ScienceForecast
A digital science library

Review Article
Published: 19 Jun, 2020

SF Journal of Medicine and Research

To Order or Not to Order? The KUB Radiograph in Patients Presenting with Symptoms of Urolithiasis

*Chu SM[1], Chee QMJ[1] and Lateef F[1,2,3,4]**

[1]Yong Loo Lin School of Medicine, National University of Singapore, Singapore

[2]Dept of Emergency Medicine, Singapore General Hospital, Singapore

[3]Duke NUS Graduate Medical School, Singapore

[4]Sing Health Duke NUS Institute of Medical Simulation (SIMS), Singapore

Abstract

Plain Kidney, Ureter, Bladder (KUB) radiography has been the primary investigation of choice for urolithiasis in the Emergency Department (ED). However, the advent of new imaging modalities which confer greater sensitivity and specificity has led to a change in ED protocols. Therefore, emergency physicians face a dilemma: should they still order a KUB radiograph? This study reviews the latest literature available on the diagnostic accuracy of a plain KUB radiograph in assessing for stones in the urinary tract and its advantages and disadvantages in relation to other imaging modalities. From this review, plain KUB radiography is still an effective tool in the diagnosis of urolithiasis of adults in the ED because of its positive predictive value, and it can be augmented with Ultrasound KUB and technological advances such as Digital Tomosynthesis.

Key Pointers:

1. Plain KUB radiograph has to be utilized with adequate bowel preparation to ensure maximum sensitivity and specificity (this may be challenging in the ED where acute patients present).

2. Plain KUB radiograph has good sensitivity for stones that are >5 mm and located in the upper ureter which are clinically significant because these stones are less likely to be spontaneously passed out and therefore will require urological intervention.

3. Plain KUB radiograph has a good PPV ranging from 94.9-100%. This suggests that KUB is useful in the ED because it is cheap, fast, and easily accessible, and will help to focus more time consuming and technically complex investigations such as IVU and CT KUB to a smaller group of patients, thus reducing the burden on resources in the ED.

4. The comparatively lower sensitivity of plain KUB radiography can be augmented with Ultrasound KUB or technological advances such as Digital Tomosynthesis.

Keywords: KUB radiograph; Urolithiasis, Calculus, Haematuria

Introduction

In recent years, the incidence of patients presenting with symptoms of urolithiasis in the Emergency Department (ED) has been on the rise, [1-3] with an estimated recurrence rate of 50% within 5-10 years and 75% within 20 years [2]. This occurrence can be attributed to a myriad of socio-economic factors such as an increase in obesity and incidence of diabetes mellitus, diet rich in protein, salt and sugar, decrease in water intake as well as an increase in calcium supplement use [1,4].

The assessment of these patients involves obtaining a thorough history, performing a physical examination, requesting various blood and urine tests alongside imaging studies. The workup is required in order to confirm the presence, number, size and site of urinary stones, exclude complications associated with urolithiasis, rule out other differential diagnoses which may present similarly as well as to determine the best treatment modality.

A classical presentation for patients with urolithiasis typically involves a paroxysmal intense flank pain radiating towards the groin, gross haematuria as well as nausea and vomiting. Other accompanying symptoms such as dysuria, urinary urgency and increased frequency have also been observed. Signs such as lower quadrant and/or costovertebral angle tenderness may also be present

OPEN ACCESS

*Correspondence:
Fatimah Lateef, Yong Loo Lin School of Medicine, National University of Singapore, Singapore.
E-mail: Fatimah.abd.lateef@singhealth.com.sg

Received Date: 23 May 2020
Accepted Date: 15 Jun 2020
Published Date: 19 Jun 2020

Citation: Chu SM, Chee QMJ, Lateef F. To Order or Not to Order? The KUB Radiograph in Patients Presenting with Symptoms of Urolithiasis. SF J Med Res. 2020; 1(1): 1003.

[1]. Urinalysis may reveal microscopic haematuria in patients who did not note gross haematuria. The next step in the workup involves imaging. Due to its simplicity, plain Kidney, Ureter, Bladder (KUB) radiography has been the primary investigation of choice for many years in the ED [5,6]. However, the advent of Unenhanced Helical Computed Tomography (UHCT) KUB has led to a change in the protocols in many ED's because it confers greater sensitivity and specificity in the diagnosis of urolithiasis [6].

Objectives

This systematic review aims to determine the diagnostic accuracy of a plain KUB radiograph in assessing for stones in the urinary tract, using its sensitivity, specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV). It also aims to discuss the advantages and disadvantages of plain KUB radiograph in relation to other imaging modalities and hence its value as a diagnostic tool in the ED today.

Materials and Methods

This systematic review focuses on the sensitivity and specificity, positive and negative predictive values of a plain KUB radiograph in the context of adult patients presenting with acute flank pain to the ED with the suspected diagnosis of urolithiasis. The PubMed and Embase databases were searched in April 2020 for published studies using the following terms: Urolithiasis, Urinary Calculi, Urinary Stone, Ureterolithiasis, Nephrolithiasis, Kidney Stone, Bladder Stone, Renal Colic, Ureteric Colic, KUB X-ray, KUB Radio*, Kidney Stone Imaging, Kidney Urinary Bladder X-Ray, Kidney Ureter Bladder Radio*, KUB Imaging, Diagnos* Accura* and Overview. Boolean operators (or, and) were used in conjunction to narrow or broaden the search.

Studies were then selected based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) (Figure 1).

Duplicate studies were excluded. Two authors (CSM, CQMJ) then independently identified all studies that appeared to fit the inclusion and exclusion criteria based on the title and abstract. Disagreements were resolved by consensus between both authors, failing which studies were deferred to the senior author (FL) for resolution.

The inclusion criteria were as follows:

- Articles after January 1, 2000.

- Only studies written in English.

- Studies design with CT KUB as the reference standard and/or demonstrated presence of stone *via* follow-up of patient outcome such as reported passing of stone or stone removed via urological intervention.

The exclusion criteria included the following:

- Study population not representative of the general population such as studies which analyzed only patients confirmed to have stones, included asymptomatic patients with incidental findings, patients previously diagnosed with stone on follow up and no symptoms and cadaveric studies.

- Study population inclusive of patients under the age of 21.

- Study design such as case reports, conference abstracts, comments or reviews that are not systematic, opinion pieces or letters to the editor or meta-analyses.

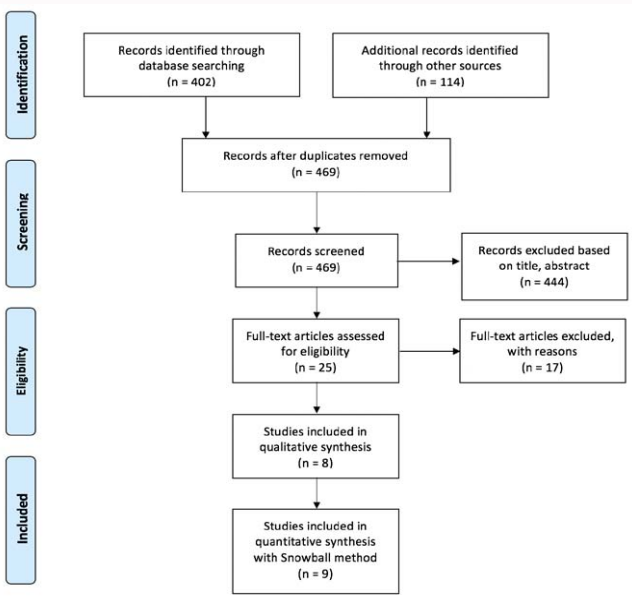

Figure 1: PRISMA flowchart for selection of articles.

Table 1: Reasons for exclusion of full-text articles.

Reason for exclusion	Number of articles excluded
No data on sensitivity or specificity of plain KUB radiograph	7
Study not in English	6
Study population only included patients with confirmed diagnosis of renal colic	2
Study design such as correspondence and book review, descriptive piece	2

25 articles were selected for full-text review for eligibility and 17 were excluded with reasons (Table 1). 8 full-text articles were selected to be included in quantitative synthesis, with an additional 1 study included based on the snowball method of references of these 8 selected articles.

The following variables that are relevant to this study were extracted: first author, year of publication, duration of study, size of study population, demographics (age, gender, BMI), the sensitivity, specificity, predictive and negative predictive values of plain KUB radiograph and the limitations of each study.

Results

9 papers were included in this systematic review, reporting a total of 2216 patients [3,5,7-13].

These studies were composed of both prospective and retrospective cross-sectional studies and the study demographics consisted of patients aged 17-93 years (Table 2).

A high sensitivity of a plain KUB radiograph will give clinicians the confidence to exclude alternative diagnoses which may mimic urolithiasis if no stone is observed. Conversely, a high specificity will allow clinicians to be certain that a patient's symptoms are related to urolithiasis if the presence of stone(s) is noted. The PPV represents the likelihood of a patient being diagnosed with urolithiasis if a stone is reported on plain KUB radiograph. On the other hand, the NPV represents the likelihood of a patient not being diagnosed with urolithiasis if a stone is not observed on plain KUB radiograph. From

Table 2: Table of included studies.

Study	Study type	Duration of study	Number of patients	Population
Brisbane et al. 2016 [3]	Values are derived from values published by the American College of Radiography (ACR) and American Urological Association (AUA), which have obtained from pooled data analysis	NR	NR	NR
Chan et al. 2008 [5]	Retrospective cross-sectional study	32 months	100	M: 63, F: 37 Age: 17-80 (mean 45 years)
Ekici et al. 2011 [7]	Retrospective cross-sectional study	42 months	300	M: 168, F: 132 Age: 21-79 (mean 46 years)
Eray et al. 2003 [8]	Prospective cross-sectional study	12 months	65	M: 37, F: 28 Age: mean 38.8 years (SD ±13.5)
Kanno et al. 2017 [9]	Retrospective cross-sectional study	21 months	822	M: 553, F: 269 Age: median 60 years Mean BMI 24.3 ±4.2
Kobayashi et al. 2003 [10]	Prospective cross-sectional study	18 months	560	M: 432. F: 128 Age: 20-93 (mean 47.7 years, SD ±14.5)
Mitterberger et al. 2005 [11]	Prospective cross-sectional study	NR	98	M: 53, F: 45 Age: 19-74 (mean 23.3 years)
Poletti et al. 2006 [12]	Prospective cross-sectional study	1 day	71	M: 49, F: 22 Age: mean 43 years
Varma et al. 2009 [13]	Retrospective cross-sectional study	NR	200	NR

Table 3: Table of outcomes and limitations of included studies.

Study	Sensitivity (Sn) and Specificity (Sp) %	Positive Predictive Value (PPV) and Negative Predictive Value (NPV) %	Limitations
Brisbane et al. 2016 [3]	Sn: 57 Sp: 76	NR	Spectrum bias
Chan et al. 2008 [5]	Sn: 66 (95% CI, 56.8% to 75.4%) Sp: 95.1 (95% CI, 90.9% to 99.3%)	PPV: 95.1 (95% CI, 90.9% to 99.3%) NPV: 66 (95% CI, 56.8% to 75.4%)	Delay in index and reference test Blinding of 2 radiologists to the clinical details of the patients.
Ekici et al. 2011 [7]	Sn: 61.2 (CI 54.3% to 67.8%) Sp: 50 (CI 25.4% to 74.6%)	PPV: 95 (CI 95.2% to 99.4%) NPV: NR	No consensus about the size of the clinically insignificant stones Operator dependence
Eray et al. 2003 [8]	Sn: 69 Sp: 82	PPV: 94.9 NPV: 34.6	Spectrum bias Quality of image affected by lack of bowel preparation, position of patient, technical ability of radiology technician No correlation among multiple radiologists in interpreting KUB films
Kanno et al. 2017 [9]	Sn: 49.1 Sp: 99.1	PPV: 98.8 NPV: 56	Spectrum bias Data limited to renal stones and did not analyse number of renal stones per kidney Confounding bias Improved detection rate attributable to experienced sonographers in which results may be difficult to translate into other practice models
Kobayashi et al. 2003 [10]	NR	PPV: NR NPV: 39.9	No reference standard hence unable to calculate sensitivity and specificity
Mitterberger et al. 2005 [11]	Sn: 64 Sp: NR	NR	Spectrum bias No correlation between imaging findings with BMI
Poletti et al. 2006 [12]	Sn: 78.1 Sp: 97.4	PPV: 96.2 NPV: 84.4	NR
Varma et al. 2009 [13]	Sn: 42.9 Sp: 100	PPV: 100 NPV: 81.8	NR

CI = Confidence Interval; KUB = Kidney, Ureter, Bladder

the 9 included studies, the reported sensitivity, specificity, PPV and NPV for a plain KUB radiograph for diagnosis of urolithiasis are 42.9-78.1%, 50-100%, 94.9-100% and 34.6-84.4% respectively (Table 3).

These studies had their limitations (Table 3). For instance, spectrum bias affects the results of a study due to differing clinical settings which in turn leads to varying patient population. A prospective study done by Eray et al., [8] included patients who presented to the ED for flank pain, which could have led to an increase in number of false positive and negative cases compared to studies which included patients from both the ED and outpatient stone/urology clinics. Additionally, studies such as that by Kanno et al., [9] and Mitterberger et al., [11] may have reported an improved detection rate of plain KUB radiograph as their study population consisted of patients with a lower BMI. Therefore, the data derived may not be as applicable to patients with higher body weight.

Discussion

Plain KUB radiograph is a fast and cheap imaging modality that can be used as a first-line examination in the diagnosis of urolithiasis, [1,9,14] especially since 90% of urinary calculi are said to be radio-opaque [5,11].

Table 4: Advantages of plain KUB radiograph compared to other modalities.

	Plain KUB Radiograph
US KUB	- Operator independent [4] - Not limited by patient BMI [9] - Lower cost [3] - Improves time-effectiveness and diagnostic accuracy of US KUB [11]
CT KUB	- Lower radiation dose [3-5,7,9] - Lower cost [3,4,7,8] - Widely available [11] - Time-effective [7,8]
MRU	- Lower cost [3] - Widely available [11] - Time-effective [19]

Table 5: Disadvantages of plain KUB radiograph compared to other modalities.

	Plain KUB Radiograph
US KUB	- Only portable imaging modality for evaluation of nephrolithiasis [3] - Usability in paediatric and pregnant patients because lack of ionizing radiation [3]
CT KUB	- Allows for examination of renal and ureteric anatomy [1,3] - Able to determine stone size, location and composition more accurately [1-3,5] - Able to screen for complications of urolithiasis simultaneously [1-3,5] - Able to rule out extrarenal causes of flank pain [2,3,5] - Reduces overall time of diagnosis and management cost [14]
MRU	- 3D imaging without radiation [3] - Usability in pregnant patients because lack of ionizing radiation [3]

In this systematic review, the sensitivity and specificity of plain KUB radiograph ranged from 42.9-78.1% and 50-100% respectively. However, these values have to be taken in the context of the limitations of the papers included in this review. For instance, the sensitivity and specificity of plain KUB radiograph is highly dependent on the state of the overlying bowel and the use of adequate bowel preparation [6,8,13]. This could have accounted for the wide variation in reported values for sensitivity and specificity. In particular, the sensitivity of the plain KUB radiograph also varied when considered in relation to the size and location of the stone.

Stones >5 mm are clinically significant because stones <5 mm are more easily passed out spontaneously and thus a lower percentage of such stones require urological intervention [7,9,13]. For example, Kanno et al., [9] reported sensitivity of plain KUB radiograph to be 49.1% overall, however when considering only stones >5 mm, this increases to 77.8%. Likewise, Ekici et al., [7] reported a sensitivity of 61.2% overall, however this factored in several stones <5 mm detected on UHCT and not on plain KUB radiograph and thus it is likely the sensitivity for only stones >5 mm would have been higher. A study by Liu et al., [6] further demonstrated that with adequate bowel preparation, detection rate on plain KUB radiograph for stones >5 mm reached 100%.

Stones in the upper ureter are less likely to be spontaneously passed out than those in mid-ureter, distal ureter or ureterovesical junction stones, and thus a greater percentage of these stones will require urological intervention [15-17]. In a study by Coll et al., [15] only 48% of stones in the proximal ureter were spontaneously passed, as compared to, 60% for mid ureteral stones, 75% for distal stones, and 79% for ureterovesical junction stones. The plain KUB radiograph has been shown to be more sensitive for stones in the proximal ureter, and thus further supports its utility as a first-line diagnostic tool. This is evidenced in Chan et al., [5] study where the sensitivity of plain KUB radiograph was 66.7% in the proximal ureter, as compared to 12.5% in the mid-ureter and 25% in the distal ureter. Overall, this is comparable, if not better than the reported sensitivity and specificity for Ultrasound (US) KUB, which is 57% and 67% respectively; however it is much lower than that of Magnetic Resonance Urography (MRU) at 82% and 98% respectively, and CT KUB at 95% and 98% respectively, according to pooled data analysis by the American College of Radiography (ACR) and the American Urological Association (AUA) [3]. Interestingly, the sensitivity and specificity rises to 89.9-96% and 68.2-91% respectively [9,11] when plain KUB radiograph is combined with US KUB, and several studies, including the AUA best practice guidelines and European Association of Urology (EAU) guidelines recommend a combination of plain KUB radiograph and US KUB as the standard in the acute phase of renal colic [9,11,14].

The PPV for plain KUB radiograph ranged from 94.9-100% and this suggests that plain KUB radiograph is suitable for confirming the diagnosis of urolithiasis in patients with stone observed on investigation. However in cases where a stone is not observed, there is a wide variability (NPV 34.6-84.4%) over the likelihood as to whether a patient truly does not have urolithiasis. In such a case, a follow-up investigation such as US KUB, IVU or CT KUB is typically ordered to rule out disease depending on the presentation of the patient [1,4,18]. This variation in NPV can be attributed to the wide variation in sensitivity and specificity and can be improved with adequate preparation as discussed previously. Overall, this points to the utility of the KUB in the emergency department to diagnose urolithiasis, because it is cheap, fast, and easily accessible [1,9,14]. In offering a high PPV it will help to focus more time consuming and technically complex investigations such as IVU and CT KUB4, [7] to a smaller group of patients, thus reducing the burden on resources in the ED [8].

Table 4 and 5 summarize the advantages and disadvantages of plain KUB radiograph compared to other imaging modalities currently available in the diagnosis of urolithiasis.

In the emergency department, the use of a combination of plain KUB radiograph and US KUB as the initial diagnostic steps for urolithiasis is widely practiced [4,9,11,13]. This is because sensitivity and specificity is improved as it augments the sensitivity of US KUB with the specificity of plain KUB radiography3 whilst retaining many of the benefits over CT KUB such as lower radiation dose, lower cost, time-effective and being more accessible (Table 4). This can be attributed to the utility of US KUB in viewing non-radiopaque stones such as cystine, struvite, uric acid and matrix stones that are poorly or not visible on plain KUB radiography, and in viewing stones from multiple angles, thus improving accuracy [3]. Ordering a plain KUB radiograph before US KUB may also help to locate suspected urinary calculi and guide sonographic examination, thus decreasing the time of examination whilst improving detection rates [11].

The utility of the plain KUB radiograph has been rapidly evolving as well. In particular, Brisbane et al., [3] discusses how Digital Tomosynthesis (DTS) has shown significant promise as it combines the low-radiation dose of plain KUB radiography with the computational imaging capacity of CT KUB, allowing visualization of stones from multiple angles. This is further demonstrated in a study by Liu et al., [6] comparing DTS and plain KUB radiography, which showed that DTS had a better detection rate for clinically significant urinary calculi (>5 mm) and that it was not affected by intestinal gas or observer experience, unlike plain KUB radiography, whilst maintaining cost-effectiveness.

Thus overall, the comparatively lower sensitivity of plain KUB radiography can be augmented with US KUB or technological

advances such as DTS [3].

Conclusion

In conclusion, plain KUB radiography is still an effective tool in the diagnosis of urolithiasis of adults in the ED because of its positive predictive value, and it can be made more effective with US KUB and technological advances such as DTS.

References

1. Alabousi A, Dreizin D, Patlas MN. Imaging of Patients with Renal Colic: A Paradigm Shift. Current Radiology Reports. 2016.
2. Belfield J, Kennish S. Pitfalls in Stone Imaging. Semin Roentgenol. 2016; 51: 49-59.
3. Brisbane W, Bailey MR, Sorensen MD. An overview of kidney stone imaging techniques. Nat Rev Urol. 2016; 13: 654-662.
4. Cupisti A, Pasquali E, Lusso S, Carlino F, Orsitto E, Melandri R. Renal colic in Pisa emergency department: epidemiology, diagnostics and treatment patterns. Intern Emerg Med. 2008; 3: 241-244.
5. Chan VO, Buckley O, Persaud T, Torreggiani WC. Urolithiasis: how accurate are plain radiographs? Can AssocRadiol J. 2008; 59: 131-134.
6. Liu S, Wang H, Feng W, Hu X, Guo J, Shang Q, et al. The value of X-ray digital tomosynthesis in the diagnosis of urinary calculi. ExpTher Med. 2008; 15: 1749-1753.
7. Ekici S, Sinanoglu O. Comparison of conventional radiography combined with ultrasonography versus nonenhanced helical computed tomography in evaluation of patients with renal colic. Urological Research. 2012; 40: 543-547.
8. Eray O, Cubuk MS, Oktay C, Yilmaz S, Cete Y, Ersoy FF. The efficacy of urinalysis, plain films, and spiral CT in ED patients with suspected renal colic. Am J Emerg Med. 2003; 21: 152-154.
9. Kanno T, Kubota M, Funada S, Okada T, Higashi Y, Yamada H. The Utility of the Kidneys-ureters-bladder Radiograph as the Sole Imaging Modality and Its Combination With Ultrasonography for the Detection of Renal Stones. Urology. 2017; 104: 40-44.
10. Kobayashi T, Nishizawa K, Watanabe J, Ogura K. Clinical characteristics of ureteral calculi detected by nonenhanced computerized tomography after unclear results of plain radiography and ultrasonography. J Urol. 2003; 170: 799-802.
11. Mitterberger M, Pinggera GM, Pallwein L, Gradl J, Feuchtner G, Plattner R, et al. Plain abdominal radiography with transabdominal native tissue harmonic imaging ultrasonography vs unenhanced computed tomography in renal colic. BJU Int. 2007; 100: 887-890.
12. Poletti PA, Platon A, Rutschmann OT, Verdun FR, Schmidlin FR, Iselin CE, et al. Abdominal plain film in patients admitted with clinical suspicion of renal colic: should it be replaced by low-dose computed tomography? Urology. 2006; 67: 64-68.
13. Varma G, Nair N, Salim A, Marickar YM. Investigations for recognizing urinary stone. Urol Res. 2009; 37: 349-352.
14. Pfister SA, Deckart A, Laschke S, Dellas S, Otto U, Buitrago C. Unenhanced helical computed tomography vs intravenous urography in patients with acute flank pain: accuracy and economic impact in a randomized prospective trial. Eur Radiol. 2003; 13: 2513-2520.
15. Coll DM, Varanelli MJ, Smith RC. Relationship of spontaneous passage of ureteral calculi to stone size and location as revealed by unenhanced helical CT. AJR Am J Roentgenol. 2002; 178: 101-103.
16. Jendeberg J, Geijer H, Alshamari M, Cierzniak B, LidÈn M. Size matters: The width and location of a ureteral stone accurately predict the chance of spontaneous passage. Eur Radiol. 2017; 27: 4775-4785.
17. Sfoungaristos S, Kavouras A, Perimenis P. Predictors for spontaneous stone passage in patients with renal colic secondary to ureteral calculi. Int Urol Nephrol. 2012; 44: 71-79.
18. Kennish SJ, Bhatnagar P, Wah TM, Bush S, Irving HC. Is the KUB radiograph redundant for investigating acute ureteric colic in the non-contrast enhanced computed tomography era? Clin Radiol. 2008; 63: 1131-1135.
19. Regan F, Kuszyk B, Bohlman ME, Jackman S. Acute ureteric calculus obstruction: unenhanced spiral CT versus HASTE MR urography and abdominal radiograph. Br J Radiol. 2005; 78: 506-511.