, including inadequate hydration, dietary imbalances, metabolic problems, and environmental factors, can account for the early onset of stone disease. The findings are in line with those of Amjad Sattar et al. and Marsoul et al., who also noted a high prevalence of urinary stone illness in younger children. Particularly in regions with warm temperatures, such as Pakistan, where ambient temperatures are likely to contribute to dehydration and concentrated urine and hence promote the development of stones, there has been an increased frequency in these age groups (26, 27). Moreover, as 62.2% of the research sample was male, the current study had a high male dominance. The gender distribution is also similar to other published studies done previously, such as Soliman and Sakr (2020) and Ahmed Danoon Marsoul et al. (2018), who also found a higher prevalence of urolithiasis in male patients. The feminisation effect has been attributed to hormonal influences, metabolic variations, and factors that are related to lifestyle. It has been demonstrated that testosterone enhances urine oxalate production and oestrogen is protective in that, it suppresses the formation of calcium oxalate crystal. This deviation can also be occasioned by the difference in eating patterns, physical activity, and fluid consumption between male and female children. The age and gender distribution of this paper is mostly aligned with the regional and international studies that endorse the epidemiological patterns of paediatric urolithiasis (28). The present research report concluded that the total diagnostic rate of low dose CT-KUB (LDCT) in detecting the renal and ureteral calculi is 93 percent which is relatively similar to the findings reported in earlier articles. In a comparative analysis by Soliman and Sakr (2020), the general diagnosis accuracy of low-dose CT procedures was reported to be more than 95 percent, and in a study by Pari Gul et al. (2024), the accuracy was 91.67 percent. A drastically reduced radiation dose does not have a significant effect on the diagnostic capability even in the paediatric population as seen by the almost identical results of the current study with other studies. These findings suggest that LDCT-KUB can generate a diagnostically suitable image, which can be used to identify renal and ureteral calculus correctly (29). The second evidence to substantiate the effectiveness and usefulness of low-dose CT procedures as a valid and credible alternative to the conventional CT-KUB is the high diagnostic quality of the specified investigation. Children are highly susceptible to the damaging long-term effects of ionizing radiation because they have undeveloped tissues and live longer. Since LDCT-KUB has the lowest radiation dose, diagnostic reliability, is a compromise between patient safety and diagnostic effectiveness. This means that the results of the current study support the common practice of using low-dose CT methods in routine paediatric imaging particularly in the diagnosis and treatment of suspected urinary tract stone disease. (30). The sensitivity and specificity of the CT-KUB of the current study was low; 96 and 95, respectively, but it is a very good sign showing the ability of this mode of imaging to determine the presence and, by implication, the absence of renal and ureteric calculi. It is especially relevant to the paediatric patients, as a misdiagnosis can lead to self-limiting symptoms, delays of the therapy, urinary obstruction, or infection. High specificity also aids in avoiding unnecessary therapeutic interventions and other imaging since it ensures that there is low percentage of false-positive outcomes. These results are similar to those of Sharaf et al. (2023), who found sensitivity of between 90 and 97 per cent with ultra-low-dose CT, or Marsoul et al. (2018), who found a sensitivity of 93 per cent and specificity of 100. The validity of LDCT-KUB in a variety of clinical settings and imaging modalities is supported by the close proximity of these studies (31The slightly high sensitivity of the study can be explained by the use of modern multi-slice CT equipment, which provides a better spatial resolution and image reconstruction at a reduced radiation dose. Also, the interpretation provided by only one competent radiologist of the images would have also helped to enhance consistency in the diagnosis of the images through reduction of inter-observer variation. Its great specificity also shows that LDCT-KUB will produce a limited number of false-positive results that can be used to make accurate diagnosis, false-negative ones can be avoided, and unnecessary procedures and questioning that are particularly crucial when dealing with children (32). In terms of the size of stones, which was assessed in this experiment, LDCT was demonstrated to be in agreement with the traditional CT to a considerable extent among both little (0.1-5 mm) and big (5.1 mm-1.5 cm) stones that were considered. As it has been revealed by Aggarwal et al. (2023) and Matthew J. Roberts et al. (2020), the diagnostic usefulness of LDCT in detecting small stones was determined to be 93. These studies demonstrate that although very small stones (less than 3 mm) can sometimes be missed at lower radiation doses because of excessive picture noise and partial volume effects, at higher radiation doses LDCT is very sensitive in detecting calculi greater than 3 mm in diameter with a high degree of confidence. But since small calculi can easily be expelled by themselves and may not need any intrusive treatment, one can tolerate these limitations in clinical practice. In general, the results also indicate that LDCT-KUB is a clinically viable tool in assessing the presence of paediatric urolithiasis (33). The current experiment did not show any major differences in the observation of incredibly small calculi. Because these discrepancies are deemed clinically acceptable because stones of such magnitude often pass spontaneously without the need of invasive intervention or surgical intervention. Moreover, in paediatric patients, where conservative treatment is often preferred, small calculi have an even smaller chance to contribute to quick clinical decision-making. Such results also reinforce the importance of low-dose CT-KUB (LDCT) in regular practice in paediatrics, because the most significant is the balance between radiations and quality of diagnosis (34). Since it directly influences the course of therapy and treatment approach, proper localization of calculi in the urinary tract is an important part of the imaging assessment. In the present study, LDCT had a diagnostic accuracy of 91 in localization of stones, sensitivity of 92 and specificity of 95. The findings show that there is a high level of correlation between LDCT and conventional CT-KUB in determining the exact anatomical location of stones. The results are in line with Roberts et al. (2020) and Kandasamy et al. (2024), who also reported increased concordance rates in ureteric stones relative to renal stones, especially with low-dose imaging protocol. (35,36). The minor decrease in the precision of calyceal stone detection demonstrated by some studies have been attributed to the small size of the calyceal stones and problems with partial volume effects, which are more pronounced in low radiation dose cases. The complexity of the kidney and respiratory movement can possibly have a secondary impact on the appearance of small calculi in renal interstitium. These potential limitations have not been found to affect the current investigation wherein LDCT-KUB remains rather efficient in distinguishing between renal and ureteric calculi. LDCT-KUB is a suitable image modality to diagnose and treat paediatric urolithiasis and this performance suffices to make clinical decisions (36). Due to the fact that it is directly related to the discussion of whether or not the conservative management regimen, medical expulsive therapy, or surgery is to be discussed, stone load evaluation is a major consideration in the decision making that is to be made to address paediatric urolithiasis. In the current trial Low-dose CT-KUB (LDCT) has proven to be very accurate in terms of the number of calculi (93 percent), sensitivity (96 percent), and specificity (90 percent). These results indicate that the level of consensus between LDCT and conventional CT-KUB is very high as far as sorting single and many stones is concerned. The findings of Marsoul et al. (2018) and Harsha (2020) are consistent with the fact that low dose and standard CT methods have high concordance in measuring the load of stones (37). The minor discrepancies that were found in the present study were largely attributed to the discovery of several relatively small calculi. Nevertheless, since the choice is often made between therapeutic options that are determined by the size, location and the symptoms of the largest stone and not by the precise number of small calculi, these variations are generally not particularly clinically relevant. Therefore, treatment strategies or patient outcomes would not be affected by the slight variations. On the whole, the results prove that LDCT-KUB could be considered a good and effective tool in identifying a stone load of a paediatric patient (38). One of the most valuable aspects that this study shows about LDCT-KUB is that the technology has the potential to achieve high radiation dose reductions without compromising the diagnostic accuracy. This is specifically important to paediatric patients, who are more prone to negative radiation effects because they are inherently more radiosensitive and have longer life expectancies. Therefore, radiation safety is an important clinical and ethical problem in paediatric imaging. The findings of the current research strongly relate to the international guidelines provided by such organizations as the American Urological Association (AUA) and the European Association of Urology (EAU) that promotes the use of low-dose imaging regimes in children wherever feasible and dose optimizing strategies. The implementation of LDCT-KUB is in line with those recommendations and it helps to promote safer and evidence based imaging in pediatric urolithiasis (39). The current study's results are in line with those of systematic reviews by Xiang et al. (2017) and Chen et al. (2015), which both showed that low-dose CT methods significantly reduce radiation exposure while preserving high diagnostic reliability for the identification of urinary tract calculi. These in-depth studies had pointed to the fact that major dosage cuts can be realized without any noticeable decline in image quality or diagnostic performance due to the advances in CT equipment and dose optimization methods. In light of these findings, follow-up examinations and LDCT-KUB are safe to use in paediatric patients with possible or recurring urolithiasis, and as a first-line imaging modality to minimize cumulative radiation exposure over time (40). The low-dose CT-KUB is a reliable, more precise, and safer method of detecting renal and ureteric calculi among paediatric patients than the usual CT-KUB, based on the overall results of the study and the strong correlation with previous studies. LDCT-KUB can be introduced into the routine clinical practice to achieve a significant reduction in radiation exposure at the cost of the diagnostic accuracy. Finally, the high prevalence of the LDCT procedures will lead to enhanced patient safety, increased adherence to ethical imaging principles, and compliance with the global standards of radiation protection in paediatric imaging (41).

## CONCLUSION

In the research, low-dose CT-KUB has been demonstrated to be equally diagnostic as conventional CT-KUB with regards to the detection of renal and ureteric calculi in paediatric patients. The findings were excellent in terms of sensitivity, specificity, and diagnostic accuracy in identifying, locating, size and quantity of stones. Crucially, LDCT addressed a major safety concern in children by achieving these benefits while drastically lowering radiation dose. LDCT-KUB is a safer and more dependable imaging option because urolithiasis is recurring and the paediatric population is more radiosensitive. Consequently, without sacrificing diagnostic quality, low-dose CT-KUB can be confidently advised as a first-line or follow-up imaging modality in paediatric urolithiasis.

### Limitations

There are a number of limitations to this study that should be taken into account. The single-center approach and somewhat small sample size may restrict the findings' applicability to larger populations and various healthcare environments. Furthermore, the study's cross-sectional design made it impossible to assess long-term results or the recurrence of renal and ureteric calculi. It's possible that a single radiologist's interpretation of the images introduced observer bias and hindered the evaluation of inter-observer variability. Additionally, radiation dose settings were protocol-based rather than patient-specific, and extremely small calculi may have been overlooked on low-dose CT due to increased picture noise at lower radiation levels.

### Recommendations

To reduce radiation exposure, it is advised that low-dose CT-KUB be used as the initial imaging modality for identifying renal and ureteric calculi in paediatric patients; conventional CT-KUB should be saved for situations with unclear results or suspected complicated disease. Low-dose techniques should be regularly incorporated into standardized and optimized paediatric CT regimens. Larger multi-center studies are also required to validate and generalize these results, and in order to minimize bias and evaluate inter-observer reliability, future research should involve numerous radiologists. It is also advised to do long-term follow-up studies to assess cumulative radiation exposure, recurrence rates, and clinical outcomes.

## REFERENCES

1. Zeng, G., Zhu, W., Somani, B., Choong, S., Straub, M., Maroccolo, M. V., Kamal, W., Ibrahim, T. A., Cho, A., Mazzon, G., Chai, C. A., Ferretti, S., Zhong, W., Onal, B., Mohamed, O., Saulat, S., Jurkiewicz, B., Sezer, A., Liu, Y., … Sarica, K. (2024). International alliance of urolithiasis (IAU) guidelines on the management of pediatric urolithiasis. *Urolithiasis*, *52*(1). https://doi.org/10.1007/s00240-024-01621-z
2. Xiang, H., Chan, M., Brown, V., Huo, Y. R., Chan, L., & Ridley, L. (2017). Systematic review and meta-analysis of the diagnostic accuracy of low-dose computed tomography of the kidneys, ureters and bladder for urolithiasis. *Journal of Medical Imaging and Radiation Oncology*, *61*(5), 582-590. https://doi.org/10.1111/1754-9485.12587
3. Ubeda, C., Vano, E., Perez, M., Jimenez, P., Van Deventer, E., Ramirez, R., Nader, A., & Miranda, P. (2023). Optimization of radiation protection in pediatric interventional radiology in Latin America and the Caribbean: Development, advancements, challenges and achievements of the OPRIPALC program. *Children*, *10*(12), 1858. https://doi.org/10.3390/children10121858
4. Smith-Bindman, R., Moghadassi, M., Wilson, N., Nelson, T. R., Boone, J. M., Cagnon, C. H., Gould, R., Hall, D. J., Krishnam, M., Lamba, R., McNitt-Gray, M., Seibert, A., & Miglioretti, D. L. (2015). Radiation doses in consecutive CT examinations from five University of California medical centers. *Radiology*, *277*(1), 134-141. https://doi.org/10.1148/radiol.2015142728
5. Shabbir, R., Reddy, R., Camejo, L., Dhanikonda, N., Woodford, A., & Meshekow, J. (2025). Recent developments in pediatric interventional radiology: Growth, innovation, and clinical outcomes. *Journal of Medical Imaging and Interventional Radiology*, *13*(1). https://doi.org/10.1007/s44326-025-00089-4
6. Jaiswal, P., Shrestha, S., Dwa, Y., Maharjan, D., & Sherpa, N. T. (2022). CT KUB evaluation of suspected urolithiasis. *Journal of Patan Academy of Health Sciences*, *9*(1), 58-64. https://doi.org/10.3126/jpahs.v9i1.43895
7. Sattar, A., & Hafeez, M. (2020). Efficacy of plain computed tomography (CT) abdomen for urinary stone disease in symptomatic patients. *Methodology*.
8. Poletti, P., Platon, A., Rutschmann, O. T., Schmidlin, F. R., Iselin, C. E., & Becker, C. D. (2007). Low-dose versus standard-dose CT protocol in patients with clinically suspected renal colic. *American Journal of Roentgenology*, *188*(4), 927-933. https://doi.org/10.2214/ajr.06.0793
9. Niemann, T., Kollmann, T., & Bongartz, G. (2008). Diagnostic performance of low-dose CT for the detection of urolithiasis:

A meta-analysis. *American Journal of Roentgenology*, *191*(2), 396-401. https://doi.org/10.2214/ajr.07.3414

10. Moore, C. L., Daniels, B., Ghita, M., Gunabushanam, G., Luty, S., Molinaro, A. M., Singh, D., & Gross, C. P. (2015). Accuracy of reduced-dose computed tomography for ureteral stones in emergency department patients. *Annals of Emergency Medicine*, *65*(2), 189-198.e2. https://doi.org/10.1016/j.annemergmed.2014.09.008
11. Marsoul, A., Rasool, H., & Judi, M. (2018). A comparison between low dose and standard dose computed tomography scan in detection of urolithiasis. *Medical Journal of Babylon*, *15*(3), 258. https://doi.org/10.4103/mjbl.mjbl_78_18
12. Marsoul, A., Rasool, H., & Judi, M. (2018). A comparison between low dose and standard dose computed tomography scan in detection of urolithiasis. *Medical Journal of Babylon*, *15*(3), 258. https://doi.org/10.4103/mjbl.mjbl_78_18
13. Li, H., Jelley, C. R., Forster, L., Arad, J., Mudhar, G. S., Bardgett, H. P., Stewart, A. B., & Forster, J. A. (2022). Ultra-low-dose CTKUB: The new standard of follow-up of ureteric calculi not visible on plain radiograph? *International Urology and Nephrology*, *54*(4), 781-787. https://doi.org/10.1007/s11255-022-03134-3
14. Lee, J. Y., Andonian, S., Bhojani, N., Bjazevic, J., Chew, B. H., De, S., Elmansy, H., Lantz-Powers, A. G., Pace, K. T., Schuler, T. D., Singal, R. K., Wang, P., & Ordon, M. (2021). Canadian urological association guideline: Management of ureteral calculi. *Canadian Urological Association Journal*, *15*(12). https://doi.org/10.5489/cuaj.7581
15. Kandasamy, M., Chan, M., Xiang, H., Chan, L., & Ridley, L. (2023). Comparison of diagnostic accuracy of ultra low-dose computed tomography and X-ray of the kidneys, ureters and bladder for urolithiasis in the follow-up setting. *Journal of Medical Imaging and Radiation Oncology*, *68*(2), 132-140. https://doi.org/10.1111/1754-9485.13605
16. Ellison, J. S., & Yonekawa, K. (2018). Recent advances in the evaluation, medical, and surgical management of pediatric Nephrolithiasis. *Current Pediatrics Reports*, *6*(3), 198-208. https://doi.org/10.1007/s40124-018-0176-5
17. DOAA E. SHARAF; RIEHAM S., W. A. (2024). Ultra-low dose multi-detector CT-KUB for identification of urinary tract stones. *The Medical Journal of Cairo University*, *92*(06), 575-0. https://doi.org/10.21608/mjcu.2024.371366
18. Allam, E. A. (2024). Urolithiasis unveiled: Pathophysiology, stone dynamics, types, and inhibitory mechanisms: a review. *African Journal of Urology*, *30*(1). https://doi.org/10.1186/s12301-024-00436-z
19. Chen, T. T., Wang, C., Ferrandino, M. N., Scales, C. D., Yoshizumi, T. T., Preminger, G. M., & Lipkin, M. E. (2015). Radiation exposure during the evaluation and management of Nephrolithiasis. *Journal of Urology*, *194*(4), 878-885. https://doi.org/10.1016/j.juro.2015.04.118
20. Den Harder, A. M., Willemink, M. J., Van Doormaal, P. J., Wessels, F. J., Lock, M. T., Schilham, A. M., Budde, R. P., Leiner, T., & De Jong, P. A. (2017). Radiation dose reduction for CT assessment of urolithiasis using iterative reconstruction: A prospective intra-individual study. *European Radiology*, *28*(1), 143-150. https://doi.org/10.1007/s00330-017-4929-2
21. Brenner, D. J., Elliston, C. D., Hall, E. J., & Berdon, W. E. (2001). Estimated risks of radiation-induced fatal cancer from pediatric CT. *American Journal of Roentgenology*, *176*(2), 289-296. https://doi.org/10.2214/ajr.176.2.1760289
22. Wilcox, C. R., Whitehurst, L. A., Cook, P., & Somani, B. K. (2020). Kidney stone disease: An update on its management in primary care. *British Journal of General Practice*, *70*(693), 205-206. https://doi.org/10.3399/bjgp20x709277
23. Shim, Y. S., Park, S. H., Choi, S. J., Ahn, S. J., Pak, S. Y., Jung, H., & Park, S. H. (2019). Comparison of submillisievert CT with standard-dose CT for urolithiasis. *Acta Radiologica*, *61*(8), 1105-1115. https://doi.org/10.1177/0284185119890088
24. Roberts, M. J., Williams, J., Khadra, S., Nalavenkata, S., Kam, J., McCombie, S. P., Arianayagam, M., Canagasingham, B., Ferguson, R., Khadra, M., Varol, C., Winter, M., Sanaei, F., Loh, H., Thakkar, Y., Dugdale, P., & Ko, R. (2020). A prospective, matched comparison of ultra-low and standard-dose computed tomography for assessment of renal colic. *BJU International*, *126*(S1), 27-32. https://doi.org/10.1111/bju.15116
25. Shah, L., Ansari, F., Ahmad, M., Younis, M. N., & Ali, Z. (2025). Diagnostic accuracy of flourodeoxyglucose-18 positron emission computed tomography in the evaluation of recurrent papillary thyroid carcinoma with patients' raised thyroglobulin level in Lahore. *Indus Journal of Bioscience Research*, *3*(8), 97-104. https://doi.org/10.70749/ijbr.v3i8.1842
26. Marsoul, A., Rasool, H., & Judi, M. (2018). A comparison between low dose and standard dose computed tomography scan in detection of urolithiasis. *Medical Journal of Babylon*, *15*(3), 258. https://doi.org/10.4103/mjbl.mjbl_78_18
27. Sattar A, Hafeez M. Efficacy of plain computed tomography (CT) abdomen for urinary stone disease in symptomatic patients. Vol. 12. 2020;12(3). https://www.imj.com.pk/wp-content/uploads/2020/09/4.-B-1-OA-1077-03-20-Efficacy-of-plain-computed-tomography-CT-abdomen.pdf
28. Soliman, A., & sakr, L. (2020). Evaluation of the accuracy of low dose CT in the detection of urolithiasis in comparison to standard dose CT. *Al-Azhar International Medical Journal*, *0*(0), 0-0. https://doi.org/10.21608/aimj.2020.22462.1082
29. Zubair, M., Javed, M., Javed, A., Ali, N., Iqbal, Z., & Javaid, M. (2019). Ultrasonography determination of renal stones with flank pain among children at radiology department of children hospital Lahore, Pakistan. *ASRJETS*, *60*(1), 184-90.
30. Shabbir, R., Reddy, R., Camejo, L., Dhanikonda, N., Woodford, A., & Meshekow, J. (2025). Recent developments in pediatric interventional radiology: Growth, innovation, and clinical outcomes. *Journal of Medical Imaging and Interventional Radiology*, *13*(1). https://doi.org/10.1007/s44326-025-00089-4
31. Smith-Bindman, R., Moghadassi, M., Wilson, N., Nelson, T. R., Boone, J. M., Cagnon, C. H., Gould, R., Hall, D. J., Krishnam, M., Lamba, R., McNitt-Gray, M., Seibert, A., & Miglioretti, D. L. (2015). Radiation doses in consecutive CT examinations from five University of California medical centers. *Radiology*, *277*(1), 134-141. https://doi.org/10.1148/radiol.2015142728
32. Aggarwal, G., & Adhikary, S. D. (2022). Assessment of the efficacy of reduced-radiation noncontrast computed tomography scan compared with the standard noncontrast computed tomography scan for detecting urolithiasis: A prospective single-center study. *Current Urology*, *17*(1), 18-24. https://doi.org/10.1097/cu9.0000000000000162
33. Jaiswal, P., Shrestha, S., Dwa, Y., Maharjan, D., & Sherpa, N. T. (2022). CT KUB evaluation of suspected urolithiasis. *Journal of Patan Academy of Health Sciences*, *9*(1), 58-64. https://doi.org/10.3126/jpahs.v9i1.43895

34. Kandasamy, M., Chan, M., Xiang, H., Chan, L., & Ridley, L. (2023). Comparison of diagnostic accuracy of ultra low-dose computed tomography and X-ray of the kidneys, ureters and bladder for urolithiasis in the follow-up setting. *Journal of Medical Imaging and Radiation Oncology*, *68*(2), 132-140. https://doi.org/10.1111/1754-9485.13605
35. Roberts, M. J., Williams, J., Khadra, S., Nalavenkata, S., Kam, J., McCombie, S. P., Arianayagam, M., Canagasingham, B., Ferguson, R., Khadra, M., Varol, C., Winter, M., Sanaei, F., Loh, H., Thakkar, Y., Dugdale, P., & Ko, R. (2020). A prospective, matched comparison of ultra-low and standard-dose computed tomography for assessment of renal colic. *BJU International*, *126*(S1), 27-32. https://doi.org/10.1111/bju.15116
36. Shim, Y. S., Park, S. H., Choi, S. J., Ahn, S. J., Pak, S. Y., Jung, H., & Park, S. H. (2019). Comparison of submillisievert CT with standard-dose CT for urolithiasis. *Acta Radiologica*, *61*(8), 1105-1115. https://doi.org/10.1177/0284185119890088
37. Rodger, F., Roditi, G., & Aboumarzouk, O. (2018). Diagnostic accuracy of low and ultra-low dose CT for identification of urinary tract stones: A systematic review. *Urologia Internationalis*, *100*(4), 375-385. https://doi.org/10.1159/000488062
38. Moore, C. L., Daniels, B., Ghita, M., Gunabushanam, G., Luty, S., Molinaro, A. M., Singh, D., & Gross, C. P. (2015). Accuracy of reduced-dose computed tomography for ureteral stones in emergency department patients. *Annals of Emergency Medicine*, *65*(2), 189-198.e2. https://doi.org/10.1016/j.annemergmed.2014.09.008
39. Xiang, H., Chan, M., Brown, V., Huo, Y. R., Chan, L., & Ridley, L. (2017). Systematic review and meta-analysis of the diagnostic accuracy of low-dose computed tomography of the kidneys, ureters and bladder for urolithiasis. *Journal of Medical Imaging and Radiation Oncology*, *61*(5), 582-590. https://doi.org/10.1111/1754-9485.12587
40. Zeng, G., Zhu, W., Somani, B., Choong, S., Straub, M., Maroccolo, M. V., Kamal, W., Ibrahim, T. A., Cho, A., Mazzon, G., Chai, C. A., Ferretti, S., Zhong, W., Onal, B., Mohamed, O., Saulat, S., Jurkiewicz, B., Sezer, A., Liu, Y., … Sarica, K. (2024). International alliance of urolithiasis (IAU) guidelines on the management of pediatric urolithiasis. *Urolithiasis*, *52*(1). https://doi.org/10.1007/s00240-024-01621-z