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ROLE OF MULTIDETECTOR CT UROGRAPHY IN EVALUATING PATIENTS WITH HAEMATURIA

Radio-Diagnosis

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ABSTRACT

Objectives: To evaluate the range of imaging findings in patients with hematuria, assess the accuracy of Multidetector CT Urography (MDCTU) in detecting underlying causes of hematuria compared to other imaging modalities such as radiography and ultrasonography (USG), and determine whether MDCTU alone can guide. **Methods:** This prospective observational study was conducted in the Department of Radiodiagnosis at GMC Nagpur over a 24-month period, including a total of 78 cases. **Results:** Among the 78 cases, the findings were as follows: urolithiasis (35.8%), renal masses (14.1%), renal infections (2.5%), cystitis (7.6%), urinary bladder masses (19.3%), benign prostatic hyperplasia (0.1%), prostatic carcinoma (2.6%), trauma (3.9%), and extra-urothelial pathologies (5%). **Conclusion:** MDCTU proved highly accurate in detecting and characterizing a range of pathologies responsible for hematuria, outperforming other imaging methods such as radiography and ultrasonography (USG).

KEYWORDS

MDCT, Haematuria, Urography, ultrasonography, urolithiasis, renal masses.

INTRODUCTION:

Hematuria, defined as the abnormal presence of red blood cells (RBCs) in urine, is a common and concerning sign of urinary tract disorders. It is classified into gross (visible) and microscopic forms. Gross hematuria can occur with as little as 1 ml of blood in 1 litre of urine, so urine colour does not reliably indicate blood loss. According to the American Urological Association, microscopic hematuria is diagnosed when there are at least three RBCs per high-power field on microscopic examination of centrifuged urine in two out of three freshly voided, clean-catch samples. The primary causes of hematuria include urinary tract infections, calculi, trauma, polycystic kidney disease, cancers, benign prostatic hyperplasia (BPH), and other factors such as bleeding disorders, medications, diabetes, hypertension, sickle cell anaemia, chronic kidney disease, and vigorous exercise. Evaluating hematuria begins with a thorough history and physical exam, followed by imaging tests. Initial investigations often include X-ray of the kidneys, ureters, and bladder (KUB), renal ultrasonography (USG), and intravenous pyelography (IVP). Second-line imaging may involve CT KUB, CT Urography, MRI KUB, or Magnetic Resonance Urography (MRU). X-ray KUB has limited utility due to its moderate sensitivity (45–60%) in detecting stones and lack of utility for urothelial malignancies. CT KUB is now the preferred first-line test for diagnosing urinary calculi, with high sensitivity (96–100%) and specificity (94–100%). However, CT KUB comes with the drawback of increased radiation exposure, and it often reveals incidental non-urinary findings (12% of cases). Historically, IVP was the gold standard for upper urinary tract imaging, with sensitivity of 60.5% and specificity of 90.9% for urological abnormalities in hematuria. However, IVP has several disadvantages, including longer imaging times, radiation exposure, and risk of contrast reactions. While it can identify renal masses, it cannot distinguish cystic from solid masses and has limited sensitivity for small lesions (less than 3 cm). Ultrasonography (USG) is advantageous for its lack of radiation and is better than IVP for detecting renal masses, with sensitivities of 67% for IVP and 79% for USG. USG can distinguish between solid and cystic masses, but it has limited ability to detect urothelial malignancies, especially renal pelvis carcinoma, with a sensitivity as low as 12%. Multidetector CT Urography (MDCTU) has recently replaced IVP as the preferred imaging method for the urinary tract. MDCT scanners, with their superior spatial resolution, high speed, and isotropic reconstruction abilities, allow for comprehensive urinary tract evaluation. MDCTU can provide detailed 3D images in a single breath-hold, which is particularly useful for assessing hematuria. MDCTU has shown superior accuracy in diagnosing upper urinary tract carcinomas (sensitivity 96%, specificity 100%) compared to IVP (sensitivity 75%, specificity 86%). It is also highly effective in identifying urinary stones and characterizing renal masses. Furthermore, MDCTU offers the advantage of imaging the periureteric tissues and retroperitoneum, areas that IVP cannot adequately assess. This study aims to evaluate MDCTU's potential as a comprehensive, single-step diagnostic tool for assessing the urinary tract, especially in hematuria cases.

AIMS AND OBJECTIVES:

1. To study the accuracy of MDCT Urography in identifying various pathologies of urinary tract causing hematuria.
2. To study the spectrum of imaging findings in patients presenting with gross as well as microscopic hematuria.
3. To study whether with a single investigation of MDCT Urography can assist in formulating the right management strategy in every patient of hematuria.

MATERIALS AND METHODOLOGY:

This prospective observational study of 78 patients was conducted at Department of Radio-diagnosis, G.M.C, Nagpur over period of 24 months (June 2022 to June 2024) after necessary approval from the institutional ethics committee.

Inclusion Criteria:

- All patients coming for CT Urography having the complaints for gross hematuria.
- Documented unresolving microscopic hematuria with associated risk factors for developing urologic disease.
- Patients with hematuria who are suspected to have some urinary tract pathology on other modalities and were then referred for CT Urography.
- Patients whose complete medical or surgical treatment follow up is available.
- Written informed consent.

Exclusion Criteria:

- Patients lost to follow up.
- Patients with non-urological cause of hematuria.
- Patient whose serum creatinine value is more than 1.5mg/dL.
- Patients known to be allergic to iconic a or non-iconic contrast media.
- Pregnant patients.
- Post operative cases.

CT Urography Technique:

All patients underwent CT Urography using a Dual Energy 128-slice SIEMENS SOMATOM DEFINITION AS CT machine. Patients fasted for 6 hours before the procedure to minimize complications during contrast administration. Risks associated with contrast medium were explained, and consent was obtained. Patients were given 800-1000 mL of water as a negative contrast medium.

CT scans were performed from the lung bases to the ischial

tuberosities, using a 5 mm collimator, a pitch of 1.5, 150-200 mA, and 120 kV. An initial anteroposterior topogram of the abdomen was taken in the supine position with breath-holding. Each scan started with a plain scan, followed by an intravenous contrast scan during suspended inspiration. Sequential images were captured in the corticomedullary phase (40-60 seconds), nephrographic phase (80-120 seconds), and excretory phase (180 seconds). Additional scans were conducted if further evaluation of specific pathologies was needed.

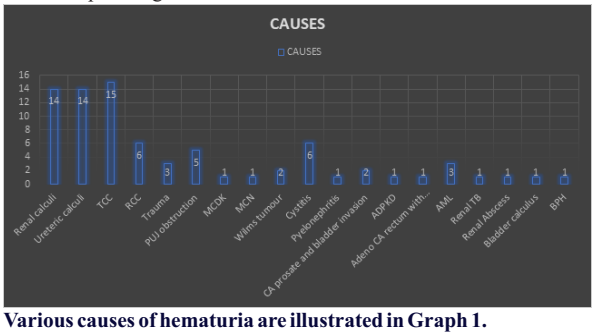
Images were reconstructed at a 0.5 mm thickness, and sagittal and coronal views were generated as required. Advanced techniques like curved planar reformatting, volume rendering, and maximum and minimum intensity projections were utilized when necessary. Patient follow-up was conducted in collaboration with the Urology department, monitoring diagnostic or therapeutic interventions and, where relevant, histopathology findings.

Stastical Analysis: Data collected were computed and analyzed using MS Excel (2010) for descriptive statistics, and all statistical analyses were performed with MedCalc ® v12.5 statistical software for Windows.

OBSERVATION AND RESULTS:

Our study included a total of 78 patients with a history of hematuria, comprising 55 males (71%) and 23 females (29%). The majority of patients were aged 31 to 40 years, accounting for 13 cases (16.6%), followed by 12 cases (15.3%) each in the 51-60 and 21-30 age groups, 17 cases (17%) in the 41-50 age group, 10 cases (12.8%) each in the 61-70 and >70 age groups, and 9 cases (11.5%) in the 0-20 age group. The oldest patient was 75 years old, while the youngest was 4 months. The mean age was 51 years, with a male-to-female ratio of 2.5:1, indicating male predominance.

Among the 78 cases, MDCTU identified pathologies in 32 cases (41%) in the kidneys, 14 cases (18%) in the ureters, 24 cases (31%) in the urinary bladder, 8 cases (7%) in the prostate, and 3 cases (3%) in the urethra. The pathologies detected by MDCTU included 28 cases (36%) of urolithiasis, 12 cases (16%) of renal masses, 3 cases (4%) of renal infection, 5 cases (6.5%) of cystitis, 15 cases (19%) of urinary bladder masses, no cases of BPH, 2 cases (2.5%) of prostatic carcinoma, 3 cases (4%) of trauma, and 3 cases (4%) of extra-urothelial pathologies.



Various causes of hematuria are illustrated in Graph 1.

In our study, the most common cause of hematuria was urolithiasis, observed in 28 cases (35.8%). Urolithiasis was the leading cause of painful hematuria, seen in 28 cases (35.8%), while the most common cause of painless hematuria was urinary bladder masses, found in 18 cases (19.3%). Urolithiasis was more prevalent in males (23 cases, 30%) and in the 31-40 year age group (14 cases, 18%). Of the identified calculi, 14 (46%) were in the kidneys, 14 (46%) in the ureters, and 2 (8%) in the urinary bladder. All calculi were accurately identified by MDCTU, demonstrating 100% sensitivity, specificity, and accuracy. In comparison, USG had a sensitivity of 92.1%, specificity of 100%, and accuracy of 97%. Below table depicts distribution of patients according to MDCT Urographic findings.

Table 1: Distribution Of Patients According To MDCT Urographic Findings:

	MDCT findings	Percentage
Bladder mass	15	19.2
Renal masses	12	15.3%
Renal calculi	15	19.2%
Rectal mass with bladder invasion	1	1.28%
Prostatic masses	2	2.56%
ADPKD	1	1.28%
MCDK	1	1.28%
Cystitis	5	6.41%
PUJ obstruction	4	5.12%
Renal trauma	3	3.84%
Urinary tract injury	3	3.84

Renal infection was observed in 3 cases (4%), all of which were correctly diagnosed by MDCTU, with 100% sensitivity, specificity, and accuracy. USG, on the other hand, showed a sensitivity of 52%, specificity of 97.91%, and accuracy of 94%. The renal infections included 1 case each of renal abscess, acute pyelonephritis, and renal tuberculosis. One renal tuberculosis case was initially misdiagnosed as normal by MDCTU, possibly due to early papillary necrosis without perinephric fat stranding, but follow-up revealed pyonephrosis, and culture confirmed tuberculosis.

Cystitis was found in 6 cases, more common in females (4 cases, 66.6%). One female diabetic patient had emphysematous cystitis. MDCTU identified cystitis with 83.3% sensitivity, 97.92% specificity, and 97% accuracy, compared to USG's sensitivity of 56%, specificity of 96.4%, and accuracy of 97%.

Urinary tract masses were diagnosed in 32 cases (41%), with 26 (81.2%) being malignant, 5 (15.6%) benign, and 1 (3%) metastatic. Renal masses were more common in males and in the 51-60 year age group. The most common renal mass was renal cell carcinoma, found in 16 cases (20%), primarily in patients over 50 years, with a predominance in males (83.3%). MDCTU showed enhancement in all cases, with 12 (42.8%) having haemorrhagic components, 15 (53.5%) calcifications, 20 (71%) necrosis, 3 (10.7%) fat components, and 13 (46.4%) associated with hydronephrosis. The tumours often invaded the renal vein, IVC, and lymph nodes, with some showing metastasis to bones and lungs. Angiomyolipoma (AML) was diagnosed in 3 cases (8%), and transitional cell carcinoma (TCC) in 18 cases (19.3%). Wilms' tumour was diagnosed in 2 male children (2.5%), both showing necrosis and haemorrhage, with 100% lymph node metastasis, and MDCTU had 100% sensitivity and specificity for Wilms' tumour. Below table characterization of renal and bladder masses (n=28).

Table 2: Characterization Of Renal And Bladder Masses (n=28).

Characterization	Percentage involved	No of cases
Enhancement	100%	28
Necrosis	71%	20
Hemorrhage	42.8%	12
Calcifications	53.5%	15
Fat	10.7%	3
Hydroureteronephrosis	35.7%	10
Vascular invasion	46.4%	13
Local invasion	42.8%	12
Lymph nodal metastases	71.4%	20
Distant metastases	7.1%	02

Table 3: Comparison Of Various Modalities In Diagnosing The Causes Of Hematuria:

Diagnosis	No of patients with X ray diagnosis	No of patients with USG diagnosis	No of patients with MDCTU diagnosis	Final diagnosis (based on microbiological, operative and histopathological)
Urolithiasis	25	22	28	28
Renal masses	00	12	12	12
Renal infections	00	02	03	03
Cystitis	00	05	05	06
Urinary bladder masses	00	16	15	18
BPH	00	01	00	01
Prostatic carcinoma	00	00	02	02
Trauma	00	01	03	03
Extra urothelial pathologies	00	01	03	03

In total, 18 cases (18%) of urinary bladder masses were identified, all

diagnosed as transitional cell carcinoma. These masses were more common in males and in the 61-70 year age group. All showed enhancement and irregular wall thickening. While MDCTU and USG were close in diagnosing these masses, MDCTU further characterized the masses, which USG could not. Benign prostatic hyperplasia (BPH) was diagnosed in 1 case (1.5%), and prostatic carcinoma in 2 cases (2.5%). MDCTU accurately diagnosed both prostatic carcinoma cases, identifying extra-capsular extension, although it missed one case of BPH. Three trauma cases were included, all with renal injuries (grades III/IV), and MDCTU findings were correlated with intraoperative results. MDCTU showed 100% sensitivity and specificity for trauma, with USG demonstrating 100% sensitivity and 99% accuracy. Lastly, 3 cases (3.85%) of extra-urinary pathologies were identified as the cause of hematuria: a cervical mass infiltrating the urinary bladder, rectal adenocarcinoma infiltrating the bladder wall, and a retroperitoneal nodal mass with ureteric infiltration, each making up 33% of the cases.

DISCUSSION:

Based on the American Urological Association's definition, microscopic hematuria is identified as the presence of three red blood cells (RBCs) per high power field on microscopic examination of centrifuged urine specimens, observed in at least two of three freshly voided, clean-catch, midstream urine samples. Normally, around one million RBCs are excreted into the urine each day, which translates to about 1 to 3 RBCs per high power field in microscopic examinations.
In our study, we observed that hematuria was more common in males (71%) compared to females (29%), with a male-to-female ratio of 2.4:1. This finding aligns with previous research by Song JH et al [31} and Maheswari E et al[32], which reported male-to-female ratios of 1.17:1 and 1.47:1, respectively. Other studies by Sonali Mhaske et al [33] and Ranjan Kumar et al [34] also noted a male predominance.

Our study found that urolithiasis was the most frequent cause of hematuria, accounting for 35.8% of cases. This finding is consistent with Manik Mahajan et al [35}, who identified urolithiasis (both renal and ureteric calculi) as the most common clinically significant cause of hematuria in young adults, present in 84.2% of cases. Varsha Rathi et al [36] also reported urolithiasis as the leading cause of hematuria, found in 25.7% of cases.

For cases of painless hematuria, urinary bladder masses were the most common cause in our study, seen in 15 cases (19.3%). This is similar to the findings of Nidhi Tyagi et al [37], who observed urinary bladder masses as the leading cause of painless hematuria in their study of 31 patients, found in 17 cases (54.8%).

Overall, the prevalence of various diseases causing hematuria in our study is comparable with the findings from other research, as summarized in the table below.

Table 4: Comparison Of Disease Prevalence In Patients With Hematuria Evaluated By MDCTU In Different Studies.

Diagnosis	Cowan et al (n=1001)	Maheswari et al (n=200)	Kannan et al (n=100)	Present study (n=78)
Calculus disease	16.3%	7.5%	33%	35.8%
Renal infections	0.2%	-	8%	2.5%
Renal malignancies	2.4%	-	33%	14.1%
Cystitis	-	2%	4%	7.6%
Renal injuries	-	-	2%	3.9%
UB TCC	18.6%	9%	18%	19..3%
BPH	-	5%	4%	0.1%
Prostate carcinoma	3.5%	-		2.6%
Extra urothelial malignancies	-	-	5%	11.5%

In the studies reviewed, malignancies were identified as the most common cause of hematuria in individuals over 40 years old. However, our study revealed a different distribution of pathologies. We found that 34 cases (43.5%) involved the kidneys, 19 cases (24.3%) affected the ureters, 25 cases (32.0%) were related to the urinary bladder, and 3 cases (8.4%) involved the prostate. No cases of urethral involvement were observed.This distribution of organ involvement in our study is consistent with findings from Cowan NC et al [38] and Maheswari E et al., where the urinary bladder was also identified as the most frequently affected organ.

Table 5.comparison With Above Mentioned Studies Enlisted In Below Table.

Organ	Cowan et al	Maheswari et al	Kannan et al	Present study
Kidneys	18%	7.2%	43.8%	43.5%
Ureters	2.2%	6%	14.5%	24.3%
Urinary bladder	19.8%	11%	32.3%	32.0%
Prostate	3.5%	5%	8.4%	3.8%
Urethra	-	-	1%	-

In our study, MDCT Urography (MDCTU) effectively identified all renal masses associated with hematuria and provided detailed characterization of these masses. The most common renal mass detected was renal cell carcinoma (RCC), found in 6 out of 78 patients (14.1%). RCC was predominantly observed in males (5 out of 6 cases, or 83.3%) and was most common in those over 50 years old (3 out of 6 cases, or 50%). This is consistent with Verhoest G et al [39] study, which reported a 6% incidence of RCC in individuals aged 80 years with a male predominance.

Wilm's tumor was diagnosed in 2 patients (14.2%) under the age of 5 years. This aligns with Lonergan et al [40], who noted that Wilm's tumor typically peaks between ages 3 and 4, with 80% of cases occurring in children under 5 and a male predominance.

Oncocytoma was found in one male patient aged 70 years (7.1%), but it was initially misdiagnosed as RCC. This finding reflects Blanca Pano et al [41] 's research, which highlighted the difficulty in distinguishing RCC from benign lesions like oncocytoma using current imaging techniques.

MDCTU also revealed extra-urinary findings in 11.5% of cases. This is higher than the 6.8% prevalence of significant extra-urinary findings reported by Song JH et al. MDCTU identified and accurately characterized all cases of urinary tract injuries, and these findings were confirmed by intraoperative results. This is consistent with Tomer Erlich et al [42].'s study, which found that CT Urography had 100% sensitivity and specificity for detecting renal injuries.

Compared to other imaging modalities like X-ray and ultrasound, MDCTU detected a greater number of pathologies causing hematuria. Additionally, it identified various congenital anomalies, including absent kidneys, ectopic kidneys, crossed fused ectopia, malrotated kidneys, and duplex ureters.

CONCLUSION:

Multidetector CT Urography is highly accurate in detecting the full range of urinary tract pathologies that cause hematuria, outperforming other modalities like X-ray and Ultrasonography. It is particularly sensitive and specific for identifying renal and urinary bladder masses, making it valuable for the further characterization and staging of neoplastic masses. As a result, Multidetector CT Urography has the potential to become the primary diagnostic tool for evaluating the urinary tract, especially in cases of hematuria. However, the use of contrast material, radiation exposure, and the time required are limitations of MDCTU. Additionally, a limitation of the current study is the small number of cases evaluated. While MRU offers specific advantages, particularly concerning radiation exposure and non-contrast imaging, its limitations in detecting calcifications and broader accessibility issues currently position MDCTU as the more favourable first-line imaging modality in most clinical scenarios involving hematuria.

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