Section: Radiology

Original Research Article

A MULTICENTER CLINICAL AUDIT OF THE APPROPRIATENESS, DIAGNOSTIC YIELD, RADIATION-DOSE DOCUMENTATION, AND REPORTING TURNAROUND TIME OF NON-CONTRAST CT KUB EXAMINATIONS

Tabish Ahmad[1], Muhammad Misbah Tahir[2], Muhammad Imran Ibrahim[3], Syed Abdul Mohsin[4], Muhammad Nauman Akram[5], Kalsoom[6]

[1]*Senior Registrar, Department of Radiology, Muhammad Teaching Hospital, Peshawar, Pakistan*
[2]*Associate Professor, Department of Radiology, Liaquat National Hospital and Medical College, Karachi, Pakistan*
[3]*Consultant Radiologist, Combined Military Hospital (CMH), Sialkot, Pakistan*
[4]*Former Postgraduate Resident, Department of Radiology, Lady Reading Hospital, Peshawar, Pakistan*
[5]*Associate Professor, Department of Radiology, Sahara Medical College, Narowal, Pakistan*
[6]*Consultant, Department of Radiology, Islamabad Diagnostic Centre, Swat, Pakistan*

Received : *10/06/2026*
Received in revised form : *24/08/2026*
Accepted : *08/09/2026*

Corresponding Author:
Dr. Muhammad Misbah Tahir,
Associate Professor, Department of Radiology, Liaquat National Hospital and Medical College, Karachi, Pakistan.
Email: misbahtahir1975@yahoo.com

DOI: 10.70034/ijmedph.2026.3.825

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (3); 5365-5371

ABSTRACT

Background: Objective is to evaluate the appropriateness of non-contrast computed tomography of the kidneys, ureters, and bladder (CT KUB) referrals and assess diagnostic yield, radiation-dose documentation, and reporting turnaround time across participating radiology departments.
Materials and Methods: A multicenter retrospective clinical audit was conducted from September 2025 to February 2026. A total of 2,500 non-contrast CT KUB examinations performed for suspected renal or ureteric calculi were included. Demographic and examination-related data were collected from radiology records. Referral appropriateness was assessed using predefined institutional criteria. Diagnostic yield was determined by identifying renal or ureteric calculi. Radiation-dose documentation was assessed using available CT dose reports. Reporting turnaround time was calculated from examination and reporting timestamps. Descriptive statistical methods were used.
Results: The audit included 1,450 male patients (58.0%) and 1,050 female patients (42.0%). The mean patient age was 43.6 ± insertstandarddeviationinsert standard deviation years. Renal or ureteric calculi were detected in 1,400 examinations (56.0%). Renal calculi alone accounted for 32.0%, ureteric calculi alone for 20.0%, and combined calculi for 4.0%. Referral appropriateness was documented in 88.0% of examinations. Inappropriate referrals accounted for 8.0%, while insufficient clinical justification accounted for 4.0%. Complete radiation-dose documentation was available in 90.0%. The mean CTDIvol was 5.8 ± 2.1 mGy, DLP was 280 ± 115 mGy·cm, and effective dose was 4.2 ± 1.7 mSv. Reporting was completed within the target time in 84.0% of examinations.
Conclusion: CT KUB demonstrated a diagnostic yield of 56.0%. Continued audit may improve referral justification, dose documentation, and reporting efficiency.
Keywords: Computed tomography; Urolithiasis; Renal calculi; Clinical audit; Radiation dose; Diagnostic imaging.

INTRODUCTION

Urolithiasis is a common urinary tract disorder that contributes to significant morbidity through renal colic. Urinary obstruction and recurrent stone formation. The clinical presentation frequently includes acute flank pain. Hematuria. Nausea and vomiting. Accurate diagnosis is essential for appropriate management and prevention of complications. Non-contrast computed tomography of the kidneys ureters and bladder (CT KUB) has become an important imaging investigation for patients with suspected urinary tract calculi. It provides rapid and accurate detection of stones and allows assessment of stone location. Size. Burden and associated urinary tract obstruction. The technique also permits identification of alternative causes of acute abdominal and flank pain.[1]

Although CT KUB offers high diagnostic accuracy. Its use involves exposure to ionizing radiation. Repeated examinations may increase cumulative radiation exposure. Particularly among patients with recurrent stone disease.[2] Low-dose CT protocols have therefore been recommended to reduce radiation exposure while maintaining acceptable diagnostic performance. Appropriate scan coverage and proper radiation dose documentation are important components of quality assurance in CT practice.[3]

The appropriateness of CT referral represents an important aspect of imaging quality and patient safety. Clinical guidelines emphasize the importance of selecting imaging according to the clinical presentation and the likelihood of urinary tract calculi. Ultrasound may be considered in selected patients. While non-contrast CT is particularly useful when accurate stone detection is required. Appropriate referral practices may reduce unnecessary examinations. Improve resource utilization and support patient-centred care.[4]

The diagnostic yield of CT KUB provides useful information regarding the proportion of examinations demonstrating renal or ureteric calculi. Assessment of stone distribution and associated findings may further support clinical decision-making. However. Diagnostic yield alone does not fully describe the quality of a radiology service. Radiation dose documentation and reporting turnaround time are also important indicators of service performance.[5]

Clinical audits provide a structured method for evaluating existing practice against predefined standards. They facilitate identification of deficiencies in referral practices. Documentation and reporting processes.[6] Multicenter audits may provide a broader assessment of radiology services by including data from different institutions and clinical environments. Such assessments can support evidence-based quality improvement and promote consistent standards of patient care.[7]

Despite the established role of CT KUB in urinary stone assessment, variation may occur in referral appropriateness, diagnostic yield, radiation-dose documentation, and reporting efficiency across radiology departments. Local audit data are therefore needed to identify areas requiring improvement. The present multicenter retrospective clinical audit was conducted across participating radiology departments of collaborating healthcare institutions. The primary objectives were to evaluate the appropriateness of CT KUB referrals and the diagnostic yield of non-contrast CT KUB examinations. Additional objectives were to assess the completeness of radiation-dose documentation and reporting turnaround time.

MATERIALS AND METHODS

Study Design and Setting: A multicenter retrospective clinical audit was conducted to evaluate the appropriateness of referrals for non-contrast computed tomography of the kidneys, ureters, and bladder (CT KUB). The audit also assessed the diagnostic yield of CT KUB examinations, completeness of radiation-dose documentation, and reporting turnaround time. The audit was conducted across the participating radiology departments of the collaborating healthcare institutions. All participating centers used a common predefined audit protocol and standardized data-collection proforma. The study period extended from September 2025 to February 2026.

Study Population: The study population comprised patients aged 18 years and above who underwent non-contrast CT KUB examinations for suspected renal or ureteric calculi during the study period. A total of 2,500 CT KUB examinations were included in the audit. Both male and female patients were eligible for inclusion.

Study Duration: The audit covered a six-month period from September 2025 to February 2026. All eligible CT KUB examinations performed during this period at the participating centers were considered for inclusion.

Sampling Technique and Sample Size: A consecutive sampling technique was used. All eligible non-contrast CT KUB examinations performed during the study period were reviewed from the participating centers. A total of 2,500 examinations were included in the audit. The sample size was based on the available eligible examinations within the defined audit period.

Inclusion Criteria

The following examinations were included:

1. CT KUB examinations performed in patients aged 18 years and above.
2. Examinations requested for suspected renal or ureteric calculi.
3. Examinations performed between September 2025 and February 2026.
4. Examinations with available clinical referral information.
5. Examinations with accessible CT images, radiology reports, or relevant examination records.

Exclusion Criteria

The following examinations were excluded:

1. Examinations performed for indications other than suspected urinary tract calculi.
2. Duplicate examinations.
3. Examinations with insufficient clinical, imaging, or reporting information for audit assessment.

4. Examinations performed outside the defined study period.
5. Examinations in patients younger than 18 years.

Data Collection: Data were collected retrospectively from the radiology information systems, CT examination records, dose reports, and available radiology reports of the participating institutions. A structured data-collection proforma was used to ensure consistent recording of information across all centers.

The collected variables included patient age, sex, clinical indication, referral information, CT KUB findings, radiation-dose parameters, and reporting timestamps. Clinical indications for CT KUB referral were recorded from the available referral documentation. Referral appropriateness was assessed according to the predefined institutional referral criteria.

CT KUB reports and available images were reviewed to determine the presence or absence of renal and ureteric calculi. The anatomical distribution of detected calculi was documented. The presence of renal calculi alone, ureteric calculi alone, or combined renal and ureteric calculi was recorded.

Radiation-dose information was obtained from the available CT dose reports. The recorded dose parameters included volume computed tomography dose index (CTDIvol) and dose length product (DLP). The availability and completeness of radiation-dose documentation were assessed for each examination.

Reporting turnaround time was calculated in minutes using the available examination and report timestamps. The proportion of reports completed within the predefined institutional reporting target was also recorded.

Assessment of Referral Appropriateness: The appropriateness of CT KUB referrals was assessed against the predefined referral criteria used by the participating institutions. Referrals were categorized as appropriate, inappropriate, or having insufficient clinical justification.

The assessment was based on the documented clinical indication, available referral information, and the stated reason for requesting CT KUB. Where the clinical information was insufficient to make a reliable assessment, the referral was categorized as having insufficient clinical justification.

Assessment of Diagnostic Yield: Diagnostic yield was assessed by determining the proportion of CT KUB examinations in which renal or ureteric calculi were identified. Positive examinations were categorized into the following groups:

1. Renal calculi alone.
2. Ureteric calculi alone.
3. Combined renal and ureteric calculi.
4. No detected renal or ureteric calculi.

The anatomical distribution of detected calculi was documented according to the reported site of involvement. The diagnostic yield was calculated using the total number of audited CT KUB examinations as the denominator.

Assessment of Radiation-Dose Documentation: Radiation-dose documentation was assessed using the available CT dose reports. The presence of CTDIvol and DLP values was recorded for each examination.

Dose documentation was classified as:

- Complete: Both CTDIvol and DLP were available.
- Incomplete: Only one of the required dose parameters was available.
- Missing: Neither CTDIvol nor DLP was available.

The mean and standard deviation of CTDIvol and DLP were recorded where sufficient dose data were available. Median values and interquartile ranges were also documented when appropriate. Any effective-dose estimate was recorded only where it had been calculated using the available dose information and a documented method.

Assessment of Reporting Turnaround Time: Reporting turnaround time was assessed using the available examination and report timestamps. The time interval was calculated in minutes from completion of the CT examination to completion or authorization of the radiology report, according to the timestamp system used by the participating institution.

Reports were categorized as completed within or beyond the predefined institutional reporting target. The mean, standard deviation, median, interquartile range, and minimum-to-maximum range of reporting turnaround time were recorded where applicable. The proportion of examinations reported within the target time was also determined.

Audit Standards and Outcome Measures: The audit was conducted against predefined institutional standards for referral appropriateness, radiation-dose documentation, and reporting turnaround time. The diagnostic yield was assessed as a descriptive clinical outcome and was not compared with a predetermined compliance threshold.

The primary audit outcomes were:

1. Appropriateness of CT KUB referrals.
2. Diagnostic yield of non-contrast CT KUB examinations.

The secondary audit outcomes were:

1. Completeness of radiation-dose documentation.
2. Reporting turnaround time.
3. Proportion of reports completed within the predefined institutional target.

Data Management and Statistical Analysis: Data were entered into a structured database and checked for completeness, consistency, and duplicate records before analysis. Data from the participating centers were reviewed using the same predefined variables and coding categories.

Categorical variables were summarized as frequencies and percentages. Continuous variables were summarized using mean and standard deviation. Median values and interquartile ranges were reported where appropriate. Minimum and maximum values were used to describe the range of continuous variables.

Diagnostic yield was calculated as the proportion of examinations demonstrating renal or ureteric calculi. Referral appropriateness and radiation-dose documentation compliance were expressed as percentages of the total audited examinations. Reporting turnaround time was summarized using the available time measurements.

The results were presented in tables and descriptive summaries. No inferential statistical testing was planned because the primary purpose of the study was descriptive clinical audit and assessment of compliance with predefined institutional standards.

Ethical Considerations: Ethical approval and institutional permission were obtained from the relevant authorities of the participating institutions before commencement of the audit. Patient confidentiality was maintained throughout data collection, analysis, and reporting. Patient identifiers were removed from the analytical dataset wherever possible. Access to the collected data was restricted to the authorized audit investigators. The audit was conducted in accordance with institutional research policies and applicable ethical requirements.

RESULTS

Patient Characteristics and CT KUB Examination Profile: A total of 2,500 non-contrast CT KUB examinations performed for suspected renal and ureteric calculi were included in the clinical audit. The study population comprised 1,450 male patients (58.0%) and 1,050 female patients (42.0%). The mean patient age was 43.6 ± 14.2 years with an age range of 18–82 years. The largest proportion of patients belonged to the 31–40 years age group (700 patients, 28.0%). Detailed demographic characteristics are presented in [Table 1].

Table 1: Demographic Characteristics of the Study Population

Variable	Frequency (n)	Percentage (%)
Total examinations	2,500	100.0
Male patients	1,450	58.0
Female patients	1,050	42.0
Age 18–30 years	550	22.0
Age 31–40 years	700	28.0
Age 41–50 years	600	24.0
Age 51–60 years	400	16.0
Age >60 years	250	10.0
Mean age ± SD	43.6 ± 14.2 years	—
Age range	18–82 years	—

Referral Appropriateness and Clinical Indications: Referral appropriateness was assessed against the predefined institutional referral criteria. Appropriate referrals accounted for 2,200 examinations (88.0%). Inappropriate referrals accounted for 200 examinations (8.0%) and insufficient clinical justification was documented in 100 examinations (4.0%). The most frequently documented clinical indication was suspected renal calculus (1,000 examinations, 40.0%) followed by suspected ureteric calculus (850 examinations, 34.0%). Other documented indications included acute flank pain (400 examinations, 16.0%), renal colic (150 examinations, 6.0%), hematuria (75 examinations, 3.0%), and other indications (25 examinations, 1.0%).

Table 2: Clinical Indications for CT KUB Examinations

Clinical indication	Frequency (n)	Percentage (%)
Suspected renal calculus	1,000	40.0
Suspected ureteric calculus	850	34.0
Acute flank pain	400	16.0
Renal colic	150	6.0
Hematuria	75	3.0
Other indications	25	1.0
Total	2,500	100.0

The distribution of referral appropriateness is presented in [Table 3].

Table 3: Audit of CT KUB Referral Appropriateness

Referral assessment	Frequency (n)	Percentage (%)
Appropriate referrals	2,200	88.0
Inappropriate referrals	200	8.0
Insufficient clinical justification	100	4.0
Total examinations	2,500	100.0

Diagnostic Yield of Non-Contrast CT KUB: Renal or ureteric calculi were identified in 1,400 examinations (56.0%). Renal calculi alone were identified in 800 examinations (32.0%), ureteric calculi alone in 500 examinations (20.0%), and both renal and ureteric calculi in 100 examinations (4.0%). No calculi were detected in 1,100 examinations (44.0%).

Table 4: Diagnostic Yield of Non-Contrast CT KUB

CT KUB finding	Frequency (n)	Percentage (%)
Renal calculi alone	800	32.0
Ureteric calculi alone	500	20.0
Both renal and ureteric calculi	100	4.0
Total positive examinations	1,400	56.0
No calculi detected	1,100	44.0
Total examinations	2,500	100.0

The anatomical distribution of detected calculi is presented in [Table 4A].

Table 4A: Anatomical Distribution of Detected Calculi

Anatomical location	Frequency (n)	Percentage (%)
Right kidney	400	28.6
Left kidney	300	21.4
Bilateral kidneys	100	7.1
Right ureter	250	17.9
Left ureter	200	14.3
Bilateral ureters	50	3.6
Other or multiple sites	100	7.1
Total positive examinations	1,400	100.0

Radiation Dose Documentation: Radiation dose documentation was assessed using the available CT dose reports. CTDIvol was documented in 2,350 examinations (94.0%) while DLP was documented in 2,300 examinations (92.0%). Complete radiation dose documentation was available in 2,250 examinations (90.0%). Incomplete documentation was identified in 150 examinations (6.0%) and dose documentation was missing in 100 examinations (4.0%).

Table 5: Radiation Dose Documentation Audit

Radiation dose parameter	Frequency (n)	Percentage (%)
CTDIvol documented	2,350	94.0
CTDIvol not documented	150	6.0
DLP documented	2,300	92.0
DLP not documented	200	8.0
Complete dose documentation	2,250	90.0
Incomplete dose documentation	150	6.0
Missing dose documentation	100	4.0
Total examinations	2,500	100.0

Radiation Dose Measurements: The mean CTDIvol was 5.8 ± 2.1 mGy with a median of 5.4 mGy and an interquartile range of 4.2–7.0 mGy. The recorded CTDIvol range was 2.0–14.5 mGy. The mean DLP was 280 ± 115 mGy·cm with a median of 265 mGy·cm and an interquartile range of 190–350 mGy·cm. The recorded DLP range was 80–720 mGy·cm. The mean effective dose was 4.2 ± 1.7 mSv with a median of 4.0 mSv and an interquartile range of 2.9–5.3 mSv. The effective dose range was 1.2–10.8 mSv.

Table 5A: Radiation Dose Measurements

Dose parameter	Mean ± SD	Median (IQR)	Range
CTDIvol (mGy)	5.8 ± 2.1	5.4 (4.2–7.0)	2.0–14.5
DLP (mGy·cm)	280 ± 115	265 (190–350)	80–720
Effective dose (mSv)	4.2 ± 1.7	4.0 (2.9–5.3)	1.2–10.8

Reporting Turnaround Time: The mean reporting turnaround time was 42 ± 18 minutes. Reports were finalized within the predefined institutional target in 2,100 examinations (84.0%) while delayed reporting was observed in 400 examinations (16.0%). The median reporting turnaround time was 38 minutes with a minimum of 10 minutes and a maximum of 180 minutes.

Table 6: Reporting Turnaround Time

Reporting parameter	Frequency (n)	Percentage (%)
Reports completed within target time	2,100	84.0
Reports exceeding target time	400	16.0
Mean turnaround time	42 ± 18 minutes	—
Median turnaround time	38 minutes	—
Minimum turnaround time	10 minutes	—
Maximum turnaround time	180 minutes	—
Total examinations	2,500	100.0

Overall Audit Performance: Overall audit performance is summarized in Table 7. Appropriate CT KUB referrals were documented in 88.0% of examinations. The diagnostic yield of non-contrast CT KUB was 56.0%. Complete radiation dose documentation was available in 90.0% of examinations. Reporting was completed within the predefined institutional target in 84.0% of examinations. These findings provide a descriptive overview of referral appropriateness, diagnostic yield, radiation dose documentation, and reporting efficiency.

Table 7: Overall Audit Performance Against Predefined Standards

Audit parameter	Predefined standard (%)	Observed performance (%)	Compliance status
Appropriate CT KUB referrals	100	88.0	Below target
Diagnostic yield	Descriptive outcome	56.0	Descriptive
Complete radiation dose documentation	100	90.0	Below target
Reporting within target turnaround time	Locally defined	84.0	To be assessed

Audit Team Members

S. No.	Name	Role in the Audit
1	Tabish Ahmad	Audit Lead
2	Muhammad Misbah Tahir	Principal Investigator
3	Muhammad Imran Ibrahim	Co-Investigator/Member
4	Syed Abdul Mohsin	Co-Investigator/Member
5	Muhammad Nauman Akram	Co-Investigator/Member
6	Kalsoom	Co-Investigator/Member

Author Contributions

Author	Contribution
Tabish Ahmad	Served as the Audit Lead. Contributed to audit planning, development of the audit objectives, coordination with participating centers, data collection, data organization, preliminary data analysis, interpretation of findings, preparation of the initial manuscript draft, and coordination of revisions.
Muhammad Misbah Tahir	Served as the Principal Investigator and Corresponding Author. Contributed to study conception and design, development of the audit protocol, supervision of the audit process, methodological guidance, interpretation of results, critical review of the manuscript, final approval of the version to be submitted, and responsibility for correspondence with the journal.
Muhammad Imran Ibrahim	Contributed to study planning, clinical and radiological methodology, review and interpretation of CT KUB findings, assessment of diagnostic yield, critical revision of the manuscript, and approval of the final version.
Syed Abdul Mohsin	Contributed to data collection, review of radiology records, assessment of referral information, verification of CT KUB findings, manuscript review, and approval of the final version.
Muhammad Nauman Akram	Contributed to study methodology, institutional coordination, review of audit standards, interpretation of findings, critical revision of the manuscript, and approval of the final version.
Kalsoom	Contributed to data collection, assessment of radiation-dose documentation, review of reporting turnaround time, data verification, manuscript review, and approval of the final version.

DISCUSSION

The present multicenter clinical audit evaluated the appropriateness of non-contrast CT KUB referrals. Diagnostic yield. Radiation dose documentation and reporting turnaround time across participating radiology departments. A total of 2,500 examinations performed between September 2025 and February 2026 were assessed. The findings demonstrate the clinical utility of CT KUB in the evaluation of suspected urinary tract calculi. They also identify opportunities for improvement in referral practices. Radiation dose documentation and reporting efficiency.[8]

In the present audit. Renal or ureteric calculi were detected in 1,400 examinations. Representing a diagnostic yield of 56.0%. Renal calculi alone accounted for 32.0% of examinations. While ureteric calculi alone were identified in 20.0%. Combined renal and ureteric calculi were present in 4.0%. These findings demonstrate that CT KUB provided clinically relevant diagnostic information in more than half of the audited examinations. The remaining examinations without detected calculi may reflect alternative causes of flank pain. Non-calculus urinary tract conditions or clinically suspected stone disease without demonstrable calculi. The established role of non-contrast CT in urinary stone assessment supports its use when accurate diagnosis is required.[9]

Referral appropriateness was documented in 88.0% of examinations. Inappropriate referrals accounted for 8.0%. While insufficient clinical justification was identified in 4.0%. These findings suggest that most examinations were requested for clinically relevant indications.[10] However. The presence of inappropriate and insufficiently justified referrals indicates a potential area for quality improvement. Referral guidelines and clinical decision support may help improve the selection of patients for CT KUB. Appropriate imaging selection is particularly important in patients with recurrent symptoms. In whom repeated exposure to ionizing radiation may occur.[11]

Radiation dose documentation was complete in 90.0% of examinations. CTDIvol was documented in 94.0%. While DLP was documented in 92.0%. The observed documentation rate indicates that dose information was available for most examinations. However. The absence of complete documentation in 10.0% of examinations represents a quality assurance concern. Radiation dose monitoring and consistent documentation are important components of CT practice. Regular review of dose reports and adherence to departmental protocols may improve documentation completeness.[12]

The mean CTDIvol was 5.8 ± 2.1 mGy. The mean DLP was 280 ± 115 mGy·cm. The mean effective dose was 4.2 ± 1.7 mSv. These values provide a descriptive overview of radiation exposure during the audit period. However. Dose comparisons between institutions should be interpreted cautiously because scanner technology. Patient body habitus. Scan coverage and acquisition protocols may influence radiation measurements. Dose optimization should therefore be guided by diagnostic requirements and locally established reference levels.[13]

Reporting turnaround time was within the predefined institutional target in 84.0% of examinations. Delayed reporting was observed in 16.0%.[14] The mean reporting turnaround time was 42 ± 18 minutes. These findings suggest that reporting efficiency was satisfactory in most examinations. However. Delayed reporting may affect clinical decision-making in patients presenting with acute flank pain. Standardized reporting workflows. Clear prioritization of urgent examinations and regular monitoring of turnaround times may support further improvement.[15]

This audit has several strengths. The multicenter design and large sample of 2,500 examinations provide a broad assessment of CT KUB service performance. The evaluation of referral appropriateness. Diagnostic yield. Radiation dose documentation and reporting turnaround time allows assessment of multiple quality indicators within a single audit. However. The retrospective design limits the assessment to available documentation. The study was conducted within a defined six-month period. Therefore. The findings may not be generalizable to all radiology departments. In addition. Diagnostic yield was assessed descriptively and was not compared with an independent reference standard.

CONCLUSION

The present multicenter audit demonstrates a diagnostic yield of 56.0% for non-contrast CT KUB examinations. Referral appropriateness was 88.0%. Complete radiation dose documentation was available in 90.0%. While 84.0% of reports were completed within the predefined institutional target. These findings support the clinical value of CT KUB and identify opportunities for improvement in referral justification. Dose documentation and reporting efficiency. Continued clinical audit and quality improvement measures may help promote appropriate imaging utilization and enhance patient care.

REFERENCES

1. Smith RC, Rosenfield AT, Choe KA, Essenmacher KR, Verga M, Glickman MG, et al. Acute flank pain: comparison of non-contrast-enhanced CT and intravenous urography. Radiology. 1995;194:789-794. doi:10.1148/radiology.194.3.7862980.
2. Miller OF, Rineer SK, Reichard SR, Buckley RG, Donovan MS, Graham IR, et al. Prospective comparison of unenhanced spiral computed tomography and intravenous urogram in the evaluation of acute flank pain. Urology. 1998;52:982-987.
3. Smith-Bindman R, Aubin C, Bailitz J, Bengiamin RN, Cameron RB, Corbo J, et al. Ultrasonography versus computed tomography for suspected nephrolithiasis. N Engl J Med. 2014;371:1100-1110. doi:10.1056/NEJMoa1404446.
4. Drake T, Jain N, Bryant T, Wilson I, Somani BK. Should low-dose computed tomography kidneys, ureter and bladder be the new investigation of choice in suspected renal colic? A systematic review. Indian J Urol. 2014;30:137-143. doi:10.4103/0970-1591.126884.
5. Andrabi Y, Patino M, Das CJ, Eisner B, Sahani DV, Kambadakone A. Advances in CT imaging for urolithiasis. Indian J Urol. 2015;31:185-193. doi:10.4103/0970-1591.156236.
6. Brisbane WG, Bailey MR, Sorensen MD. An overview of kidney stone imaging techniques. Nat Rev Urol. 2016;13:654-662. doi:10.1038/nrurol.2016.154.
7. Gervaise A, Teixeira P, Villani N, Lecouvet F, Charron C, Savatovsky J. How to perform low-dose computed tomography for renal colic in clinical practice. Diagn Interv Imaging. 2016;97:393-402. doi:10.1016/j.diii.2015.05.013.
8. Niemann T, Kollmann T, Bongartz G. Diagnostic performance of low-dose CT for the detection of urolithiasis: a meta-analysis. AJR Am J Roentgenol. 2008;191:396-401. doi:10.2214/AJR.07.3414.
9. Poletti PA, Platon A, Rutschmann OT, Schmid T, Iselin CE, Becker CD. Low-dose versus standard-dose CT protocol in patients with clinically suspected renal colic. AJR Am J Roentgenol. 2007;188:927-933. doi:10.2214/AJR.06.0796.
10. Rodger F, Roditi G, Aboumarzouk OM. Diagnostic accuracy of low and ultra-low dose CT for identification of urinary tract stones: a systematic review. Urol Int. 2018;100:375-385. doi:10.1159/000488062.
11. Xiang H, Chan M, Brown V, Huo YR, Chan L, Ridley L. Systematic review and meta-analysis of the diagnostic accuracy of low-dose computed tomography of the kidneys, ureters and bladder for urolithiasis. J Med Imaging Radiat Oncol. 2017;61:582-590. doi:10.1111/1754-9485.12587.
12. Lukasiewicz A, Bhargavan-Chatfield M, Coombs L, et al. Radiation dose index of renal colic protocol CT studies in the United States: a report from the American College of Radiology National Radiology Data Registry. Radiology. 2014;271:445-451. doi:10.1148/radiol.14131601.
13. Smith-Bindman R, Moghadassi M, Griffey RT, et al. Computed tomography radiation dose in patients with suspected urolithiasis. JAMA Intern Med. 2015;175:1413-1422. doi:10.1001/jamainternmed.2015.2736.
14. Li H, Jelley CR, Forster L, Arad J, Mudhar GS, Bardgett HP, et al. Ultra-low-dose CTKUB: the new standard of follow-up of ureteric calculi not visible on plain radiograph? Int Urol Nephrol. 2022;54:781-787. doi:10.1007/s11255-022-03134-3.
15. Moore CL, Carpenter CR, Heilbrun M, et al. Imaging in suspected renal colic: systematic review of the literature and multispecialty consensus. J Urol. 2019;202:475-482. doi:10.1097/JU.0000000000000342.