DOI: 10.7860/IJARS/2017/23458:2250

Original Article

Radiology Section

Evaluation of Imaging Abnormalities of Ureter using MDCT Urography

VEDARAJU KADABA SHAMACHAR, VIJAY KUMAR KENCHANAHALLI RANGASWAMY, CHANDALINGAPPA KURI, BOOBAPATHI RAJA

ABSTRACT

Introduction: Computed Tomography (CT) has become the primary imaging modality for assessment of excretory system. It has essentially replaced intravenous urography as the first line imaging modality. The major advantage of CT-urography is not only in its superior visualisation of the urinary tract, but also assessment of adjacent structures and other organs of the abdomen where intravenous urography fails.

Aim: The aim of this study is to identify the pattern of pathologies involving the ureter and provide a systematic approach to interpret such abnormalities at CT urography.

Materials and Methods: A prospective study was done using data gathered from 100 patients over a period of six months who were referred for contrast enhanced CT examination of the KUB region for suspected urinary abnormalities between age group of 18-70 years. Non-contrast, cortico-medullary, nephrographic and excretory phases were obtained and analyzed for ureteral abnormalities. Findings were recorded and analyzed using descriptive statistics.

Results: The mean age group of study subjects was 38.4±14 years. The imaging findings in our study were basically classified into five groups – congenital abnormality, filling defects, ureteral dilatation, narrowing and deviation in course. Ureteral duplication was the most common congenital abnormality found in our study while calculi were the most common cause of filling defects. Ureteral obstruction due to various causes including calculi, clots, malignancy etc., was the predominant etiology of ureteral dilatation while strictures were the commonest etiology of ureteral narrowing. Two cases of deviation in course of the ureter were reported, one due to retroperitoneal fibrosis and the other due to abdominal aortic aneurysm.

Conclusion: This study outlines the most common findings in patients referred for contrast enhanced CT scans for KUB and their imaging findings. A systematic approach to interpreting ureteral abnormalities includes assessment for congenital abnormalities, filling defects, dilatation, narrowing, and deviation in course. Because of the prevalence of ureteral abnormalities, it is vital for radiologists to recognise the varied appearance of ureteral disease at CT-urography.

Keywords: Calculi, Clots, Congenital abnormality, Ureteral dilatation

INTRODUCTION

Computed Tomography (CT) has become the primary imaging modality for assessment of excretory system in the past decade [1-4]. CT-urography has essentially become superior to intravenous urography as the first line imaging modality since it has more accuracy and sensitivity, particularly for evaluation of haematuria.The major advantage of CT-urography is not only in its superior visualisation of the urinary tract, but also assessment of adjacent structures and other organs of the abdomen where intravenous urography fails [5]. CT-urography is currently the preferred imaging modality for many clinical scenarios involving the urinary tract particularly for hematuria and in the staging and follow-up of urothelial tumors. The purpose of this study is to comprehensively review the role of CT-urography in evaluation of urinary tract obstruction, depiction of complex congenital or postsurgical urinary tract anatomy, and any clinical scenarios where comprehensive evaluation of the urinary tract is needed.

MATERIALS AND METHODS

This study was a prospective study done in patients presenting to Victoria Hospital, Bowring and Lady Curzon Hospital and Vani Vilas Hospital attached to Bangalore Medical College and Research Institute, Bengaluru, India, over a period of six months from July 2015 to December 2015. Total 100

patients were studied. Sample size was calculated based on the prevalence of abnormalities with 15% error allowance. All adult patients of age group between 18 to 70 years who were referred for contrast enhanced CT examination of the KUB region for suspected urinary abnormalities were included in the study. Patients with known hypersensitivity to contrast media were excluded. Those with abnormal renal function tests (serum creatinine greater than 2.0 mg/dL) were also excluded from the study. Prior ethical committee approval was obtained. Informed consent was taken from all the patients.

The patients underwent CT-scans of Kidney, Ureter and Bladder (KUB) region using a 6-slice Siemens SOMATOM and a 128-slice Philips Ingenuity Core CT scanner. Non-enhanced and contrast enhanced scans were done. Contrast enhanced CT was performed using a three-phase protocol. All patients were administered 400–500 mL of water orally 20-30 minutes before the examination. Unenhanced CT-scans of the abdomen and pelvis were obtained. Corticomedullary phase images were acquired first at 40 seconds and nephrographic phase images beginning 100 seconds after a 30-second injection of iohexol (Omnipaque 300, GE Healthcare) at a dose of 1.5 mL/kg. Eight minutes after the injection of contrast material, excretory phase images were obtained. Tube current used ranged from 110–380 mA with pitch of 1.375 and a collimation of 1.25 mm. Unenhanced, cortico medullary and nephrographic phase images were reconstructed as 3 mm thick sections. The excretory phase scans were reconstructed as 1.25 mm thin sections.Multiplanar reconstruction, maximum intensity projection and volume rendered images were obtained wherever necessary. Images thus acquired were analysed for various pathologies.

STATISTICAL ANALYSIS

Data was recorded and presented in the form of graphs and charts. Descriptive studies were presented in terms of mean and standard deviation.Qualitative data were presented as frequency multivariate analysis. Other sub stratified analysis will be carried out using appropriate software.

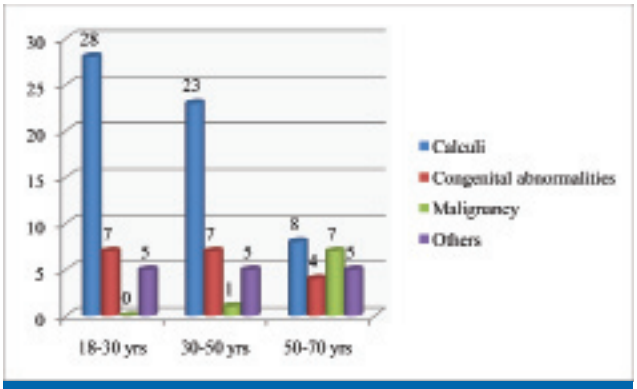
RESULTS

All adult patients of age group between 18 to 70 years who were referred for contrast enhanced CT examination of the KUB region for suspected urinary abnormalities were studied. Patients presenting with urinary symptoms like flank pain, oliguria, anuria, haematuria, etc., were included. The mean age of the study subjects was 38.4 years as shown in [Table/Fig-1]. Malignancy was more prevalent in older age groups while ureteric calculi were the most common finding in the younger and middle age groups as shown in [Table/Fig-2].

The most common presenting symptom in patients for CT-urography in our study was abdominal/flank pain (45 cases),

Age Group (18-70yrs)	No. of Patients (Total 100)
18-30 years	40
30-50 years	36
50-70 years	24

[Table/Fig-1]: Distribution of study subjects according to age.
*Mean age is 38.4±14

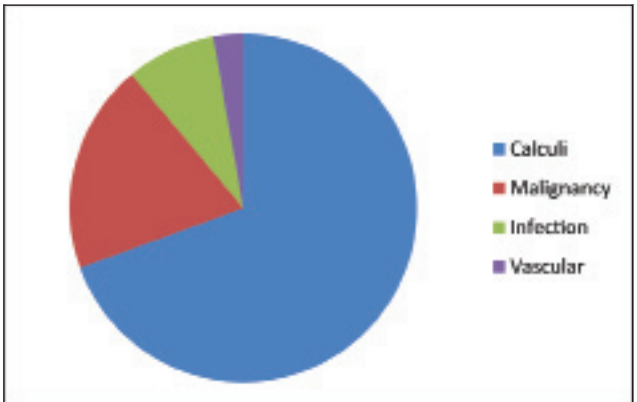


[Table/Fig-2]: Distribution of abnormalities according to age groups.

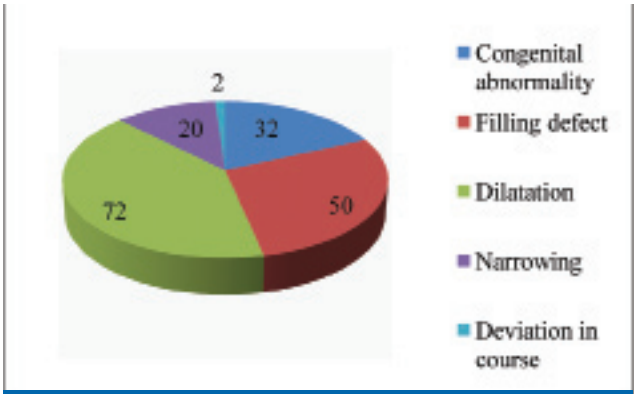
followed by haematuria (36 cases) [Table/Fig-3], trauma (3 cases), evaluation of a congenital abnormality (10 cases), oliguria and anuria (4 cases) and suspected genito-urinary tuberculosis (2 cases).

The imaging findings in our study were basically classified into five groups – congenital abnormality, filling defects, ureteral dilatation, narrowing and deviation in course. Many filling defects and congenital abnormalities will cause ureteral dilatation. Malignancies can cause filling defects with dilatation and narrowing. Hence, the classification is overlapping and not mutually exclusive as shown in [Table/Fig-4].

Congenital Abnormalities: These were classified under ureteral duplication which may be complete or partial, smooth muscle dysfunction which includes PUJ obstruction and primary megaureter, and abnormal termination of a



[Table/Fig-3]: Hematuria according to causes.



[Table/Fig-4]: Imaging findings according to the abnormality.

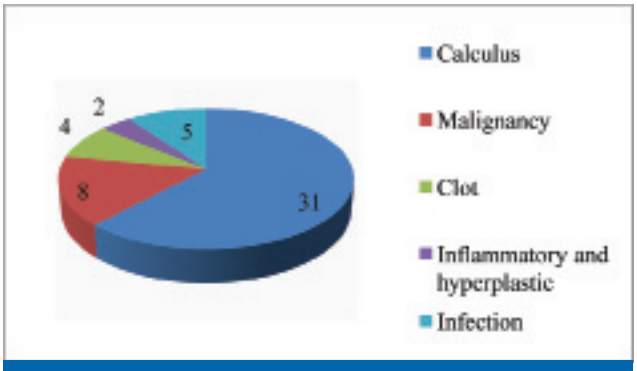
single ureter (no duplication) which includes ectopic ureter, ureteroceles and VUR [Table/Fig-5].

Ureteral Filling Defects: The most common cause of ureteral filling defect observed in our study was calculus [Table/Fig-6]. Total 31 patients had a calculus in the ureter of which the most common location was the vesico-ureteric junction (20 patients- 70%). Twenty eight out of the 31 patients had obstructive features presenting with proximal ureteric dilatation and hydronephrosis to various extents.

The second most common cause was malignancy (8 patients). seven out of the eight patients were proved to be uroepithelial tumors on further histopathology while one was found to be squamous cell carcinoma. Four patients presented with a clot which appeared as a high attenuating non enhancing focus.

Ureteral Duplication	10	Complete	2
		Partial	8
Smooth Muscle Dysfunction	9	PUJ Obstruction	7
		Primary Megaureter	2
Abnormal Termination	13	Ectopic Ureter	1
		Ureterocele	5
		Vesicoureteric Reflux	7

[Table/Fig-5]: Congenital abnormalities in ureter.



[Table/Fig-6]: Causes for filling defects.

Two had a history of antecedent trauma while the rest two were on anticoagulants.

Infectious etiology was found in five patients out of which four patients had tuberculosis characterised by nodular wall thickening and debris by sloughed papilla. One case of papillary necrosis was reported in our study.

Other uncommon causes of ureteral filling defects like hyperplastic lesions (leukoplakia, malacoplakia) were not found in our study.

Ureteral Dilatation: The most common cause of ureteral dilatation in our study was ureteral obstruction [Table/Fig-7] due to one or the other causes (54 patients) out of which an obstructing calculus was the predominant imaging finding (28 patients). Out of the 78 patients, 18 of them had bilateral dilated ureter. VUR (five cases) and bladder outlet obstruction (eight cases) were the predominant causes of bilateral dilated ureter. An enlarged prostate (five cases) was the most common finding in bladder outlet obstruction while the rest were malignancy.

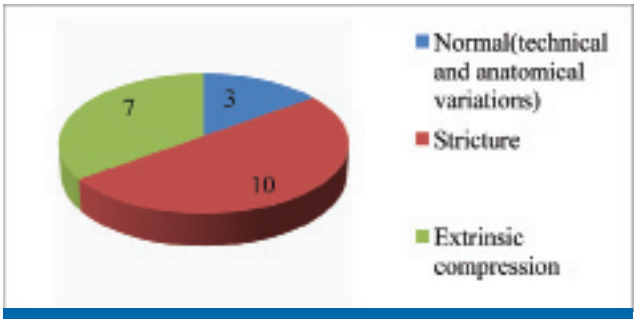
Ureteral Narrowing: Strictures [Table/Fig-8] were the most common cause of ureteral narrowing which included malignancy (four cases), Infection (three cases), Radiation therapy (two cases) and iatrogenic (one case).

Extrinsic compression is also an important cause of Ureteral narrowing – pelvic malignancy (four cases), CA colon, retroperitoneal fibrosis and a giant fibroid (one case each).

A normal ureter can appear narrowed at its UPJ, pelvic brim and VUJ, an abrupt turn or kink or due to an incomplete opacification.

Etiology	No. of Cases (%)
Ureteral Obstruction	48 (66.7%)
Vesicoureteric Reflux	7 (9.7%)
Primary Megaureter	2 (2.7%)
Ectopic Ureter	1 (1.3%)
Ureterocele	5 (6.9%)
Bladder Outlet Obstruction	8 (11.1%)
Neurogenic Bladder	1 (1.3%)

[Table/Fig-7]: Causes for dilated ureter.



[Table/Fig-8]: Causes for ureteral narrowing.

Deviation in Course: One case of retroperitoneal fibrosis and one case of abdominal aortic aneurysm showed a deviated ureter.

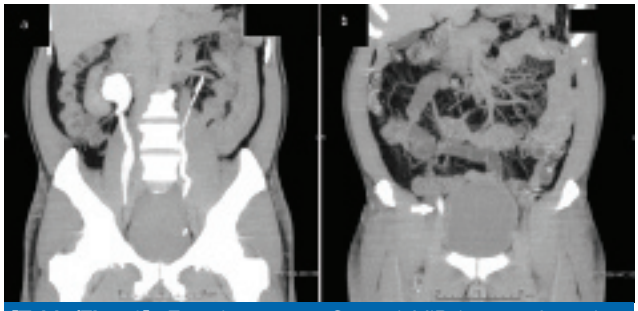
DISCUSSION

Findings in pathologic ureteral conditions can be classified as congenital abnormality, filling defect, dilatation, narrowing, or deviation in course.

Congenital Abnormalities: Ureteral duplication is the most common congenital anomaly of the urinary tract in our study. Duplications can be unilateral or bilateral, partial or complete [Table/Fig-9]. A partial duplication occurs when the initially separate upper and lower pole ureters fuse proximal to the vesico-ureteric junction into a common ureter, which then empties into the urinary bladder. Partial duplications are more common than complete duplications and most often are not clinically significant [6].

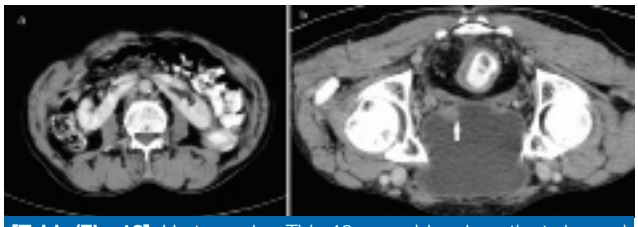
[Table/Fig-9]: Duplication of ureter - Coronal reformatted CT image of 42 years old male patient shows a duplicated ureter with the upper moiety showing hydronephrosis which was due to a calculus in its midpart.

A complete duplication occurs when the duplicated ureters remain separate throughout their course. The Weigert-Meyer rule states that in a complete duplication, the upper pole ureter terminates inferior and medial to the lower pole ureter [6,7]. The lower pole moiety is prone to reflux due to an abnormal VUJ valve mechanism, while the upper pole moiety generally has an ureterocele or an ectopic insertion [Table/Fig-10,11] or normal insertion on the bladder [6]. Ureterocele [Table/Fig-12] is a bulbous dilatation into the bladder wall. On imaging, it appears as a rounded filling defect that projects into the lumen of the bladder [8,9].



[Table/Fig-10]: Ectopic ureter - Coronal MIP image of patient who presented with right sided flank pain shows right sided hydroureteronephrosis due to an ectopic insertion of right ureter into the lateral wall of the bladder.

[Table/Fig-11]: Ectopic ureter - Coronal and axial reformatted images of a patient who presented with left sided abdominal pain showed an gross dilatation of left ureter with an ectopic insertion of the ureter into the prostatic urethra.



[Table/Fig-12]: Ureterocele - This 40 year old male patient showed a horse-shoe kidney with a fibrous band with ureterocele on the right side.

Smooth muscle dysfunction can occur as either proximally at the Pelvi-Ureteric Junction (PUJ) resulting in a PUJ obstruction or distally at the vesico-ureteric junction resulting in a primary megaureter. The important feature of PUJ obstruction is proximal dilatation of the renal pelvis and calyces with abrupt narrowing. Rest of the ureter appears normal. Primary megaureter refers to a abnormality at the VUJ causing abnormal peristalsis [7,10]. At CT-urography, the abnormal ureteral segment is often normal in caliber with marked proximal dilatation.

Filling Defects: Filling defect is one of the commonest manifestations of various pathologies involving the ureter. The most common causes of filling defects are calculi, tumours and clots. Calculi are identified at non enhanced CT as hyper dense foci along the course of the ureter. Any filling defect with

which is not hyper dense and is with a soft-tissue attenuation are to be considered malignant until proven otherwise and should be further assessed by ureteroscopy and biopsy.

Calculi were the most common cause of ureteral filling defects in our study [Table/Fig-13]. Typically, they measure more than 200 HU. Hence, caution is advised while interpreting in an excretory phase image since they may be obscured by excreted contrast. A bone window setting might be but not always useful in such scenarios. Hence, always a non-enhanced CT is the preferred modality for diagnosing ureteral calculi and a contrast phase is essential to look for anomalies or conditions that might predispose and to look for the function and excretion of the kidneys. Calculi are most often located at the normal anatomic sites of ureteral narrowing such as PUJ, pelvic brim, and VUJ.

[Table/Fig-13]: Filling defect - Calculi are the most common imaging finding in a filling defect. The above coronal reformatted MIP image shows a filling defect in the left proximal ureter due to a.

Transitional cell carcinoma is the most common uro-epithelial tumour. The commonest locations are the urinary bladder and second in the renal pelvis. As far as ureter is concerned [Table/Fig-14] it frequently involves the distal ureter [11].

A ureteral clot can occur from an intraureteral haemorrhage due to trauma, calculi, underlying malignancy, or anticoagulation. At CT, clots appear as a small rounded filling defect or as a vermiform defect that fills the ureter. It does not enhance. It can be identified on a non-enhanced image as hyper attenuating (>50 HU) both to urine and the surrounding soft tissues, A urine clot interface can also be occasionally identified [12]. Follow-up imaging is also useful as it may demonstrate resolution of the clot.

Ischaemic filling defects are uncommon. Renal papillary necrosis is the most common causative factor. Papillary necrosis can occur due to analgesic abuse, obstructive uropathy, sickle cell disease, pyelonephritis, renal vein thrombosis, tuberculosis, and diabetes [13]. Necrotic papillae can also cause hydroureteronephrosis by embolizing themselves. Hence, it is important to look for signs of papillary necrosis such as caliceal cavities and blunting in any case of ureteral filling defect.

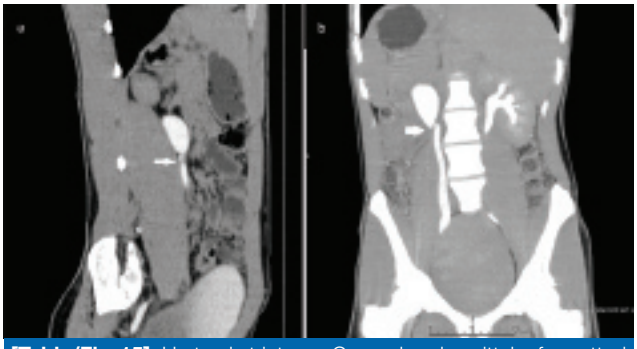
In a study of 57 patients with haematuria and unexplained hydronephrosis evaluated with both CT-urography and retrograde pyelography after acquisition of non-diagnostic excretory urograms or US scans, there were 38 intrinsic urothelial lesions including 15 transitional cell carcinomas, 13 urinary stones, five cases of ureteropelvic junction obstruction, three cases of ureteral stricture, and two bladder polypoid lesions [14]. While in our study, out of the 78 cases of dilated ureter, calculus was the predominant imaging finding (28 patients). Other causes of ureteral obstruction and proximal

[Table/Fig-14]: Urothelial malignancy - Coronal and sagittal reformatted CT images in a 62 year old male patient showed an enhancing intraluminal lesion extending from the left mid-ureter to the vesico-uretericjunction causing proximal obstructive features (white arrow and black asterisk).

dilatation included malignancy (eight patients), clots (three patients), extrinsic compression (seven patients) and strictures (eight patients).

Ureteral Dilatation/Narrowing: The normal diameter of ureter is 3 mm or less.Obstruction is the most common, but not only the cause of a dilated ureter.

Physiologic narrowing can be identified by the absence of proximal dilatation and by changing nature in different phases and acquisitions. Proximal dilatation can occur due to abrupt turns or kinks throughout its course. A ureteral narrowing is called a stricture when it is a fixed narrowing with associated proximal dilatation [Table/Fig-15]. The location (i.e., proximal, mid, or distal ureter) and length of the stricture must be described accurately in the report for proper surgical planning [15,16].



[Table/Fig-15]: Ureteral stricture - Coronal and sagittal reformatted MIP images of a 50 year old male patient shows dilatation of right proximal ureter secondary to a stricture. The patient had history of prior ureteric calculi.

LIMITATIONS

The study concentrates mainly on the intrinsic ureteral imaging patterns. Many of these pathologies on imaging are due to a cause outside the ureter which includes the proximal and distal excretory system. While contrast enhanced CT-scan of the KUB region provides a lot of information about the whole of the excretory system including masses and abnormalities of the vasculature and kidneys which could lead to potential abnormalities in the ureter, these were not concentrated adequately in the study. Secondly, children less than 18 years of age were not included in the study in whom, the prevalance and patterns might be different than those of adults.

CONCLUSION

This study outlines the most common findings in patients referred for contrast enhanced CT-scans for KUB and their imaging findings. Interpreting ureteral abnormalities systematically includes looking for congenital abnormalities, filling defects, dilatation, narrowing, and deviation in course. The major use of non-enhanced phase is included to identify urinary tract calculi or a hyperdense clot and to determine attenuation values within a mass so that we can assess the degree of enhancement on contrast-enhanced images. Wide windows are a must to see small lesions that may be obscured by excreted contrast material. Multiplanar Reconstruction (MPR), volume-rendered and Maximum Intensity Projection (MIP) images provide important additional information which might be missed in intial imaging. It is vital for radiologists to recognise the varied appearance of ureteral disease at CT urography since it has been getting implemented very widely.

REFERENCES

[1] Joffe SA, Servaes S, Okon S, Horowitz M. Multi-detector row CT urography in the evaluation of hematuria. Radio Graphics 2003;23(6):1441–56.

[2] Kawashima A, Vrtiska TJ, LeRoy AJ, Hartman RP, Mc Collough CH, King BF Jr. CT urography. Radio Graphics. 2004;24(suppl 1):S35–54.

[3] Silverman SG, Leyendecker JR, Amis ES Jr. What is the current role of CT urography and MR urography in the evaluation of the urinary tract? Radiology. 2009;250(2):309–23.

[4] Raman SP, Horton KM, Fishman EK. MDCT evaluation of ureteral tumors: advantages of 3D reconstruction and volume visualization. Am J Roentgenol. 2013;201(6):1239–47.

[5] Ramchandani P, Kisler T, Francis IR, et al. ACR Appropriateness Criteria: hematuria. American College of Radiology. http://www.acr.org/~/media/ACR/Documents/AppCriteria/Diagnostic/Hematuria.pdf. Updated 2008. [Accessed 13 January, 2016].

[6] Wein AJ, Kavoussi LR, Campbell MF, Walsh PC. Campbell Walsh urology. 10th ed. Philadelphia, Pa: Elsevier Saunders,2012. Pg604.

[7] Berrocal T, López-Pereira P, Arjonilla A, Gutiérrez J. Anomalies of the distal ureter, bladder, and urethra in children: embryologic, radiologic, and pathologic features. Radio Graphics. 2002;22(5):1139–64.

[8] Shokeir AA, Nijman RJ. Ureterocele: an ongoing challenge in infancy and childhood. BJU Int. 2002;90(8):777–83.

[9] Glassberg KI, Braren V, Duckett JW, et al. Suggested terminology for duplex systems, ectopic ureters and ureteroceles. J Urol. 1984;132(6):1153-54.

[10] Farrugia MK, Hitchcock R, Radford A, Burki T, Robb A, Murphy F, et al. British Association of Paediatric Urologists consensus statement on the management of the primary obstructive megaureter. J Pediatr Urol. 2014;10(1):26–33.

[11] Vikram R, Sandler CM, Ng CS. Imaging and staging of transitional cell carcinoma. II. Upper urinary tract. Am J Roentgenol. 2009;192(6):1488–93.

[12] Dunnick NR. Textbook of uroradiology. 4th ed. Philadelphia, Pa: Lippincott Williams & Wilkins, 2008, Pg 270-75.

[13] Jung DC, Kim SH, Jung SI, Hwang SI, Kim SH. Renal papillary necrosis: review and comparison of findings at multidetector row CT and intravenous urography. Radio Graphics. 2006;26(6):1827–36.

[14] Mc Carthy CL, Cowan NC. Multidetector CT urography (MD-CTU) for urothelial imaging (abstr). Radiology. 2002; 225(P):137.

[15] Vikram R, Sandler CM, Ng CS. Imaging and staging of transitional cell carcinoma. I. Lower urinary tract. Am J Roentgenol. 2009;192(6):1481–87.

[16] Potenta SE, D'Agostino R, Sternber KM, Tatsumi K, Perusse K. CT-urography for evaluation of the ureter. Radio Graphics 2015;35:709–26.

AUTHOR(S):

1. Dr. Vedaraju Kadaba Shamachar
2. Dr. Vijay Kumar Kenchanahalli Rangaswamy
3. Dr. Chandalingappa Kuri
4. Dr. Boobapathi Raja

PARTICULARS OF CONTRIBUTORS:

1. Professor and HOD, Department of Radio Diagnosis, Bangalore Medical College & Research Institute, Bengaluru, Karnataka, India.
2. Associate Professor, Department of Radio Diagnosis, Bangalore Medical College & Research Institute, Bengaluru, Karnataka, India.
3. Post Graduate Student, Department of Radio Diagnosis, Bangalore Medical College & Research Institute, Bengaluru, Karnataka, India.
4. Post Graduate Student, Department of Radio Diagnosis, Bangalore Medical College & Research Institute, Bengaluru, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Vedaraju Kadaba Shamachar,
515 2nd C Main Nagarabhavi
2nd Stage, 11th Block,
Bengaluru-560072, India.
E-mail: vedarajuks@yahoo.in

FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Publishing: **Apr 01, 2017**