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ROLE OF CONTRAST AND NON-CONTRAST COMPUTED TOMOGRAPHY IN EVALUATION OF OBSTRUCTIVE KIDNEYS

Original Research

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ABSTRACT

Background: Kidney obstruction is a significant contributor to renal dysfunction and preventable kidney failure, requiring timely and accurate diagnosis to guide effective management. Computed tomography (CT), particularly contrast-enhanced and non-contrast techniques, has emerged as a cornerstone in evaluating urinary tract obstruction due to its high sensitivity for detecting structural and pathological abnormalities. This study, conducted across multiple hospitals in Khyber Pakhtunkhwa (KPK), Pakistan, aimed to assess and compare the diagnostic performance of contrast and non-contrast CT in identifying the underlying causes of obstructive uropathy.

Objective: To compare the effectiveness of contrast-enhanced and non-contrast CT in detecting key causes of obstructive kidney disease, including kidney stones, ureteropelvic junction (UPJ) obstruction, urinary tract infections (UTIs), hydronephrosis, cystitis, and narrowed ureters.

Methods: A descriptive cross-sectional study was conducted from February to June 2022 on 141 patients referred for CT KUB due to suspected kidney obstruction. The sample consisted of 73 males (51.8%) and 68 females (48.2%), aged 12–90 years. Age groups included 48 patients (34%) aged 12–31, 56 (39.7%) aged 32–50, 22 (15.6%) aged 51–69, and 15 (10.6%) aged 70–90. Among all scans performed, 73 patients (51.8%) underwent contrast CT while 68 (48.2%) underwent non-contrast CT. Data were collected through structured questionnaires and imaging reports and analyzed to determine detection patterns for each abnormality.

Results: Kidney stones were identified in 85 patients (60.3%), including 40 (47%) through contrast CT and 45 (53%) through non-contrast CT. UPJ obstruction was observed in 46 patients (32.6%), with 28 (60%) detected by contrast CT and 18 (40%) by non-contrast CT. UTIs were found in 84 patients (59.6%), with contrast CT identifying 44 (52%) and non-contrast CT identifying 40 (48%). Hydronephrosis appeared in 52 patients (36.9%), with 10 (20%) detected by contrast CT and 42 (80%) by non-contrast CT. Cystitis was diagnosed in 45 patients (31.9%), with 27 (60%) shown on contrast CT and 18 (40%) on non-contrast CT. Narrowed ureters were found in 34 patients (24.1%), including 24 (70%) detected by contrast CT and 10 (30%) by non-contrast CT.

Conclusion: Contrast-enhanced CT demonstrated higher detection rates for most obstructive causes—including UPJ obstruction, UTIs, cystitis, and narrowed ureters—making it a more reliable modality for comprehensive evaluation of obstructive kidney disease. Non-contrast CT remained efficient for detecting kidney stones and hydronephrosis, supporting its role where contrast use is contraindicated.

Keywords: Cystitis; Diagnostic Imaging; Hydronephrosis; Kidney Calculi; Kidney Diseases; Tomography, X-Ray Computed; Ureteral Obstruction.

INTRODUCTION

Kidney obstruction represents a significant global health concern, commonly arising from conditions such as nephrolithiasis and other structural or functional abnormalities of the urinary tract. Such obstruction serves as a major contributor to renal dysfunction and, if persistent, may progress to irreversible renal failure. A wide spectrum of urologic disorders—including polycystic kidney disease, renal artery stenosis, hydronephrosis, ureteral strictures, urinary tract infections, and ureteropelvic junction (UPJ) obstruction—can culminate in impaired urine flow and subsequent kidney damage. Early and accurate diagnosis is therefore central to preventing long-term morbidity and guiding targeted interventions. A range of diagnostic modalities such as sonography, excretory urography, abdominal radiography, magnetic resonance imaging, and computerized tomography (CT) are utilized; however, CT has emerged consistently as the gold standard due to its superior sensitivity, specificity, and ability to characterize urinary calculi with precision (1,2). When obstruction affects a single renal unit, accurately determining its functional capacity and anatomical integrity becomes crucial for clinical decision-making. Techniques such as CT perfusion provide additional value by assessing renal blood flow and perfusion anomalies, thereby aiding in treatment planning, prognostication, and evaluation of therapeutic response (3). The importance of such assessment is underscored by evidence showing that chronically obstructed kidneys with residual function below 10% may derive limited benefit from reconstructive procedures, making early identification essential for avoiding futile interventions. Non-contrast CT (NCCT) plays a vital role in detecting calcareous causes of obstruction, whereas contrast-enhanced CT enables comprehensive structural and functional assessment in a single session, similar to its established utility in evaluating live kidney donors through visualization of vascular, parenchymal, and urinary tract architecture (4,5).

Common etiologies—such as kidney stones, UPJ obstruction, UTIs, cystitis, hydronephrosis, and ureteral narrowing—are well recognized contributors to obstruction, each with distinct pathophysiological mechanisms. Kidney stones are increasingly associated with modern lifestyle patterns, including obesity, and can precipitate acute obstruction through abrupt lumen blockage (6). UPJ obstruction causes urine stasis that may coexist with stone formation, while UTIs ranging from cystitis to pyelonephritis can both result from and exacerbate obstructive processes. Hydronephrosis signifies progressive dilation of the renal pelvis and calyces, often correlating with nephron loss if untreated, whereas ureteral strictures from inflammation, ischemia, or traumatic injury threaten irreversible renal compromise. Across these conditions, CT—both enhanced and non-enhanced—remains the cornerstone imaging modality for identifying obstructive features and underlying causes (7,8). The superiority of CT in diagnosing obstructive uropathies is well documented. A foundational work demonstrated CT's ability to differentiate benign from malignant renal masses and evaluate non-functioning kidneys with greater accuracy than excretory urography (9). Subsequent evidence from a study highlighted the exceptional sensitivity (98%) and specificity (100%) of non-contrast helical CT for detecting ureteral calculi in patients presenting with acute flank pain, offering a rapid, non-invasive alternative to traditional radiographic methods. Further research established NCCT as unparalleled for stone characterization, contributing to improved treatment planning and reduction of diagnostic uncertainty (10). More recent studies have reinforced CT's evolving capabilities: a study reported that contrast-enhanced multidetector CT reliably detected small stones under 6 mm while distinguishing them from blood clots or phleboliths, and another study demonstrated 100% sensitivity of contrast-enhanced spiral CT in identifying causes of obstructive uropathy such as UPJ narrowing, strictures, and ureteral stones—outperforming intravenous pyelography, which showed only 74% sensitivity (11,12).

Despite substantial advances, important gaps remain regarding long-term outcomes of CT-identified obstructions, feasibility of integrating artificial intelligence-based CT analysis for predictive modeling, and cost-effectiveness comparisons between contrast and non-contrast CT across diverse populations. Additionally, exploring genetic, environmental, and anatomical factors contributing to recurrent obstruction—and evaluating the durability of endoscopic interventions for CT-confirmed strictures—may refine preventative and therapeutic strategies (13). Addressing these gaps is essential to improving patient care and resource allocation in urologic practice. In light of these considerations, the present study aims to evaluate obstructive kidneys using both contrast and non-contrast CT, comparing their efficacy in identifying common causes such as stones, UPJ obstruction, UTIs, hydronephrosis, cystitis, and ureteral narrowing. The objective is to generate evidence that supports optimized imaging selection and informs timely, accurate clinical decision-making (14).

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METHODS

The study was conducted as a cross-sectional investigation designed to determine the causes of obstructive kidneys using both contrast-enhanced and non-contrast computed tomography, and to identify the anatomical or pathological abnormalities responsible for urinary tract obstruction. The study was carried out in a tertiary-care radiology department from February to June 2022. A total sample of 141 patients was selected based on preliminary patient-flow information obtained from the supervising radiologist, who reported an approximate flow of 220 CT cases over four months. Using this estimate as the sampling frame, the sample size was calculated through the RaoSoft calculator, which recommended a minimum of 141 participants (15). A non-probability convenience sampling method was used, and data were collected through a structured, closed-ended questionnaire administered to eligible patients. Participants aged 12 to 90 years of all genders presenting with obstructive kidneys or with abnormalities known to cause obstruction were included (16). Individuals younger than 12 or older than 90 years, those diagnosed with non-obstructive renal conditions (17), patients who had undergone nephrectomy, and those currently on dialysis were excluded. Prior to data collection, permission was obtained from the hospital administration and the radiology department. Ethical approval was provided through Institutional Review Board (IRB) of the relevant institute. Written informed consent was obtained from all participants before the questionnaire was administered, ensuring voluntary participation and confidentiality. Data were collected by trained researchers who distributed and explained the questionnaire to patients meeting the inclusion criteria. Information regarding demographics, clinical symptoms, imaging findings, and suspected causes of obstruction was recorded. All completed questionnaires were verified for completeness and accuracy before entry into the Statistical Package for the Social Sciences (SPSS), version 22, where data were coded and analyzed. Descriptive statistics were generated and summarized in the form of tables and figures to present the prevalence and distribution of obstructive causes.

RESULTS

A total of 141 patients with suspected kidney obstruction were analyzed. The sample demonstrated a nearly equal gender distribution, with 73 males (51.8%) and 68 females (48.2%). Age distribution showed that 48 patients (34%) were between 12–31 years, 56 (39.7%) between 32–50 years, 22 (15.6%) between 51–69 years, and 15 (10.6%) between 70–90 years. Among the study population, 86 participants (61%) were married and 55 (39%) were unmarried. Patient weight categories revealed that 9 individuals (6.4%) weighed 30–50 kg, 60 (42.6%) weighed 51–70 kg, 69 (48.9%) weighed 71–90 kg, and 3 (2.1%) weighed 91–110 kg. Residence-based analysis showed that 79 patients (56%) belonged to urban areas, whereas 62 (44%) were from rural areas. Imaging history indicated that 129 participants (91.5%) had undergone at least one prior imaging scan, while 12 (8.5%) had never been imaged before. A total of 85 respondents (60.3%) reported having been informed by physicians about their kidney disease; 56 (39.7%) had not received such information. Awareness of contrast media was divided, with 70 patients (49.6%) stating they were familiar with it, while 71 (50.4%) were not. Regarding imaging modality, 73 patients (51.8%) underwent contrast-enhanced CT, and 68 (48.2%) underwent non-contrast CT. Creatinine testing prior to contrast-enhanced imaging was performed by 72 individuals (51.1%), while 69 (48.9%) did not undergo this test. Only 16 patients (11.3%) reported a history of contrast allergy, compared to 125 (88.7%) without such reactions. Kidney stones were identified in 85 patients (60.3%), with 40 stones (47%) detected by contrast CT and 45 stones (53%) by non-contrast CT. A family history of renal calculi was also reported by 85 patients (60.3%). UPJ obstruction was detected in 46 patients (32.6%), whereas 95 (67.4%) had no UPJ involvement; of the cases identified, 28 (60%) were detected by contrast CT and 18 (40%) by non-contrast CT. Pain distribution showed right kidney pain in 92 patients (65.2%) and left kidney pain in 78 patients (55.3%).

Urinary abnormalities included hematuria in 61 patients (43.3%) and absence of hematuria in 80 (56.7%). Blood or foamy urine was reported by 111 patients (78.7%), while 30 (21.3%) did not report such abnormalities. UTIs were detected in 84 patients (59.6%), with contrast CT identifying 44 cases (52%) and non-contrast CT identifying 40 cases (48%). Hydronephrosis was observed in 52 patients (36.9%), among whom 5 cases (9.6%) were detected by contrast CT and 47 (90.4%) by non-contrast CT. Cystitis was diagnosed in 45 patients (31.9%), with 27 cases (60%) shown on contrast CT and 18 (40%) on non-contrast CT. A total of 34 patients (24.1%) had narrowed ureters, while 107 (75.9%) did not. Among the narrowed ureter cases, 24 (70%) were shown by contrast CT and 10 (30%) by non-contrast CT. Difficulty in urine excretion was reported by 74 patients (52.5%). Medication use to manage kidney obstruction was reported by 85 individuals (60.3%), while 30 (21.3%) reported difficulty adhering to prescribed medications. Comparative analysis of contrast versus non-contrast CT revealed notable variation in the detection of obstructive causes; however, the dataset did not include p-values, confidence intervals, or diagnostic accuracy metrics, limiting the ability to determine statistical significance. Cross-tabulation showed that contrast CT demonstrated higher detection of UPJ obstruction (60% vs 40%), cystitis (60% vs 40%), narrowed ureter (70%

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vs 30%), and UTIs (52% vs 48%), whereas non-contrast CT identified a greater proportion of hydronephrosis cases (90.4% vs 9.6%). Kidney stone detection was nearly comparable between modalities, with non-contrast CT slightly higher (53% vs 47%). Despite these observable differences, no comparative effectiveness tests, such as chi-square, sensitivity/specificity calculations, or predictive value assessments, were applied. As a result, the relative diagnostic performance of contrast versus non-contrast CT remains descriptive rather than inferential, and the magnitude of true modality superiority cannot be statistically confirmed.

Table 1: Demographic Characteristics of the Study Participants

S. No	Variables	Details	Frequency/Values	Percent
1	Gender	Males	73	51.8%
		Females	68	48.2%
2	Age	11–20 years	48	34%
		21–25 years	56	39.7%
		26–30 years	22	15.6%
		31–40 years	15	10.6%
3	Marital Status	Married	86	61%
		Unmarried	55	39%
4	Weight (kg)	30–50	9	6.4%
		51–70	60	42.6%
		71–90	69	48.9%
		91–110	3	2.1%
5	Residence	Urban	79	56%
		Rural	62	44%

Table 2: Patients' Knowledge and Imaging-Related Responses

Question	Detail	Frequency	Percent
Do you have ever performed any imaging scan?	Yes	129	91.5%
	No	12	8.5%
Do you have ever been told about kidney disease by doctor?	Yes	85	60.3%
	No	56	39.7%
Do you know about contrast media?	Yes	70	49.6%
	No	71	50.4%
Which type of imaging scan you have performed for diagnosis?	Contrast	73	51.8%
	Non-Contrast	68	48.2%
Have you performed creatinine test before contrast imaging scan?	Yes	72	51.1%

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Question	Detail	Frequency	Percent
	No	69	48.9%
Do you have any type of contrast allergy?	Yes	16	11.3%
	No	125	88.7%

Table 3: Patients' Clinical Responses and Obstruction-Related Findings

Question	Detail	Frequency	Percent
Do you have any ureter narrowing shown on CT scan?	Yes	34	24.1%
	No	107	75.9%
Distribution of narrowed ureter on the basis of contrast imaging and non-contrast imaging scans. TOTAL CASES: 34	Contrast	24	70%
	Non-Contrast	10	30%
Do you have any difficulty in urine excretion?	Yes	74	52.5%
	No	67	47.5%
Have you taken any medications to prevent the kidney obstruction?	Yes	85	60.3%
	No	56	39.7%
Do you have any difficulty taking your prescribed medication?	Yes	30	21.3%
	No	111	78.7%

Table 4: Cross-Tabulation of Obstructive Causes by CT Modality

Obstructive Cause	Total Cases (n)	Detected by Contrast CT n (%)	Detected by Non-contrast CT n (%)
Kidney stones	85	40 (47%)	45 (53%)
UPJ obstruction	46	28 (60%)	18 (40%)
Urinary tract infection	84	44 (52%)	40 (48%)
Hydronephrosis	52	5 (9.6%)	47 (90.4%)
Cystitis	45	27 (60%)	18 (40%)
Narrowed ureter	34	24 (70%)	10 (30%)

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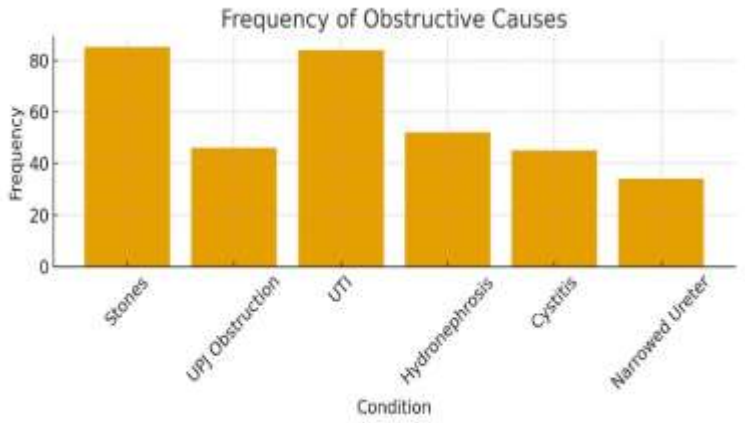


Figure 2 Frequency of Obstructive Causes

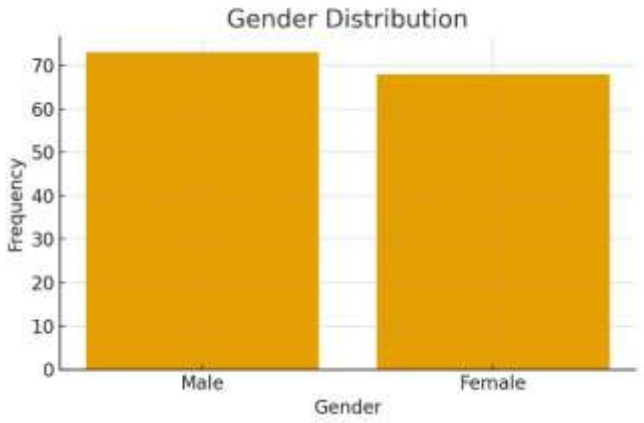
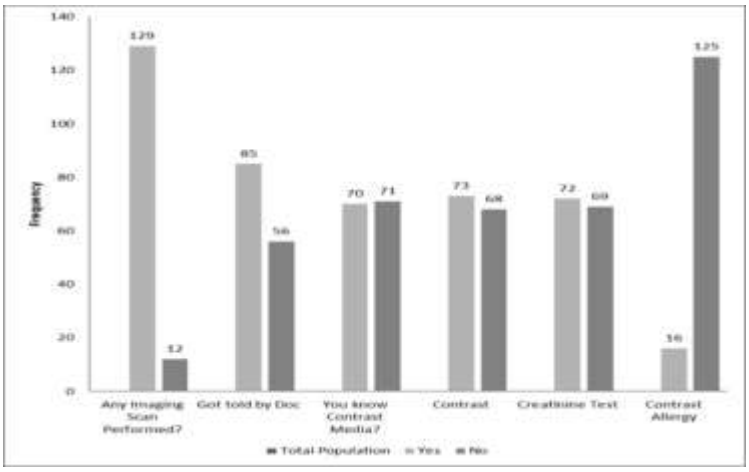
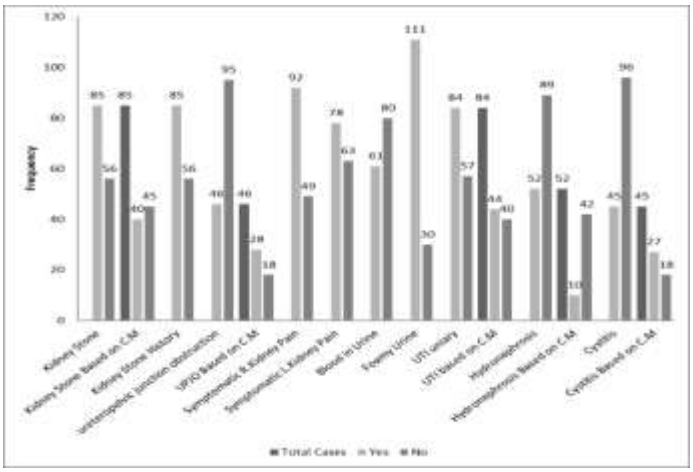
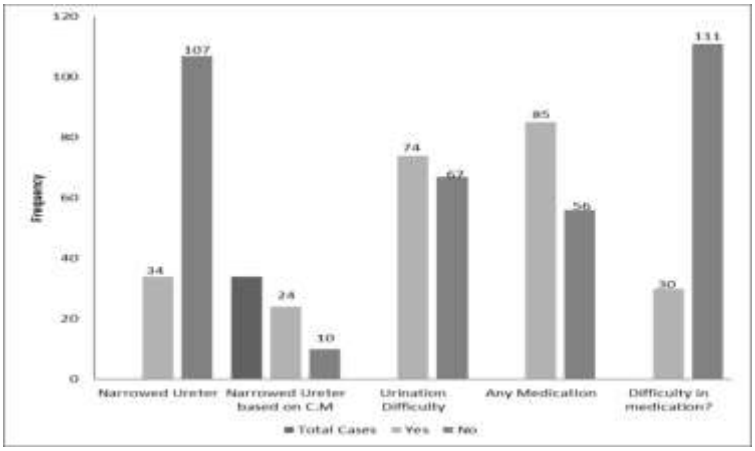


Figure 2 Gender Distribution







DISCUSSION

The findings of this multi-hospital cross-sectional study provide important insights into the diagnostic performance of contrast and non-contrast CT in patients with suspected kidney obstruction within the Khyber Pakhtunkhwa region. The demographic distribution, with a nearly equal representation of males and females, mirrors patterns reported in earlier research that described a modest male

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predominance in obstructive uropathies, although regional variation has been recognized in the literature (15). The concentration of cases in the 32–50-year age group resembles global epidemiological trends in urolithiasis and obstructive pathology, reinforcing the observation that working-age adults remain disproportionately affected by stone disease and related complications. The predominance of urban residents in the sample also reflects the population distribution of the selected hospitals, although environmental and lifestyle differences between rural and urban populations may have influenced disease patterns and should be considered when interpreting results (16,17). The comparative performance of contrast versus non-contrast CT revealed clinically meaningful differences consistent with previously published work. Contrast CT showed superior detection of conditions such as UPJ obstruction, UTIs, cystitis, and narrowed ureters, aligning with earlier studies that highlighted the enhanced visibility of inflammatory and structural abnormalities during contrast-enhanced phases (18). The 70% detection rate for narrowed ureter by contrast CT in this study supports prior reports where contrast imaging resolved complex or unclear ureteral blockages in the majority of cases. Conversely, non-contrast CT demonstrated better performance in identifying hydronephrosis and maintained a slightly higher detection rate for renal calculi, replicating established evidence on the accuracy of NCCT for stone disease and obstructive dilation while avoiding risks associated with contrast administration (19,20). These findings reinforce the clinical principle that imaging modality selection should be tailored to the suspected pathology, with contrast CT favored for complex obstructive patterns and NCCT preferred when stone disease is the primary concern.

Several strengths enhance the value of this study. The inclusion of three hospitals increases generalizability within the region, and the balanced use of both imaging modalities allows a direct comparison of detection patterns. Additionally, the sample size was appropriately calculated and achieved, and the study incorporated multiple obstructive causes, offering a broad overview of diagnostic outcomes. Despite these strengths, certain limitations warrant consideration. The absence of comparative statistical testing, such as chi-square analysis or diagnostic accuracy metrics, restricts inference regarding true superiority between modalities. The study relied predominantly on descriptive frequencies without calculating sensitivity, specificity, or predictive values, which are essential for determining diagnostic performance. Moreover, the hospital-based sampling strategy introduces selection bias and may not reflect community-level disease prevalence. The lack of long-term follow-up further limits understanding of clinical impact, as treatment outcomes and modality-related management changes could not be assessed. These methodological limitations highlight the need for more rigorous analytical approaches in future investigations. The implications of these findings underscore CT's established role as the gold standard in diagnosing obstructive uropathies (21,22). The higher detection rates observed with contrast-enhanced CT support its use in identifying complex anatomical and inflammatory etiologies, whereas NCCT remains reliable for stone disease and hydronephrosis, offering a safer alternative for patients with renal impairment or contrast contraindications. Future research should incorporate larger multicenter cohorts, inferential statistical analysis, and diagnostic performance metrics to strengthen evidence. Longitudinal designs may also clarify how imaging modality influences treatment decisions and renal outcomes over time. Cost-effectiveness assessments would be particularly valuable in resource-limited regions where imaging accessibility remains a challenge. Overall, the study contributes meaningful regional data and supports a balanced, pathology-driven approach to selecting between contrast and non-contrast CT for evaluating obstructive kidney disease (23,24).

CONCLUSION

The study concluded that computed tomography remains the most effective modality for evaluating obstructive kidney conditions, with both contrast and non-contrast techniques offering valuable diagnostic information. While non-contrast CT performed reliably for conditions such as hydronephrosis and renal calculi, contrast-enhanced CT demonstrated superior ability to identify a broader range of obstructive causes, including structural abnormalities, inflammatory changes, and complex ureteral pathologies. These findings highlight the practical importance of selecting imaging modalities based on the suspected underlying pathology, with contrast-enhanced CT emerging as the preferred choice for comprehensive assessment of obstructive uropathies. Overall, the study reinforces CT's pivotal role in guiding timely diagnosis and informed clinical decision-making, ultimately contributing to improved patient outcomes.

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AUTHOR CONTRIBUTION

Author	Contribution
Gulzar Azam*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Salman Khalid	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Raza Ullah	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Syeda Tahreem Zahra	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Shah Zeb	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Usama	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

REFERENCES

1. Hisamune R, Yamakawa K, Umemura Y, Ushio N, Mochizuki K, Inokuchi R, et al. Association Between IV Contrast Media Exposure and Acute Kidney Injury in Patients Requiring Emergency Admission: A Nationwide Observational Study in Japan. Crit Care Explor. 2024;6(9):e1142.

2. Macdonald DB, Hurrell C, Costa AF, McInnes MDF, O'Malley ME, Barrett B, et al. Canadian Association of Radiologists Guidance on Contrast Associated Acute Kidney Injury. Can Assoc Radiol J. 2022;73(3):499-514.

3. Ciccarese F, Brandi N, Corcioni B, Golfieri R, Gaudiano C. Complicated pyelonephritis associated with chronic renal stone disease. Radiol Med. 2021;126(4):505-16.

4. David E, Del Gaudio G, Drudi FM, Dolcetti V, Pacini P, Granata A, et al. Contrast Enhanced Ultrasound Compared with MRI and CT in the Evaluation of Post-Renal Transplant Complications. Tomography. 2022;8(4):1704-15.

5. Spiesecke P, Thiemann J, Conen P, Clevert DA. Contrast enhanced ultrasound of cystic renal lesions, from diagnosis up to treatment. Clin Hemorheol Microcirc. 2024;88(s1):S21-s33.

6. Müller L, Emrich T. Contrast Media Subtraction for Kidney Stone Detection: Not All Problems Are Solved with Photon-Counting Detector CT. Acad Radiol. 2024;31(9):3657-8.

7. Lee CC, Chan YL, Wong YC, Ng CJ, Chang CH, Hung CC, et al. Contrast-enhanced CT and Acute Kidney Injury: Risk Stratification by Diabetic Status and Kidney Function. Radiology. 2023;307(5):e222321.

8. Kazmierski BJ, Sharbidre KG, Robbin ML, Grant EG. Contrast-Enhanced Ultrasound for the Evaluation of Renal Transplants. J Ultrasound Med. 2020;39(12):2457-68.

9. Masino F, Eusebi L, Bertolotto M, Pizzileo SM, Pizzolorusso F, Sortino G, et al. Contrast-enhanced ultrasound in renal cystic lesions: an update. J Med Ultrason (2001). 2024;51(4):635-47.

10. Aggarwal A, Goswami S, Das CJ. Contrast-enhanced ultrasound of the kidneys: principles and potential applications. Abdom Radiol (NY). 2022;47(4):1369-84.

11. Davenport MS, Perazella MA, Nallamothu BK. Contrast-Induced Acute Kidney Injury and Cardiovascular Imaging: Danger or Distraction? Circulation. 2023;147(11):847-9.

12. Oh A, Bhardwaj L, Cacciamani G, Desai MM, Duddalwar VA. Cost-effectiveness of Contrast-Enhanced Ultrasound for Diagnosis and Active Surveillance of Complex Cystic Renal Lesions. Urol Pract. 2023;10(1):11-9.

13. Nair AD, Kumar A, Gamanagatti S, Gupta A, Kumar S. CT findings in renovascular injuries following abdominal trauma: a pictorial review. Emerg Radiol. 2022;29(3):595-604.

14. Shin H, Taghavifar S, Salehi S, Joyce P, Gholamrezanezhad A. Current comments on contrast media administration in patients with renal insufficiency. Clin Imaging. 2021;69:37-44.

15. Dai C, Xiong Y, Zhu P, Yao L, Lin J, Yao J, et al. Deep Learning Assessment of Small Renal Masses at Contrast-enhanced Multiphase CT. Radiology. 2024;311(2):e232178.

16. Barrios López A, García Martínez F, Rodríguez JI, Montero-San-Martín B, Gómez Rioja R, Diez J, et al. Incidence of contrast-induced nephropathy after a computed tomography scan. Radiologia (Engl Ed). 2021;63(4):307-13.

17. Juliebø-Jones P, Semins MJ, Seitz C, Krambeck A, Keller EX, Davis NF, et al. Management of Kidney Stones in Pregnancy: A Worldwide Survey of Practice Patterns. J Endourol. 2024;38(10):1092-6.

18. Goyal A, Gulati M, Sharma R, Gamanagatti S, Seith Bhalla A, Seth A. Multimodality imaging evaluation of pseudotumors in chronic renal dysfunction: exposing the masquerade! Acta Radiol. 2023;64(1):387-94.

19. Warren H, Poon D, Srinivasan R, Thomas K, Rottenberg G, Bultitude M, et al. Non-contrast computed tomography characteristics in a large cohort of cystinuria patients. World J Urol. 2021;39(7):2753-7.

20. Lee Y, Hwang I, Cho YJ, Han SS, Yoon SH. Outpatient Renal Function Screening Before Contrast-Enhanced CT Examinations. J Korean Med Sci. 2024;39(38):e298.

21. Choi B, Heo S, McDonald JS, Choi SH, Choi WM, Lee JB, et al. Risk of Contrast-Induced Acute Kidney Injury in Computed Tomography: A 16 Institutional Retrospective Cohort Study. Invest Radiol. 2025;60(6):376-86.

22. Choi M, Kim Y. Ultrasonographic and contrast-enhanced CT imaging diagnosis of idiopathic renal hematuria with bilateral hydronephrosis and hydroureter in a dog. Vet Radiol Ultrasound. 2022;63(6):E21-e5.

23. Barr RG. Use of lumason/sonovue in contrast-enhanced ultrasound of the kidney for characterization of renal masses-a meta-analysis. Abdom Radiol (NY). 2022;47(1):272-87.

24. Scarcella S, Tiroli M, Torino G, Mariscoli F, Cobellis G, Galosi ABJTIJoMR, et al. Combined treatment of ureteropelvic junction obstruction and renal calculi with robot-assisted laparoscopic pyeloplasty and laser lithotripsy in children: Case report and non-systematic review of the literature. 2021;17(3): e2246.