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# Role of Computed Tomography in the Evaluation of Urolithiasis.

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**ABSTRACT**

Urolithiasis refers to stones originating anywhere in the urinary system, including the kidneys, ureters and bladder. Radiological Imaging enables not only the diagnosis of urinary tract calculi, but also the characterization of stones, planning and stratification of further treatment and prediction of response to such treatment. Computed tomography-KUB (CT-KUB) is now accepted as the gold standard imaging modality for urinary tract calculi because of its high diagnostic accuracy. This study evaluated the efficiency and reliability of CT scan for the diagnosis of urolithiasis in the patients with flank pain prospectively. Fifty patients with radiologically diagnosed Urolithiasis were included in this study. CT imaging was performed with 128 slice Philips ingenuity CT scanner. In this study it was observed that the most common side affected for urinary tract stone was right (40%) followed by left side (30%) and bilateral (30%). Most of the patients had unilateral stones (70%) followed by bilateral (30%). In the present study, it was observed that nephrolithiasis (56%) and ureterolithiasis (28%) were the most common in patients with urolithiasis. Our result confirms the significant role of non-contrast computed tomography scan in evaluating Urolithiasis. From the results, it has been concluded that the CT-KUB is the gold standard investigation for the diagnosis of urinary tract stones.

**Keywords:** tomography, urolithiasis, CT-KUB, urinary stones.

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## INTRODUCTION

Kidney stone disease, also known as urolithiasis, is the condition when a solid piece of material develops in the urinary tract. It is an increasing urological disorder of human health, affecting about 12% of the world population [1]. A small stone may pass without causing symptoms. If a stone grows to more than 5 millimeters, it can cause blockage of the ureter resulting in severe pain in the lower back or abdomen. About half of people will have another stone within ten years [2]. Stones form in the kidney when minerals in urine are at high concentration. The diagnosis is usually based on symptoms, urine testing, and medical imaging. Blood tests may also be useful. Stones are typically classified by their location: nephrolithiasis (in the kidney), ureterolithiasis (in the ureter), cystolithiasis (in the bladder), or by what they are made of (calcium oxalate, uric acid, struvite, cystine) [3].

Urolithiasis refers to stones originating anywhere in the urinary system, including the kidneys, ureters and bladder [3]. Nephrolithiasis refers to the presence of such stones in the kidneys. Calyceal calculi are aggregations in either the minor or major calyx, parts of the kidney that pass urine into the ureter [3]. The condition is called ureterolithiasis when a calculus is located in the ureter. Solid calculi which are primarily found in the urinary bladder are called bladder stones [4]. Stones less than 5 mm in diameter pass spontaneously in up to 98% of cases, while those measuring 5 to 10 mm in diameter pass spontaneously in less than 53% of cases [5]. Stones that are large enough to fill out the renal calyces are called staghorn stones, and are composed of struvite in a vast majority of cases, which forms only in the presence of urease-forming bacteria.

Various laboratory examinations can be performed for the diagnosis of renal stones. Microscopic examination of the urine, which may show red blood cells, bacteria, leukocytes, urinary casts, and crystals are performed routinely. Urine culture are occasionally required to identify any infecting organisms present in the urinary tract and sensitivity to determine the susceptibility of these organisms to specific antibiotics. Complete blood count, renal function tests, 24 hour urine collection are some other investigations which can be performed for the diagnosis of renal calculus. Radiological imaging of kidney stone is an important diagnostic tool and initial step in deciding which therapeutic options to use for the management of kidney stones [6]. For the diagnosis of urinary tract stones, a variety of imaging modalities are available to the practicing urologist, including conventional radiography (KUB), intravenous urography (IVU), ultrasound (US), magnetic resonance urography, and computed tomography (CT) scans, each with its advantages and limitations. [7]. Accurate imaging is of the utmost importance in the diagnosis of urinary calculi.

The kidneys/ureters/bladder (KUB) radiograph is considered most useful in the follow-up of previously detected radio-opaque calculi and in planning and assessing the effects of therapeutic interventions [6]. Intravenous urography (IVU) has largely been superseded by Computed tomography-KUB (CT-KUB) in recent years, as the latter has a higher sensitivity [8]. Ultrasound plays an important role in diagnosing urinary tract calculi. It is a safe and readily available imaging technique, but its sensitivity is modest and hugely dependent on the operator and the body habitus of the patient. The advantage of ultrasound relates to its relative portability and lack of non-ionizing radiation [9].

CT-KUB is now the accepted gold standard imaging modality for urinary tract calculi as a result of its high diagnostic accuracy [10]. Most stones will be visible on unenhanced CT with a sensitivity of 95 per cent in the diagnosis of acute ureteric colic. Jaiswal et al. evaluated the use of CT KUB in suspected urolithiasis in the patients with severe flank pain where they demonstrated the CT KUB as the gold standard [11]. CT-KUB allows for rapid diagnosis of renal calculi and has been adopted in many centers as a first-line imaging strategy for renal stones because of its unparalleled ability in diagnosis of ureteric calculi [6]. The presence of hydronephrosis and other signs of urinary tract obstruction can also be elucidated from CT-KUB, and accurate measurements of stone size can be undertaken [6]. CT-KUB allows for 3-D reconstructions of data and is especially useful in planning PCNL procedures. Plain CT is combined with a contrast enhanced CT pyelogram to facilitate accurate representation of the calyceal anatomy and planning of percutaneous tracks [12]. Lowe et al. conducted a study in which they demonstrated the importance of abdominal and pelvic CT in revealing multiple ureteric calculus in the patients with acute flank pain [13].

Some additional imaging procedures are also important such as Radionuclide imaging, Magnetic resonance urography (MRU) and retrograde ureterorenography. Radionuclide imaging using $^{99m}$Tc-MAG3 can be of use in determining the secondary effects of calculi, namely obstruction and subsequent relative loss of function between the two kidneys [14]. It is especially useful in the determination of ongoing obstruction in those patients with long-standing ureteric/pelvicalyceal dilation. Magnetic resonance urography (MRU) can be utilized for children or pregnant patients where radiation is contraindicated. It allows for depiction of ureteric/pelvicalyceal dilation as a result of obstruction, but accurate identification of a calculus may be challenging as many artefacts mimicking stones may be encountered [15]. Retrograde ureterorenography can be performed to demonstrate and assist in the removal of stones at cytoscopy and ureteroscopy through endoscopic cannulation of the ureter and subsequent retrograde injection of contrast material [16]. However, retrograde ureterorenography may be utilized if other investigations have proven inconclusive.

Each modality has its differing strengths and weaknesses, and the choice of imaging technique should always relate back to the strength of clinical suspicion. In those non-emergent patients with vague symptoms, investigation with plain film KUB and ultrasound may be sufficient. However, it is now well established that CT-KUB is the gold standard investigation for the diagnosis of urinary tract stones and its use in the acute setting is the optimal means of investigating urinary calculi.(6) In this study, we have evaluated the efficiency and reliability of CT scan for the diagnosis of urolithiasis in the patients with flank pain.

## MATERIALS AND METHODS

A prospective study was conducted on 50 patients (33 male & 17 female; Age: 2-60 years) with clinical impression of urolithiasis. This study has been approved by the institutional review committee of S.V.S.U. Subharti Medical College, Meerut, India. All patients with radiologically diagnosed Urolithiasis were included in this study. However, pregnant patient and the patients having contrast allergy were excluded in this study. The clinical history of each patient was recorded and underwent routine biochemical investigations as per Performa. Flank pain was the most common clinical Symptom. In this study, CT imaging was performed with 128 slice Philips ingenuity CT scanner.

The procedure was briefly explained to the patient including the risks of contrast examination. Routine blood investigation like serum creatinine was mandatorily performed on patient before performing contrast enhanced CT. Patients were advised to take nothing but clear liquids at least 4 hours before the exam. Informed consent was taken from all the patients before CT examination. All the metallic objects were removed from the body before CT examination. Proper breathing instruction was given to the patient. Image acquisition of patients was taken during full bladder. Non-ionic contrast media was used for enhanced CT whenever prescribed. CT acquisition and the diagnosis of urolithiasis was done as by the qualified technologist and radiologists respectively as per departmental protocols. CT acquisition parameters have been presented in the table 1. Statistical analysis were done using SPSS 19.

## RESULTS

Among the 50 patients who had undergone for CT examinations to rule out nephrolithiasis, 66% were male and 34% were female as shown in **Figure 1**. In this study, patients from 2 years to 60 years were included for CT imaging. Study population has been presented on the basis of age distribution as shown in **figure 2**. During the CT image interpretation of 50 patients, 28 patients (56%) had stone in kidneys (nephrolithiasis), 2 patients (4%) had PUJ calculus, 14 patients (28%) had ureterolithiasis and 6 patients (12%) had VUJ calculus as shown in **figure 3**. In this study, we did not find any patient with cystolithiasis. We have also presented the results on the basis of sidewise distribution of renal stones. Among 50 patients, we found that the maximum number of patients (40%) had stone in right side as shown in **figure 4**. As per **figure 5**, maximum number of the patients (70%) have unilateral stone. **Figure 6** shows the CT images of the patients diagnosed with left and right renal calculi. **Figure 7** shows patient having bilateral nephrolithiasis. **Figure 8** shows the CT image of patient having left proximal ureteric calculus.

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**Table 1**

| CT Scan Parameters | |
|---|---|
| **Patient position** | Supine |
| **Patient orientation** | Feet first |
| **Centre** | Xiphisternum |
| **Anatomical landmarks** | Mid axillary line |
| **Field of view** | Diaphragm to pubic symphysis |
| **Mode of sequence** | Inspiratory scan |
| **Scan type** | Helical |
| **Scan orientation** | Cranio caudal |
| **Gantry tilt** | 0 degree |
| **Slice thickness** | 5mm |
| **Pith** | 1 |
| **Reconstruction** | 1.5mm |
| **Kvp** | 120 |
| **mAs** | 250 |

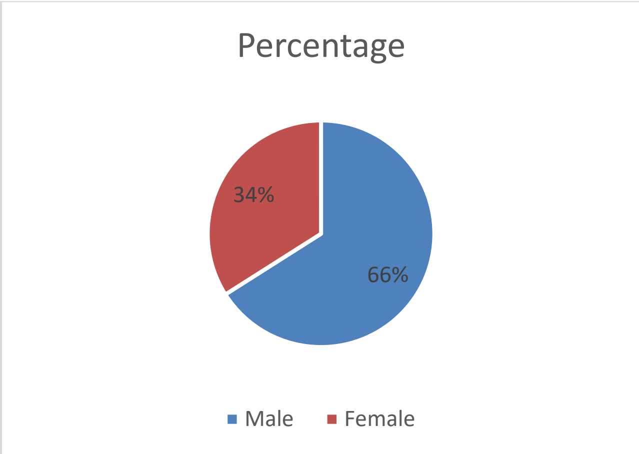


**Figure 1: Sex distribution in study population**

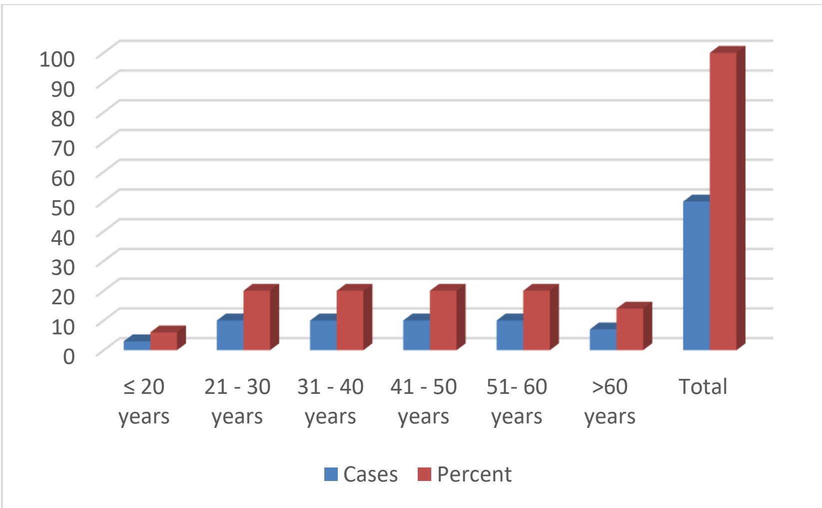


**Figure 2: Age distribution in study population**

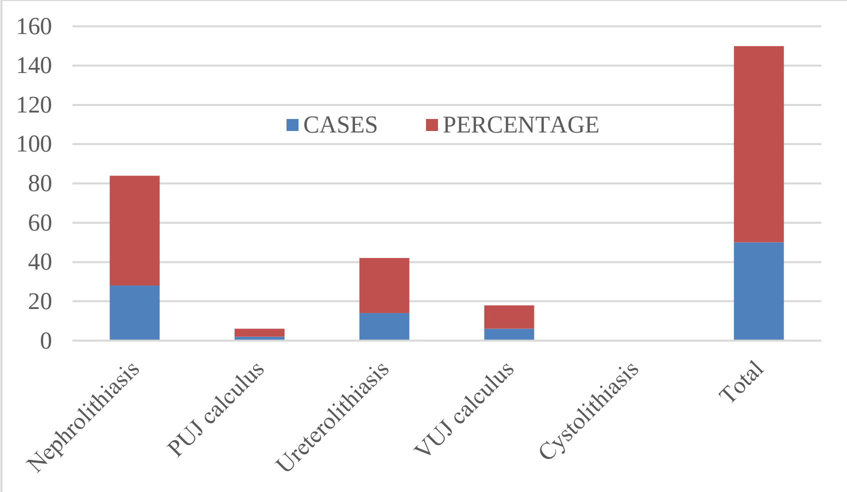


**Figure 3: Distribution of patients on the basis of site.**

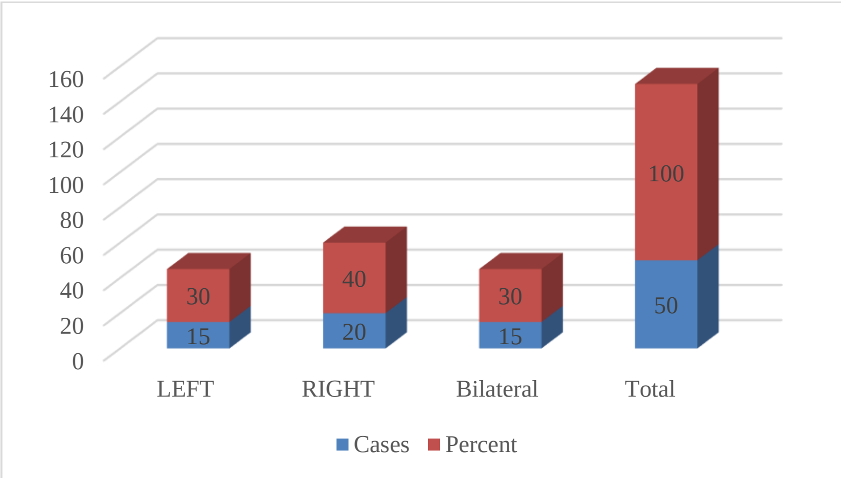


**Figure 4: Sidewise distribution**

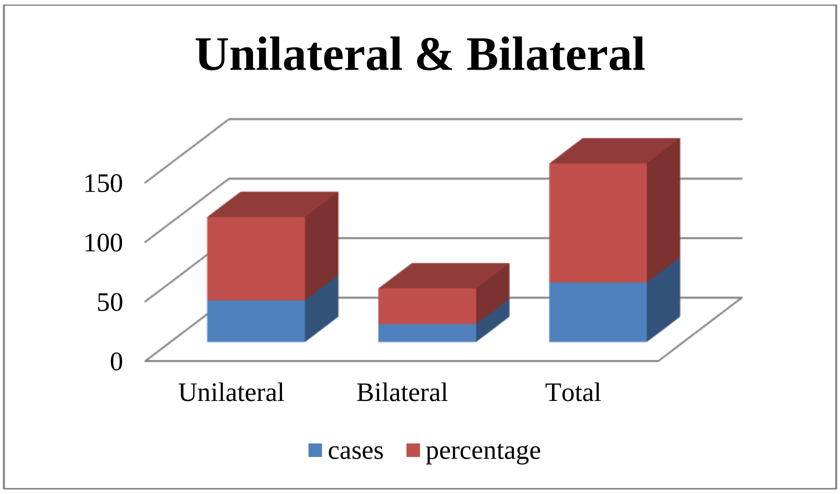


**Figure 5: Distribution of unilateral and bilateral**

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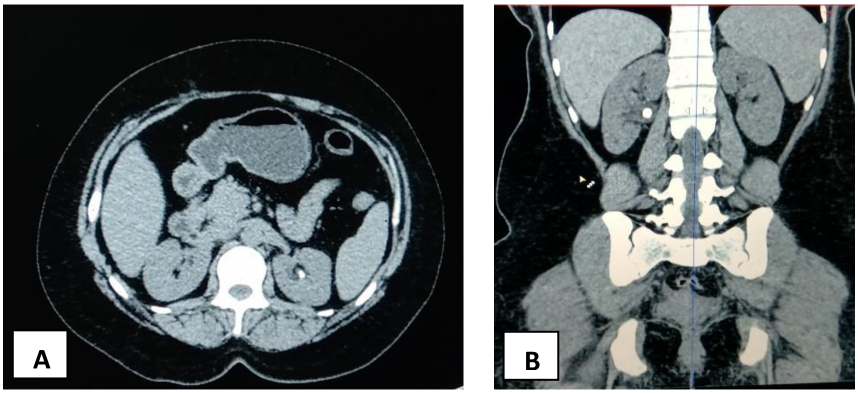


**Figure 6: CT images shows left (A) and right (B) nephrolithiasis.**

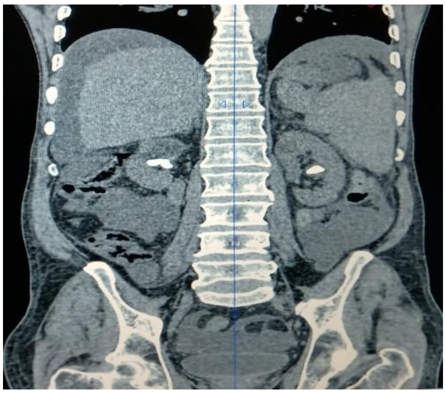

**Figure 7: CT images shows bilateral nephrolithiasis.**


**Figure 8: CT images shows left (A) and right (B) proximal ureteric calculus.**

## DISCUSSION

A prospective study was done to evaluate the efficiency and reliability of Computed Tomography in the evaluation of renal calculi and to assess the site of urolithiasis. In the present study it was observed that 21 to 60 years (80%) were the most common age group in the population followed by above 60 years (14%) and less than 20years (6%). Among the 50 patients, the mean of the affected gender was found to be 33 male patients (66%) and 17 female patients (34%) which shows that the males were affected more than female. The most common side affected was right side (40%) followed by left side (30%) and bilateral (30%). Most of the patients had unilateral (70%) followed by bilateral (30%). In the present study, it was observed that Nephrolithiasis (56%) and ureterolithiasis (28%) were the most common in patients with urolithiasis. Thoeny et al. performed unenhanced spiral CT to investigate patients with acute flank pain to diagnose suspected urinary tract calculi where they concluded that CT scan can frequently detect or exclude other causes of acute flank pain, thus guiding subsequent imaging and the therapeutic management [17].

In this study non contrast CT scan is used because it plays a vital role in evaluating Urolithiasis. Use of CT imaging has increased dramatically over the last two decades in many countries. Approximately 72 million scans were performed in the United States in 2007 and more than 80 million a year in 2015. A non-contrast helical CT scan with 5 millimeters sections is the diagnostic modality of choice in the radiographic evaluation of suspected nephrolithiasis. Lund et al. assessed the inter-observer variability of unenhanced helical computed tomography (UHCT) in patients with acute renal colic admitted into a low-volume hospital and found that the UHCT method to be safe and reliable with a good inter-observer agreement and Kappa value [18]. All stones are detectable on CT scans except very rare stones composed of certain drug residues in the urine, such as from indinavir. Calcium-containing stones are relatively radio dense, and they can often be detected by a traditional radiograph of the abdomen that includes the kidneys, ureters, and bladder (KUB radiograph). Approximately 60% of all renal stones are radiopaque. In general, calcium phosphate stones have the greatest density, followed by calcium oxalate and magnesium ammonium phosphate stones. Cystine calculi are only faintly radio dense, while uric acid stones are usually entirely radiolucent. Huang et al. determine the ability of low- and conventional-dose CT in identification of uric acid stones, which are of lower density than calcium oxalate stones. In their study both low- and conventional-dose CTs demonstrate excellent sensitivity and specificity for the detection of ureteral uric acid stones. Andrabi et al. discussed the current and emerging role of CT in the management of patients with urinary stone disease and their impact on planning treatment strategies and patient follow-up [10].

Further CT advances include the use of dual source imaging, a relatively new technique that utilizes two X-ray tubes and two detector units, which can be used to extract virtual 'non-contrast' images from contrast enhanced data and allows for determination of the chemical content of stones. In particular, this method is useful for distinguishing uric acid stones from calcium stones, as the former can be treated noninvasively with urine alkalinisation. The disadvantage of CT imaging is that it uses ionizing radiation. The effective dose from a MDCT KUB is dependent upon many factors such as patient habitus, the type of CT scanner and scanning protocol utilized. However it is estimated that approximately 2–9mSv dose is received from an abdominal CT compared to 0.5mSv for an abdominal radiograph.

## CONCLUSION

In this study, our result confirms the significant role of non-contrast computed tomography scan in evaluating Urolithiasis. From the results, it is now well established that computed tomography – KUB is the gold standard investigation for the diagnosis of urinary tract stones.

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