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Original Article

Internal Medicine Section

Role of Multi-Detector Computed Tomography Urography in Evaluation of Renal Tract Abnormalities

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ABSTRACT

Introduction: Computed Tomography Urography (CTU) is currently the modality of choice for imaging the urinary tract. Advanced CTU allows a thorough evaluation of the kidneys, ureters, urinary bladder and other structures simultaneously. Common conditions investigated by means of CTU include renal calculi, renal cancer, congenital kidney and ureter abnormalities, and certain renal inflammatory conditions.

Aim: To evaluate the efficacy of Multi-Detector Computed Tomography (MDCT) urography in diagnosing renal tract abnormalities and correlation of the imaging data with clinical features.

Materials and Methods: It was a descriptive study conducted between November 2017 and November 2019 involving fifty patients, aged 18-80 years with various renal abnormalities. This was a descriptive study involving both outpatients and inpatients. Triphasic examinations were carried out, including noncontrast, contrast enhanced and delayed images using a multidetector-row CT scanner. Chi-square and Fisher's-Exact Test were used to assess the significance of study parameters.

Results: Of the 50 suspected cases, 48 (96%) had renal tract abnormalities. The most common diagnosed condition was urolithiasis (36%), followed by congenital abnormalities (24%), renal masses/cysts/infections (14%), and bladder pathology/collecting system abnormalities/postoperative complications (16%). Urolithiasis was characterised by severe abdominal pain. Patients having renal masses in the urinary tract exhibited haematuria and weight loss. In case of congenital renal abnormalities, the clinical features were not significantly correlated.

Conclusion: MDCT urography is a very useful tool for diagnosing renal tract abnormalities.

Keywords: Cysts, Haematuria, Infections, Renal masses, Urinary bladder, Urolithiasis

INTRODUCTION

Intravenous (IV) urography has been conventionally used for imaging of the upper urinary tract. However, recently, this imaging technique has largely been replaced by CTU [1]. Some of the common conditions that are referred for a CTU investigation include renal calculi formation, haematuria, flank and abdominal pain, suspected renal or urothelial neoplasm, a variety of inflammatory conditions, and congenital anomalies of the kidneys and ureters [2].

The new generation CT scanners have better speed and spatial resolution. They have advanced multiplanar and volume-rendered image reconstruction capacity. This helps imaging of kidneys, ureters and urinary bladder at one go. Also, CTU is often used as a screening tool for imaging the urothelium in patients at high risk for developing bladder cancer [3].

The *American Urological Association Best Practices Policy Guidelines* recommend IV urography or CTU as the initial imaging investigation for patients with asymptomatic microscopic haematuria [3]. Importantly, the *American College of Radiology* has also recommended CTU for the evaluation of haematuria [3]. Moreover, clinically important extra-urinary findings can be found in some patients undergoing CTU. CTU is contraindicated in patients who cannot receive iodinated contrast media because of renal insufficiency, severe allergic reactions, or pregnancy [3].

CTU combines the advantages of excretory urography with cross-sectional imaging into a single investigation that is capable of accurately visualising the renal parenchyma, collecting system and ureters [4]. This technique is based on the acquisition of non-enhanced and enhanced CT scans of the abdomen and pelvis. It includes acquisition of thin section helical CT scans of the urinary tract during the excretory phase of enhancement. Multiplanar 2-Dimensional (2D) and 3-Dimensional (3D) reformation images are produced from axial source images during the excretory phase. CTU enables a single breath-hold inclusion of the whole urinary tract, faster imaging and the partial volume effect is reduced [5].

The primary aim of the study was to evaluate the role of MDCT urography in the diagnosis of renal tract abnormalities and to corelate clinical features with the imaging results.

MATERIALS AND METHODS

This was a descriptive study that was conducted between November 2017 and November 2019, involving Fifty patients (29 male and 21 female, from outpatients, inpatients, and referral Departments of Rajarajeswari Medical College and Hospital and Institute of Nephro-urology, Bengaluru, India. The study was approved by the Institutional Ethics Committee (RRJMC-RD-11/17-321) and informed consent was taken from all the study participants.

Inclusion criteria: Patients with suspected

- Urinary tract calculi, infections
- Renal parenchymal masses
- Renal papillary or medullary abnormalities, collecting system abnormalities
- Congenital anomalies of kidneys and ureters
- Renal cystic diseases
- Diseases of the urinary bladder and
- Postoperative patients between 18 and 80 years of age

Exclusion Criteria:

- Patients below 18 and above 80 years of age
- Pregnant women
- Renal failure patients
- Cardiac failure patients
- those with allergy to contrast media

Procedures

Triphasic examinations, including non-contrast, contrast enhanced and delayed imaging was carried out. Non-contrast imaging was carried out from the top of the kidneys through the bladder. The aim was to check for the presence of calculi, fat-containing lesions, parenchymal calcifications and to provide baseline attenuation for assessment of lesion enhancement. Contrast media was administered intravenously. After a delay of 90 to 100 seconds, scanning of the abdomen and pelvis was performed during the nephrographic phase. The final acquisition was obtained during the excretory phase after a delay of 12 to 15 minutes. During this phase, opacification and distention of the collecting systems, ureters and bladder was observed.

Scanning was carried out using a multi-detector row CT scanner (Siemens 128 slice). CT scans were obtained from the kidneys to the bladder using the following parameters: (i) collimator-5 mm; (ii) pitch- 1.5/2 Hz; and (iii) current- 120 mA. The thickness of the reconstructed images was 1 mm. A 3D reconstruction of the non-enhanced, nephrogenic phase and excretory phase were performed as and when required. The follow-up diagnosis was established on the basis of histopathologic findings or the findings of urologic procedures, such as cystoscopy, ureteroscopy or retrograde pyelography.

STATISTICAL ANALYSIS

In the present study, descriptive and inferential statistical analysis were carried out. Continuous measurements were presented as mean±SD (min-max) and categorical measurements were presented as number and percentage (%). A 5% level of significance was used in the present study. Chi-square and Fisher's-Exact Test were used to assess the significance of study parameters on categorical scale between two or more groups.

The Statistical Package for the Social Sciences (SPSS) (Version 18.0) and R environment (Version 3.2.2) were used for data analysis and MS Word and MS Excel were used for generating the graphs and tables. p-value <0.05 was regarded as moderately significant, while a p-value <0.01 was regarded as highly significant.

RESULTS

Age Distribution

The study included patients aged between 18 and 80 years. Maximum number of patients were seen in the age group 31-40 years, consisting of 15 (30%) patients. This was followed by the age group 20-30 years 9 (18%) patients, making up 18% of all patients. The least number of patients were in the age group >70 years, consisting of only 2 (4%) patients. The average age of the patients was 41.84±16 years (mean±SD).

Clinical Symptoms

The presentation of clinical symptoms is mentioned in [Table/Fig-1]. Some of the patients presented with more than one symptoms. Forty patients (80%) complained of abdominal pain. Seventeen patients (34%) presented with haematuria, 12 patients (24%) had fever, while 4 patients (8%) reported loss of weight [Table/Fig-1].

Pathology

The pathological conditions that were studied included: (1) urolithiasis; (2) congenital anomalies; (3) infections; (4) renal masses; (5) cysts; and (6) others.

Urolithiasis

Urolithiasis was found in 18 out of 50 patients (36%) and was the most common pathology diagnosed. Calculi were identified in 8 patients (16%) on the left side (kidney/pelvi ureteric junction/ureter/vesico-ureteric Junction) and in 6 patients (12%) on the right side (kidney/pelvi ureteric junction/ureter/vesico-ureteric junction). Four patients (8%) were found to have calculi in the bladder.

Clinical symptoms	No. of patients	Percent (%)
Abdominal pain	40	80
Fever	12	24
Weight loss	4	8
Haematuria	17	34

[Table/Fig-1]: Clinical symptoms of patients.

Out of the 18 patients diagnosed with urolithiasis, 11 patients (22%) had renal calculi. Four patients (8%) had staghorn calculi (since the calculi resemble the horn of a stag or male deer), 3 patients (6%) had calculi in upper and lower calyx and 1 patient (2%) had calculi in the middle calyx.

Three patients (6%) had calculi in the pelvi ureteric junction, 3 patients (6%) had calculi in the ureter, 1 patient (2%) in the vesico ureteric junction and 2 patients (4%) in the bladder [Table/Fig-2].

Congenital Anomalies

Out of 50 patients, 38 (76%) did not have any congenital anomalies, while 12 patients (24%) had these anomalies. The most common congenital anomaly diagnosed was pelvi-ureteric junction obstruction, which was seen in 6 cases. Other congenital anomalies diagnosed were mega ureter, crossed fused ectopic kidney, and duplex collecting system.

Presence/Location/Type of calculi	No. of patients	Percent (%)
No	32	64
Yes	18	36
Left	8	16
Right	6	12
Bladder	4	8
Kidney		
No	39	78
Yes	11	22
Staghorn	4	8
Lower calyx	3	6
Upper calyx	3	6
Middle calyx	1	2
Pelvi-ureteric junction		
No	47	94
Yes	3	6
Ureter		
No	47	94
Yes	3	6
Distal	2	4
Proximal	1	2
Vesico-ureteric junction		
No	49	98
Yes	1	2
Bladder		
No	48	96
Yes	2	4

[Table/Fig-2]: Distribution of calculi in patients.

Infections

Out of 50 patients, 43 (86%) did not have any infections. Seven patients (14%) had infection in the renal tract. The most common infection was acute pyelonephritis, which was diagnosed in 4 patients (57%). The remaining infections caused cystitis, which was diagnosed in 3 patients (43%).

Renal Masses

Renal masses were seen in 7 cases (14%), while 43 (86%) did not exhibit any masses. Out of the 7 cases, 4 patients (8%) had masses in their left kidney, 1 patient (2%) in the right kidney and 2 patients (4%) in their urinary bladder. Three of the 5 masses in the kidneys were histopathologically proven to be renal cell carcinoma and the bladder masses turned out to be transitional cell carcinoma. One patient exhibited angiomyolipoma.

Cysts

Cysts are membranous sacs or cavities within the body that have an abnormal character and contain fluids. Cysts were seen in 7 cases (14%), while 43 (86%) did not exhibit any cysts. Three patients (6%) showed cysts in their left kidney, 3 patients (6%) showed cysts in both kidneys (bilateral), and 1 patient (2%) showed cysts in the right kidney.

Others

Some of the other conditions in this category included collecting system abnormalities, papillary abnormalities, and urinary bladder pathology. Bladder pathologies included calculi formation, urothelial tumours, bladder diverticula, and bladder malignancies of various types. Bladder pathology was found in 6 patients (12%), collecting system abnormality (stricture) was found in 1 patient (2%) and 1 post-nephrectomy patient (2%) underwent CT. There were no cases of papillary abnormalities.

Secondary Signs and Incidental Findings

The secondary signs include hydronephrosis, hydroureteronephrosis and delayed renal excretion. Hydronephrosis/hydroureteronephrosis were found in 15 patients (30%) and delayed renal excretion was found in 2 patients (4%). Incidental findings which were not related with the renal tract, such as cholelithiasis, hepatosplenomegaly, uterine fibroids and ovarian cysts were found in 6 patients (12%) [Table/Fig-3].

Condition	No. of patients	Percent (%)
Hydronephrosis/Hydroureteronephrosis	15	30
Delayed renal excretion	2	4
Incidental findings	6	12

[Table/Fig-3]: Secondary signs and incidental findings.

Diagnosis

Of the 50 cases that were clinically suspected as having renal tract abnormalities, it was possible to correctly diagnose 48 patients (96%), using MDCT urography. The other 2 cases which were clinically suspected to have renal tract abnormality turned out to have no pathology on MDCT urography.

Among the 48 cases with renal tract abnormality, the most commonly diagnosed pathology was urolithiasis which was observed in 18 cases (36%). This was followed by congenital anomalies, which was observed in 12 cases (24%). Renal masses, infections and cysts accounted for 7 cases (14%) each. Other conditions, such as bladder pathology, collecting system abnormality and postoperative cases were observed in 16% of patients [Table/Fig-4].

Correlation of Clinical Features in Patients with Urolithiasis

Among the patients referred for MDCT urography, pain was the only clinical symptom that had a significant correlation with the presence of urolithiasis [Table/Fig-5].

Diagnosis	No. of patients	Percent (%)
Normal study	2	4
Positive cases	48	96
Urolithiasis (calculi)	18	36
Congenital anomalies	12	24
Infection	7	14
Mass	7	14
Cysts	7	14
Bladder pathology	6	12
Collecting system abnormality	1	2
Papillary abnormality	-	-
Postoperative	1	2

[Table/Fig-4]: Diagnosis of various conditions in patients.

Clinical features	Presence of urolithiasis		Total (n=50)	p-value
	No (n=32)	Yes (n=18)		
Pain	22 (68.7%)	18 (100%)	40 (80%)	**0.009****
Fever	8 (25%)	4 (22.2%)	12 (24%)	1.000
Weight loss	4 (12.5%)	0 (0%)	4 (8%)	0.283
Haematuria	9 (28.1 %)	8 (44.4%)	17 (34%)	0.242

[Table/Fig-5]: Clinical features associated with urolithiasis.
Chi-square/Fisher's-exact test; **Highly significant

Correlation of Clinical Features in Patients Exhibiting Congenital Anomalies

Among the patients referred for MDCT urography, haematuria was the only clinical feature that had a significant correlation with the presence of congenital anomalies [Table/Fig-6].

Clinical features	Congenital anomaly		Total (n=50)	p-value
	No (n=38)	Yes (n=12)		
Pain	31 (81.6%)	9 (75%)	40 (80%)	0.686
Fever	11 (28.9%)	1 (8.3%)	12 (24%)	0.248
Weight loss	4 (10.5%)	-	4 (8%)	0.560
Haematuria	16 (42.1%)	1 (8.3%)	17 (34%)	**0.039***

[Table/Fig-6]: Clinical features associated with congenital anomalies.
Chi-square/Fisher's-exact test; *Moderately significant

Correlation of Clinical Features in Patients with Renal Masses

Among the patients referred for MDCT urography, weight loss and haematuria were the only two clinical features that had significant correlation with the presence of renal masses [Table/Fig-7].

Clinical features	Renal masses		Total (n=50)	p-value
	No (n=43)	Yes (n=7)		
Pain	35 (81.4%)	5 (71.4%)	40 (80%)	0.616
Fever	11 (25.6%)	1 (14.3%)	12 (24%)	1.000
Weight loss	-	4 (57.1%)	4 (8%)	**<0.001****
Haematuria	12 (27.9%)	5 (71.4%)	17 (34%)	**0.037***

[Table/Fig-7]: Clinical features associated with renal masses.
Chi-square/Fisher's-exact test; *Moderately significant; **Highly significant

DISCUSSION

The present study included 50 patients who were strongly suspected to have urinary tract abnormalities. Triphasic MDCT urography was carried out, which included non-contrast, contrast enhanced and delayed images. Non-contrast images extending from the top of the kidneys through the bladder were generated. Intravenous contrast media was administered and following a delay of 90-100 seconds, the abdomen and pelvis were scanned. The final acquisition was during the excretory phase after a delay of 12-15 minutes.

Urinary tract abnormalities were classified into urolithiasis, congenital anomalies, renal mass formation, infections, cyst formation, bladder pathology, collecting system abnormalities, papillary abnormalities, and postoperative patients. Secondary signs were noted, which included hydronephrosis/hydroureteronephrosis and delayed renal excretion. Incidental findings, which were not related to the renal tract, such as cholelithiasis, hepatosplenomegaly, uterine fibroids, and ovarian cysts were also recorded.

Clinical features were noted under four categories, which included abdominal pain, fever, weight loss and haematuria. Moreover, clinical features were correlated with the presence of urolithiasis, congenital anomalies and renal mass formation as they were the most commonly observed urinary tract abnormalities.

Urolithiasis is the formation of calcified stones or calculi within the urinary system. Calcification within the lumen of the urinary tract is known as nephrolithiasis, whereas intraparenchymal calcification is termed as nephrocalcinosis [6].

The congenital anomalies of the kidneys included horseshoe kidney, renal ectopia with or without crossed-fusion, hypertrophied column of Bertin, and renal agenesis. Anomalous kidneys may also have complications, such as duplicated ureters, stone disease, vesico-ureteric reflux, traumatic injury, and pelvi-ureteric junction obstruction. These can all be detected by MDCT urography [7,8].

With regard to infections, pyelonephritis was the most common infection. Pyelonephritis is the inflammation of the kidneys as a result of bacterial infection. It exhibits a number of symptoms, including bacteriuria, pyrexia and flank pain. Pyelonephritis may occur due to ascending infection caused by *Escherichia coli* in 85% of cases or due to haematogenous seeding caused by *Staphylococcus aureus* in 15% of cases [9].

Renal masses can be benign and malignant. These may include renal cell carcinoma and angiomyolipoma, especially during the nephrographic phase. Other less common masses include renal lymphoma (primary or secondary), transitional cell carcinoma, multilocular cystic nephroma, oncocytoma, and metastatic disease [10]. The most common abnormality to be diagnosed was urolithiasis. The location and morphology of the calculi were noted. Pre-contrast phase of MDCT urography could correctly diagnose calculi in all cases of urolithiasis.

Retrospective comparison of the results of MDCT urography with other clinical results (pyeloureteroscopy, surgery or spontaneous passage of the calculi) and imaging examinations (retrograde pyelography or sonography) were performed.

The mean age of the patients in the present study was 41.84±16 years. This was correlated with studies carried out by Lin WC et al., and Caoili EM et al., [1,5]. There was no significant correlation between age and renal tract abnormalities in the present study.

Urolithiasis was the most common renal tract abnormality found in the present study, which was observed in 18 patients (36%). This was similar to the findings of the study conducted by Lin WC et al., [1], where 38% of the patients were diagnosed with urolithiasis. However, the study conducted by Caoili EM et al., found that only 8% of the patients had urolithiasis [5]. Kumar R et al., studied 50 patients with haematuria, out of which 20% had renal calculi [11]. In a study by Shamachar VK et al., renal calculi were the most common abnormality among the 100 patients studied for the evaluation of ureter abnormalities [12].

In the present study, all the 18 patients with urolithiasis were diagnosed in the pre-contrast phase of MDCT urography. Most of the patients diagnosed with urolithiasis were between 30-50 years of age. In the study by Kumar R et al., renal calculi were more common among younger age group of patients [11]. Similar results were shown in the study by Shamachar VK et al., [12]. Hundred patients were studied and renal calculi were found more commonly in younger age group. Abdominal pain was the only statistically significant clinical feature associated with urolithiasis in the present study. In the other studies, there was no correlation between clinical symptoms and diagnosis.

In the present study, congenital anomalies were diagnosed in 12 patients (24%), which were higher compared to the studies conducted by Lin WC et al., and Caoili EM et al., [1,5]. The most common age group in which congenital anomalies occurred in the present study was 31-40 years. The most common congenital anomaly detected in the present study was pelvi-ureteric junction obstruction, which was observed in 6 out of 12 cases. There was no significant clinical feature that correlated with the congenital anomalies in the present study. In the study by Shamachar VK et al., the most common ureter anomalies were pelvi-ureteric junction obstruction and vesico-ureteric reflux [12].

In the present study, 14% of patients had renal masses, which is almost similar to the other studies conducted by Lin WC et al., and Caoili EM et al., [1,5]. In the study by Kumar R et al., 16% of patients with haematuria had urothelial carcinoma and 6% of patients with haematuria had renal cell carcinoma [11]. Haematuria and loss of weight were the only two statistically significant clinical features that were associated with malignancy in the present study. Renal mass formation was confirmed by postoperative follow-up of the patients.

Limitation(s)

The sample size was small, compared to the spectrum of renal tract abnormalities that were present. Not all patients with suspected renal tract abnormalities could undergo MDCT urography due to financial constraints. As pregnant women were excluded from the study, the role of MDCT urography in these women could not be evaluated. Since, the study included patients between 18 and 80 years of age, abnormalities diagnosed before 18 years and after 80 years could not be assessed.

CONCLUSION(S)

Based on the study findings, it may be concluded that MDCT urography is a very powerful and useful diagnostic tool for the detection and evaluation of renal tract abnormalities.

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