Original Research Article

MDCT urography as a one stop shop for urinary tract abnormalities at present era

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Abstract

Background: CT has evolved from single–detector row scanners into multi–detector row helical volumetric acquisition techniques, and these advances have had a significant impact on imaging of the urinary tract.

Aim and objectives: To evaluate the CTU compare to other imaging modalities for urinary tract abnormalities in light of present knowledge, To study the role of CTU in evaluation of various abnormalities those are not detected by conventional IVP, Benefits of CTU over IVP, To provide information about the extent of the lesions involving kidneys and its relation to surrounding structure and Characterizing the lesions whether they are benign or malignant and helping the surgeons for the further management, Grading the renal injuries.

Materials and methods: Data was collected from patients who attended the surgical O.P.D. or emergency of S.S.G.H., Baroda with clinically suspected renal abnormalities. A study was conducted over a period of two years on 50 patients with clinically suspected renal abnormalities. Informed consent was taken from every patient. Patients were evaluated with Multidetector Computed Tomography (G.E. Bright Speed).

Results: Our Study included 10 patients of renal stones, 8 patients of renal masses, 3 patients of pyelonephritis, 7 patients of renal injury, 5 patients of PUJ obstruction, 7 patients of ureteric stricture, 5 patients of anomalies, and 5 patients of bladder mass.

Among all pathology CT urography is more helpful and gives better imaging findings as compare to conventional urography that helps in better management of patients.

Conclusion: CTU gives reliable information not about the extent of lesion but also the characteristics of lesions which makes surgeons to take proper decision aboutthe further management of patients, it also avoids unnecessary laparotomy surgery in case of blunt abdominal trauma patients by giving the precious extent of renal injuries. For all these gold standard benefits of MDCTU over conventional

IVP makes MDCTU as “one stop shop” for urinary tract abnormalities and nearly completely replacing the IVP in recent era.

Key words

CT urography, Urinary tract imaging, Urinary tract abnormalities, Benefits of CTU over IVP.

Introduction

CT has evolved from single–detector row scanners into multi–detector row helical volumetric acquisition techniques, and these advances have had a significant impact on imaging of the urinary tract. Since CT is a cross-sectional technique, overlapping structures (e.g. bowel), so long a confounding issue with intravenous urography, were not a problem with CT urography. Hence, the indications for CT were expanded to include hematuria [1-3], and CT urography has essentially replaced intravenous urography in most imaging practices [4].

It gives valuable information to the clinician about the extent of the lesions Involving kidneys and its relation to surrounding structure and characterizing the lesions whether they are benign or malignant. It also helps in grading the renal injuries which help in its management which could not be evaluated by conventional IVP.

Material and methods

Source of data

Data for the study was collected from patients attending the surgical O.P.D. or emergency of S.S.G.H., Baroda and also the patients from the private hospitals referred to the SAHYOG imaging center located in S.S.G.H., Baroda with clinically suspected renal abnormalities.

Inclusion criteria

Patients were taken from SSGH, Vadodara and SAHYOG centre at SSGH, Vadodara with urinary tract abnormalities.

Exclusion criteria

Patients who did not come for follow up or operated case of urinary track abnormalities.

Method of collection of data

A study was conducted over a period of two years on 50 patients with clinically suspected renal abnormalities or patients who were diagnosed to have renal abnormalities on ultrasound and were referred to CT for further characterization. Informed consent was taken from every patients under went for the study.

They presented with symptoms of fever, abdominal pain, and hematuria or weight loss. Patients were evaluated with Multidetector Computed Tomography (G.E. Bright Speed). A provisional diagnosis was suggested after the CT examination and these findings were correlated with other studies did for the renal abnormalities and surgical findings as applicable (**Figure – 1 to 17**).

Results

Gender distribution was as per **Table – 1**. Age distribution was as per **Table – 2**.

Table – 1: Gender distribution.

Gender	No. of patients
Male	34
Female	16

Table – 2: Age distribution.

Age group (Years)	No. of patients	%
0-10	6	12 %
11-20	7	14%
21-30	6	12%
31-40	5	10%
41-50	12	24%
51-60	5	10%
61-70	5	10%
>70	4	8%

In this study, the most common part of urinary tract involved is PUJ with 21 patients were affected (**Table – 3**).

Table – 3: Distribution of urinary system.

Urinary system	No. of patients
Kidneys	17
Ureters	7
Bladder	5
PUJ involvement	21

Most common age group was 0-20 years in which 8 patients were affected at PUJ (**Table – 4**). There were total no of 8 patients of renal masses among them 7 patients had enhancing and only one patients had non enhancing mass lesion that suggestive of nearly all renal mass are enhancing post contrast study (**Table – 5**). There was more than 15 HU difference between pre and post contrast images of mass lesion suggestive of malignant mass lesion (**Table - 6**).

Table – 4: Age-wise distribution of urinary system.

Age group (Years)	Kidneys	Ureters	Bladder	PUJ	Total
0-20	4	1	0	8	13
21-40	5	0	0	6	11
41-60	5	5	1	5	16
61-80	3	1	4	2	10
Total	17	7	5	21	50

Discussion

MDCTU is superior to IVU in the visualization of urinary calculi and other causes of acute lumbar pain, including extra urinary disorders. Unenhanced CT was 100% sensitive for calculi [5]. Contrary to IVU; MDCTU was reported to visualize extra urinary pathologies, considered as a major advantage [6].

Table – 5: Enhancement patterns of renal masses after IV contrast.

Enhancement	No. of patients	Percentage of enhancing masses
Enhancing	7	87%
Non-enhancing	1	13%
Total	8	100%

Pathogenesis of urinary tract abnormalities and its MDCTU imaging correlation

Renal stone

Renal, ureteral, and bladder calculi are a common cause of hematuria. Twelve percent of people develop kidney stones at some point during their lifetime [7]. The best imaging modality for evaluating calculi is unenhanced helical CT, which is commonly performed in patients with renal colic to detect obstructing calculi [8–10]. CT urography, however, does reliably show signs of obstruction, including hydronephrosis, hydroureter, ipsilateral renal enlargement, perinephric and periureteric fat stranding [11, 12]. The combination of hydronephrosis, hydroureter, and perinephric stranding has a positive predictive value of 90% for obstruction in the presence of urinary tract calculi.

Conventional radiography had a sensitivity of only 60% in detecting urolithiasis and in combination with US, the sensitivity increased to 70%. Although, excretory urography is reasonably accurate for detecting urinary tract stones, some reports suggest that it fails to demonstrate calculi in up to 48% of cases unenhanced CT is more accurate than excretory urography in demonstrating the presence, size and location of urinary tract calculi. The diagnosis of obstructing urinary tract calculi is usually confirmed by the detection of the secondary signs of obstruction. Presence of “soft tissue rim sign,” a circumferential rim of soft-tissue attenuation surrounding an abdominal or pelvic calcification, is a strong indicator that a calcification along the course of the ureter is a calculus [13, 14].Unenhanced CT allows for relatively easy detection of Ureteric course, non-obstructing calculi are more easily detected by MDCTU than on excretory urography. In contrast, one of the disadvantages in the evaluation of acute urinary tract obstruction with excretory urography is the difficulty in detecting the site of urinary tract obstruction. This often necessitates delayed radiographs at intervals up to 24 hours. In this scenario, MDCTU has advantages over excretory urography as the entire unopacified ureter can usually be “tracked” to the site of obstruction [15].

Table – 6: Attenuation characteristics of individual renal mass on pre and post contrast scans.

Renal masses	Pre contrast average hu value	Post contrast average hu value	No of patients
RCC	28	54	4
AML	10	18	1
Renal cyst	14	16	1
Metastasis	27	53	1
Lymphoma	14	24	1

Renal trauma

In 90% of cases, there will be renal injury due to blunt trauma during vehicular accident. Unlike in injury to the spleen and the liver, in renal trauma we also need to evaluate the collecting system. CT has facilitated shift toward non-operative management. 98% of renal injuries are now NOM. When injury is present, get delayed imaging to evaluate collecting system.

Pyelonephritis

Pyelonephritis is more common in a diabetic patients and immune compromised patients. Acute pyelonephritis is usually well characterized by MDCTU with findings of a “striated nephrogram” in a swollen kidney and stranding of the perinephric fat. Occasionally there can be thickening of the pelvicaliceal wall, which can also show increased mucosal enhancement. Bacterial renal infections, except those caused by gram-positive organisms, occur via the ascending route and span a continuum of varying severity from uncomplicated acute pyelonephritis through progressively worsening stages of interstitial inflammation to frank abscess formation.

Renal mass

Renal masses frequently manifest with hematuria. Characterization of a renal mass as a simple cyst, a complex cyst, or a solid mass is essential. Simple cysts are benign and do not warrants further evaluation. Solid masses, with the exception of angiomyolipomas, are presumed to be malignant and usually require surgery.

Features of complex cysts that must be evaluated include wall thickness, presence and thickness of septa, calcifications, attenuation of the cyst, and foci of enhancement. Cystic renal masses are often characterized according to the Bosniak classification system [16–18].

As a general rule, category I and II lesions are benign, whereas category III and IV lesions are possibly malignant and warrant surgery. In cystic masses that are difficult to differentiate as category II or category III lesions and in cysts with thick calcifications, category IIF may be used, and these lesions warrant close follow-up .CT has been shown to be more accurate in the detection of parenchymal masses compared to ultrasound or excretory urography with sensitivities of 94% reported compared to 67%

and 79% for excretory urography and ultrasound respectively. CT can detect up to 47% of masses measuring 5mm and 75% of masses measuring 10 15 mm in diameter.

Figure – 1: A) (case:1) axial post contrast and B) (case:2) VR images showing perinephric fat stranding on left kidney and left VUJ, upper Ureteric calculi with left sided HN,HU.

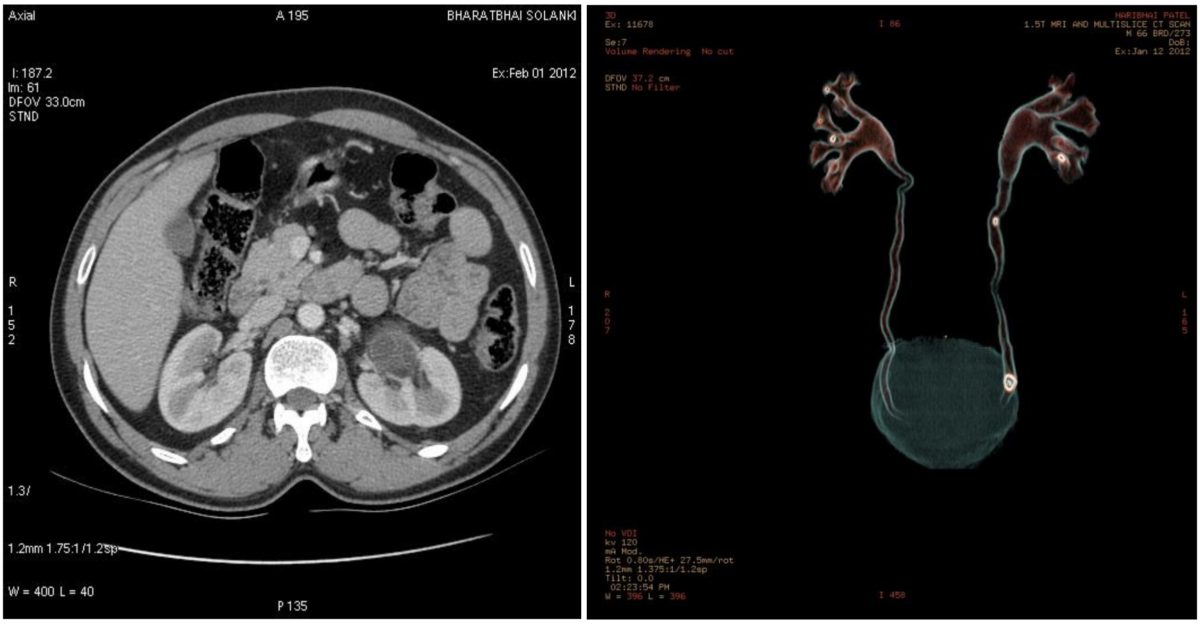
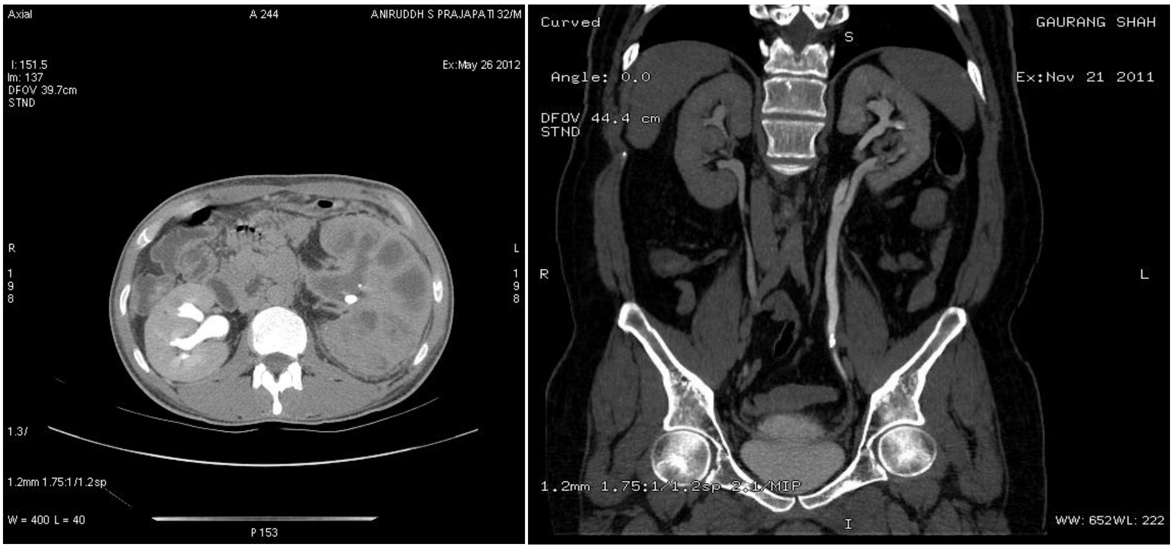


Figure – 2: A) (case:3) axial post contrast and B)MIP images showing left renal enlargement with pelvic calculus and Incomplete duplication of left renal pelvis & upper ureter with 2 left lower Ureteric calculi with HN,HU.

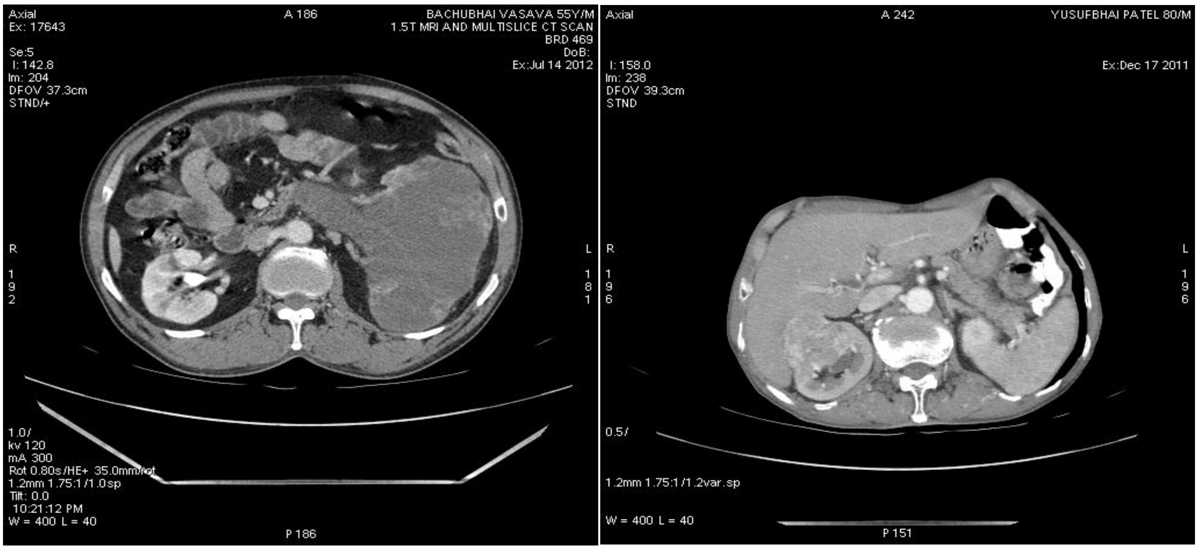


PUJ obstruction

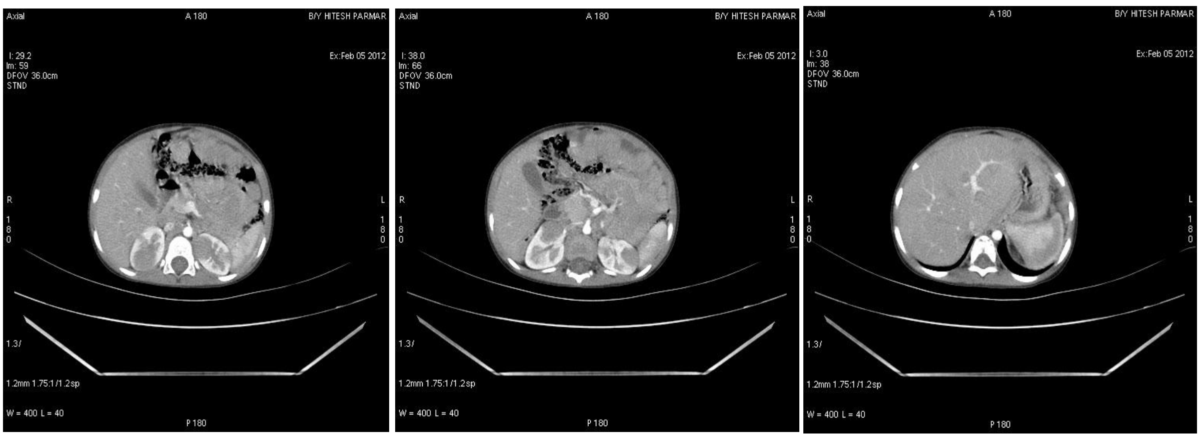
PUJO is defined as functional or anatomic obstruction to urine flow from the renal pelvis into the ureter at their anatomic junction, which, if left untreated, results in symptoms, renal damage, or both. PUJO generally implies a congenital partial proximal Ureteric obstruction detected in utero or in later life, although the exact cause and possible embryologic source of PUJO are not known at this time. Failure of recanalization and the presence of valves are not likely causes. However, the problem is more likely due to an intrinsic abnormality of collagen or muscle than to an extrinsic cause. Secondary

PUJO strictures from iatrogenic causes, inflammation, or tumor are less common. Multicystic dysplastic kidney may represent the end result of complete PUJO, although the natural history of partial PUJO remain unclear, and therapeutic intervention is largely based on symptoms or image-based evidence of asymmetric dysfunction or the morphologic change of hydronephrosis [19].

<u>Figure – 3</u>: A) (case: 11) and B) (case: 16) post contrast axial images showing left renal solid cystic mass with enhancing solid component (BOSNIAK: IV) [a] and right renal enhancing exophytic mass with Hounsfield value more than 20[b].



<u>Figure – 4</u>: a) (case: 14), b) (case: 14) and c) (case: 15) post contrast axial images showing mildly enhancing solid masses involving B/L kidneys and liver, with multiple infiltrating mesenteric masses.

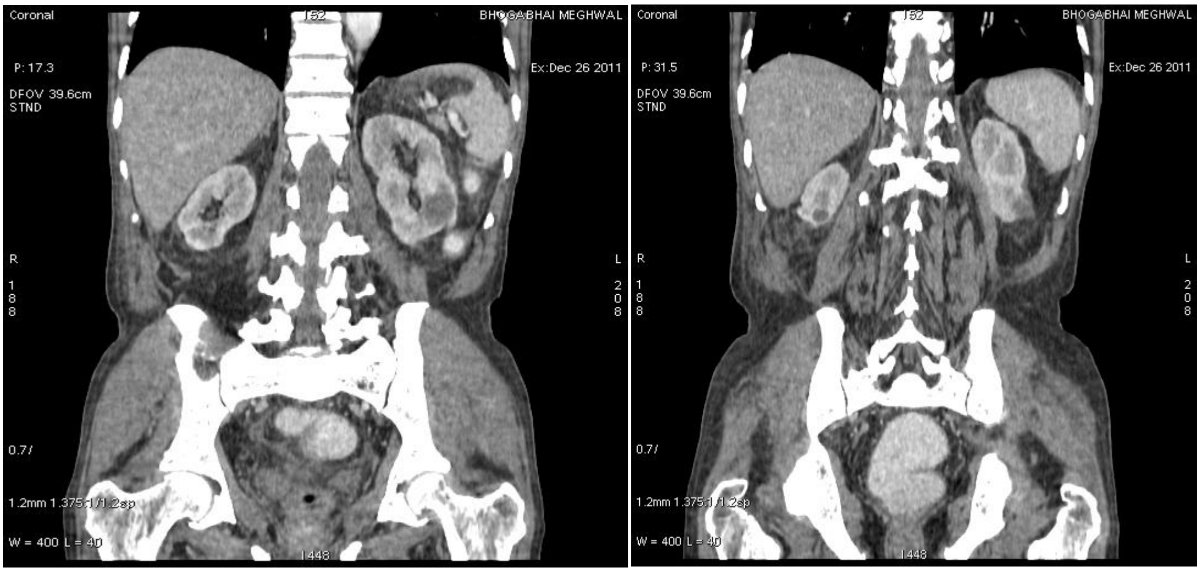


In PUJO characteristic pattern of hydronephrosis on coronal reformatted images that first leads to the suggestion of PUJO is involvement of the extra renal collecting system more than the intrarenal portion and assumes an inverted teardrop shape tapering to the point of transition with the normal ureter [20]. The severity of hydronephrosis should be noted, as this does affect surgical outcome.

Ureteric stricture

MDCTU is helpful in identification and characterization of the causes of Ureteric obstruction including short segment malignant strictures with associated mural thickening, retroperitoneal masses and lymphadenopathy, retroperitoneal fibrosis, benign Ureteric strictures and iatrogenic causes such as post hysterectomy and colectomy injuries and MDCTU is more sensitive for these causes of Ureteric stricture.

<u>Figure – 5</u>: a) (case: 17) and b) (case: 17) post contrast coronal images showing B/L non-enhancing cystic lesions (BOSNIAK: I).



<u>Figure – 6</u>: a) (case: 15) and b) (case: 15) post contrast axial images showing B/L hypodens lesions with lesion affecting left kidney shows contrast extravasations.

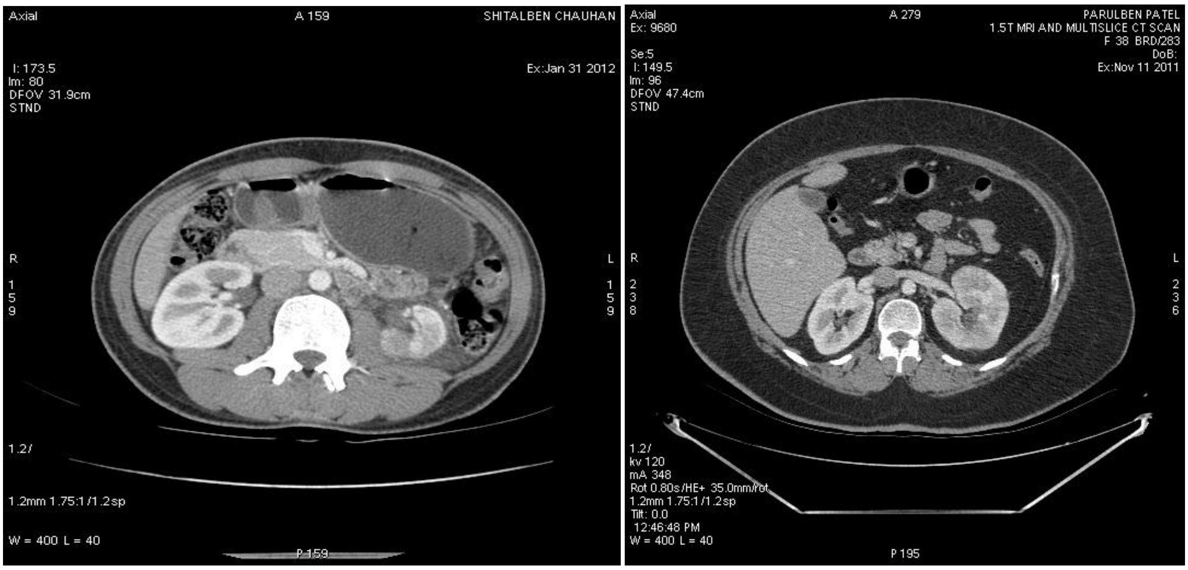
Anomalies

Congenital anomalies developed due to defect in the embryonic development of urinary tract from Ureteric buds. Most congenital anomalies of urinary tract can be appreciated with MDCTU. Congenital anomalies of renal position, number and form are well depicted by MDCTU [21]. With optimum opacification of ureters, partial and complete duplication of the collecting system can beseen on axial source images. Improved z-axis resolution is a welcome consequence of MDCTU and aid in obtaining diagnostic quality three-dimensional reconstructions, particularly in coronal plane.

These factors have improved our ability to thoroughly evaluate the urinary tract for variant anatomy. 3D reconstructions can be very useful in the characterization of urinary tract anomalies such as ureteral duplication and ectopic ureter or ureterocele [22]. An advantage of MDCTU in this clinical setting is that MDCTU can depict not only opacified ureters but also unopacified ureters, which cannot be visualized on excretory urography [23]. Anomalous kidneys may be complicated by duplicated ureters, stone disease, vesico ureteral reflux, traumatic injury, and ureteropelvic junction obstruction. CT urography is well suited to detect such complications.

Figure – 7: a) (case:19) and b) (case:21) post contrast coronal images showing enlarged left and right kidneys in a) and b) images respectively with patchy enhancement on excretory phase.

Figure – 8: a) (case: 19) and b) (case: 20) post contrast axial images showing left sided striated nephrogram with perinephric fat stranding in image a).

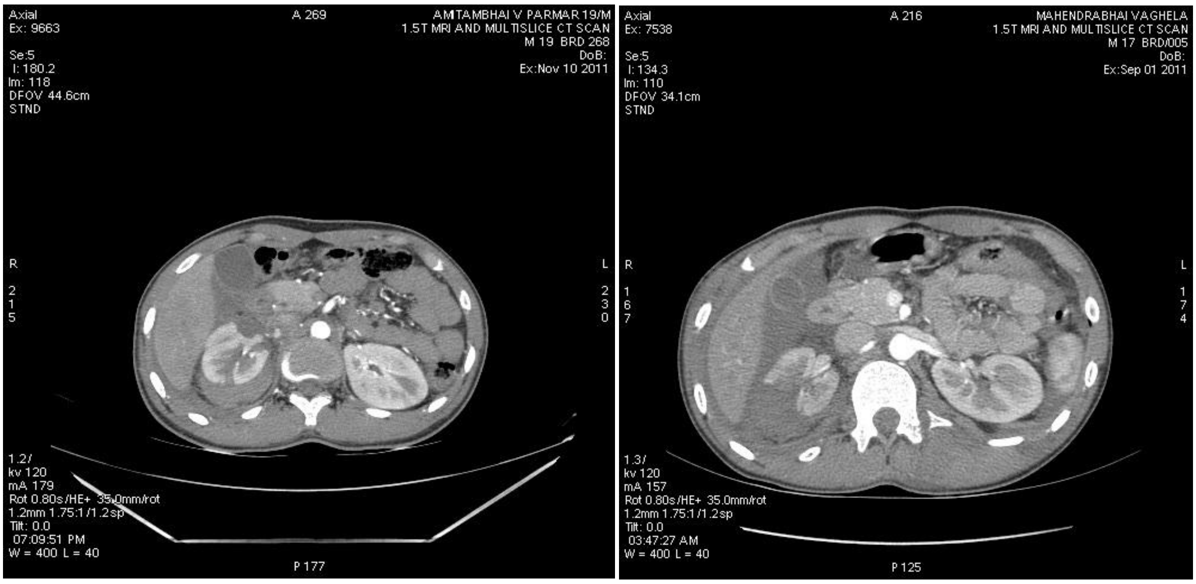


Bladder mass

Bladder abnormalities are a common cause of hematuria and include neoplasms, usually transitional cell carcinoma, particularly in patients with exposure to aniline dyes, phenacetin, tobacco, and prior radiation therapy.

Squamous cell carcinoma and adenocarcinoma are less common bladder neoplasm. Evaluation of the bladder by MDCTU requires pre-and post contrast studies. The pre-contrast study is useful as calcifications within the bladder wall or lumen are easily detected. However, bladder masses frequently cannot be detected on non-contrast images. Focal bladder wall calcification can occur with transitional cell or Squamous cell carcinoma of the bladder. Focal areas of bladder wall thickening suggest bladder carcinoma particularly when it is associated with increased enhancement of the bladder wall at that point. Scanning of a fully distended contrast filled bladder may demonstrate these tumors as filling defects.

<u>Figure – 9</u>: a) (case: 22) and b) (case: 23) axial post contrast images showing GRADE: III [a] and GRADE: IV [b] right renal injury with free fluid in Morison's pouch.



<u>Figure – 10</u>: a) (case: 27) axial and b) (case: 25) coronal post contrast images showing GRADE: II and GRADE: III left and right renal injury with liver laceration in image b) and intra peritoneal free fluid in image a).

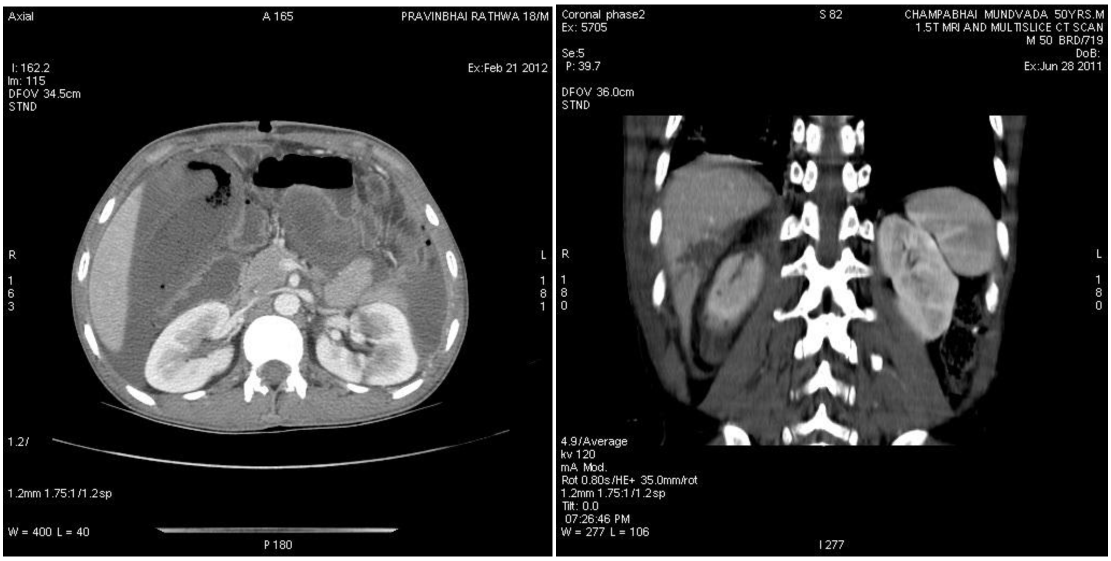


Figure – 11: a) (case:30) coronal post contrast and b) (case:33) VR images showing B/L dilated extra renal pelvis and tear drop shaped tapering of the point of transition of normal ureter.

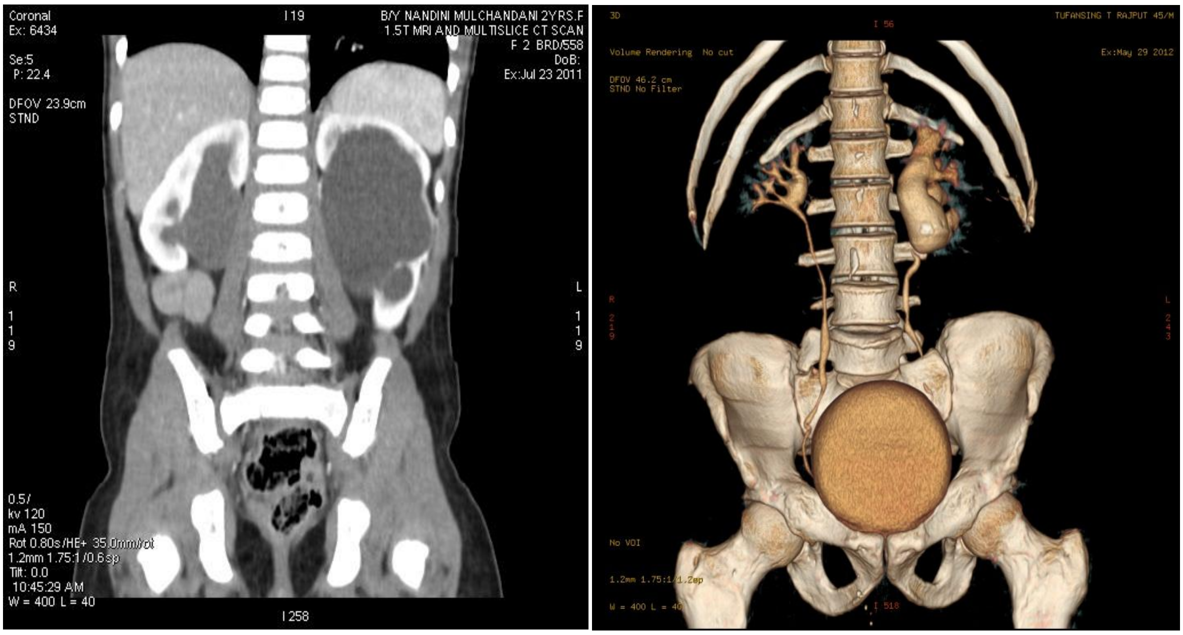
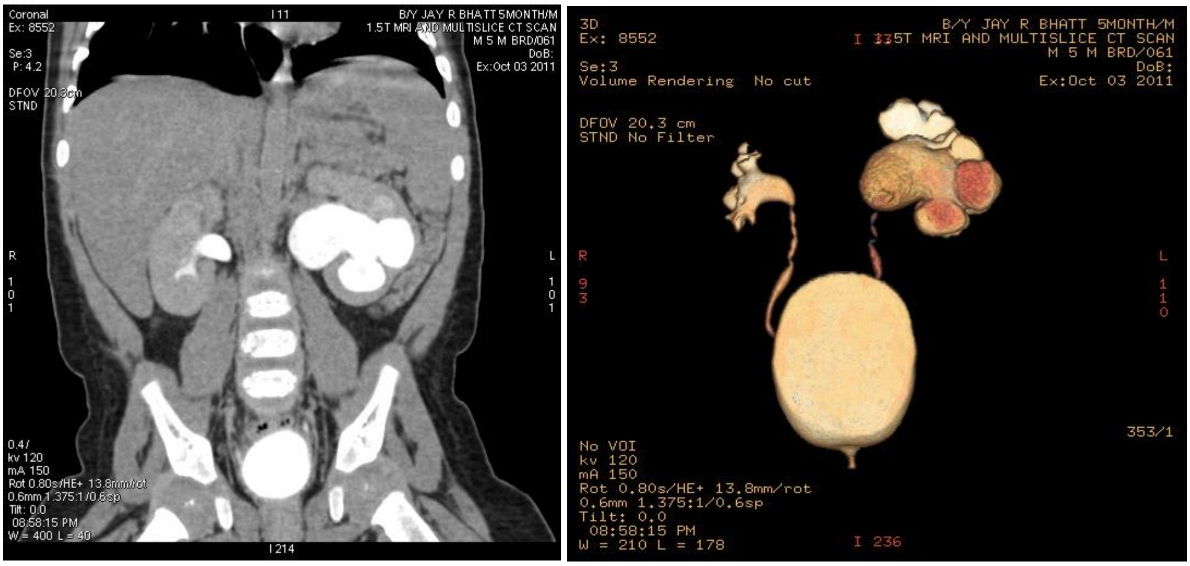


Figure – 12: a) (case:31) post contrast coronal and b) (case:31) VR images showing B/L dilated extra renal pelvis and tear drop shaped tapering of the point of transition of normal ureter and enlarged left kidney.

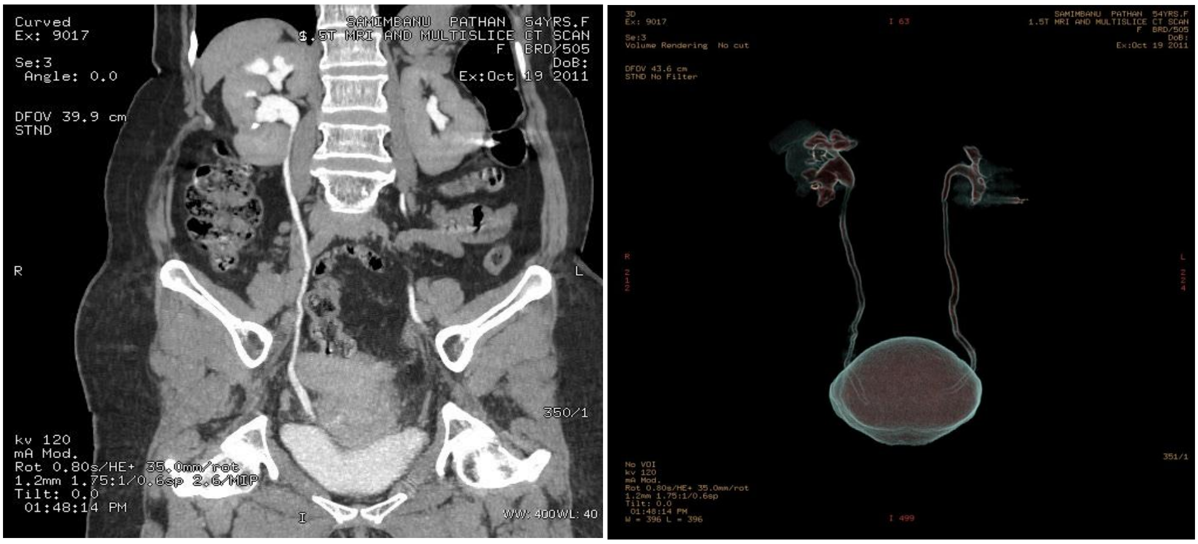


Conclusion

The proper techniques of MDCTU give all relevant information about the abnormalities of urinary system to the clinician to make reliable decisions which are evidence based. Looking at the benefits of CTU over conventional IVP it makes CTU as first line investigation when imaging investigation required for urinary tract abnormalities. CTU gives reliable information not about the extent of lesion but also the characteristics of lesions which makes surgeons to take proper decision about the further management of patients. CTU avoids unnecessary laparotomy surgery in case of blunt abdominal trauma patients by giving the precious extent of renal injuries. For all these gold standard benefits of MDCTU over conventional IVP makes MDCTU as “one stop shop” for urinary tract abnormalities and nearly completely replacing the IVP in recent era. For the all of the

CTU benefits over conventional IVP we can recommend it as first line investigation for the renal abnormalities in the clinical practice.

<u>Figure – 13</u>: a) (case: 38) post contrast coronal and b) (case: 38) VR images showing narrowing at right upper ureter with peri ureteral fat stranding and right sided mild HN.



<u>Figure – 14</u>: a) (case:39) and b) (case:39) post contrast coronal images showing heterogeneously enhancing mass lesion invading base, lateral wall of bladder and left vesico Ureteric junction with HN,HU on left side.

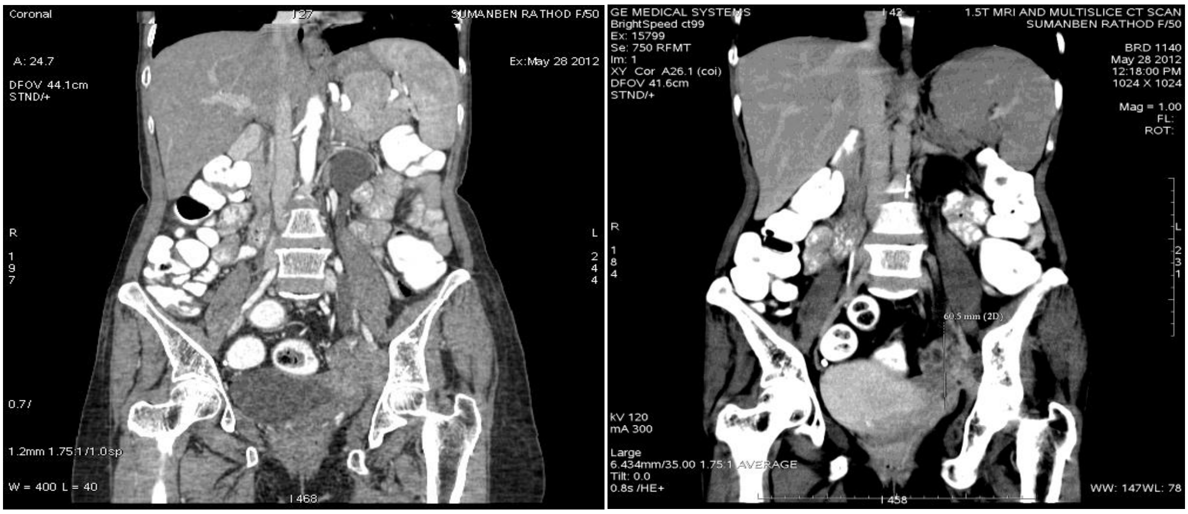


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Figure – 15: a) (case:42), b) (case:42) post contrast coronal and c) (case:42) VR images showing complete duplication of right renal pelvis and ureter with ureterocele of upper moiety and HN,HU of both upper and lower moiety.

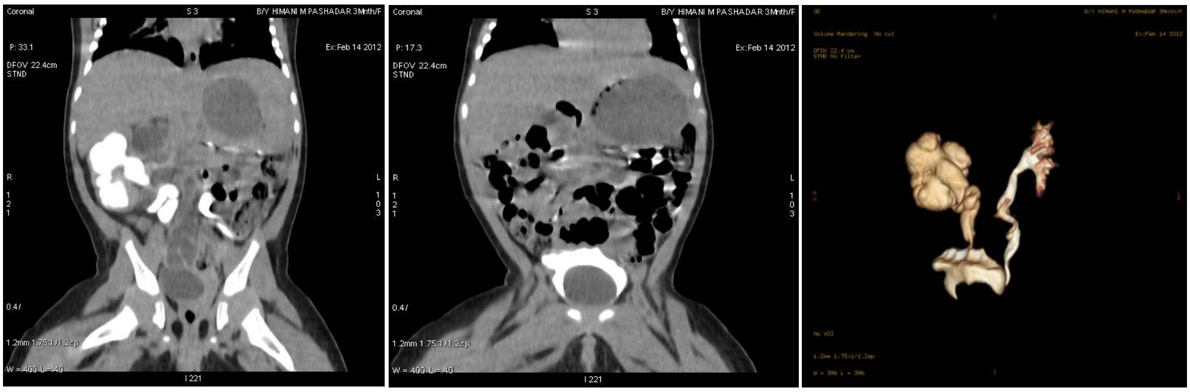

Figure – 16: a) pre-contrast coronal (case:43), b) (case:43) post contrast coronal and c) (case:43) VR images showing complete duplication of right renal pelvis and ureter with HN,HU of right upper moiety secondary to lower Ureteric calculus.

Figure – 17: a) (case: 14) axial , b) (case: 14) VR and c) (case: 15) post contrast coronal images showing well defined heterogeneously enhancing mass involving the base of bladder and infiltrating B/L VUJ with B/L HN and HU.