Utility of Unenhanced CT KUB: Beyond Urolithiasis

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Abstract

Objective: To determine the frequency of urinary and extra-urinary pathologies and audit the missed findings on CT KUB scan.

Methods: We retrospectively reviewed 250 consecutive CT KUB studies requested for suspected renal colic at the Radiology department of tertiary care hospital. A consultant radiologist reviewed the CT KUB images for calculus, non-calculus urinary pathologies, and extra urinary incidental findings recorded on the proforma. Another consultant reviewed the initial radiological report and tallied it for any discrepancies. Findings were recorded on the same proforma.

Results: The mean age of patients was 38.56 ±15.22 years. The majority of patients were males as compared to females, i.e., 163 (65.2%) and 87 (34.8%) respectively. Overall positive yield for urolithiasis was 61.2%, congenital anomalies were observed in 6.2%, cyst in 2.8%, infection in 2.2%, and miscellaneous renal findings in 2.8%. Extra-urinary findings were found in 32% of cases and majority involved hepatobiliary/spleen (32.5%) followed by musculoskeletal (27.5%).Extra-urinary findings were more common in females with gynecological etiology being the second common. Discordant findings were seen in 5.2% of the cases and were mostly in the older age group (above 40years).

Conclusion: Unenhanced CT KUB is an ideal investigation for diagnosing renal / ureteric calculi with added benefit of excluding alternative diagnosis of renal colic mimickers. However, it should be wisely advised by physician for considering ionizing radiation and cost of radiological investigation, particularly in our low socio-economic settings and overburdened health care system.

Keywords: Extra urinary, non-contrast-enhanced CT, renal colic, urolithiasis

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Introduction

Renal colic is one of the most common symptoms encountered in the Emergency Departments, and it affects a wide gamut of the patient population, irrespective of race, culture or geographic boundaries. One of the most common cause of renal colic is Urolithisiasis. Imaging has a critical role in the initial diagnosis, treatment planning and post-treatment surveillance of patients with renal colic. Traditionally, it was investigated with a plain radiograph of KUB (kidneys, ureters, and bladder) and ultrasound followed by intravenous urography[1]. Unenhanced helical CT KUB (UHCT) has be-come the main stay for diagnostic imaging of patients with suspected urinary tract stones presenting with acute flank pain as recommended by the European Association of Urology and the American Urological Association[2, 3, 4]. It has the highest sensitivity (up to 95%) of all the available modalities for detecting renal calculi[5]. Intravenous urography (IVU) was utilized since 1923 to investigate acute loin pain, however, unenhanced helical CT KUB has revolutionized the way uninary tract disease is imaged and has replaced acute IVU[6]. This superiority of UHCT is

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due to its ability to (i) detect ureteral stones regardless of size, location and chemical composition, (ii) detect extra-urinary abnormalities like appendicitis, diverticulitis, gynecological abnormalities like hemorrhagic cysts or ovarian torsion that mimic renal colic (iii) does not require intravenous contrast administration or bowel preparation, (iv) can be rapidly performed and used in planning endourological procedures[7] in predicting success of various interventions like percutaneous nephrolithotomy (PCNL) and shock wave lithotripsy (SWL). (V) presence of ureteral wall oedema / perinephricoedema (Vi) recognition of various anomalies, presence of ectopic, horse-shoe kidney, malrotation, etc in better planning to avoid complications.

The symptoms of ureteric colic-flank pain, vomiting, and microscopic hematuria, overlap with other extra-urinary pathologies, including appendicitis, gynecological problems like hemorrhagic cyst rupture or ovarian torsion , or diverticulitis[6]. The fore-most advantage of Unenhanced helical CT KUB is in patients with atypical symptoms, vague history, symptoms overlapping more than one body system, or clinical presentation from two different disease processes. Diagnosis of extra-urinary pathology is essential to adequately triage and manage patients. It can detect significant conditions with effects on the course of clinical management[8]. Studies have observed indication creep for CT KUB–a scenario where clinicians have broadened the indications for unenhanced helical CT KUB after a period of time. This phenomenon has been observed with decreasing positive unenhanced helical CT KUB for stones from 49 to 28% and an increase in the alternative extra urinary pathology detection from 16 to 45%[9].

Knowledge of extra urinary pathologies allows radiologists to focus their attention on other structures when no stone is encountered on unenhanced helical CT KUB. They will be able to recognize the mimics of urinary colic, detect unrelated but clinically significant incidental findings, and establish a systematic approach to improving the detection of an alternate diagnosis. Our study aims to determine the frequency of urinary and extra-urinary pathologies and audit the missed findings on unenhanced helical CT KUB scans.

Methods

This retrospective cross-sectional study was conducted at a tertiary care hospital after exemption from the ethical review board with consecutive sampling of 250 UHCT KUB scans between January to March 2020. All adult patients with renal colic referred from the emergency department, clinics, in-patients, and outpatients for UHCT KUB were included in the study. CT Scans with artifacts or incomplete data were excluded from the study.

Consultant radiologist with at least 5 years post-fellowship experience reviewed the images UH CT KUB to scrutinize for calculus and non-calculus urinary pathologies, as well as extra-urinary incidental findings. These findings were recorded on a proforma. The radiologist reviewing the scan was blinded to the initial radiological report. The reports were subsequently reviewed by another consultant radiologist to determine if these pathologies were mentioned in the primary report. Findings were recorded on the same proforma. Results were classified as positive and negative for renal calculi, presence of incidental extra urinary findings as well as whether these were mentioned in the initial report.

All CT examinations were conducted on 64-slice MDCT (Siemens) machine. The images were viewed on the Hospital management and information system (HMIS) with 5-mm axial sections. Reformatted 3-mm coronal and sagittal sections were available for analysis.

The CT procedure was performed using departmental protocol using exposure factors set at 120 kV and 250–300 mA. The abdomen is scanned from the level of the xiphoid sternum to the lower border of the symphysis pubis, using 5-mm collimation with the patient supine once they had the urge to void. Additional views were obtained with the patient prone if needed for confirmation of suspected distal ureteric calculi.

SPSS version 24 is used for statistical analysis. Mean ± SD was calculated for quantitative variables like the age of the patient. Frequency and percent-ages were calculated for qualitative variables like gender, urinary findings, extra-urinary findings, and discordant findings. Inferential statistics were expl-ored using the chi-square test/Fisher Exact test. P-value <0.05 was considered significant.

Results

The mean age of the patients was 38.56 ±15.22 years with 152 (60.8%) patients'≤40 years of age and 98 (39.2%) patients of more than 40 years of age. Majority of the patients were males as compared to females, i.e., 163 (65.2%) and 87 (34.8%) respectively.

Renal findings were observed in 178 (71.2%) cases and the overall positive yield for urolithiasis was 61.2% (60.7% for males and 54.0% for females). Of these 178 cases, congenital anomalies were observed in 11 (6.2%), cysts in 5 (2.8%), infection in 4 (2.2%) while 5 (2.8%) cases presented with miscellaneous renal findings (Figure1). Moreover, these findings were mentioned in 171 (96.1%) reports. An insignificant association of calculi was observed with age (p-value 0.285) and gender (p-value 0.089) of the patients.

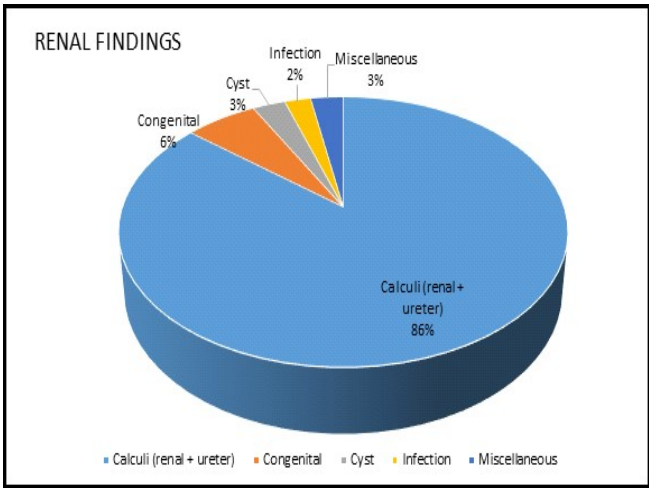

Fig 1. Percentage of Renal Findings on CT KUB

Extrarenal findings were found in 80 (32%) cases (Table 1). They were more common in females 34/80. In 80 cases, hepatobiliary/spleen diseases were the most common extrarenal findings found in 26 (32.5%) cases followed by musculoskeletal disease in 22 (27.5%), gastrointestinal tract in 11 (13.8%), genital in 10 (12.5%) while 11(13.8%) had miscellaneous extrarenal findings. Gynecological findings were the second most common incidental findings in females (8 out of 34–23.5%). Of these extra-renal findings, only 67 (83.75%) were mentioned in reports. The reported and missed extrarenal findings are shown in figure 2. Two of the cases with positive extrarenal findings are given in figures 3 and 4.The frequency of discordant findings was 13 (5.2% of the cases). A significantly higher proportion of discordant findings were observed in patients with > 40 years of age as compared to ≤ 40 years of age, i.e., 4 (2.6%) and 9 (9.2%) respectively (p-value 0.023). However, gender was found.

Table 1: Comparison of presence of urinary and extra-urinary findings with reporting (n=80)

	Total (n=80)		Age ≤ 40 years (n=33)		Age >40 years (n=47)		Male (n=46)		Female (n=34)	
Extra Renal Findings	Mentioned in Report		Mentioned in Report		Mentioned in Report		Mentioned in Report		Mentioned in Report	
	Yes (n=67) n (%)	No (n=13) n (%)	Yes (n=29) n (%)	No (n=4) n (%)	Yes (n=38) n (%)	No (n=9) n (%)	Yes (n=37) n (%)	No (n=7) n (%)	Yes (n=30) n (%)	No (n=4) n (%)
Gastrointestinal Tract	11 (100)	0 (0)	2 (100)	0 (0)	9 (100)	0 (0)	8 (100)	0 (0)	3 (100)	0 (0)
Musculoskeletal System	17 (77.3)	5 (22.7)	11 (84.6)	2 15.4)	6 (66.7)	3 (33.3)	12 (80)	3 (20)	5 (71.4)	2 (28.6)
Genital	9 (90)	1 (10)	6 (85.7)	1 (14.3)	3 (100)	0 (0)	2 (100)	0 (0)	7 (87.5)	1 (12.5)
Hepatobiliary/spleen	20 (76.9)	6 (23.1)	6 (85.7)	1 (14.3)	14 (73.7)	5 (26.3)	12 (70.6)	5 (29.4)	8 (88.9)	1 (11.1)
Miscellaneous	10 (90.9)	1 (9.1)	4 (100)	0 (0)	6 (85.7)	1 (14.3)	3 (75)	1 (25)	7 (100)	0 (0)

insignificant (p-value 0.754).

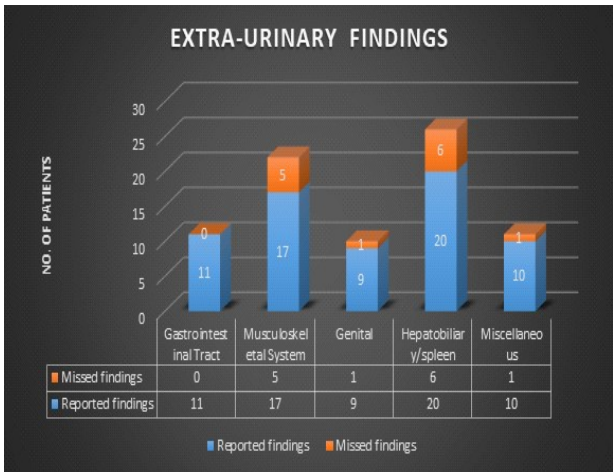

Fig 2. Extra urinary Findings on CT KUB

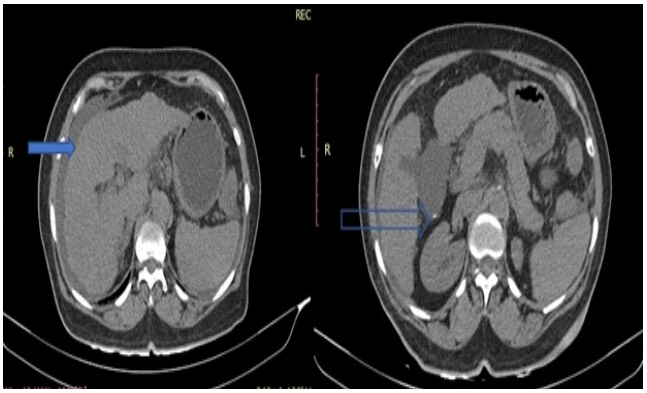

Fig 3. UHCT KUB axial section of a 47-year-old female with: (a) Irregular nodular margins of liver and ascites (solid arrow). (b) Cholelithiasis (arrow)

Fig 4. UHCT KUB axial section of a 51-year-old male with multiple mucosal outpouchings in sigmoid colon representing diverticular disease

Discussion

In this era, unenhanced CT KUB is indispensable for the diagnosis and management of renal/ureteric stone disease which is the one of the most common cause of renal colic and it affects a wide gamut of the patient population, irrespective of race, culture or geographic boundaries. It is accurate, readily available, easy to interpret, and provides additional information on clinically significant alternate diagnoses. It can be performed in patients with renal failure when intravenous contrast is contraindicated[10] unenhanced CT KUB is also being utilized to predict the composition of calculi by measurement of attenuation value (Hounsfield Unit – HU). Uric acid stones have an attenuation of less than 400 HU and calcium oxalate stones with more than 600HU[11]. Attenuation values are also useful in predicting treatment response to shockwave lithotripsy - higher attenuation requires more number of shocks and is associated with lower success rat es[12]. It can also use to detect congenital abnormalities to avoid complications like horse shoe kidney, ectopic kidneys and used in pre-operative planning in predicting success of various endourological interventions like percutaneous nephrolithotomy (PCNL) and shock wave lithotripsy (SWL). One of the major limitations of CT is the radiation dose, besides cost and availability.

The mean age of the patients in our study was 38.5 ±15.2years which is similar to a study conducted by Nadeem M et al at a different tertiary care hospital in Karachi, Pakistan. The overall positive yield for urolithiasis is also comparable in the two studies - 61.2% and 64% respectively[13]. However, some of the older studies by Chowdhury et al and Patatas et al have reported a lower positive yield of 44% and 47.5%[14,15]. This could be due to increasing awareness of clinicians regarding radiation risk and better clinical assessment with a strong suspicion for urolithiasis. Education and awareness of clinicians regarding radiation risk and protection can help in further reducing unnecessary investigations.

The lifetime chance of urolithiasis is twice in males compared to females – 10% in males and 5-10% in females[16]. In our study, the positivity rate for urolithiasis was slightly higher in males than in females, however, it was not statistically significant – males 60.7% and females 54.0% versus 74% and 52% respectively by H. Jo et al[17]. This could be explained by different study population in the two studies and also change in dietary patterns over the years. Few Studies regarding global trends in incidence and burden of urolithiasis has revealed that worldwide the disease burden secondary to urolithiasis has increased from 1990 and are not uniform across various ethnicities and cultures. Recently studies have shown that the prevalence of urolithiasis in females has increased in the past decade[16-18].

One of the most common genitourinary finding other than urolithiasis was congenital anatomic variations which were found in nearly equal distribution among both genders. This was followed by renal cysts. It however differs from other similar local studies conducted by Nadeem M et al and Ali A et al which reported renal cysts as the most common genitourinary finding after urolithiasis[13, 19].

Extra renal findings were found in 32% of cases in our study, these have been reported in other studies to be as high as 45%[20]. In a study by Morgan et al, 62.7% of patients had incidental findings, however only 11% were clinically significant[21]. The large variation among various studies reporting incidental findings on CT KUB is likely due to the classification of incidental pathologies into “clinically significant” and “truly incidental”. Few studies conducted on large sample size regarding the incidental findings on CT KUB and found that most of these findings were clinically irrelevant .Also, clinical judgment and investigation ordering protocols vary significantly in various health facilities around the world.

Similar to other studies, extra urinary findings were higher in females than in males[15, 17, 18]. In our study we observed that hepatobiliary pathologies and splenic pathologies are the most commonly found without showing gender predilection , which is in contrast to other studies where gynecological findings were more common in females. A possible explanation for this observation in our low to medium-income developing country and already overburdened health care system could be the increasing use of sonography as the first line of investigation, which is readily available and of lower cost compared to unenhanced CT KUB. It has been suggested in several studies that young females and pediatric patients should first be evaluated with sonography to rule out alternate diagnosis[22]. Sonography has several added easily availability as most of our population resides in rural areas with minimum to null health care facilities , advantages of lack of ionizing radiation, cost-effectiveness, high sensitivity and specificity for renal, upper ureteral, and ureterovesical junction calculi as well diagnosis of extra renal pathologies such as appendicitis and gynecological findings[23]. Many studies have suggested a combination of renal ultrasound paired with an X-ray KUB as an alternative to unenhanced CT KUB scans thereby reducing cost as well as radiation[24].

Musculoskeletal incidental findings were more common in less than 40 years age group whereas hepatobiliary/spleen pathologies were more common in the older age group[25]. These two systems comprise most of the missed pathologies on CT KUB, with hepatobiliary being more common. The reporting radiologist should be vigilant in analyzing the entire scan, particularly when the CT KUB scan is negative for urolithiasis. These systems should be thoroughly scrutinized by radiologists to avoid reporting errors.

The limitation of our study include following

(1) Small sample size as we collected data of only 250 patients which could not represents a large population size and ethnicity.

(2) We collected data retrospectively by convenient sampling hence carries selection bias and does not represent general population

(3) We did not classified incidental pathologies as clinically significant or insignificant as only clinically significant pathologies have impact on patient management and should not be missed.

Hence further studies in future with larger sample size and prospective nature as well as classifi-cation of incidental findings into significant and non-significant would be of great help for accurate population depiction.

Conclusion

Unenhanced CT KUB is an ideal investigation for diagnosing renal / ureteric calculi with added benefit of excluding alternative diagnosis of renal colic mimickers. It is preferred due to easy availability, speed, ease of image acquisition, absence of need for oral or intravenous contrast media administration, and ability to detect extra-urinary pathologies such as appendicitis, diverticulitis or gynecological pathologies such as hemorrhagic cyst or ovarian torsion. However, it should be wisely advised by physician considering risk of ionizing radiation especially in children and females and relatively high cost as compared to other radiological investigation in our low socio-economic setting and overburdened health care system and recommendation of using sonography as first line of imaging for young women and pediatric patients.

Conflict of Interest

Authors have no conflict of interest and no grant/funding from any organization.

References

1. Shaaban MS, Kotb AF. Value of non-contrast CT examination of the urinary tract (stone protocol) in the detection of incidental findings and its impact on the management. Alex J Med 2016;52(3):209-17. [DOI: 10.1016/j.ajme.2015.08.001]. Available from: https://www.sciencedirect.com/sdfe/reader/pii/S2090506815000548/pdf. Accessed on 25th February 2023.

2. Ahmed F, Zafar AM, Khan N, Haider Z, Ather MH. A paradigm shift in imaging for renal colic - Is it time to say good bye to an old trusted friend? Int J Surg. 2010;8(3):252-6. [DOI: 10.1016/j.ijsu.2010.02.005]. Available from: https://www.sciencedirect.com/science/article/pii/S1743 9191100003 85?via%3Dihub. Accessed on 25th February 2023.

3. Turk C, Skolarikos A, Neisius A, et al. EAU guidelines on urolithiasis. In: EAoUG Office, editor. EAU guidelines. Edn published as the 34th EAU Annual Meeting, Barcelona. Arnhem, the Netherlands: European Association of Urology Guidelines Office;2019. Available from: https://uroweb.org/guideline/urolithiasis/. Accessed on 25th February 2023.

4. Assimos D, Krambeck A, Miller NL, Monga M, Murad MH, Nelson CP, et al. Surgical Management of Stones: American Urological Association/Endourological Society Guideline, PART I. J Urol 2016;196(4):1153-60.[DOI:10.1016/j.juro.2016.05.090].Availablefrom:https://www.auajournals.org/doi/10.1016/j.juro.2016.05.090. Accessed on 25th February 2023.

5. Coursey CA, Casalino DD, Remer EM, Arellano RS, Bishoff JT, Dighe M, et al. ACR Appropriateness Criteria® acute onset flank pain—suspicion of stone disease. Ultrasound Q. 2012;28(3):227-33. [DOI: 10.1097/RUQ.0b013e3182625974]. Availabel from:https://acsearch.acr.org/docs/69362/Narrative/. Accessed on 25th February 2023.

6. Wah, Tze Min. Unenhanced CT in the evaluation of renal/ureteric colic. Imaging in Medicine. 2013;5:371-382. [DOI:10.2217/iim.13.27]. Available from:https://www.openaccessjournals.com/articles/unenhanced-ct-in-the-evaluation-of-renalureteric-colic.html.Accessed on 25th February 2023

7. Heidenreich A, Desgrandschamps F, Terrier F. Modern approach of diagnosis and management of acute flank pain: review of all imaging modalities. Eur Urol. 2002;41(4):351-62. [DOI: 10.1016/s0302-2838(02)00064-7]. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0302283802000647. Accessed on 25th February 2023

9. Chen MY, Zagoria RJ, Saunders HS, Dyer RB. Trends in the use of unenhanced helical CT for acute urinary colic. AJR Am.J. Roentgenol. 173(6), 1447–1450 (1999). [DOI: 10.2214/ajr.17 3.6.105 84780]. Available from: https://www.ajronline.org/doi/epdf/10.2214/ajr.173.6.10584780. Accessed on 25th February 2023

10. Ather MH, Memon W, Aziz W, Sulaiman MN. Non-contrast CT in the evaluation of urinary tract stone obstruction and haematuria. Intech Open; 2017. [DOI:10.5772/intechopen.68769]. Available from: https://www.intechopen.com/chapters/55857. Accessed on 25th February 2023

11. Nakada SY, Hoff DG, Attai S, Heisey D, Blankenbaker D, Pozniak M. Determination of stone composition by noncontrast spiral computed tomography in the clinical setting. Urology. 2000;55(6):816-9.[DOI:10.1016/s0090-4295(00)00518-5]. Available from: https://linking hub.elsevier.com/retrieve/pii/S0090429500005185. Acces sed on 25th February 2023

12. Brisbane W, Bailey MR, Sorensen MD. An overview of kidney stone imaging techniques. Nat Rev Urol2016;13(11):654-62.[DOI:10.1038/nrurol.2016.154]. Available from: https://pubmed.ncbi.nlm.nih.gov/27578040/.

13. Nadeem M, Ather MH, Jamshaid A, Zaigham S, Mirza R, Salam B. Rationale use of unenhanced multi-detector CT (CT KUB) in evaluation of suspected renal colic. Int J Surg, 10 (2012), pp. 634-637. Accessed on 25th February 2023

14. Chowdhury FU, Kotwal S, Raghunathan G, Wah TM, Joyce A, Irving HC. Unenhanced multidetector CT (CT KUB) in the initial imaging of suspected acute renal colic: evaluating a new service. Clin Radiol.2007;62(10):970-7.[DOI:10.1016/j.crad.2007.04.016]. Available from: https://linking hub.elsevier.com/retrieve/pii/S0009-9260(07)00209-7. Accessed on 25th February 2023

15. Patatas K, Panditaratne N, Wah TM, Weston MJ, Irving HC. Emergency department imaging protocol for suspected acute renal colic: re-evaluating our service. Br J Radiol. 2012 Aug;85(1016):1118-22. [DOI: 10.1259/bjr/62994625]. Available from: https://www.birpublications.org/doi/10.1259/bjr/62994625?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%20%200pubmed. Accessed on 25th February 2023

16. Saeed S, Ullah A, Ahmad J, Hamid S. The Prevalence of Incidentally Detected Urolithiasis in Subjects Undergoing Computerized Tomography. Cur

conclusions- ,The %20pre valenc e%20 of%20 incidentally% 20detected%20urolith iasis%20was%2 0found%20to%20 be, were %20 found %20 in % 20the%20ureter. Accessed on 25th February 2023

17. Jo H, Buckley BT. Assessment of referral patterns for CT KUB in a tertiary setting. J Med Imaging RadiatOncol. 2009;53(6):516-21. [DOI: 10.1111/j.1754-9485.2009.02117.x.]. Available from: https://onlinelibrary.wiley.com/doi/10.1111/j.1754-9485.2009.02117.x. Accessed on 25th February 2023

18. Sarofim M, Teo A, Wilson R. Management of alternative pathology detected using CT KUB in suspected ureteric colic. Int J Surg. 2016;32:179-82. [DOI: 10.1016/j.ijsu.2016.06.047]. Avaialbel from: https://linkinghub.elsevier.com/retrieve/pii/S1743-9191(16)30207-2. Accessed on 25th February 2023

19. Ali A, Akram F, Hussain S, Janan Z, Gillani SYH. Non-contrast enhanced multi-slice CT KUB in renal colic: Spectrum of abnormalities detected on CT KUB and assessment of referral patterns. J Ayub Med Coll Abbottabad 2019;31(3):415-7.

20. Dyer J, Syrrat T, Sing S. Is CT KUB the gold standard in assessing flank pain with diagnostic uncertainty? A one-year review of 228 cases. J ClinUrol 2013;6(2):114–8. [DOI: 10.1177/2051415812471453]. Available from: https://www.researchgate.net/publication/258198778_Is_CTKUB_the_gold_st andard_ in_ assessing_ flank_pain_with_diagnostic_uncertainty_ A_one-year_review_of_ 228_ cases. Accessed on 25th February 2023

21. Morgan AE, Berland LL, Ananyev SS, Lockhart ME, Kolettis PN. Extraurinary Incidental Findings on CT for Hematuria: The Radiologist's Role and Downstream Cost Analysis. AJR Am J Roentgenol. 2015 Jun;204(6):1160-7. [DOI: 10.2214/AJR.14.12483]. Available from: https://www.ajronline.org/doi/10.2214/AJR.14.12483. Accessed on 25th February 2023

22. Patatas K. Does the protocol for suspected renal colic lead to unnecessary radiation exposure of young female patients? Emerg Med J 2010;27(5):389e90. [DOI: 10.1259/bjr/62994625]. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3587076/#:~:text=Although%20the %20CDU %20protoc ol%20f or,youn g%20f emale% 20patients%20with%20vague. Accessed on 25th February 2023

23. Ganesan V, De S, Greene D, Torricelli FC, Monga M. Accuracy of ultrasonography for renal stone detection and size determination: is it good enough for management decisions? BJU Int. 2017;119(3):464-469. [DOI: 10.1111/bju.13605]. Available from: https://bjui-journals. online library .wiley.com/doi/10.1111/bju.13605. Accessed on 25th February 2023

24. Roberson NP, Dillman JR, O'Hara SM, DeFoor WR Jr, Reddy PP, Giordano RM, et al. Comparison of ultrasound versus computed tomography for the detection of kidney stones in the pediatric population: a clinical effectiveness study. Pediatr Radiol. 2018;48(7):962-972. [DOI: 10.1007/s00247-018-4099-7]. Available from: https://link.springer.com/article/10.1007/s00247-018-4099-7#:~:text =US %20s ho wed %20 a% 20 sensitivity%20of,2). Accessed on 25th February 2023

25. Patti L, Leslie SW. Acute Renal Colic. 2021 Aug 23. In: Stat Pearls [Internet]. Treasure Island (FL): Stat Pearls Publishing; 2021 Jan.