

EVALUATION OF OBSTRUCTIVE UROPATHY BY MULTIDETECTOR COMPUTED TOMOGRAPHY UROGRAPHY: AN INSTITUTIONAL BASED STUDY

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ABSTRACT

Background: Obstructive uropathy is an important cause of renal dysfunction and may result from urinary calculi, strictures, junctional obstruction, masses, or extrinsic compression. Multidetector computed tomography urography (MDCTU) provides detailed anatomical and functional assessment of the urinary tract and helps identify the level, severity, and cause of obstruction.

Aim: To evaluate obstructive uropathy by multidetector computed tomography urography. **Materials and Methods:** This prospective observational study included 52 patients with clinical and/or ultrasonographic suspicion of obstructive uropathy. All patients underwent MDCT urography with non-contrast, nephrographic, and delayed excretory phase imaging as clinically appropriate. Laterality, level and severity of obstruction, etiology, hydronephrosis, hydroureter, renal parenchymal changes, delayed excretion, and characteristics of urinary calculi were recorded. Data were analysed using IBM SPSS Statistics version 21.0, with $p < 0.05$ considered statistically significant. **Results:** The mean age was 48.17 ± 15.24 years, and 63.46% were males. Flank pain was the most common presentation (75.00%). Unilateral obstruction was present in 82.69% of patients, while 17.31% had bilateral obstruction. The distal ureter was the most common level of obstruction (26.92%). Moderate hydronephrosis was observed in 46.15%, severe in 28.85%, and mild in 25.00%. Urinary calculi were the leading cause of obstruction (65.38%), followed by ureteric stricture (9.62%) and pelviureteric junction obstruction (7.69%). Among calculous cases, 52.94% had stones measuring 5–10 mm. Raised serum creatinine, delayed contrast excretion, and renal parenchymal thinning were significantly associated with increasing severity of hydronephrosis ($p < 0.001$). **Conclusion:** MDCT urography provided comprehensive assessment of the site, severity, etiology, and secondary effects of obstructive uropathy. It was particularly useful for characterizing calculous obstruction and associated renal changes, thereby supporting timely clinical and urological management.

INTRODUCTION

Obstructive uropathy is a clinically important condition resulting from structural or functional interference with the normal flow of urine at any level of the urinary tract, extending from the renal collecting system to the urethra. The obstruction may be unilateral or bilateral, partial or complete, and acute or chronic depending on the underlying pathology and the duration of urinary flow impairment. Persistent obstruction produces progressive elevation of pressure within the collecting system, alterations in renal haemodynamics, reduction in glomerular filtration, tubular dysfunction, and ultimately renal

parenchymal damage. The extent of renal impairment is influenced by the degree and duration of obstruction, the presence of infection, baseline renal function, and whether one or both urinary systems are involved. Early identification of the obstruction and its cause is therefore essential for preservation of renal function and appropriate therapeutic planning.^[1]

The etiology of obstructive uropathy is diverse and varies according to patient age, sex, clinical background, and anatomical level of involvement. Urinary tract calculi represent an important cause of upper urinary tract obstruction, while ureteric strictures, pelviureteric junction obstruction, congenital abnormalities, inflammatory lesions,

urothelial tumors, retroperitoneal lesions, pelvic masses, and extrinsic compression may also interfere with urinary drainage. Lower urinary tract obstruction can arise from bladder outlet abnormalities and other urethral or prostatic pathologies. Clinical presentation is similarly variable and may include acute flank pain, abdominal pain, haematuria, dysuria, recurrent urinary infection, fever, nausea, vomiting, reduction in urinary output, or impaired renal function. Some patients, particularly those with slowly developing obstruction, may have comparatively subtle symptoms despite significant anatomical abnormalities.^[2] Imaging plays a central role in the investigation of suspected obstructive uropathy because clinical and biochemical findings alone cannot reliably establish the anatomical level, severity, or precise cause of obstruction. Ultrasonography is commonly used as the initial imaging technique because it is widely available, inexpensive, non-invasive, and free from ionizing radiation. It is particularly useful for demonstrating hydronephrosis, hydroureter, renal size, cortical thickness, urinary bladder abnormalities, and some renal or ureteric calculi. Nevertheless, ultrasound may be limited by patient body habitus, overlying bowel gas, operator dependence, and incomplete visualization of the ureters. It may identify urinary tract dilatation without accurately characterizing its cause or distinguishing all clinically relevant obstructive lesions. Multidetector computed tomography has consequently assumed an important role when comprehensive anatomical evaluation is required.^[3]

Multidetector computed tomography urography (MDCTU) combines rapid volumetric acquisition with high spatial resolution and multiplanar image reconstruction, permitting detailed evaluation of the kidneys, pelvicalyceal systems, ureters, urinary bladder, and surrounding retroperitoneal structures. CT urography protocols can incorporate non-contrast and contrast-enhanced acquisitions tailored to the clinical indication. The non-contrast phase is particularly useful for detecting urinary calculi, calcification, haemorrhage, and baseline attenuation characteristics, whereas contrast-enhanced phases provide information regarding renal parenchymal enhancement, perfusion, masses, inflammation, and vascular relationships. Delayed excretory imaging enables assessment of contrast excretion, opacification of the collecting systems and ureters, luminal narrowing, filling defects, and the anatomical level of urinary tract obstruction.^[4] An important advantage of MDCT urography is its capacity to evaluate both the primary cause of obstruction and its secondary effects within a single examination. In patients with suspected obstructive uropathy, MDCT can demonstrate the location, number, dimensions, and attenuation of urinary calculi; identify ureteric narrowing or strictures; delineate pelviureteric and vesicoureteric junction abnormalities; characterize urinary tract masses; and

demonstrate extrinsic compression from surrounding structures. Secondary imaging findings such as hydronephrosis, hydroureter, delayed nephrogram, delayed contrast excretion, renal enlargement, perinephric or periureteric fat stranding, and progressive renal cortical thinning can further characterize the consequences and severity of obstruction. Three-dimensional and multiplanar reconstructions additionally improve anatomical visualization and facilitate communication of findings for urological management.^[5]

Despite its diagnostic advantages, appropriate CT urography protocol selection remains important because multiphase examinations involve exposure to ionizing radiation and iodinated contrast material. Protocols should therefore be adapted to the clinical indication while maintaining adequate diagnostic image quality. Advances in multidetector technology, automatic exposure control, iterative reconstruction, reduced-dose techniques, and appropriately selected acquisition phases have provided opportunities to optimize radiation exposure. This consideration is particularly relevant in patients with urolithiasis, who may undergo repeated imaging because of recurrent disease. Contemporary practice consequently emphasizes justification of individual CT phases, appropriate scan coverage, and dose optimization rather than routine use of unnecessarily extensive multiphase protocols.^[6]

MATERIALS AND METHODS

This hospital-based prospective observational study was conducted in the Department of Radiodiagnosis, Mansarovar Medical College and MGU Hospital, Sehore, Bhopal, Madhya Pradesh, India. A total of 52 patients with clinical and/or ultrasonographic suspicion of obstructive uropathy were included in the study. Multidetector computed tomography urography (MDCTU) was performed to identify the presence, level, severity, and underlying cause of urinary tract obstruction and to evaluate associated renal and extra-urinary findings. The study included 52 consecutive patients presenting with symptoms or imaging findings suggestive of urinary tract obstruction. Patients were evaluated for demographic characteristics, clinical presentation, relevant medical history, previous episodes of urinary tract obstruction, history of urolithiasis, urinary tract infection, previous urinary tract intervention, surgery, or known urinary tract abnormality. Presenting complaints including flank pain, abdominal pain, dysuria, haematuria, decreased urinary output, fever, nausea, vomiting, and recurrent urinary tract infection were recorded.

Inclusion Criteria

Patients of either sex with clinical suspicion of obstructive uropathy, ultrasonographic evidence of hydronephrosis or hydroureter, suspected urinary calculi, unexplained haematuria with possible

urinary tract obstruction, or suspected ureteric or pelviureteric junction pathology were included. Patients in whom detailed anatomical characterization of the urinary tract was required for further clinical or surgical management were also considered eligible.

Exclusion Criteria

Patients with severe renal dysfunction in whom intravenous contrast administration was contraindicated, known hypersensitivity to iodinated contrast media, pregnancy, haemodynamic instability, and patients unable to cooperate adequately during CT examination were excluded. Patients with inadequate image quality due to excessive motion or incomplete examination were also excluded from final evaluation.

Clinical and Laboratory Evaluation

A detailed clinical history and physical examination were performed before imaging. Renal function was assessed using serum creatinine and blood urea measurements before administration of intravenous contrast. Relevant laboratory parameters, including complete blood count and urine examination, were recorded whenever available. Patients with suspected infection were additionally assessed for pyuria and other relevant urinary findings. Previous ultrasonography findings were reviewed to determine the presence and grade of hydronephrosis, hydroureter, renal calculi, or other urinary tract abnormalities.

MDCT Urography Technique

MDCT urography was performed using a multidetector CT scanner. Patients were advised adequate hydration before the examination whenever clinically appropriate. Initial non-contrast images were obtained from the upper poles of both kidneys to the urinary bladder. The non-contrast phase was evaluated particularly for urinary calculi, calcification, haemorrhage, renal parenchymal abnormalities, and baseline attenuation characteristics.

Following the non-contrast acquisition, iodinated non-ionic intravenous contrast material was administered according to patient body weight and institutional protocol using a power injector. Contrast-enhanced images were obtained during the nephrographic phase to assess renal parenchymal enhancement, renal masses, inflammatory changes, renal perfusion, and associated complications. Delayed excretory-phase images were subsequently acquired to evaluate the pelvicalyceal systems, ureters, urinary bladder, site of obstruction, ureteric opacification, and urinary excretion. Additional delayed images were obtained whenever inadequate opacification or delayed contrast excretion was encountered.

Image Reconstruction and Analysis

Axial images were reconstructed at appropriate slice thickness, and multiplanar reformatted images in coronal and sagittal planes were reviewed. Maximum intensity projection and other three-dimensional reconstructed images were generated

whenever required for better delineation of the collecting system and ureters. All CT images were systematically evaluated for renal size, cortical thickness, nephrogram pattern, pelvicalyceal dilatation, ureteric dilatation, perinephric stranding, and contrast excretion.

Assessment of Obstructive Uropathy: The presence and laterality of urinary obstruction were categorized as unilateral or bilateral. The anatomical level of obstruction was classified as pelviureteric junction, proximal ureter, mid ureter, distal ureter, vesicoureteric junction, or bladder outlet level. Hydronephrosis was graded according to the degree of dilatation of the renal pelvis and calyces with associated parenchymal changes. Associated hydroureter and renal parenchymal thinning were documented. The cause of obstruction was categorized into urinary calculi, ureteric stricture, pelviureteric junction obstruction, urinary tract mass, extrinsic compression, congenital abnormality, inflammatory pathology, bladder outlet obstruction, or other identifiable causes. In patients with calculi, the number, location, maximum diameter, and attenuation value in Hounsfield units were recorded. Secondary signs including periureteric or perinephric fat stranding, renal enlargement, delayed nephrogram, and delayed excretion were also assessed.

Outcome Parameters: The major study parameters included the presence of obstructive uropathy, unilateral or bilateral involvement, anatomical level of obstruction, severity of hydronephrosis, underlying aetiology, presence and characteristics of urinary calculi, renal parenchymal changes, delayed contrast excretion, associated urinary tract abnormalities, and additional clinically relevant extra-urinary findings. The ability of MDCT urography to provide comprehensive anatomical and aetiological characterization of obstructive uropathy was evaluated.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics for Windows, version 21.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean $\pm$ standard deviation or median with interquartile range, depending on data distribution. Categorical variables were expressed as frequencies and percentages. Associations between categorical variables were assessed using the Chi-square test or Fisher's exact test, as appropriate. Continuous variables between relevant groups were compared using the independent-samples t-test or Mann-Whitney U test according to distribution. A p value of <0.05 was considered statistically significant.

RESULTS

A total of 52 patients with obstructive uropathy were evaluated in the study. The mean age of the study population was 48.17 ± 15.24 years. The largest proportion of patients belonged to the 41–50-

year age group, comprising 13 patients (25.00%). This was followed by 11 patients (21.15%) in the 51–60-year age group. Ten patients (19.23%) were aged 31–40 years and another 10 patients (19.23%) were aged above 60 years, while 8 patients (15.38%) belonged to the 18–30-year age group. Regarding sex distribution, males constituted the majority of the study population, with 33 patients (63.46%), whereas 19 patients (36.54%) were females. Flank pain was the most frequently reported clinical presentation and was present in 39 patients (75.00%). Dysuria was reported in 22 patients (42.31%), while haematuria was observed in 18 patients (34.62%). Fever was present in 12 patients (23.08%), and nausea or vomiting was reported in 11 patients (21.15%). Recurrent urinary tract infection was documented in 10 patients (19.23%), while decreased urinary output was noted in 9 patients (17.31%). As more than one symptom was present in several patients, the percentages of clinical presentations exceeded 100% when considered collectively. (Table 1)

The mean serum creatinine level among the 52 patients was 1.41 ± 0.62 mg/dL. Raised serum creatinine above 1.2 mg/dL was observed in 18 patients (34.62%). The mean blood urea level was 39.84 ± 16.72 mg/dL. Microscopic or gross haematuria was detected in 18 patients (34.62%), while pyuria was identified in 13 patients (25.00%). On initial ultrasonographic examination, hydronephrosis was the most common finding and was observed in 46 patients (88.46%). Hydroureter was identified in 30 patients (57.69%), while urinary calculi were suspected in 35 patients (67.31%). Renal parenchymal thinning was noted in 8 patients (15.38%). Suspected pelviureteric junction obstruction was observed in 5 patients (9.62%), whereas urinary bladder abnormalities were identified in 4 patients (7.69%). (Table 2)

On MDCT urography, left-sided unilateral obstruction was identified in 22 patients (42.31%), while right-sided unilateral obstruction was seen in 21 patients (40.38%). Bilateral urinary tract obstruction was present in 9 patients (17.31%). Thus, unilateral obstruction accounted for the majority of cases. With respect to the anatomical level of obstruction, the distal ureter was the most frequently affected site and was involved in 14 patients (26.92%). Proximal ureteric obstruction was identified in 12 patients (23.08%), while pelviureteric junction obstruction was observed in 8 patients (15.38%). Mid-ureteric obstruction was noted in 7 patients (13.46%), bladder outlet obstruction in 6 patients (11.54%), and vesicoureteric junction obstruction in 5 patients (9.62%). Regarding the severity of hydronephrosis, moderate hydronephrosis was the most common grade and was observed in 24 patients (46.15%). Severe hydronephrosis was present in 15 patients (28.85%), while mild hydronephrosis was observed in 13 patients (25.00%). Among the associated MDCT findings, hydroureter was the most common

and was identified in 34 patients (65.38%). Perinephric or periureteric fat stranding was observed in 20 patients (38.46%), while delayed contrast excretion was detected in 19 patients (36.54%). A delayed nephrogram was present in 17 patients (32.69%). Renal cortical or parenchymal thinning was identified in 11 patients (21.15%), whereas renal enlargement was noted in 9 patients (17.31%). More than one associated MDCT finding was present in several patients. (Table 3)

Urinary calculi were the most frequent cause of obstructive uropathy and were identified in 34 of the 52 patients (65.38%). Ureteric stricture was the second most common etiology and was detected in 5 patients (9.62%). Pelviureteric junction obstruction was present in 4 patients (7.69%). Urinary tract mass lesions and bladder outlet obstruction were each identified in 3 patients (5.77%). Extrinsic compression was responsible for obstruction in 2 patients (3.85%), while inflammatory pathology was identified in 1 patient (1.92%). Collectively, these etiologies accounted for all 52 cases of obstructive uropathy. (Table 4)

Among the 34 patients with calculous obstruction, distal ureteric calculi were the most common and were identified in 10 patients (29.41%). Proximal ureteric calculi were present in 9 patients (26.47%). Calculi at the renal pelvis or pelviureteric junction were detected in 6 patients (17.65%), and mid-ureteric calculi were also identified in 6 patients (17.65%). Vesicoureteric junction calculi were the least common and were present in 3 patients (8.82%). With respect to maximum calculus size, 18 patients (52.94%) had calculi measuring 5–10 mm. Calculi measuring less than 5 mm were identified in 8 patients (23.53%), while calculi larger than 10 mm were also found in 8 patients (23.53%). Regarding the number of calculi, a single calculus was present in 27 patients (79.41%), whereas multiple calculi were identified in 7 patients (20.59%). Analysis of CT attenuation values showed that 18 patients (52.94%) had calculi with attenuation values ranging from 500 to 1000 Hounsfield units. Calculi with attenuation values greater than 1000 HU were observed in 9 patients (26.47%), while values below 500 HU were recorded in 7 patients (20.59%). (Table 5)

Raised serum creatinine demonstrated a statistically significant association with increasing severity of hydronephrosis. Elevated serum creatinine was present in 1 of 13 patients (7.69%) with mild hydronephrosis, 6 of 24 patients (25.00%) with moderate hydronephrosis, and 11 of 15 patients (73.33%) with severe hydronephrosis. This association was statistically significant with a p value of <0.001 . Hydroureter was observed in 6 patients (46.15%) with mild hydronephrosis, 18 patients (75.00%) with moderate hydronephrosis, and 10 patients (66.67%) with severe hydronephrosis. The difference among the three groups was not statistically significant ($p=0.211$). Perinephric or periureteric fat stranding was

identified in 2 patients (15.38%) with mild hydronephrosis, 8 patients (33.33%) with moderate hydronephrosis, and 10 patients (66.67%) with severe hydronephrosis. The association between fat stranding and severity of hydronephrosis was statistically significant ($p=0.016$). Delayed contrast excretion was observed in 1 patient (7.69%) with mild hydronephrosis, 7 patients (29.17%) with moderate hydronephrosis, and 11 patients (73.33%) with severe hydronephrosis. The frequency of

delayed excretion differed significantly across the three severity groups ($p<0.001$). Renal cortical or parenchymal thinning was not observed in any patient with mild hydronephrosis. It was present in 3 patients (12.50%) with moderate hydronephrosis and in 8 patients (53.33%) with severe hydronephrosis. The association between renal parenchymal thinning and severity of hydronephrosis was statistically significant ($p<0.001$). (Table 6)

Table 1: Demographic and Clinical Characteristics of the Study Population (n=52)

Characteristic	Number (n)	Percentage (%)
Age group (years)		
18–30	8	15.38
31–40	10	19.23
41–50	13	25.00
51–60	11	21.15
>60	10	19.23
Mean age (years)	48.17 ± 15.24	—
Sex		
Male	33	63.46
Female	19	36.54
Clinical presentation*		
Flank pain	39	75.00
Dysuria	22	42.31
Haematuria	18	34.62
Fever	12	23.08
Nausea/vomiting	11	21.15
Recurrent urinary tract infection	10	19.23
Decreased urinary output	9	17.31

Table 2: Laboratory and Initial Ultrasonographic Findings among the Study Patients (n=52)

Parameter	Number (n) / Mean ± SD	Percentage (%)
Laboratory findings		
Mean serum creatinine (mg/dL)	1.41 ± 0.62	—
Raised serum creatinine (>1.2 mg/dL)	18	34.62
Mean blood urea (mg/dL)	39.84 ± 16.72	—
Microscopic/gross haematuria	18	34.62
Pyuria	13	25.00
Ultrasonographic findings		
Hydronephrosis	46	88.46
Hydroureter	30	57.69
Suspected urinary calculi	35	67.31
Renal parenchymal thinning	8	15.38
Suspected pelviureteric junction obstruction	5	9.62
Urinary bladder abnormality	4	7.69

Table 3: MDCT Urography Findings Regarding Laterality, Level and Severity of Obstruction (n=52)

MDCT finding	Number (n)	Percentage (%)
Laterality of obstruction		
Right unilateral	21	40.38
Left unilateral	22	42.31
Bilateral	9	17.31
Level of obstruction		
Pelviureteric junction	8	15.38
Proximal ureter	12	23.08
Mid ureter	7	13.46
Distal ureter	14	26.92
Vesicoureteric junction	5	9.62
Bladder outlet	6	11.54
Severity of hydronephrosis		
Mild	13	25.00
Moderate	24	46.15
Severe	15	28.85
Associated MDCT findings*		
Hydroureter	34	65.38
Perinephric/periureteric fat stranding	20	38.46
Delayed contrast excretion	19	36.54
Delayed nephrogram	17	32.69

Renal cortical/parenchymal thinning	11	21.15
Renal enlargement	9	17.31

Table 4: Etiological Distribution of Obstructive Uropathy on MDCT Urography (n=52)

Etiology	Number (n)	Percentage (%)
Urinary calculi	34	65.38
Ureteric stricture	5	9.62
Pelviureteric junction obstruction	4	7.69
Urinary tract mass lesion	3	5.77
Bladder outlet obstruction	3	5.77
Extrinsic compression	2	3.85
Inflammatory pathology	1	1.92
Total	52	100.00

Table 5: MDCT Characteristics of Urinary Calculi among Patients with Calculous Obstruction (n=34)

Calculus characteristic	Number (n)	Percentage (%)
Location of obstructing calculus		
Renal pelvis/PUJ	6	17.65
Proximal ureter	9	26.47
Mid ureter	6	17.65
Distal ureter	10	29.41
Vesicoureteric junction	3	8.82
Maximum calculus size		
<5 mm	8	23.53
5–10 mm	18	52.94
>10 mm	8	23.53
Number of calculi		
Single	27	79.41
Multiple	7	20.59
CT attenuation value		
<500 HU	7	20.59
500–1000 HU	18	52.94
>1000 HU	9	26.47

Table 6: Association of Severity of Hydronephrosis with Selected Clinical and MDCT Parameters (n=52)

Parameter	Mild (n=13)	Moderate (n=24)	Severe (n=15)	P value
Raised serum creatinine	1 (7.69%)	6 (25.00%)	11 (73.33%)	<0.001
Hydroureter	6 (46.15%)	18 (75.00%)	10 (66.67%)	0.211
Perinephric/periueteric fat stranding	2 (15.38%)	8 (33.33%)	10 (66.67%)	0.016
Delayed contrast excretion	1 (7.69%)	7 (29.17%)	11 (73.33%)	<0.001
Renal cortical/parenchymal thinning	0 (0.00%)	3 (12.50%)	8 (53.33%)	<0.001

DISCUSSION

The present study included 52 patients with obstructive uropathy, with a mean age of 48.17 ± 15.24 years. The largest proportion of patients belonged to the 41–50-year age group (25.00%), followed by 51–60 years (21.15%), while 19.23% were older than 60 years. Males constituted 63.46% of the study population, giving a clear male predominance over females (36.54%). These findings were comparable to those reported by Sharma et al. (2018), who evaluated 50 patients with obstructive uropathy and observed 31 males (62.00%) and 19 females (38.00%). Their mean age was 33.5 ± 14.3 years, with an age range of 10–61 years. Although the patients in the present study were relatively older, the sex distribution was almost identical, supporting the predominance of obstructive urinary tract disease among males.^[7] Flank pain was the predominant clinical presentation in the present study, occurring in 39 patients (75.00%), followed by dysuria in 42.31%, haematuria in 34.62%, fever in 23.08%, nausea or vomiting in 21.15%, recurrent urinary tract infection

in 19.23%, and decreased urinary output in 17.31%. Halle et al. (2016), in their study of 229 patients with obstructive uropathy, reported loin pain in 37.00%, vomiting in 28.00%, oliguria in 33.00%, anuria in 15.00%, and macroscopic haematuria in 7.00%. Their population represented a more advanced spectrum of obstructive disease, with a mean GFR of 10.3 ± 10 mL/min and 41.00% of patients requiring emergency dialysis. The higher frequency of flank pain and haematuria in the present study may therefore reflect earlier presentation and the high contribution of urolithiasis, whereas severe reduction in urine output was more prominent in the population studied by Halle et al.^[8] Laboratory evaluation in the present study demonstrated a mean serum creatinine of 1.41 ± 0.62 mg/dL, with elevated serum creatinine in 34.62% of patients, while mean blood urea was 39.84 ± 16.72 mg/dL. On initial ultrasonography, hydronephrosis was identified in 88.46%, hydroureter in 57.69%, suspected urinary calculi in 67.31%, renal parenchymal thinning in 15.38%, and suspected pelviureteric junction obstruction in 9.62%. Sen et al. (2008) evaluated 25

patients with obstructive uropathy using ultrasonography, IVU, CT and MR urography. Urinary calculi were responsible for obstruction in 17 of 25 patients (68.00%), closely corresponding to the calculous disease burden observed in the present study. Ultrasonography detected calculi in 14 of these 17 patients (82.00%), whereas CT identified all 17 cases (100.00%). These findings demonstrate that although ultrasonography effectively demonstrates collecting-system dilatation and serves as an appropriate initial investigation, CT provides superior characterization of the precise underlying obstructive pathology.^[9] Regarding the distribution of obstruction, the present study demonstrated right-sided unilateral obstruction in 40.38%, left-sided unilateral obstruction in 42.31%, and bilateral obstruction in 17.31%; thus, 82.69% of patients had unilateral disease. The distal ureter represented the most frequent individual level of obstruction (26.92%), followed by the proximal ureter (23.08%), pelviureteric junction (15.38%), mid ureter (13.46%), bladder outlet (11.54%), and vesicoureteric junction (9.62%). Youssef et al. (2013) evaluated 50 patients involving 65 obstructed ureters and reported unilateral obstruction in 35 patients (70.00%) and bilateral obstruction in 15 patients (30.00%). In their series, the lower third of the ureter was the most frequently affected segment, accounting for 38 of 65 obstructed ureters (58.46%). The predominance of unilateral obstruction and substantial involvement of the distal urinary tract in both studies indicate the importance of complete ureteric evaluation with multiplanar MDCT reconstructions.^[10] Moderate hydronephrosis was the most frequent grade in the present study, occurring in 46.15% of patients, whereas mild and severe hydronephrosis were present in 25.00% and 28.85%, respectively. Important secondary MDCT findings included hydroureter in 65.38%, perinephric or periureteric fat stranding in 38.46%, delayed contrast excretion in 36.54%, delayed nephrogram in 32.69%, renal cortical or parenchymal thinning in 21.15%, and renal enlargement in 17.31%. Ege et al. (2003), in a prospective CT study involving 110 patients with ureterolithiasis, demonstrated hydroureter in 82.70%, hydronephrosis in 80.00%, periureteric oedema in 59.00%, and unilateral renal enlargement in 57.20%. The frequencies were generally higher than those observed in the present study, probably because the study by Ege et al. exclusively included patients with acute ureterolithiasis, whereas the present population consisted of multiple obstructive etiologies and potentially different stages of obstruction. Nevertheless, both studies demonstrated that secondary MDCT signs provide important supportive evidence of the presence and physiological consequences of urinary obstruction.^[11] Urinary calculi represented the major etiological factor in the present study, accounting for 34 of 52 cases (65.38%). This was followed by ureteric stricture in 9.62%, pelviureteric junction

obstruction in 7.69%, urinary tract mass and bladder outlet obstruction in 5.77% each, extrinsic compression in 3.85%, and inflammatory pathology in 1.92%. Moawad et al. (2015) evaluated 30 patients with obstructive uropathy using MDCT urography and reported urinary tract stones as the commonest cause in 46.60%, followed by urinary bladder masses involving the ureteric orifices in 13.30%, PUJ obstruction in 10.00%, extrinsic ureteric compression in 10.00%, ureteric injuries in 10.00%, bladder neck obstruction in 6.60%, and ureteric stricture in 3.30%. Thus, although the proportion of calculous obstruction was higher in the present study (65.38% versus 46.60%), both studies demonstrated urolithiasis as the leading identifiable cause and also showed the ability of MDCT urography to characterize diverse intraluminal and extraluminal causes in a single examination.^[12] Among the 34 patients with calculous obstruction in the present study, the distal ureter was the most frequent location (29.41%), followed by the proximal ureter (26.47%), renal pelvis/PUJ and mid ureter (17.65% each), and vesicoureteric junction (8.82%). Most stones measured 5–10 mm (52.94%), while 23.53% each measured <5 mm and >10 mm; 79.41% of patients had a single calculus. Regarding attenuation, 52.94% of calculi measured 500–1000 HU, 26.47% measured >1000 HU, and 20.59% measured <500 HU. Motley et al. (2001) evaluated 100 pure urinary stones with non-contrast CT and demonstrated mean attenuation values of 440 ± 262 HU for calcium stones, 270 ± 134 HU for uric acid stones, 401 ± 198 HU for struvite stones, and 248 HU for cystine stones. They further found a significantly greater HU density for calcium stones (105 ± 43 HU/mm) than uric acid stones (50 ± 24 HU/mm; $p=0.006$). The predominance of intermediate-to-high attenuation stones in the present study therefore supports the value of CT attenuation as an additional characteristic of calculi, although the considerable overlap between stone types reported by Motley et al. indicates that attenuation alone should not be regarded as definitive evidence of stone composition.^[13] A significant relationship was observed between the severity of hydronephrosis and indicators of renal compromise in the present study. Raised serum creatinine increased from 7.69% in mild hydronephrosis to 25.00% in moderate and 73.33% in severe hydronephrosis ($p<0.001$). Similarly, delayed contrast excretion was observed in 7.69%, 29.17%, and 73.33% of mild, moderate, and severe cases, respectively ($p<0.001$), while renal cortical/parenchymal thinning increased from 0.00% to 12.50% and 53.33%, respectively ($p<0.001$). Perinephric/periureteric fat stranding also increased significantly from 15.38% in mild to 66.67% in severe hydronephrosis ($p=0.016$). Cai et al. (2015) assessed 64 patients with unilateral ureteral obstruction and divided them according to mild, moderate, and severe hydronephrosis. They found significantly reduced cortical and medullary

blood flow and blood volume in moderate obstruction, while severe obstruction was associated with significant reductions in blood flow, blood volume, and renal clearance ($p < 0.05$). Furthermore, cortical and medullary perfusion ratios showed an inverse correlation with the grade of hydronephrosis ($p < 0.01$). These observations are concordant with the present findings and indicate that increasing morphological severity on MDCT is accompanied by progressively greater functional and parenchymal impairment.^[14]

CONCLUSION

Multidetector computed tomography urography proved to be a comprehensive imaging modality for evaluating obstructive uropathy by accurately identifying the site, severity, and underlying cause of obstruction. Urinary calculi were the most common etiology, with distal ureteric involvement being frequent. MDCT urography also effectively demonstrated secondary signs such as hydroureter, delayed contrast excretion, perinephric stranding, and renal parenchymal thinning. Increasing severity of hydronephrosis was significantly associated with raised serum creatinine, delayed excretion, and renal parenchymal thinning. Overall, MDCT urography provided valuable anatomical and functional information that can assist in timely clinical and urological management.

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