ORIGINAL RESEARCH PAPER

Radiodiagnosis

ROLE OF MULTIDETECTOR CT UROGRAPHY IN EVALUATING PATIENTS WITH HAEMATURIA

KEY WORDS: MDCT, Haematuria, Urography, ultrasonography, urolithiasis.

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ABSTRACT

OBJECTIVES: To study the spectrum of imaging findings in haematuria patients. To study the accuracy of Multidetector CT Urography (MDCTU) in identifying pathologies causing hematuria in comparison with other modalities like Radiography and Ultrasonography (USG). To study whether with a single investigation MDCTU can assist in formulating the right management strategy in every patient of haematuria.

METHODS: This prospective observational study was conducted at the department Radio-diagnosis, GRMC, Gwalior over a period of 18 months. Total number of cases included 100.

RESULTS : Out of the 100 cases findings were Urolithiasis (33%), renal masses (16%), renal infection (8%), cystitis (4%), urinary bladder masses (18%), BPH (4%), prostatic carcinoma (4%), trauma (4%), extra urothelial pathologies (5%) and no causes found in (4%) of patients.

CONCLUSION: MDCTU identified and characterized various pathologies causing haematuria with high accuracy in comparison with other modalities like radiography and ultrasonography (USG).

INTRODUCTION:

Haematuria is one of the most common presentations of urinary tract pathologies and always warrants serious concern, both to the patient as well as the treating physician. Haematuria is defined as abnormal presence of red blood cells (RBCs) in urine. It is commonly divided into gross and microscopic haematuria. The causes of haematuria are urinary tract infections, urinary tract calculi, trauma, polycystic kidney disease, urological malignancies, benign prostatic hyperplasia (BPH) in adults, other causes includes ureteric obstruction, bleeding diathesis, drugs like analgesics, antibiotics, anticoagulants, diabetes, hypertension, sickle cell anaemia, chronic renal disease, vigorous exercise and etc[1].

Workup of haematuria starts with proper history taking and clinical examinations. First line investigations often include X-ray Kidney Ureter Bladder (KUB), renal USG, Intra Venous Pyelography (IVP). Second line investigations includes plain CT KUB, CT Urography, MRI KUB, Magnetic Resonance Urography (MRU)[2]. Intravenous pyelography has been the gold slandered in evaluation of upper urinary tract diseases. It has reported sensitivity of 60.5% and specificity of 90.9% for detection of urological abnormalities in patients with haematuria[3]. Its disadvantage includes a lengthy acquisition time, the radiation dose, risk of contrast reaction and it cannot differentiate cystic from solid mass. USG is superior to IVP for detection of renal masses with reported sensitivity of 67% and 79% for IVP and USG respectively [4]. It can distinguish solid from cystic masses.

CT KUB is now the first line imaging investigation in diagnosis of calculus disease with reported sensitivity of 96 to 100% and specificity of 94 to 100% [5]. The major limitation of CT KUB is the first line investigation is significant higher radiation dose. The advanced multidetector CT scanners with its superior spatial resolution, higher speed and isotropic reconstruction capability has ushered in a revolution in diagnostic imaging of urinary tract disorders [6]. MDCT urography provides a detailed anatomic depiction of the entire urinary tract in a single breath hold, thus allowing patients with haematuria to be evaluated comprehensively. Lately, it has almost supplanted the conventional urography in evaluation of the urinary tract[7]. IVP only images the ureteric lumen and cannot adequately depict any extrinsic abnormalities while MDCTU can image the periureteric tissue and retroperitoneum. The reported incidence of extra urinary pathology with CT performed for suspected calculus diseases 12%[8].

This study was intended to assess the role of MDCTU has the potential to become a one investigation to evaluate the entire urinary tract, especially in cases of haematuria.

AIMS AND OBJECTIVES:

- To study the spectrum of imaging findings in patients presenting with gross as well as microscopic haematuria.
- To study the accuracy of MDCT Urography in identifying various pathologies of urinary tract causing haematuria in comparison with other modalities like Radiography and USG.
- To study whether a single investigation of MDCT Urography can assists in formulating the right management strategy in every patient of haematuria.

MATERIAL AND METHODS:

This prospective observational study of 100 patients was conducted at department of Radio-diagnosis, G.R.M.C, Gwalior over period of 18 months (February 2018 to August 2019), after necessary approval from the institutional ethics committee.

a) Inclusion criteria:

1. All patients referred for CT Urography having complaints of gross hematuria.
2. Documented unresolving microscopic haematuria with associated significant risk factors for developing urologic disease.
3. Patients with haematuria who are suspected to have some urinary tract pathology on other modalities and were then referred for CT Urography.
4. Patients with history of trauma.
5. Patients whose complete medical or surgical treatment follow-up is available.

B) Exclusion criteria:

1. Patients lost to follow-up.
2. Patients whose serum creatinine value is above 1.5 mg/dL.
3. Patients known to be allergic to ionic or non-ionic contrast media.
4. Pregnant patients.
5. Follow up cases of hematuria.
6. Postoperative cases.

CT Urography Technique:

All cases underwent CT Urography in 128 slice (***SIEMENS SOMATOM DEFINITION AS***) Computed Tomography machine. Patients were kept nil orally 6 hrs prior to study to avoid complications while administrating contrast medium. Risks of contrast administration were explained to the patient and consent was obtained prior to the contrast study. Water (800-1000 mL) was given as negative contrast medium. CT scans were obtained from the level of lung bases to ischial tuberosities with a collimator of 5 mm, a pitch of 1.5 and with150- 200 mA, KV 120. Routine anteroposterior topogram of the abdomen was initially taken in all patients in the supine position with the breath held. In all cases plain scan was followed by intravenous contrast scan in suspended inspiration. Sections were taken in corticomedullary (40-60s), nephrographic (80-120s) and excretory phases (180s). Additional scans were taken according to the pathologies. Images were reconstructed at a thickness of 0.5 mm.

Sagittal and coronal reconstructions were made wherever necessary. Newer techniques like curved planar reformatting, volume rendering, Maximum and Minimum Intensity Projections were done as and when necessary.

Patients were followed up in consultation with Urology unit in our hospital and with regards to findings on any diagnostic or therapeutic interventions as well as histopathology.

STASTICAL ANALYSIS:

All the data collected were computed using MS-Excel (2010) and descriptive statistics were analyzed using the same. All the statistical analysis was done using MedCalc ® v12.5 for windows statistical software.

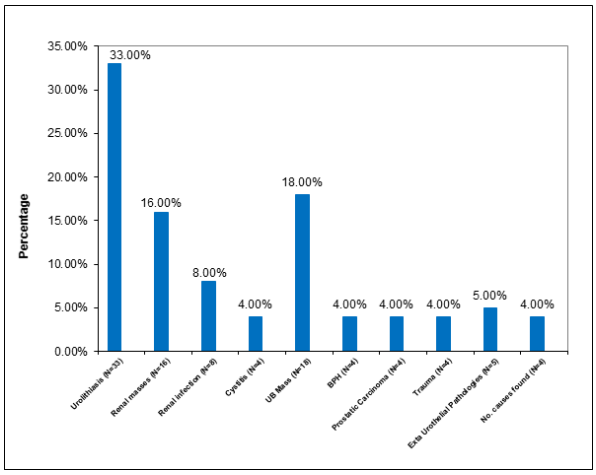
OBSERVATION AND ANALYSIS:

A total of 100 patients with history of haematuria were included in our study. Of them 72 (72%) were males and 28 (28%) females. Majority of the patients were in the age group of 31 to 40 years, that was 21 (21%) cases, followed by 51-60 yrs 18 (18%), 41-50 yrs 17 (17%), 61-70 yrs 14 (14%), 21-30 yrs 14 (14%), >70 yrs 7 (7%), 11-20 yrs 5 (5%) and <10 yrs 4 (4%). Oldest patient was 84 yrs and youngest 2.5 yrs. Mean age was 45 years. Male predominance was noted with male to female ratio of 2.5:1.

In our study, out of 100 cases pathologies identified in 96 cases. Of which 42 pathologies (43.8%) identified in kidney, 14 (14.5%) pathologies in ureters, 31 (32.3%) pathologies in urinary bladder, 8 (8.4%) pathologies in prostate and 1(1%) pathology in urethra.

The pathologies identified by MDCTU were as follows, Urolithiasis in 33 (33%) cases, renal masses in 16 (16%) cases, renal infection in 8 (8%) cases, cystitis in 4 (4%) cases, urinary bladder masses in 18 (18%) cases, BPH in 4 (4%) cases, prostatic carcinoma in 4 (4%) cases, trauma in 4 (4%) cases, extra urothelial pathologies in 5 (5%) cases and no causes found in 4 (4%) cases. Various causes of haematuria founded depicted in *graph-1*.

Graph-1: Various pathologies causing haematuria in our study (N=100)



In our study, 47 patients underwent X-ray and it could made diagnosis only in 27 patients. All patients underwent ultrasonography examination. Diagnosis made by varies modalities enlisted in *table-1*.

Table-1: Comparison of various modalities in diagnosing the causes of haematuria

Diagnosis	No. of patients with X-Ray diagnosis	No. of patients with ultrasound diagnosis	No. of patients with MDCTU diagnosis	Final Diagnosis (Based on microbiology, operative and histopathological findings)
Urolithiasis	27	30	33	33
Renal masses	00	13	16	16
Renal Infections	00	04	07	08
Cystitis	00	02	03	04
UB masses	00	14	16	18
BPH	00	04	04	04
Prostatic carcinoma	00	01	02	04
Trauma	00	03	04	04
Extra urothelial pathologies	00	05	05	05

Haematuria was divided into painless and painful with respect to pain, microscopic and macroscopic with respect to quantity. Out of 100 cases with haematuria 48 (48%) were painful and 52 (52%) were painless, 62 (62%) were microscopic and 38 (38%) were gross. Haematuria further divided with respect to pain and quantity as following, painful microscopic haematuria in 33 (33%) cases, painless gross haematuria in 23 (23%) cases, painful gross haematuria in 15 (15%) cases and painless microscopic haematuria in 29 (29%) cases.

The most common cause of haematuria in our study was urolithiasis seen in 33 (33%) cases. Most common cause of painful haematuria was urolithiasis seen in 33 (68.60%) cases, painless haematuria was urinary bladder masses 18

(34.60%), gross haematuria was urinary bladder masses 18 (47.30%), microscopic haematuria was urolithiasis 28 (45.20%), painful microscopic haematuria was urolithiasis 28 (84.8%), painless microscopic haematuria was renal masses 12 (41.40%), painful gross haematuria was urolithiasis 05 (33.20%) and painless gross haematuria was urinary bladder masses seen in 17 (74.0%) cases.

Urolithiasis was more common in males 23 (69.7%) and in the age group of 31-40 years 13 (39.4%). Of them 21 (63.6%) were obstructive and 12 (36.4%) were non obstructive. Of them locations of calculi were, 16 (48.5%) in kidney, 14 (42.4%) in ureters and 16 (48.5%) in urinary bladder. All calculi were identified correctly by MDCTU thus giving 100% sensitivity, 100% specificity and 100% accuracy in comparison with USG gave sensitivity, specificity and accuracy of 90.91%, 100.00% and 97.00% respectively.

Renal infection was seen in 8 (8%) cases of our study. Of them MDCTU correctly diagnosed 7 cases with sensitivity, specificity and accuracy of 87.5%, 100% and 99.00% respectively. USG gave sensitivity, specificity and accuracy of 50.00%, 98.91% and 95.00% respectively. Renal infection was equally common in males 4 (50%) and females 4 (50%) and most common in the age group of 41-50 years 5 (31%). Among them 3 (37.5%) were renal abscess, 3 (37.5%) were acute pyelonephritis, 1 (12.5%) was xanthogranulomatous pyelonephritis and 1 (12.5%) was renal tuberculosis. MDCTU diagnosed one renal tuberculosis case as normal. This may be due to early stage of papillary necrosis without perinephric fat stranding. On follow up that patient found to have pyonephrosis. On culture it turned out to be tuberculosis.

The prevalence of cystitis in our study was (4%), seen in 4 cases. It was more common in females 3 (75%) and each patient in following age groups <10 years, 11-20 years, 31-40 years and 51-60 years. Among them one diabetic female of age 50 year was having emphysematous cystitis. MDCTU diagnosed one cystitis case as normal, thus giving 75% sensitivity, 97.92% specificity and 97.00% accuracy in comparison with USG sensitivity, specificity and accuracy of 50.00%, 97.92% and 96.00% respectively.

In our study, renal masses were diagnosed in 16 (16%) patients with sensitivity 100% and specificity 100%. USG gave sensitivity, specificity and accuracy of 81.25%, 97.62% and 95.00% respectively. Of them 10 (62.5%) were malignant, 5 (31.3%) were benign and 1(6.2%) was metastatic. Renal masses was more common in males 12 (75%) and in the age group of 51-60 years 5 (31%). Most common renal mass was RCC seen in 6 of 16 cases (37.5%). It was most common in patients with age above 50 year 6 (100%) and in males gender 5 (83.3%). All of them 16 (100%) showed variable enhancement in corticomedullary phase. In 6 cases of RCC, 2 (33.3%) showed haemorrhagic components, 03 (50%) had calcification (*most common calcified mass in our study*), 2 (33.3%) associated with hydronephrosis, 02 (33.3%) invaded into renal vein and IVC, 3 (50%) had lymph node metastasis, 02 (33.3%) had metastatised to bones and 01 (16.7%) metastasised to lungs. One renal pelvis TCC was false positively diagnosed as RCC, thus MDCTU giving sensitivity and specificity of 100% and 97.87% respectively. Angiomyolipoma (AML) diagnosed in 3 (18.8%) cases. Of them 2 (66.7%) were females and 1 (33.3%) was male. All of them were less than 40 years in age and showed lesser enhancement than malignant masses. One female patient with giant bilateral AML was diagnosed to have Tuberous sclerosis spectrum. 1 (33.3%) AML associated with haemorrhage. MDCTU was 100% sensitive and 100% specific for AML. Renal pelvis TCC was diagnosed in 2 (12.5%) male patients with age above 50 years. All 2 (100%) showed variable enhancement in corticomedullary phase, necrosis and associated with hydronephrosis. MDCTU diagnosed one large renal pelvis TCC as RCC with 50% sensitivity and 100% specificity. Wilm's tumour was diagnosed in 2 (12.5%) male child of age less than 5 years. Of them 1 (50%) showed necrosis, 1 (50%) showed haemorrhage and 2 (100%) had lymph nodal metastasis. MDCTU was 100% sensitive and 100% specific for wilm's tumor in our study. Oncocytoma was diagnosed in a male patient of age 70 years (6.25%). It was false positively diagnosed as RCC, thus MDCTU giving 100% specificity, 99% negative predictive value with accuracy of 99% for oncocytoma in our study. Appart from diagnosing renal masses MDCTU characterised it well as listed in *table-2.*

Table-2 : Characterisation of renal masses (N=16)

Enhancement	Necrosis	Haemorrhage	Calcification	Hydronephrosis	Fat	R.enalVein invasion	IVC Invasion	Lymph node mets	Bony mets	Lung mets	Distant mets
16 (100 .0%)	10 (62. 5%)	04 (25. 0%)	03 (18. 8%)	04 (25. 0%)	03 (18. 8%)	02 (12. 5%)	02 (12. 5%)	05 (31. 3%)	02 (12. 5%)	01 (6.3 %)	00

A complex cystic mass (MLCN) was diagnosed in a male patient of age 58 years 1(6.3%). Provisional CT diagnosis was Bosniak type IIF, on histopathology it came as multilocular cystic nephroma. MDCTU was 100% sensitive and 100% specific for complex cystic masses. A female patient of age 60 year diagnosed to have renal metastasis 1 (6.2%) with primary in ovaries.

In our study, total number of urinary bladder masses were 18 (18%), all of them were histologically proved as transitional cell carcinoma. Urinary bladder masses was more common in males 17 (94.4%) and in the age group of 61-70 years 6 (33.3%). All masses were enhancing 18 (100%), of them papillary growth seen in 12 (66.7%) cases, focal wall thickening seen in 06 (33.3%) cases, 04 (22.2%) masses were having calcification, 11 (61.1%) masses were involving VUJ, 05 (27.8%) were involving urinary bladder wall and perivesicle region and 01 (5.6%) was having lymph node metastasis. MDCTU false positively diagnosed 2 UB TCC with multifocal wall thickening as cystitis, thus giving 88.89% sensitive 100% specific and 98.00% accuracy for UB masses. USG gave 77.78% sensitivity, 98.78% specificity and 95.00% of accuracy for UB masses. Even though statistics were close for diagnosing UB masses, MDCTU further characterises the masses whereas USG couldn't. Characterisation of UB masses listed in *table-3*.

Table-3: Characterisation of Urinary Bladder masses (N=18)

Histopathology	Enhancement	Growth pattern	Calcification	VUJ involvement	Wall and perivesicle involvement	Metastasis
TCC 18 (100%)	18 (100%)	Papillary 12 ((66.7%) Focal wall thickening 06 (33.3%) Nodular 00	04 (22.2%)	11 (61.1%)	05 (27.8%)	01 (5.6%)

In our study, BPH and prostatic carcinoma were more common in the age group of 61-70 years. Benign prostatic hyperplasia diagnosed in 4 (4%) patients and prostatic carcinoma diagnosed in 4 (4%) patients. Most of the prostate pathologies were causing microscopic haematuria. MDCTU correctly diagnosed 4 BPH and 2 prostatic carcinoma cases. In those 2 carcinoma cases extra capsular extension of mass, bony and lymph node metastasis were present. MDCTU falsely diagnosed 2 prostatic carcinomas as BPH of them masses were within the prostatic capsule. Thus MDCTU gave sensitivity, specificity and accuracy of 100.00%, 97.92% and 98.00% for BPH and 50%, 100% and 98.00% for prostatic carcinoma respectively. USG gave sensitivity, specificity, accuracy of 100.00%, 96.88%, 100.00% for BPH and 25.00%, 100.00%, 97.00% for prostatic carcinoma respectively.

Four cases included in our study with history of trauma. Trauma was more common in the age group of 21-30 years 2 (50%) and equally distributed in both sexes. 2 (50%) were grade V renal injuries, 1 (25%) was traumatic extra peritoneal rupture of urinary bladder and 1 (25%) was bulbar urethral rupture. All CT findings were correlated with intra operatively. MDCTU was 100% sensitive and 100% specific for trauma whereas USG was 75.00% sensitive and 99.00% accurate.

In present study, 5 (5%) extra peritoneal pathologies causing haematuria diagnosed. Extra urothelial pathologies was more common in females 3 (60%) and in the age group of 51-70 years 4 (80%). Most common cause found was cervical mass with infiltration into urinary bladder seen in 3 cases (60%), 1 (20%) was rectal adenocarcinoma with urinary bladder wall infiltration and 1 (20%) was retroperitoneal nodal mass with ureteric infiltration.

DISCUSSION:

According to American Urological Association, microscopic haematuria defined as three RBCs per high power field on microscopic examination of centrifuged urine specimen in two of three freshly voided, clean catch, midstream urine samples. Approximately one million RBCs pass into the urine daily, which corresponds to 1 to 3 RBCs per high power field in microscopic examination[9].

On analyzing the gender distribution of patients presenting with haematuria in our study, it was found that there were more males (72%) than females (28%), with a ratio of 2.5:1. Hence, the present study is in accordance with the studies conducted by **Song JH et al** [10], and **Maheshwari E et al**[11], where male to female ratios were 1.17:1 and 1.47:1, respectively. Male predominance also noted in studies done by **Sonali Mhaske et al**[12] and **Ranjan Kumar et al**[13]

Urolithiasis was most common cause of haematuria in our study (33%). **Manik Mahajan et al**[14], in their study described the most common cause of haematuria in young adults. The most common clinically significant findings were urolithiasis (renal and ureteric calculi) seen in 84.2% of cases. **Varsha Rathi et al**[15], in their study most common cause of haematuria was urolithiasis 25.7%. In our study most common cause of painless haematuria was urinary bladder masses 18 (34.60%). Our findings were similar to the findings of **Nidhi Tyagi et al**[16], who have described the causes of painless haematuria in 31 patients. In their study most common cause of painless haematuria was urinary bladder masses seen in 17 (54.8%) cases.

Prevalence of diseases in our study was comparable with studies done by **Cowan NC et al**[17], **Maheshwari E et al**[11] **and Ranjankumaret al**[13] listed in *table-4*.

Table-4: Comparison of disease prevalence in patients with haematuria evaluated by MDCTU in different studies.

Diagnosis	Cowan NC Et al[17] (n=1001)	Maheshwari E et al[11] (n=200)	Ranjan kumar et al[13] (n=50)	Present study (n=100)
Calculus disease	16.3%	7.5%	6%	33%
Renal infections	0.2%	-	2%	8%
Renal malignancies	2.4%	-	6%	
UTUT	2.2%	4.5%	4%	2%
Renal injuries	-	-	2%	2%
Cystitis	-	2%	2%	4%
UB TCC	18.6%	9%	18%	18%
BPH	-	5%	4%	4%
Pros.carcinoma	3.5%	-	2%	4%
Extra urothelial pathologies	-	-	-	5%

In all these studies most common cause of haematuria <40 years age group was calculus disease, whereas > 40 yrs age group was malignancies.

In our study, 42 (43.8%) pathologies were in kidneys, 14 (14.5%) in ureters, 31 (32.3%) in urinary bladder, 8 (8.4%) in prostate and 1 (1%) in urethra. Organs involvement of present study was comparable to those obtained by **Cowan NC et al**[17] and **Maheshwari E et al**[11], where urinary bladder was the most commonly involved primary organ. Comparison with above mentioned studies enlisted in *table-5*.

Table-5: Comparison of organs involvement in patients with haematuria on MDCT in different studies.

Organ	Cowan NC et al[17]	Maheshwari E et al[11]	Present study
Kidneys	18%	7.2%	43.8%
Ureters	2.2%	6%	14.5%
Urinary bladder	19.8%	11%	32.3%
Prostate	3.5%	5%	8.4%
Urethra	-	-	1%

MDCTU identified all renal masses causing haematuria in our study. Further it characterised the masses well. Most common renal mass was RCC seen in 6 (37.5%) cases. It was most common in males 5 (83.3%) gender and in above 50 year 6 (100%) age group. **Verhoest G et al**[18], in their study have found that the incidence of renal cell carcinoma was 6% in <40y, 38.5% in 40-60y, 52.3% in 60-80 y and 3.2% in >80 y with male predominance. Our findings were similar with this study. Wilm's tumour was diagnosed in 2 (12.5%) male child of age less than 5 years. Our findings correlate well with the findings of **Lonergan et al**[19], who have described that the peak incidence of wilm's tumor is at 3-4 years and 80% of cases are below 5 years of age with male predominance.

Oncocytoma was diagnosed in a male patient of age 70 years (6.25%). It was false positively diagnosed as RCC. This finding

was similar to that of Blanca **Pano et al**[20] study. They developed a predictive model for differentiating RCC from oncocytoma, where they mentioned that current imaging techniques have low accuracy in differentiation between RCC and benign lesions like oncocytoma.

In the present study, the incidence of extraurinary findings at MDCT urography performed for haematuria was 5%. In another study, conducted by **Song JH et al**[10], the prevalence of highly significant extraurinary findings was 6.8%.

MDCTU identified all cases of urinary tract injuries and further characterised it. All findings were correlated well with intraoperative findings. **Tomer Erlich et al**[21], in their study CT urography gave 100% sensitivity and specificity for patients with renal injury which is similar to present study.

In comparison with other modalities like X-ray and USG, MDCTU identified more number of pathologies causing haematuria. Apart from identifying pathologies causing haematuria MDCTU diagnosed many congenital anomalies like absent kidney, ectopic kidney, crossed fused ectopia, malrotated kidney, duplex ureters and in a young female with Obstructed Hemivagina and Ipsilateral Renal Anomaly (OHVIRA) syndrome.

CONCLUSION:

Multidetector CT urography detects with high accuracy the entire spectrum of urinary tract pathologies causing haematuria in comparison with other modalities like X-ray and ultrasonography. Multi detector CT urography is highly sensitive and specific for detecting renal and urinary bladder masses. It is useful for further characterization and staging of neoplastic masses. Thus, multidetector CT urography has the potential to become a one investigation for evaluation of urinary tract, especially in cases of haematuria. Even though dedicated protocols side effects of contrast material, radiation exposure and time consumption are limitations of MDCTU. Another limitation of the current study is limited number of cases evaluated.

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