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Radiodiagnosis

ROLE OF MULTI DETECTOR CT UROGRAPHY IN URINARY TRACT PATHOLOGIES

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ABSTRACT From calculus disease to hematuria, imaging has been of great importance in the diagnosis of many diseases of the urinary tract. MDCT urography represents one of the most advanced developments in imaging the urinary tract. The increased utilization of cross-sectional imaging in the investigation of the urinary tract has led to a marked reduction in number of excretory urograms being performed annually.A prospective study of 100 patients with urinary symptomatology was performed who presented at VS Hospital Ahmedabad. The study was conducted during the period from August 2015 to May 2016.Although all imaging modalities play an important role in imaging the urinary tract, CT urography represents the most comprehensive imaging examination of the urinary tract detect all types of stones, neoplasms, obstructions , congenital anomalies and other pathologies.

KEYWORDS : .MDCT Urography, neoplasms, calculi, kidneys, ureters, hydronephrosis, neoplasms.

INTRODUCTION:

From calculus disease to hematuria, imaging plays an important role in the diagnosis of many diseases of the urinary tract. Advances in imaging technology have changed the practice of uroradiology significantly. CT urography is one of the most advanced developments in imaging the urinary tract to date(1).

Excretory urography has been the initial modality for upper tract imaging in patients with hematuria, flank pain, and other urologic diseases for the past 5 decades (2,3).

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. Application of MDCT in evaluation of the urinary tract has been termed CT urography (4). The concept of CT urography is attractive since both the renal parenchyma and urothelium can be evaluated with a single comprehensive examination. CT urography potentially allows shortening the overall duration of the patient's time for diagnostic evaluation.

Multidetector CT urography (MDCTU) offers several advantages for imaging of the urinary tract: Single breath-hold coverage of the entire urinary tract with absence of respiratory misregistration, rapid imaging with optimum contrast medium opacification and reduced partial-volume effect as appropriate slices can be selected from the volumetric data. In addition, acquisition of multiple thin overlapping slices provides excellent two dimensional and three-dimensional reformations, and facilitates virtual cystoscopy(5,6). These advantages have established MDCTU as a compelling alternative to excretory urography and ultrasonography in the evaluation of the patient with hematuria.

This study is an attempt to review the role of CT Urography in various urinary tract disorders.

MATERIALS & METHOD

A prospective study of 100 patients with urinary Symptomatology was performed who presented at VS Hospital Ahmedabad. The study was conducted during the period from August 2015 to May 2016.

Inclusion criteria:

1. Patients presenting with urinary tract symptomatology.
2. Patients having normal renal function as assessed by Serum Creatinine level & Estimated GFR (eGFR).
3. Patients with good breath-holding capacity.

Exclusion criteria:

1. Patients with renal dysfunction.
2. Allergy to contrast media.
3. Pregnant or lactating women

100 patients were referred for CT Examination. Almost all these patients were symptomatic and many had multiple symptoms related to urinary tract. However, pain was the predominant symptom in as many as 58 cases.

Protocol of performing CT Urography:

TABLE 1: Imaging protocol followed at our institution is as follows:

	I	II	III	IV
Phase	Unenhanced Phase	Venous Phase	Nephrogram Phase	Excretory Phase
Range	Abdomen-Pelvis	Abdomen-Pelvis	Kidneys	Kidneys to Urinary Bladder
Slice Thickness	1mm	1mm	1mm	1mm
Increment	-1mm	-1mm	-1mm	-1mm
Pitch	1.077	1.077	1.077	1.077
Reconstruction	1mm	1mm	1mm	1mm
Scan orientation	Cranio-caudal	Cranio-caudal	Cranio-caudal	Cranio-caudal
Scan delay	-	50sec	100sec	10min

Patient preparation :

NBM for 4 hours.
Written informed consent.

All patients were checked for their serum creatinine levels.

History of allergic reaction to drugs and contrast media was obtained. Emergency drugs for any possible drug reaction were kept ready at the time of examination.

Patient registration in form of individual details, clinical history, past history.

Recording of previous X-Ray, USG, IVU & other relevant laboratory reports whenever available for evaluation.

One litre of drinking water was given 30 minutes prior to the scan. Oral positive iodinated contrast was given whenever necessary or requested by the consulting physician.

Patient position :

Supine with axial images taken, with respiration suspended at mid–inspiration.

Prone scans whenever necessary for demonstration of ureters.

Preparation on table :

Hands were raised above the head.
To clear the area of interest of removable metal objects to avoid artifacts.

Breath-holding technique was practiced on table with patient, as it improves patient compliance, decreases patient anxiety and may lessen artifacts during acquisition.

Patients were informed about the experience of diffuse warmth at the end of the injection.

Intravenous injection :
An intravenous line of no. 20 gauge intracath was taken on the forearm.

Contrast concentration used was 350 mg iodine/ml. Normally amount of contrast used was 80 ml.

A saline chaser of 40 ml was used.

Rate of injection was 3 ml per second (Using Auto-injector).

Equipment :
All patients were scanned with a SIEMENS SOMATOM 64 -slice CT scanner equipped with a new feature in multislice CT technology, so called z-axis flying focus technology.

A topogram was performed followed by a plain scan from a level just above the domes of diaphragm to the level of pubic symphysis. Then 3-phase CT Urography as described below was performed. Additional phases, e.g. arterial phase for renal tumors and delayed prone scans for demonstration of ureters were taken as and when needed. After the procedure, the patient was kept under observation for 15 to 30 minutes.

Image post-processing:
The axial images were generated from the source raw data images. The slice thickness of 1.0 mm with reconstruction increment of -1.0 mm was used. The images were then transferred to a dedicated SIEMENS Workstation for image post-processing techniques. The various techniques used were Multiplanar Reconstruction (MPR), Maximum Intensity Projection (MIP), Curved Planar Reconstruction (CPR) and Volume Rendering Technique (VRT). Although from the radiological point of view, the axial images were sufficient to diagnose, the referring urologists / physicians preferred the 3D images. In addition to film interpretation, image interpretation was performed on the dedicated 3D (SIEMENS) Workstation in an interactive manner. Two or three dimensional post processing displays such as MPR, MIP, cMPR and VRT may be helpful for a first glance to see the course of the ureters. It should be considered that any 2D or 3D reconstruction may come along with a loss of spatial resolution. Smaller calculi for instance, which are visible in the axial source, may not be seen in volume rendered images and the diagnosis can be completely missed. Therefore the primary axial slices are superior to any post processing method.

OBSERVATIONS & RESULTS:

- **Age Distribution:** the most common age group was 41-60 years (42 patients).
- **Sex Distribution:** Of the 100 patients included in the analysis, 68 were male and 32 were female. Thus, urinary tract disorders were more common in men as compared to women in this study.
- **Symptomatology:** Pain (58%) was the dominant symptom followed by hematuria (8%) & micturition disturbances (6%).
- **Distribution of the Various Causes:** obstructive pathologies comprised of a dominant group (50%).

TABLE-2: Of the 100 patients, the distribution of various etiologies is as follows:

Etiology	No. of cases
Obstructive	50
Neoplastic	14
Infective	9
Post-operative/Post intervention	7
Congenital	6
Urinary bladder pathologies	6
Renal cystic disease	5
Extra-urinary	3

Level of Disease: kidneys were more commonly affected (38%) followed by ureters (34%).

TABLE-3:

Level	No.of cases
Kidney	38
Pelvi-ureteric Junction	7
Ureter	34
Vesico-ureteric Junction	8
Urinary Bladder	13

- **Size of Obstructing Calculi:** 15 patients (35.71%) had obstructing calculi more than 8 mm, making passagethrough the urinary tract difficult.
- **Comparison Between USG and CT IVU:** accuracy of detecting pathologies by CT IVU was100% as compared to 65% of USG.

TABLE -4:

Etiology	No.of Cases	Detected by USG	Detected by CT IVP
Obstructive	50	31	50
Neoplastic	13	12	4
Infective	9	3	9
Post operative/Post Intervention	7	2	7
Congenital	6	4	6
Urinary Bladder Pathologies	6	6	6
Renal Cystic Disease	5	4	5
Extraurinary Cause	3	3	3
Total cases	100	65	100

DISCUSSION:
In the present study 100 patients with urinary tract symptomatology were included, who underwent CT-IVU. Available pathological and surgical findings were corroborated with the imaging findings. Our study was different from most other studies done on CT urography as it deals with all the urinary tract disorders and not just a specific group of lesions as is done in most studies.

Common presenting features of patients in this study were pain in 58 (58%), hematuria in 8 (8%), lump in 5 (5%) & micturition disturbances in 6 (6%). Those patients who underwent surgery / intervention of the abdomen / pelvis were included in a separate category and comprised of 16 (16%) cases. Microscopic hematuria was seen in 27 (27%) cases, which included 22 (81.5%) cases of calculus disease, 3 (11.1%) malignant neoplasms and 2 (7.4%) infections. In our study, CT urography detected all causes of microscopic hematuria. This was similar to the results of the study done by Sears et al(7).

Obstructive Uropathy:
This was commonest condition in our study being present in 50 out of 100 patients (50%). However, total patients in which back-pressure changes detected were 64 (64%). These cases included Calculus Disease in 42 (65.6%), PUJ obstruction in 6 (9.3%), stricture in 5 (7.8%), and malignant infiltration of VU junction/lower ureter in 5 (7.8%) cases. Other cases included Pyelonephritis in 2 (3.1%) associated with ureteric calculi, retrocaval ureter in 1 (1.6%), urinary bladder diverticulum in 1 (1.6%), blood clots in urinary bladder in 1 (1.6%) and post-PCNL urinary leak with residual dilatation in 1 (1.6%).

Out of the total 42 cases of calculi, renal calculi were detected in 11 (26.2%) and ureteric calculi in 31 (73.8%). In addition, one patient also had urinary bladder calculus without significant back-pressure changes. Mean age at presentation of calculus disease was 42.4 years. Londsdale(8) also reported it to be common in middle aged patients.

In our study 42 out of 42 (100%) cases had radio-opaque calculi. This is similar to the study done by Eddell Zegel(9) which reported incidence of radio-opaque calculi to vary from 90-95%.

In our study ultrasound was able to diagnose 30 out of 42 cases (71.4%). This is in close proximity with the study by Caoili EM et al (10) who showed that conventional radiography had a sensitivity of only 60% in detecting urolithiasis and in combination with USG, the sensitivity increased to 70%.

All 42 cases (100%) of calculi were detected by CT IVU. This is the same as shown by the study of Col KK Sen et al(11).

FIGURE 1: Staghorn calculus

The plain CT scan in coronal plane shows multiple right renal calculi and a pelvic Staghorncalculus extending into the lower pole calyx with mild degree of back-pressure changes.

Neoplasms:

There were 14 cases of neoplasms in our study, 7 each of kidney & urinary bladder. The mean age of renal neoplasms was 58.7 years, while the mean age for bladder neoplasms was 67.5 years.

In our study we found that USG detected 6 out of 7 cases of renal neoplasms (Sensitivity 85.7%) & 6 out of 7 cases of urinary bladder neoplasms (Sensitivity 85.7%). The sensitivity of detecting neoplasms was 100% for CT IVU. 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 intravenous urography and ultrasound respectively as shown by the study done by Fielding JR et al(12).

CT can detect up to 47% of masses measuring 5 mm and 75% of masses measuring 10-15 mm and 100% of masses measuring >15 mm in diameter as proved by the study done by Jamis – Dow et al17. surgery with similar survival rates to those achieved with radical nephrectomy (13,14).

In a study by Chow LC et al, 500 patients (327 patients with painless hematuria) underwent CT urography for urinary tract abnormalities and it was concluded that CT urography detected all proven cases of renal cell carcinoma yielding high sensitivity and specificity(15).

FIGURE 4: Renal Cell Carcinoma with renal vein & IVC thrombosis

Venous phase images in coronal plane reveal heterogeneously enhancing soft tissue mass lesion involving the upper pole of right kidney with extension of tumor thrombus into the ipsilateral renal vein & IVC, a feature highly suggestive o renal cell carcinoma. Final histopathological diagnosis was high-grade renal cell carcinoma

Infections:

There were 9 cases of upper urinary tract infections in our study which included 8 cases of pyelonephritis & 1 case of ureteritis. In addition, cystitis was detected in 7 patients.

In cases of upper urinary tract infections, USG was able to diagnose parenchymal changes in 3 out of 9 cases (Sensitivity 33.3%), while in cases of cystitis, sensitivity was 85.7% (6 out of 7 cases) in detection of urinary bladder wall thickening / intraluminal echogenic debris. CT could correctly detect and define the extent of disease in all the cases of GU infections in our study.

We had 5 cases of infections associated with calculus disease (2 cases of pyelonephritis and 3 cases of cystitis). The underlying cause of infection, i.e. calculi was detected by USG in 4 out of 5 cases. Rest of the cases of cystitis were: One case of radiation cystitis and one case each of urinary bladder diverticulum, blood clot in urinary bladder and infected renal cortical cyst associated with cystitis. Both USG & CT IVU were able to diagnose all these cases. However, USG failed to show ipsilateral lower lung consolidation in a case of pyelonephritis, which was delineated by CT IVU. Our findings were similar to the studies done by Soulen et al(16), Webb(17), Kaplan et al(18) & Rauschkolb et al(19) who reported CT IVU superior to US in detecting parenchymal abnormalities, delineating disease and detecting perinephric collections.

Congenital

There were 6 cases of congenital anomalies: 2 cases of congenital pelvi-ureteric junction obstruction, one case of medullary sponge kidney with Caroli's disease, two cases of ectopic kidney, one case of retrocaval ureter & one case of pyelogenic cyst. Both the cases of PUJ obstruction were evaluated by USG & CT IVU and the back-pressure changes were detected correctly. However, only CT IVU was able to provide information on exact level of obstruction, functional aspect and whether the obstruction was complete or incomplete. We also had 2 other cases of incidentally detected congenital anomalies, both of which had bifid renal pelvis.

CT IVU detect all the congenital anomalies, efficacy being 100%. In a retrospective cohort study done by Glodny et al(20) in 209 patients concluded CT IVU as the most reliable imaging method in cases of horseshoe kidneys & crossed fused ectopia.

Various studies done by McCollough et al(21), Nolte – Ernsting CC et al(22) & Herts BR(23) have shown CT IVU has detected a variety of congenital anomalies of the urinary tract, including partial duplications, complete duplications, ectopic ureteroceles, pelvic kidneys and horseshoe kidneys. Duplications appear to be more conspicuous when image reformatting is obtained(23). The study done by Lang et al(24) showed congenital ureteropelvic junction anomalies appropriately diagnosed with CT IVU.

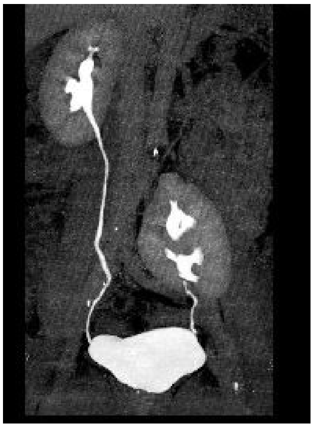

FIGURE 2: Ectopic left kidney.

Coronal MIP images of the excretory phase show ectopic left kidney in pelvis with normal excretion of contrast.

Extraurinary:

CT urography can be used to depict structures outside the urinary tract and thus is useful in detecting unsuspected extraurinary disease. In one study done by Liu et al(25), extraurinary findings were detected in 259 (75.3%) of 344 patients examined for hematuria with CT urography. Sixty-two (18.0%) patients had highly significant findings, including three cancers. In our study there were 3 cases with extraurinary cause for obstructive uropathy. These included pelvic malignancies, one each of prostate & ovarian malignancy as well as one case of recurrent pelvic mass post-hysterectomy. All three cases were detected by CT IVU & USG, however USG was less sensitive in detecting associated features like pelvic lymphadenopathy, omental nodules, hepatic metastases & urinoma formation due to leak from obstructed pelvicalyceal system.

Urinary Bladder Pathologies:

This was included in a separate category consisting of 6 cases of non-neoplastic urinary bladder pathologies, which included 3 cases of blood clots in urinary bladder and 1 case each of vesical calculus, diverticulum and radiation cystitis. Three cases were also associated with changes of cystitis (One case each of vesical diverticulum, vesical calculus & blood clot).

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