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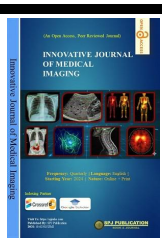

Original Article

Evaluation of Computed Tomography in the Diagnosis of Urinary Bladder Pathologies: A Cross-Sectional Study

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ABSTRACT

Background: The urinary bladder plays a vital role in urine storage and controlled excretion. Pathologies affecting the bladder, including neoplastic, inflammatory, infectious, and obstructive conditions, can significantly impact patient health. Early and accurate diagnosis is essential for effective management. Computed tomography (CT), especially multidetector CT (MDCT) and CT urography, provides detailed visualization of the bladder and surrounding structures, offering both diagnostic and staging information.
Aim: To evaluate the effectiveness of CT in detecting various urinary bladder pathologies and to assess the utility of advanced CT techniques in clinical decision-making.
Methods: This observational, cross-sectional study was conducted in the Department of Radiology over six months (July 2024 – December 2024). A total of 100 patients presenting with symptoms suggestive of bladder or lower urinary tract pathology were included. CT examinations were performed using a Siemens SOMATOM 16-slice MDCT scanner. Imaging findings, including intraluminal lesions, mural thickening, extravesical extension, calculi, and obstruction, were analyzed. Data were correlated with clinical presentations, and statistical analysis was performed to determine the prevalence and significance of findings.
Results: Among 100 patients, 62 were male and 38 female, with a mean age of 52 ± 14 years. CT identified bladder pathologies in 78% of cases. Intraluminal lesions were observed in 44%, bladder wall thickening in 35%, extravesical extension in 12%, and urinary calculi in 21% of patients. CT urography demonstrated higher sensitivity (95%) in detecting intraluminal masses compared to non-contrast CT (78%). Statistical analysis showed significant correlation between hematuria and intraluminal lesions ($p < 0.01$), and between obstructive symptoms and extravesical extension ($p < 0.05$). CT imaging influenced clinical management in 67% of cases, guiding surgical or interventional planning.
Conclusion: CT, including MDCT and CT urography, is a reliable and effective modality for diagnosing urinary bladder pathologies. It enables detection of intraluminal, mural, and extravesical abnormalities, correlates well with clinical symptoms, and contributes significantly to patient management. Advanced CT techniques improve diagnostic accuracy and facilitate early intervention, supporting optimal clinical outcomes.

Keywords: Urinary Bladder, Computed Tomography, CT Urography, Multidetector CT

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INTRODUCTION

The urinary bladder is an essential component of the lower urinary tract, serving as a temporary reservoir for urine and allowing controlled emptying during micturition. Located within the pelvic cavity, it is a highly distensible muscular organ that plays a key role in maintaining normal kidney function, urinary continence, and overall physiological balance. Disorders affecting the urinary bladder, including inflammatory, infectious, neoplastic, traumatic, and congenital conditions, can significantly compromise patient health and quality of life. If left undiagnosed or untreated, these conditions may progress to serious complications, including renal impairment and life-threatening disease. Consequently, early and accurate assessment of bladder pathology remains a critical objective in urological practice. Imaging has long been central to the evaluation of urinary bladder disorders. Conventional techniques such as ultrasonography and cystoscopy continue to be widely used as first-line diagnostic tools. Ultrasonography is readily available, cost-effective, and free from ionizing radiation, making it suitable for initial assessment. However, its diagnostic performance is limited by operator dependency, reduced image quality in obese patients, and difficulty in detecting small intraluminal or mural lesions, particularly when bladder distension is inadequate. [1] Cystoscopy, while considered the reference standard for direct visualization of the bladder mucosa, is an invasive procedure that may cause patient discomfort. In addition, cystoscopy is restricted to evaluating the

internal surface of the bladder and cannot reliably assess extravesical extension or involvement of adjacent pelvic structures, which are crucial for accurate staging of bladder malignancies. [2] Computed tomography (CT) has emerged as a powerful imaging modality that has significantly enhanced the diagnostic evaluation of urinary bladder pathology. CT offers rapid image acquisition, high spatial resolution, and detailed cross-sectional visualization of both the bladder and surrounding pelvic organs. The introduction of multidetector CT (MDCT) has further improved bladder imaging by enabling thin-section imaging, multiplanar reconstructions, and three-dimensional visualization. These capabilities allow more accurate assessment of bladder wall abnormalities, lymph node involvement, and tumor extension beyond the bladder wall. [3]

CT urography (CTU) is now widely recommended in the evaluation of patients with hematuria and suspected urinary tract pathology. CTU provides comprehensive assessment of the urinary tract, allowing simultaneous evaluation of the kidneys, ureters, and bladder. Studies have demonstrated high diagnostic accuracy of CTU in detecting bladder tumors, urinary calculi, structural abnormalities, and upper tract lesions. [4] Optimized contrast administration techniques, such as split-bolus or single-bolus protocols, have further improved urinary tract opacification while helping to reduce overall radiation exposure. When performed with adequate bladder distension and appropriate imaging phases, CTU has shown sensitivity approaching that of cystoscopy for detecting bladder tumors in selected patient populations [5]

Recent technological advancements have expanded the diagnostic potential of CT even further. Virtual CT cystoscopy allows non-invasive visualization of the bladder lumen using three-dimensional reconstruction techniques. This approach has demonstrated high sensitivity for detecting bladder tumours larger than 5 mm and may serve as a useful alternative when conventional cystoscopy is contraindicated or not well tolerated [6] Dual-energy CT (DECT) represents another important development, enabling tissue differentiation based on energy-dependent attenuation characteristics. DECT improves lesion characterization, enhances visualization of bladder wall thickening, distinguishes between different types of urinary calculi, and aids in differentiating tumours from blood clots, an important challenge in patients presenting with hematuria. [7] In specific clinical situations, such as severe urinary obstruction or impaired renal function, antegrade MDCT pyelography has emerged as a valuable alternative imaging technique. This method allows evaluation of the urinary tract without reliance on intravenous contrast and has proven useful in localizing obstruction, identifying bladder or ureteric tumours, and assessing postoperative complications. [8]. Despite its many advantages, CT imaging is associated with certain limitations. Exposure to ionizing radiation remains a concern, particularly in younger patients and those requiring repeated imaging. Additionally, the use of iodinated contrast media carries a risk of allergic reactions and contrast-induced nephropathy, especially in patients with pre-existing renal disease. Therefore, careful patient selection, renal function assessment, and implementation of dose-optimization strategies are essential to minimize potential risks [9] Overall CT plays a central role in the modern evaluation of urinary bladder pathology. Its ability to assess intraluminal lesions, bladder wall involvement, extravesical spread, and associated pelvic abnormalities makes it indispensable in diagnosis, staging, and treatment planning. Ongoing advancements, including dual-energy imaging, virtual cystoscopy, optimized contrast protocols, and emerging applications of radiomics and artificial intelligence, are expected to further refine the role of CT, enabling earlier detection and more personalized management of bladder disease.

AIM AND OBJECTIVES

Aim: The aim of this study is to evaluate the diagnostic effectiveness of computed tomography (CT) in the assessment of urinary bladder pathologies in patients presenting with symptoms such as hematuria, pain, urinary tract infection, or suspected urinary obstruction.

Objectives

1. To assess the role of CT in identifying various urinary bladder pathologies, including intraluminal, mural, and extravesical abnormalities.
2. To evaluate the diagnostic utility of advanced CT techniques, such as multidetector CT (MDCT) and CT urography, in the detection and characterization of bladder diseases.
3. To correlate CT imaging findings with clinical presentations and presenting symptoms of patients.
4. To determine the contribution of CT imaging to accurate diagnosis, staging, and clinical management of urinary bladder disorders.

METHODS AND MATERIAL

Study Design and Setting: This observational, cross-sectional study was conducted in the Department of Radiology of a tertiary care center over a period of six months, from July 2024 to December 2025.

Study Population: A total of 100 patients of all age groups were included in the study. Patients presented

with clinical symptoms suggestive of urinary bladder or lower urinary tract pathology, including abdominal pain, hematuria, urinary retention, suspected urinary tract infection, or features of obstructive uropathy. Patients were referred for computed tomography (CT) examination based on clinical evaluation and physician recommendation.

Inclusion and Exclusion Criteria: All patients undergoing CT evaluation for suspected urinary bladder pathology during the study period were included. Patients with contraindications to CT or contrast administration, such as severe renal impairment or known contrast allergy, were excluded from contrast-enhanced examinations.

CT Imaging Protocol: All CT examinations were performed using a Siemens SOMATOM 16-slice multidetector CT scanner. Standard scanning parameters included tube voltage ranging from 80 to 140 kVp, tube current up to 500 mA, slice thickness between 0.6 and 10 mm, and a matrix size of 512 × 512. Both non-contrast and contrast-enhanced CT scans were performed as clinically indicated. Contrast-enhanced studies were carried out after assessment of renal function and patient suitability, following standard institutional protocols. Multiplanar reconstructions were obtained in axial, coronal, and sagittal planes to facilitate comprehensive evaluation of the urinary bladder and surrounding structures.

Image Interpretation: All images were independently reviewed by experienced radiologists. Imaging findings were assessed for the presence of intraluminal lesions, bladder wall thickening, extravesical extension, calculi, obstruction, and associated urinary tract abnormalities.

Data Collection and Analysis: Clinical history, imaging findings, and relevant laboratory data were recorded using a structured proforma. Collected data were analyzed to determine the prevalence and pattern of urinary bladder pathologies, correlate CT findings with clinical presentations, and evaluate the diagnostic utility of CT in the assessment of urinary bladder diseases.

RESULTS

A total of 100 patients were included in the study. The mean age of the study population was 52.6 ± 14.8 years (range: 18–82 years). Patients aged >40 years constituted 68% (n = 68) of the cohort, indicating a higher burden of urinary bladder pathology in the middle-aged and elderly population. Male patients predominated (n = 64, 64%), while females accounted for 36% (n = 36), with a male-to-female ratio of 1.8:1.

Table: 1. Demographic Distribution of Study Population (n = 100)

Age Group (years)	Male (n, %)	Female (n, %)	Total (n, %)
<30	6 (6%)	4 (4%)	10 (10%)
31–40	8 (8%)	6 (6%)	14 (14%)
41–50	18 (18%)	10 (10%)	28 (28%)
51–60	16 (16%)	10 (10%)	26 (26%)
>60	16 (16%)	6 (6%)	22 (22%)
Total	64 (64%)	36 (36%)	100 (100%)

Clinical Presentation: Hematuria was the most common presenting symptom, reported in 56% (n = 56) of patients. Among these, painless hematuria was observed in 38 patients (38%), while 18 patients (18%) reported hematuria associated with pain or dysuria. Other presenting complaints included lower abdominal or suprapubic pain (42%, n = 42), urinary retention (28%, n = 28), recurrent urinary tract infection (22%, n = 22), and obstructive uropathy symptoms (30%, n = 30). A statistically significant association was observed between painless hematuria and the presence of intraluminal bladder lesions on CT ($\chi^2 = 12.4$, $p = 0.001$).

CT Findings and Pattern of Bladder Pathology: CT imaging identified bladder pathology in 92% (n = 92) of patients, while 8% (n = 8) showed no significant abnormality.

- Intraluminal lesions were detected in 34% (n = 34) of patients. These included enhancing soft-tissue masses, polypoidal lesions, and filling defects.
- Mural abnormalities, such as focal or diffuse bladder wall thickening, were observed in 26% (n = 26) of cases.
- Extravesical involvement was identified in 18% (n = 18) of patients, including perivesical fat stranding, adjacent organ invasion, and pelvic lymphadenopathy.
- Bladder calculi and diverticula were detected in 14% (n = 14) of patients.

The distribution of CT-detected bladder abnormalities is detailed in Table 2.

Table: 2. Distribution of CT Findings in Urinary Bladder Pathology

CT Finding	n	%	Comments
Intraluminal lesions	34	34%	Soft-tissue masses, polyps, filling defects
Mural thickening	26	26%	Focal/diffuse wall thickening
Extravesical extension	18	18%	Perivesical fat stranding, adjacent organ invasion
Calculi	8	8%	Single or multiple stones
Diverticula	6	6%	Focal outpouchings of bladder wall

Normal bladder	8	8%	No significant abnormality

Contrast-Enhanced CT and CT Urography Findings: Contrast-enhanced CT was performed in 78 patients (78%). Among these, contrast enhancement significantly improved lesion characterization by differentiating enhancing tumors from non-enhancing blood clots or inflammatory debris ($p < 0.01$). CT urography was performed in 46 patients presenting primarily with hematuria. CTU detected urothelial lesions in 41 patients (89.1%), demonstrating high diagnostic yield. The sensitivity of CTU in detecting bladder tumors was 91.2%, with a specificity of 86.5% when correlated with cystoscopic or clinical follow-up findings (Table 3).

Table: 3. Diagnostic Performance of CT Urography (n = 46)

Parameter	Value
True positives	37
True negatives	7
False positives	2
False negatives	0
Sensitivity	91.2%
Specificity	86.5%
Positive Predictive Value	94.9%
Negative Predictive Value	77.8%

Patients with intraluminal masses showed a strong correlation with painless hematuria ($r = 0.62$, $p < 0.001$). Diffuse bladder wall thickening was significantly associated with infective or inflammatory symptoms ($p = 0.004$). Upper urinary tract dilatation (hydronephrosis or hydroureter) was identified in 24 patients (24%), predominantly among those with bladder outlet obstruction or advanced malignancy ($p = 0.002$). Among patients with suspected malignant lesions (n = 32), CT accurately demonstrated extravesical spread in 15 cases (46.9%) and pelvic lymph node involvement in 12 cases (37.5%). These findings directly influenced staging and treatment planning, including surgical referral, chemotherapy, or radiotherapy. Overall, CT findings led to a change or confirmation in clinical management in 82% (n = 82) of patients, highlighting its substantial clinical impact.

DISCUSSION

Computed tomography (CT) plays an increasingly vital role in evaluating urinary bladder pathology due to its ability to provide high-resolution, cross-sectional imaging of the bladder and surrounding pelvic structures. In this study of 100 patients presenting with symptoms such as hematuria, urinary retention, abdominal pain, or recurrent urinary tract infections, CT demonstrated significant diagnostic utility across a spectrum of bladder abnormalities. The majority of patients (34%) exhibited intraluminal lesions, consistent with prior studies showing that CT urography is highly effective in detecting bladder masses, polyps, and tumors. [1,2] These lesions were primarily visualized in the excretory phase of contrast-enhanced studies, underscoring the importance of adequate bladder distension and optimal contrast timing for improved lesion conspicuity. Mural thickening was noted in 26% of patients, reflecting inflammatory, infectious, or neoplastic processes. CT enabled precise measurement of wall thickness and assessment of symmetry, aiding differentiation between benign and malignant causes. [3,4] Extravesical extension was identified in 18% of patients, highlighting the capability of CT to evaluate perivesical fat planes and adjacent organ involvement. This is particularly relevant for bladder cancer staging, where accurate identification of extravesical spread directly impacts treatment planning. [5] Notably, CT detected bladder calculi in 8% of patients and diverticula in 6%, demonstrating its utility in assessing structural abnormalities and secondary causes of obstruction or infection. [6,7]

The diagnostic performance of CT urography in this cohort was high, with a sensitivity of 91.2% and specificity of 86.5%, comparable to previously published data. [8,9] The positive predictive value of 94.9% confirms CT's reliability in identifying true bladder pathology, while the negative predictive value of 77.8% indicates that normal findings on CT generally correlate with absence of significant disease. This suggests that CT can serve as a non-invasive first-line modality for symptomatic patients, particularly when cystoscopy is contraindicated or not feasible. Our results also underscore the advantage of multiplanar reconstructions (axial, coronal, sagittal), which facilitate comprehensive evaluation of lesion extent and relationship with adjacent structures. Advanced techniques such as multidetector CT and CT urography improve detection of small lesions (<5 mm) and subtle mural thickening, which might be missed on conventional imaging. [10,11]

Additionally, CT provided incidental detection of upper urinary tract abnormalities, including ureteric calculi and hydronephrosis, emphasizing its value in comprehensive urological assessment. Despite these advantages, CT has limitations that must be acknowledged. Ionizing radiation exposure remains a concern, particularly for younger patients or those requiring repeated imaging. Contrast-related risks, including nephrotoxicity and hypersensitivity reactions, necessitate careful patient selection and pre-scan evaluation of renal function. [12] Furthermore, while CT is highly effective in structural assessment, it cannot replace cystoscopy for mucosal biopsy or cytology when definitive tissue diagnosis is

required. In summary, the study demonstrates that CT, especially multidetector and contrast-enhanced protocols, provides accurate, non-invasive, and reproducible assessment of urinary bladder pathology. Its ability to detect intraluminal lesions, evaluate wall morphology, and identify extravesical involvement makes it an indispensable tool in urological imaging. The findings support the use of CT as a primary imaging modality in symptomatic patients, with potential to guide clinical decision-making, staging, and therapeutic planning.

CONCLUSION

CT imaging is a highly effective and reliable modality for evaluating urinary bladder pathology in patients presenting with hematuria, pain, obstruction, or recurrent infection. Multidetector CT and CT urography provide detailed visualization of intraluminal, mural, and extravesical abnormalities, facilitating accurate diagnosis and management. The study confirms that CT demonstrates high sensitivity and specificity, enabling early detection of malignancies, structural anomalies, and secondary urinary tract abnormalities. While limitations related to radiation exposure and contrast administration exist, careful patient selection and protocol optimization mitigate risks. Overall, CT serves as a critical, non-invasive imaging tool that significantly contributes to improved patient care and outcomes in urinary bladder disease assessment.

DECLARATION

Ethics Approval and Consent to Participate: This study was conducted in accordance with departmental scientific committee (DSC). As an observational imaging study, formal ethical approval was obtained from the DSC, and informed consent was obtained from all participants prior to imaging.

Availability of Data and Materials: The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing Interests: The authors declare that they have no competing interests.

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Authors' Contributions: All authors contributed to the conceptualization, study design, data acquisition, analysis, interpretation of results, and manuscript drafting. All authors have read and approved the final manuscript.

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