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Role of CT urography in patients with suspected urinary tract calculi

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Abstract
An observational study carried out in a period of two years, in the Department of Radio-Diagnosis, Dr. D. Y. Patil Medical College, Hospital and Research centre, Pimpri, Pune. 50 patients with suspected or known cases of urinary tract calculi who came with renal colic or hematuria were subjected to CT urography. The study comprised of 23 females (46%) and 27 males (54%), thus showing male preponderance. The majority of the patients were from the age group of 12-30 years, with mean age of 38.96 years. 35 patients had urolithiasis. 22 patients (44%) had renal calculi, 7 patients (14%) had calculi at other sites and 6 patients (12%) had calculi at multiple sites. At other sites, calculi were most commonly seen in ureters, followed by PU junction, VU junction and urinary bladder. Right kidney was more commonly affected than left kidney. Obstructive changes were commonly due to calculi in ureters. Nephrographic phase was delayed in 1 patient (2%) and absent in 1 patient (2%), while excretory phase was delayed in 5 patients (10%) and absent in 2 patients (4%). Other pathological findings were identified in the study included renal cysts, reflux nephropathy, lymphocele, abscess, pyelonephritis, PUJ block, polycystic kidneys and neoplasm. The anatomical variants seen in the study included supernumerary kidneys, duplex collecting system, trifid pelvis, ectopic kidney, horse shoe kidney and retrocaval ureter.

Keywords: Urolithiasis, stones, anatomical variants of collecting system, retrocaval ureter, duplex collecting system, supernumerary kidneys, function of kidney

Introduction
Urinary tract calculi are concretions formed within the renal tract by the crystallization of one or more substances normally found within the urine. Ureteral calculi almost always primarily originate in the kidneys, however they may continue to grow after they lodge in the ureter. CT (Computed Tomography) Urography is a diagnostic examination which is optimized for imaging the kidneys, ureters and bladder with thin slice MDCT (Multi detector computed tomography), intravenous administration of contrast medium and image acquisition in the excretory phase [1]. CT Urography facilitates multiplanar imaging of the urinary system, thus is an excellent technique in evaluating the urinary tract calculi and renal masses with high sensitivity and specificity. CT Urography is essentially defined as a CT examination of the urinary tract which includes non-contrast or unenhanced phase imaging and imaging after administration of contrast [2]. According to The European Society of Urogenital Radiology CT Urography is a diagnostic examination which is optimized for imaging the kidneys, ureters and bladder with thin slice MDCT, intravenous administration of contrast medium and image acquisition in the excretory phase [3]. The non-contrast or unenhanced images are useful for evaluation of fat-containing lesions, calculi and parenchymal calcifications and also to provide baseline attenuation for assessment of lesion enhancement. However, in 10-15 percent cases when the non-contrast scan is equivocal about the diagnosis of renal calculus, contrast is administered to clarify the diagnosis. After an unenhanced acquisition, the corticomedullary, nephrographic and pyelographic section images are obtained 25 -70 seconds [4], 90-110 seconds and 5-15 minutes respectively after administration of an iodinated non-ionic contrast agent. Corticomedullary phase images provide information regarding renal vasculature and perfusion. They also help in the early detection of masses. Nephrographic phase enhanced imaging has the highest sensitivity in the detection of renal masses. Pyelographic phase scans are used for evaluation of the urothelium [2, 5]. Common indications for doing CT urography includes flank or abdominal pain, hematuria, urinary calculus disease, suspected renal or urothelial neoplasm, variety of

inflammatory conditions. It is also useful to look for congenital anomalies of the urinary tract. In a percentage of patients undergoing CT Urography, extra-urinary findings which may be clinically significant, can be found. Patients with renal insufficiency who cannot receive iodinated contrast, prior severe reaction or pregnancy are major contraindications to CT Urography [6].

Studies have shown CT to be superior to radiography and intravenous urography for the detection of urolithiasis.

Material and Methods

A observational study carried out in a period of two years, in the Department of radio-Diagnosis, Dr. D. Y. Patil Medical College, Hospital and Research centre, Pimpri, Pune. The patients with suspected or known cases of urinary tract calculi who came with renal colic or hematuria were subjected to CT urography, carried out in Philips Ingenuity core 128 slice CT. Patients with deranged renal function or hypersensitive to contrast media were excluded from the study. CTU was performed by adjusting a tube voltage of 120kVp and a tube current of 250mAs, with a pitch of 1.5:1 and collimation of 2.5mm. Firstly, topogram of the abdomen was done with the patient being told to hold his breath. Non contrast images of slice thickness 5mm were taken from the top of the kidneys up to the base of the urinary bladder. After this, 1ml/kg of non-ionic iodinated contrast media was administered at the rate of 2mL/sec. The contrast enhanced images were obtained with a slice thickness of 3mm. First, corticomedullary phase images were obtained at 25-70 seconds from the time of contrast administration. Then, nephrographic phase images were obtained at 90-110 seconds and delayed phase images were obtained at 5-15 minutes from the time of contrast administration. Coronal and sagittal reconstructions of the images were done. Maximum intensity projection reconstruction was done as and where necessary.

Observations and Results

Demographics

22 patients (44%) belonged to the age group of 12-30 years which were in majority, followed by 51-70 years.

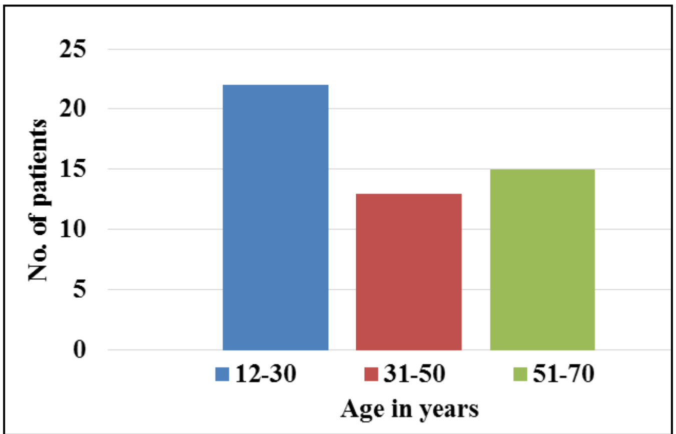


Fig 1: Graph showing age distribution of study participants

There was slight male preponderance in the study. Male population was 54% while females were 46%.

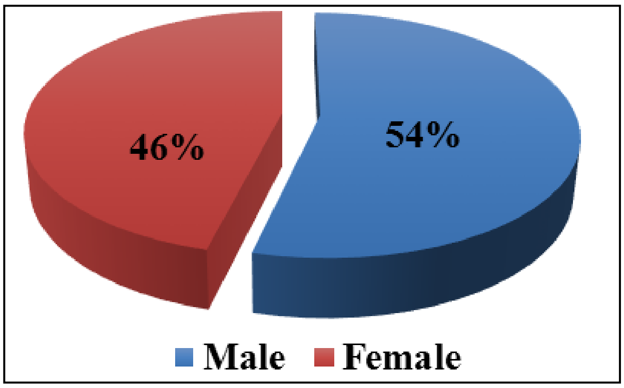


Fig 2: Pie chart showing gender distribution of study participants

Radiological findings

Out of total 50 cases, 35 patients (70%) had urolithiasis. 15 patients were negative for calculus on imaging. Out of 35 patients, 20 patients had single calculus, while 15 patients had multiple calculi.

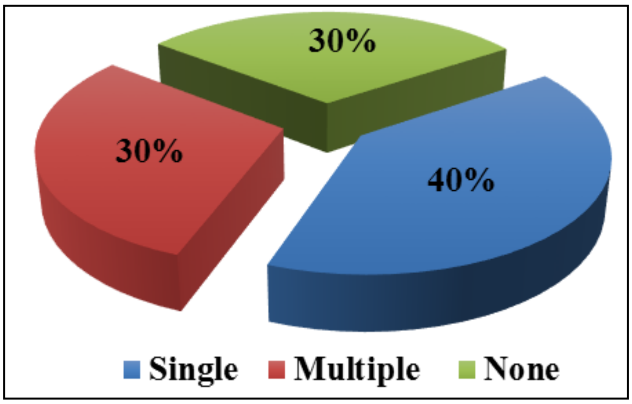


Fig 3: Pie chart showing number of calculus among all study participants

The most common site for urolithiasis was kidney. 22 patients (44%) had renal calculi, 7 patients (14%) had calculi at other sites and 6 patients (12%) had calculi at renal as well as other locations.

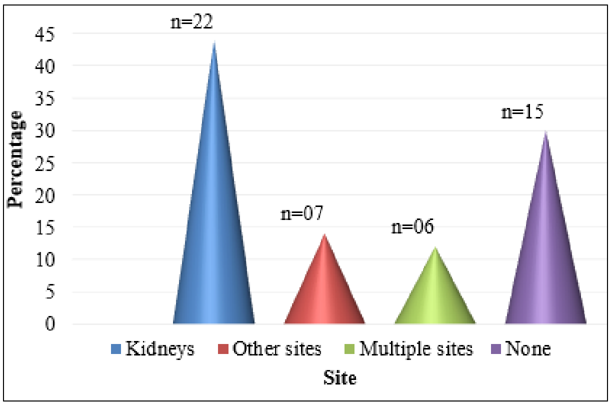


Fig 4: Graph showing site of calculus

Among the other sites, the most common location for the calculi was ureter. Less common sites included PU junction, VU junction and urinary bladder.

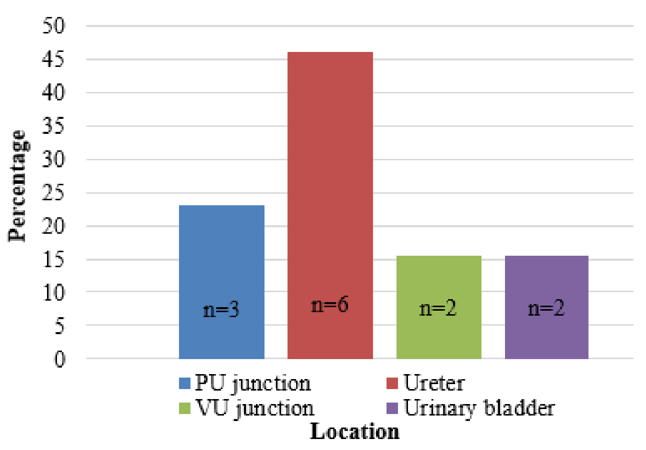


Fig 5: Graph showing sites of calculus other than kidney among study participants

14% of the total cases had bilateral renal calculi. In cases of unilateral disease, right side was more commonly involved (26%) than left (16%).

Table 1: Laterality of renal calculus among study participants

Side	No. of patients	Percentage
Right side only	13	26
Left side only	8	16
Both sides	7	14
Nil	22	44
Total	50	100

Hydronephrosis and hydroureter are most common signs of obstruction. Hydronephrosis was seen in 50% cases, while hydroureter was seen in 26% of cases.

Table 2: Obstructive changes among study participants

Obstructive changes	No. of patients	Percentage
Hydronephrosis	25	50
Hydroureter	13	26

The corticomedullary phase of kidneys was normal in all the cases. The nephrographic phase was delayed in 1 case (2%) and was absent in 1 case (2%). The excretory phase was absent in 2 cases (4%) and delayed in 5 cases (10%).

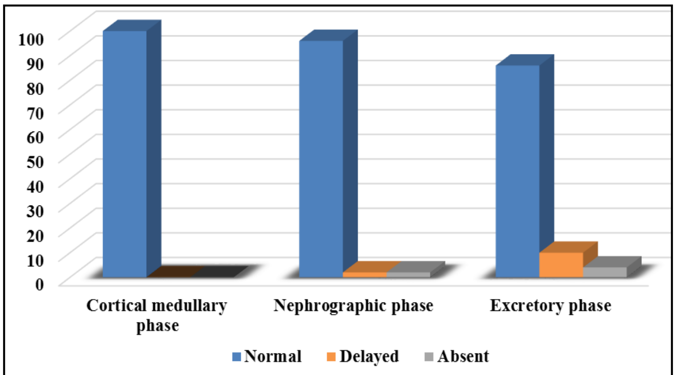


Fig 6: Graph showing excretory phases among study participants

The size of the calculi is important in determining the further management of the disease.

The mean size of the calculi in the right kidney was 11.5mm. The mean size of the calculi in the left kidney was 10.1mm. The mean size of the calculi at other site was 13.2mm.

Table 3: Measurement of calculi among study participants

Descriptive statistics	Size (mm)* (Right)	Size (mm)* (Left)	Size (mm)* (Other Sites)
Mean	11.5	10.1	13.2
SD	9.7	7.7	6.5
Median	8	8	13
Interquartile range	3 – 19.5	4 - 14	7 – 18
Range	30	27	21
Minimum	2	3	4
Maximum	32	30	25

* Calculations are based on largest sized calculi in case of multiple calculi

Table 4: Association between hydronephrosis and site of calculi

Site of calculus	Hydronephrosis		p value#
	No n (%)	**Yes** n (%)	
Kidney	14 (50)	14 (50)	0.98
Ureter	1 (9.1)	10 (90.9)	0.002*
Bladder	2 (100)	0	0.15

p value based on Chi-square test, *statistically significant

The p value was statistically significant between the location of the calculus in the ureter and hydronephrosis, thus indicating high probability of obstructive changes in cases of ureteric calculi.

Table 5: Association between hydroureter and number of stones

Site of calculus	Hydroureter		p value#
	No n (%)	**Yes** n (%)	
Kidney	22 (78.6)	6 (21.4)	0.41
Ureter	5 (45.5)	6 (54.5)	0.02*
Bladder	2 (100)	0	0.15

p value based on Chi-square test, *statistically significant

The p value was statistically significant between the location of the calculus in the ureter and hydronephrosis, thus indicating high probability of obstructive changes in cases of ureteric calculi.

Table 6: Association between hydronephrosis and density of calculi

Density of lesion	Hydronephrosis		p value#
	No	Yes	
Mean (SD)	811.8 (459.3)	1686.1 (2603)	0.17

p value based on student t test

No statistical significant relationship was noted between hydronephrosis and density of the calculus.

Table 7: Association between hydroureter and density of calculi

Density of lesion	Hydroureter		p value#
	No	Yes	
Mean (SD)	906 (438)	2289 (3669)	0.29

p value based on student t test

No statistical significant relationship was noted between hydroureter and density of the calculus. Thus density of the calculus does not affect the obstructive changes.

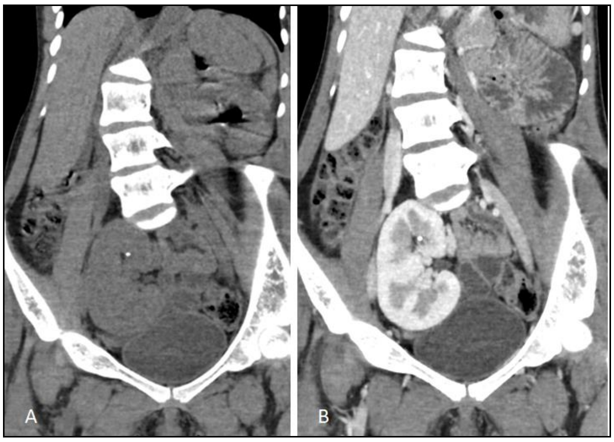
Table 8: Details of other findings and anatomical variations among study participants

Other findings	No. of cases	Percentage
Small sized kidney	2	8
Supernumerary kidney	1	4
Trifid renal pelvis	1	4
Duplex collecting system	2	8
Ectopic kidney	2	8
Horseshoe kidney	1	4
PUJ block	3	12
Retrocaval ureter	2	8
Angiolipoma	1	4
Renal cyst (Bosniak I,I,III)	3	12
Bilateral polycystic kidney	1	4
Reflux nephropathy	1	4
Lymphocoele	1	4
Renal abscess	1	4
Pyelonephritis	1	4
Neoplasm	2	8
Total	25	100

*Many of the participants had more than one pathology

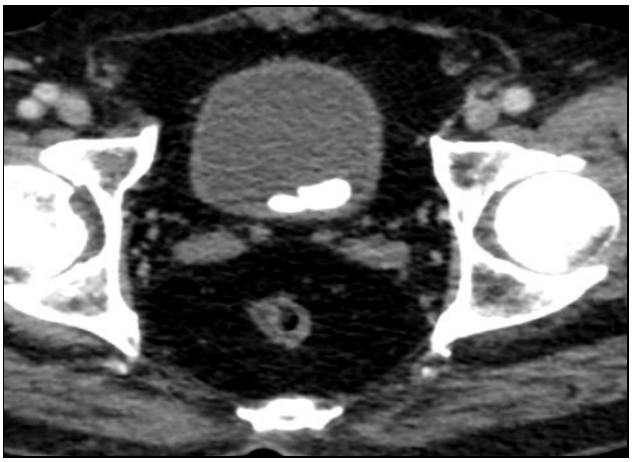
Numerous other pathologies and anatomical variants were identified during the study.

Case Gallery
Case 1



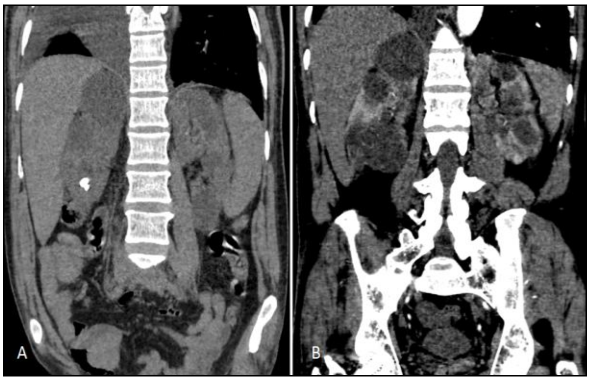
Non-contrast (A) and post contrast nephrographic phase (B) coronal reformatted CT images showing solitary ectopic right kidney with non-obstructive calculus in upper pole calyx. Scoliosis of lumbar spine is noted.

Case 2



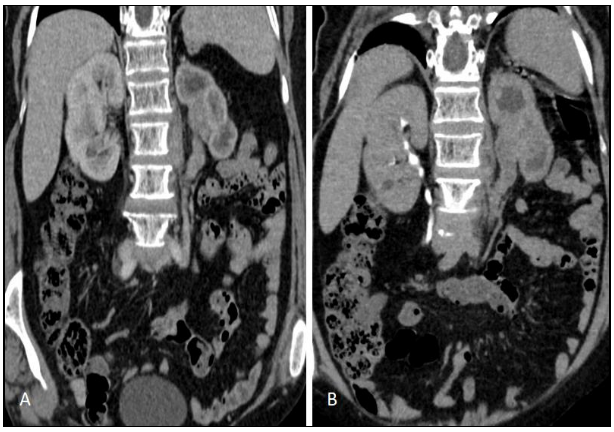
Axial post contrast CT scan at the level of urinary bladder showing two vesical calculi.

Case 3



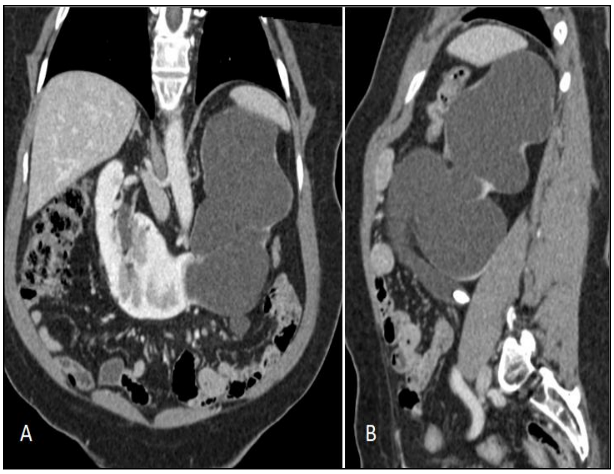
(A) Plain reformatted coronal CT image showing calculus in the lower pole calyx of the right kidney. (B) Post contrast nephrographic phase reformatted coronal CT image showing bilateral polycystic kidneys.

Case 4



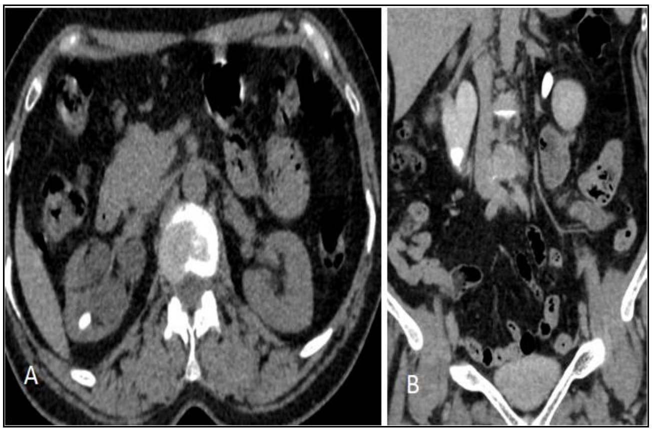
Reformatted coronal CT images in nephrographicphase (A) and excretory phase (B) showing heterogeneously enhancing soft tissue density lesion in left renal pelvis, extending in ureter with no excretion of contrast in excretory phase suggestive of urothelial carcinoma. Retroperitoneal lymph node is also seen.

Case 5



Reformatted coronal (A) and sagittal (B) CT images in nephrographicphase showing horseshoe kidney. Left upper ureteric calculus is noted causing hydronephrosis and proximal hydroureter. There is thinning of the left renal cortex.

Case 6

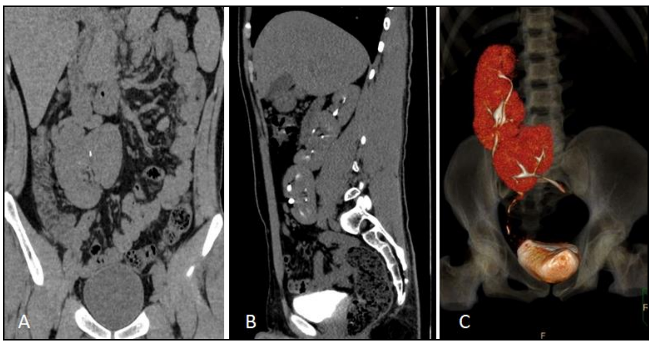


Plain axial (A) and reformatted post contrast coronal image in nephrographic phase (B) showing right renal calculus and right PU junction calculus with bifid renal pelvis.

Case 7

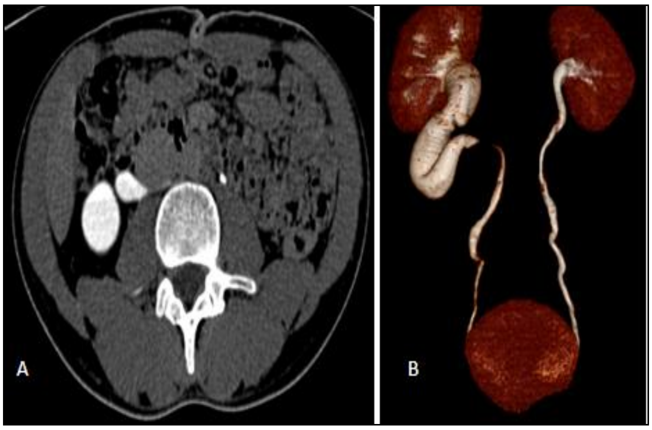
Reformatted post contrast coronal CT image in nephrographic phase showing ectopic left kidney with trifid renal pelvis and multiple obstructive renal calculi.

Case 8



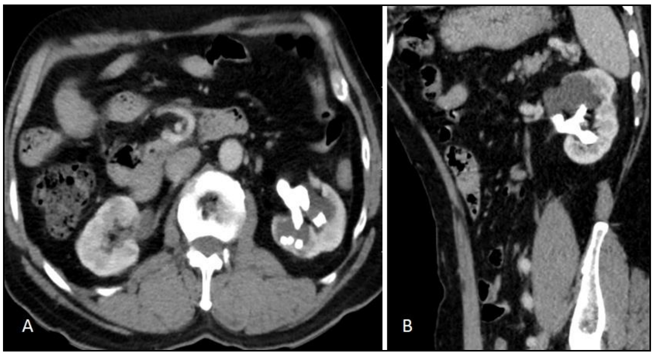
Reformatted coronal plain CT (A) showing tiny calculus in the interpolar region of cross fused left kidney. Post-contrast excretory phase reformatted sagittal (B) and volume rendered (C) images show supernumerary right kidneys with cross fused left kidney.

Case 9



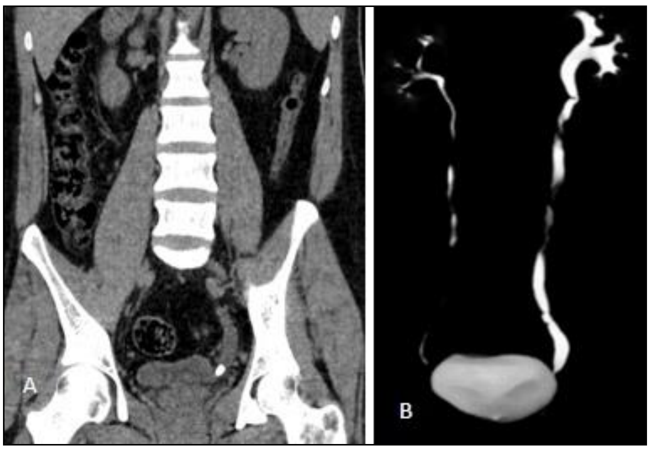
Axial post contrast excretory phase (A) and volume rendered image (B) showing right hydronephrosis and hydroureter due to retrocaval ureter.

Case 10



Axial (A) and reformatted sagittal (B) post contrast nephrographic phaseshowing obstructive left staghorn calculus and calyceal calculi.

Case 11



Reformatted coronal plain CT (A) and MIP image (B) showing obstructive left VUJ calculus.

Discussion

Demographics

Most of the patients with urolithiasis present between 30-60 years of age. In our study, the mean age of the study subjects was 38.96 years. In a similar study by Sourtzis *et al.* [7], mean age of the patients was 40 years. Mean age in a study by Khan N *et al*. [8] on 139 subjects with high suspicion for urolithiasis was 30 years. Urolithiasis affects men three times as more often as it affects women. Out of total 50 subjects, 54% were males with male to female ratio of 1.2:1. Thus, the number of male patients was more as compared to females. Similarly, in the study by Khan *et al*. [8], 62.5% of their study subjects were males with a ratio of 2.3: 1.

Presence of disease

Urolithiasis was observed in 70% of cases and 15 patients had no renal calculi in our study. In a study by Feroze *et al.* [9], CT detected 40 cases of urolithiasis amongst the 100 cases observed. In a study by Sharma *et al*. [10] out of 50 patients presenting with obstructive changes, 66% patients had urolithiasis. Of the 139 patients, 102 patients, that is, 73.4% had positive findings for urolithiasis on CTU in study by Khan *et al*. [8].

Location

Location of the urinary calculi is of paramount importance in management of patients with urinary calculi, the more proximal the location of the stone in the ureter, the less likely that it will pass spontaneously. In the present study, the most common site of renal calculi was calyx seen in 16% of the calculus cases, followed by renal pelvis in 12%who had calculi. Other than kidney, the other sites in the urinary tract where calculi were most frequently observed were in the ureter seen in 12% of the study subjects followed by pelvi-ureteric junction in 6% of the study subjects, urinary bladder in 4% and vesico-ureteric junction in 4% of the study subjects. A similar study was conducted by Khan N *et al*. [8] for the diagnosis of urolithiasis and ureteric obstruction. Of the 139 patients, 102 patients, that is, 73.4% had positive findings for urolithiasis on CTU. Of these, 67 (48.2%) patients had calculi in the calyx, 63 (45.2%) of the patients had calculi in the ureter and 3 (2.2%) in the bladder.

Obstructive changes

In the present study, hydronephrosis was observed in 50% cases while hydroureter was observed in 26% cases. Occurrence of hydronephrosis and hydroureter was significantly associated with presence of calculus (p<0.05), however no association was observed with number of calculus (p>0.05). Khan N *et al*. [8] in their study observed hydronephrosis in 62% and hydroureter in 24.5% cases.

Laterality

In my study, the study subjects were distributed according to side as well. According to the study, 40% were right sided, 34.28% of the calculi were left sided, 25. 71% were bilateral and 5.7% in the urinary bladder. In a similar study by Ketata *et al*. [11], 41.5% and 32.4% calculi were present on left and right side respectively while bilateral calculi were present in remaining 25.9% cases.

Size and density

In our study, the range of size of calculi was 3mm to 32mm, the mean size being 11.5mm in right kidney, 10.1mm in left kidney and 13.2mm at other sites. The range of density of calculi was 100 to1700 HU, the mean size being 863.85 HU. There was no significant difference observed in mean size and density of calculi with respect to presence or absence to hydronephrosis. In a study by Nakada *et al*. [12], the calculi ranged in size from 1-28mm and majority of the calculi had a mean attenuation measurement of 900 HU. There was no correlation between size and composition of calculi for the presence of hydronephrosis and hydroureter. However, the size and composition of renal calculi do have a role in the management of urinary calculi as larger sized stones require intervention by percutaneous lithotomy or surgery. And dissolution therapy is preferred for uric acid calculi whose CT attenuation is between 150-500 HU. [13] Fielding *et al*. [14] have stated that the findings with strongest positive predictive values for renal colic were ureteral stones, hydronephrosis and hydroureter. In fact, the results were strong enough for the authors to suggest that if there is no hydronephrosis or hydroureter then an alternative diagnosis out to be explored.

Functioning

In our study, corticomedullary phase was normal in all the case. Nephrographic function was delayed in 2% cases (1 case) and absent in 2% (1case). Excretory function was delayed in 12% (6 cases) and absent in 4% (2 cases). The cause of non-excretion in both the cases was staghorn calculus.

Other findings

In our study, incidental findings were seen in 50% patients on CT urography which includedvarious anatomic variations and pathological findings. The findings included angiolipoma (1case), small sized kidney (2cases), renal cysts (3 cases), PUJ block (3 cases), reflux nephropathy (1 case), lymphocele (1 case), renal abscess (1 cases), pyelonephritis (1 case), Neoplasm (2 case). The anatomical variations included supernumerary kidney (1 case), duplex collecting system (2 cases), trifid renal pelvis (1 case), ectopic kidney (1 case), horseshoe kidney (1 case)and retrocaval ureter (2 cases).About 16.6% incidental findings were seen by Khan *et al*. [8]. While 20% incidental findings were noted by Thomson J *et al*. [15].

Conclusion

CT Urography is a precise examination for the evaluation of urinary tract pathologies. It provides more diagnostic information as compared to other modalities. It combines the benefits of excretory urography with those of cross sectional imaging into a single study which depicts the renal parenchyma, collecting system and ureters. It has a high sensitivity and specificity in detection of urinary tract calculi. It is also helpful in the detection of urinary pathologies. It has in most parts of the world, replaced IVU which used to be the gold standard of urologic imaging.

CT Urography provides better evaluation of location of the calculi and degree of obstruction. It helps in better assessment of exact site and degree of the obstruction. Other causes leading to the symptoms or obstruction are better evaluated.

Anatomical variants are useful to plan surgery, which are identified in CT urography. Functioning of the kidney is well evaluated in the CT urography. Accurate measurement of size and density of the calculus provides better detail to plan the treatment of the patient.

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