



## Role of Non-Contrast CT in Management of Urolithiasis

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### Abstract

*Urolithiasis is estimated to have a lifetime incidence of 5-12 percent usually presenting in patients 30-60 years of age and is approximately three times more common in males<sup>1, 2</sup> and out of these has recurrence rate approximate 50 %<sup>3</sup>. Acute flank pain is a very common presentation in patients attending emergency and OPD. It is; therefore, important to address this problem after making early diagnosis by using traditional different imaging techniques like X-rays (X-Ray KUB) and conventional ultrasound (USG) or intravenous pyelogram (IVP). And also Non-Contrast CT (NCCT) which is becoming increasingly popular due to its high accuracy, less time consuming, no contrast allergy and detecting radiolucent stones in addition to alternate diagnosis.*

**Keywords:** *Urolithiasis; Imaging techniques; Non Contrast CT; Radiation Exposure; Alternate diagnosis.*

### Introduction

In Indian scenario, the prevalence of disease is higher in the northern, north western and central parts. The incidence of kidney stones is moderate in Deccan Plateau and less in Southern India due to diet. The condition like hypercalciuria due to increase calcium levels in hyperparathyroidism<sup>4</sup>, malignancy<sup>5</sup>, sarcoidosis<sup>6</sup> and increase absorption from the gut. The struvite stones account for 15% formed in alkaline urine due to urea splitting bacteria include proteus, Klebsiella, Pseudomonas and Staphylococcus<sup>7</sup>. Uric acid stones account for approximately 8 % of all kidney stones. Uric acid stone formation is influenced by low urine volume, low urinary pH and hyperuricosuria, with low urine pH being the most important factor<sup>8</sup>. Recent researches suggest that diabetes mellitus, obesity and hypertension may be risk factors for the development of uric acid stones<sup>9</sup>.

The concentrations of calcium, oxalate, and phosphate in urine makes it supersaturated, however, inhibitory molecules like citrate prevent stone formation<sup>10</sup>. The Horsfall mucoprotein and uropodin have been shown to inhibit crystal aggregation<sup>11</sup> therefore, stone formation. In view of high incidence and 50 % recurrence within five years presenting with acute flank pain needs early accurate detection by using presently available imaging techniques so as to treat urolithiasis. This study is an attempt to analyse the efficacy and safety of individual imaging modality in management of urolithiasis as well as alternate diseases when present.

### Methods

In this study, 50 patients above 14 yrs both sex presenting first time with flank pain with or without other urinary symptoms except pregnancy

were included between 1<sup>st</sup> July 2014 to 30<sup>th</sup> June 2015 in Department of Surgery, IGMSC Shimla. In each case detail history followed by clinical examination and further investigations were carried out to know the exact cause of flank pain and its management thereof.

In all cases x-ray KUB, ultrasound followed by NCCT of whole of abdominal was done. In these patients, in addition, secondary changes due to urolithiasis were also seen with USG & NCCT. Incidental pathologies/diagnosis causing flank pain were seen & managed accordingly. Traditional imaging technique, IVP which was not without risk of dye reaction & nephrotoxicity in already obstructive kidney (in late arrival of patients in this hilly terrain) therefore not used.

### Results

The following observations were made as majority of patients were between 20 to 60 years of age (84%) and 27 (54%) were female and 23 (46%) were male out of 50. The most common presenting complaint was flank pain in 49 patients (98%) followed by increase in frequency of urine in 34 patients (68%), burning micturition present in 26 patients (52%), Hematuria present in 6 patients (12%) and fever was present in 15 patients (30%). The total leukocyte was raised in 10 (20%) out of 50 patients. The most common biochemical abnormality was raised serum creatinine, which was raised in 18 patients (36%). Blood urea was elevated in 9 patients (18%). Urine microscopic examination detected calcium oxalate crystals in 14 patients (28%) and amorphous urate crystals in 9 patients (18%) whereas urine infection was detected in 12 patients (32%).

In this study, out of 50 patients, 39 were diagnosed with urolithiasis whereas 11 were without any urolithiasis. Out of these 11 cases, 5 cases had UTI, 2 cases were having chronic cholecystitis, and one case was of mesenteric lymphadenitis & others one each of leucorrhea one recently passed stone and one diagnosed as rhabdomyolysis. Incidental diagnosis were

observed in this study by USG were in 9 cases while with NCCT it was in 13 cases.

**Table-1:** Detection of Stone & Secondary Signs of Urolithiasis by various Modalities

Modality	Stone	Hydronephrosis	Hydroureter	Stranding
X-ray	14	0	0	0
USG	20	36	24	0
NCCT	39	31	25	11

In total, 28 operative procedures were performed on 24 patients, however, 3 patients requiring more than one operative procedure. Small & single non obstructive stones (<8.00mm) seen on NCCT in 19 patients were put on a trial of Medical expulsive therapy. Ultrasound is also very good at identifying secondary signs of obstruction during renal colic. Besides urolithiasis, in the present study, ultrasonography was suggestive of hydronephrosis in 36 (92%) and hydroureter in 24(61%) of the studied 50 patients. The sensitivity and specificity of USG for hydronephrosis was 92.30% and 63.63% respectively. The sensitivity and specificity of USG for hydroureter in the present study was 61.54% and 81.82% respectively. In concordance to literature studies, this new imaging protocol of using NCCT-KUB in our institution, has demonstrated urolithiasis in 39 (100%) out of the 39 patients diagnosed with urolithiasis per operatively. Out of the 39 cases 15 were of kidney stones, 14 were of ureteral stones, 8 cases were of both kidney and ureteral and 1 case each of urethral and bladder stone. The stone size diagnosed on NCCT ranged from 2 mm to 44mm). NCCT proved to have a sensitivity of 100% (39 out of 39 patients) in demonstration of urolithiasis and specificity of 90.90% (10 out of 11 patients). In addition, NCCT detected inflammatory changes in the form of stranding in 11 (28%) as shown in table 1.

### Discussions

Radiological imaging plays a key role in management of patients presenting with suspected acute flank pain Selection of the patients on the basis of these modalities leads to high sensitivity

but low specificity for urolithiasis in addition to difficulties in detecting smaller stones; ultrasound has been shown to overestimate stone size which has direct implications in selecting the modalities of treatment. Moreover, in developing countries like India, patients present late with obstructive uropathy and deranged renal functions, use of traditional gold standards i.e. IVP is not without risk. Meanwhile, NCCT has become the referral standard in evaluation of suspected acute renal pain<sup>12-15</sup>. Acute flank pain in as many as one third of patients can be due to other abdominal conditions and capability of NCCT to detect such conditions reliably make it modality of choice. Therefore, at our institutions new imaging protocol was introduced in July, 2013 replacing traditional approach of X-ray, USG or IVP with NCCT KUB. In order to evaluate the effectiveness of new approach with NCCT KUB, this study of 50 consecutive cases was undertaken.

In the present study, The sensitivity of X-ray KUB to detect urolithiasis in the present study was 35.89% and the specificity 72.72% similar to Levine and colleagues (1997)<sup>16</sup> reviewed 178 patients with acute flank pain finding KUBs with a sensitivity of 45% to 59% and specificity of 77% in detection of urinary tract calculi. When ultrasound is added to X-ray KUB is sensitivity and specificity is remarkably increased to 96%, and 91% respectively as shown by Mitterberger et al (2007)<sup>17</sup>. The use of tomography has been shown to improve the diagnostic accuracy of X-ray KUB in evaluation of urolithiasis by Goldwasser et al (1989)<sup>18</sup>. In 46% of patient's additional stones were seen on tomograms versus KUB and in 8 % of patients stones were not seen on KUB but identified on tomograms.

Ultrasonography (USG) is the modality of choice in pregnant patients and children to avoid radiation. As a bedside procedure, it is quickly performed to see secondary signs of presence of stone<sup>19</sup>. As stated earlier, ultrasound is less sensitive at detecting stones in the ureter than in the kidney and its limitation in identifying stones location, size especially in obese. The stone size

was significantly smaller in the patients in whom ultrasound failed to diagnose a stone (4mm vs.6mm). In addition to difficulties in identifying small stones, ultrasound has been on to overestimate stone size compared to NCCT.

In the present study, USG KUB correctly diagnosed urolithiasis in 20 (51%) out of total 39 patients with urolithiasis, with a sensitivity, specificity, 51.28%, 90.90%, respectively. Out of 20 cases 10 were of kidney stones, 7 were of ureteral stones and 3 cases were of both kidney and ureteral stones. The stone size diagnosed on USG ranged from 2mm to 50 mm. These results were comparable to a study by Fowler and colleagues (2002)<sup>20-21</sup>, The advantage of no radiation exposure comes at a cost of decreased sensitivity and specificity, especially for ureteral calculi. Ultrasound is less accurate at imaging ureteral stones. In the present study, USG correctly diagnosed 10 ureteral stones (45%) out of the total 22 ureteral stones seen eventually on NCCT, with sensitivity, specificity, of 45.45%, 63.63%, respectively. This was similar to a study by Yilmaz and colleagues and also Sheafar et al (2000)<sup>22</sup>, showing the sensitivity for ultrasound diagnosing a ureteral stone 61% versus 96% for NCCT.

Similar results were observed in a study by Ripolles et al (2004)<sup>23</sup>, where ultrasound identified hydronephrosis in 95%, ureteral dilation in 89% and perirenal fluid in 23% of the patients as in present study. As previously highlighted, due to low individual sensitivities and specificities, the KUB should always be paired with another imaging modality such ultrasound<sup>24</sup>. In the present study X-ray KUB when combined with USG, correctly diagnosed urolithiasis in 35 (70%) of the 39 patients with urolithiasis. It was recommended that plain X-ray KUB should be performed before the USG examination with the understanding that only USG confirms a positive urolithiasis since calcifications on abdominal films can be misleading.

Ultrasound can be useful for follow up in patients who are diagnosed with distal ureteral stones with

evidence for obstruction on NCCT and are offered conservative management to rule out persistent obstruction. It is also useful for follow up of patients who undergo uncomplicated surgical procedures to rule out new or residual obstruction. Additionally, in the absence of renal calculi or hydronephrosis, ultrasonography has additional role in diagnosis of alternate pathologies as reported by Patlas et al (2001)<sup>25</sup> comparing ultrasound and NCCT for the evaluation of renal colic in 62 patients, similar to present study.

Ha M (2004)<sup>26</sup> in his study, observed the advantage of NCCT in diagnosing urolithiasis when stone has passed over IVP. Similarly, Varanelli MJ et al (2001)<sup>27</sup> commented on the secondary and indirect signs of calculus disease in the renal system detected on NCCT in the form of perinephric, stranding, ureteral dilatation, perinephric fluid, collecting system dilatation, periureteral stranding and nephromegaly. Secondary signs are indicative of a localized inflammatory reaction or irritation caused by the presence or passing of ureteral stones or other acute urinary obstruction. These indirect signs are thought to follow a well defined time course corresponding to the physiological changes caused by an acutely obstructing stone. The peak time of appearance of these secondary signs is reported to be 6 to 8 hours following obstruction, based on a study of 227 patients with stone diagnosis on NCCT<sup>27</sup>.

There are other advantages NCCT holds over IVP and other imaging modalities for the evaluation of acute flank pain. NCCT is quickly performed and does not require intravenous contrast. Unlike plain radiography such as KUB and IVP, NCCT can detect stones of almost any composition. The exception to this, as studied by Sundaram CP et al (1999)<sup>28</sup> is stones formed by protease inhibitors such as indinavir, which may not be visible on NCCT. However, often in these cases, there are secondary signs of stones such as hydroureter and periureteral or perinephric inflammation which aide in the diagnosis<sup>28</sup>.

The pitfall with NCCT is the false-positive result as in present study due to phleboliths to be differentiated from ureteral calculi as also pointed out by Boridy et al. Another pitfall false negative result has been reported, with rates ranging from 2% to 7%<sup>29</sup>. These false negative results have been attributed to a probable combination of volume averaging (small stone size, i.e. <2mm relative to collimation) and stone composition. This is a particular problem in the case of patients positive for human immunodeficiency virus who are being treated with the protease inhibitor indianvir. In these patients, the majority of calculi are low attenuating (matrix stones) on NCCT images<sup>29</sup>. It is, therefore, useful to look closely for secondary signs of obstruction, i.e. hydronephrosis and hydroureter.

There are, however, some contentious issues regarding the use of NCCT in suspected acute renal colic. Firstly, NCCT cannot access the functional status of kidneys, for which renal scan or IVP is additionally needed. Secondly, according to published reports, patients are usually exposed to a three to five times higher dose of radiation with NCCT compared to the dose with IVP<sup>30</sup>. Hence, NCCT cannot be used in paediatric age group and in pregnant females. In addition, because patients with stone disease are often relatively young and may thus be repeat stone formers who may thus require multiple NCCT examinations during their life time, there should be an effort to reduce the radiation dose of CT<sup>31</sup>. The effective dose for a KUB and IVP has been reported to be approximately 1.3 and 3 mSv respectively, by Mettler et al (2008)<sup>32</sup>. The number of images obtained during an IVP affects the dose, with the more shots taken, the higher the effective dose. The effective dose of the KUB was calculated to be 0.67mSv, and the effective dose of each tomogram was 1.1mSv. The effective dose of a 'low-dose' NCCT was 3.04mSv. Typically, when KUB and tomograms are performed, a KUB is taken along with 3-4 tomograms. This yields a total dose of 3.97-5.07 mSv.



**Table-2:** Radiation exposure of different imaging modalities M Masarani et al (2007)

Technique	Radiation Exposure (mSv)
X-ray KUB	0.5-0.9
IVP	1.5-3.5
Regular-Dose CT	8-16
Low Dose CT	2.8-4.7
Ultra low Dose CT	0.5-0.7

Also, with advancement in minimally invasive treatment options available for managing urolithiasis, like PCNL and ESWL, which results in small residual stone fragments in urinary tract, increasing number of NCCTs are being requested in follow up of such patients, thus increasing the radiation exposure per patient. And lastly, such a change in the use of NCCT can result in a significant impact on radiology workflow and budgets and can radically alter the diagnostic process. Although there are studies that have demonstrated a cost-equivalence between the two techniques, others are in agreement that NCCT introduces cost savings. This would thus make an even more compelling case for implementation of such an imaging protocol.

### Conclusion

In order to decide precise modality of management, the available imaging should provide accurate information regarding the presence, size and precise location of urolithiasis along with intra calyceal anatomy. But no single technique is ideal and the choice is heavily dependent on local resources. The present study concluded that NCCT-KUB is the most accurate first line modality for precisely detecting urolithiasis. The present series of 50 consecutive cases highlighted the clinical utility of NCCT, due to its exceptional sensitivity and specificity for identifying a stone, size, composition, location or secondary changes, to only accurate diagnose it but also to diagnose alternate diseases/findings and thus help in determining appropriate surgical management. However, restriction of its use in paediatric patients and pregnant women due to the increased risks from radiation exposure, a low

dose NCCT or a combination of X-ray KUB and USG can be used an alternative in these patients. Indiscriminate use of NCCT not only increases the workload on radiology department but also risks the normal population especially females with flank pain due to UTI/ Leucorrhoea. USG/X-ray KUB should be used in follow up patients post operatively (ESWL/PCNL) with residual stone fragments rather than using NCCT.

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