Bedside ultrasound and the assessment of renal colic: a review

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ABSTRACT

Renal colic is a common emergency department (ED) presentation. The use of CT in the diagnosis of renal colic has increased over the past two decades and is now the most common imaging modality used in many institutions. However, with growing concerns about cumulative radiation exposure, increasing healthcare costs and patient flow in EDs, alternative approaches may need to be considered. Point-of-care ultrasound may offer a radiation-free, rapid and cost-effective alternative. The authors reviewed the literature and synthesised some of the data comparing point-of-care ultrasound with CT scanning as well as some of the evidence for how it might be incorporated into a renal colic management strategy. It is concluded that there is enough evidence to define a rational algorithm for renal colic management. A prospectively validated algorithm would greatly assist primary care and emergency practitioners while reducing costs and radiation dose.

INTRODUCTION

Imaging is frequently used to direct the diagnosis and management of renal colic. Choices for assessing the urinary tract include kidney–ureter–bladder x-ray films (KUB), intravenous pyelourethrography (IVPU), ultrasound and CT. Over the past 20 years the use of imaging has changed considerably, with IVPU use declining dramatically in the USA and CT use increasing. CT is now the most common imaging modality,[1–6] however, ultrasound remains an important diagnostic tool and is the imaging modality of choice in young patients and pregnant women.

More recently, 'point-of-care' clinician-performed bedside ultrasound (BUS) has emerged as a diagnostic imaging option when assessing emergency department (ED) patients,[7] including those presenting with flank pain.[8–17] With growing concern over CT-related radiation exposure,[18–20] increasing ED patient volumes and healthcare cost-consciousness, there is growing interest in the potential of BUS to provide meaningful clinical information in a rapid and cost-effective manner for renal colic management.

We will look at some of the published evidence examining the use of BUS in the clinical assessment of renal colic and nephrolithiasis (see online supplementary material).

Note: Where summary statistics have been reported we have used the authors' own calculations. Where we have made calculations from their data, we have denoted these derived statistics with an asterisk in the text and tables. All confidence intervals (CI) are 95% confidence intervals calculated with Wilson's method.

EPIDEMIOLOGY

Renal colic is the clinical syndrome of acute flank pain with cyclical intensity which may radiate to the groin, labia or testicles and which may include haematuria. The most common cause of renal colic is nephrolithiasis.[12] Nephrolithiasis has a peak incidence between 20 and 50 years of age and is less common as a first presentation in patients aged >50 years. It is more common in white patients and there is a predilection for men.[21 22]

It is estimated that between 3% and 15% of adults will experience renal colic due to nephrolithiasis in their lifetime.[12 21 22] Renal colic accounted for approximately 1.7% of adult ED presentations in US hospitals between 2000 and 2008, with an estimated 2.1 million visits annually.[2] About 19% of people presenting with flank pain to an ED are ultimately diagnosed with nephrolithiasis.[3]

IMAGING STUDIES IN NEPHROLITHIASIS

CT

In 1995 Smith and colleagues showed that CT was superior to IVP for the detection of renal stones in patients with flank pain in a small study of 20 patients.[23] In 1996, a larger prospective trial by Smith and colleagues showed that unenhanced helical CT had a high level of accuracy in identifying renal stones with a sensitivity of 97% and a specificity of 96%.[24] This was followed by multiple confirmatory studies and much interest in CT as an alternative to IVP. Finally, in 2000, Smith and Varanelli declared: '… in relation to stone disease, unenhanced helical CT is truth'.[25] This assessment is not without merit; CT is highly accurate, can image other abdominal structures and does not require intravenous contrast agents with their attendant risks.[4–6 23 24] In the USA it is increasingly available on a 24 h basis and can be performed swiftly. In the field of emergency medicine in the USA, CT has all but replaced IVPU as the imaging strategy of choice in assessing acute flank pain.

In recent years, however, several authors have raised concerns about CT, in particular the cumulative radiation dose and increased lifetime risk of cancer.[18–20] This is especially concerning for patients with renal stones as they are prone to recurrence, re-presentation and re-imaging. About 50% of patients with renal stones have at least one recurrence within 10 years of their initial presentation,[26] and a subset have multiple episodes of renal colic and are subject to high levels of CT imaging.[18]

Two recent studies based on the National Hospital Ambulatory Medical Care Survey (NHAMCS), a national registry in the USA which monitors reasons for presentation, diagnosis and test ordering in outpatient visits, have shown that the use of CT for investigating flank pain is increasing.[2 3] CT investigation was used in 4% of renal colic cases in 1996–8 (CI 2.0% to 6.1%),[3] 19.6% in 2000 (CI 14.5% to 26.0%) and 45.5% in 2008 (CI 40.4% to 50.7%),[2] representing a 7–12-fold increase in the use of CT for this common presentation. Both studies also indicated that the proportion of stones being diagnosed in these patients has not increased concomitantly with the rise in CT use. Significantly, Westphalen and colleagues demonstrated that the proportion of important alternative diagnoses (an often cited anecdotal reason for preference of CT) has remained constant, even with more comprehensive imaging.[3] These national findings confirm suspicions previously voiced elsewhere in the literature.[1 18] All of this raises the important question as to whether CT scans are required or are the best test in the initial assessment of flank pain.

Ultrasound and stones

In assessing flank pain, the strength of ultrasound is its ability to detect obstructive uropathy. This is useful to the clinician if suspicion for stone disease is high, because it can be taken as presumptive evidence of obstructing stone disease. It may suggest the duration of the obstruction,[8] and possibly the size of the obstructing stone.[16 17] If stones are less likely or other pathology is important to exclude, the absence of obstructive uropathy may direct investigations elsewhere.

Hydronephrosis is the preferred de facto measure of stone presence as ultrasound is poorly sensitive for directly imaging stones. Only stones proximal to the ureteropelvic junction (UPJ) and distal to the ureterovesicle junction (UVJ) can be visualised consistently as the ureter is difficult to assess. This translates to approximately 64% of stones being in the 'field of view'.[27] Of these, ultrasound is about 16% sensitive for stones <7 mm and 75% sensitive for those ≥7 mm.[4]

Bedside ultrasound (BUS)

BUS performed by clinicians is well-established in the trauma setting (the FAST exam).[28 29] Its use has grown in recent years, such that it is considered a compulsory skill for emergency physicians for a range of ED presentations[7] and is mandated in emergency medicine residency training programs in the USA. Once a clinician has been orientated to the physics and 'knobology' of the machine, ultrasound can be used for a range of applications depending on the clinical need. BUS allows the physician to answer focused algorithmic 'yes or no' questions in order to differentiate patients into risk groups. It is important to stress that it is not meant to replace formal ultrasound but rather to streamline diagnostic testing.

The skills required to answer these focused questions can be easily acquired with suitable didactic courses and a minimum number of hands-on scans.[9 12 14 15] The experience with FAST, for instance, demonstrates that, after structured didactic teaching with hands-on experience, maximal operator sensitivity may be achieved with as few as 50–100 scans.[28]

Detecting hydronephrosis on BUS is easily learnt. The protocol usually involves evaluating the renal parenchyma and pelvis by fanning through the kidney in both longitudinal and transverse planes. The bladder is interrogated in two planes to assess for distention versus underfilling, to look for stones at the UVJ and to assess for ureteral jets. Mandavia and colleagues found that second year emergency medicine residents given a 16 h ultrasound course (of which 45 min was dedicated to renal ultrasound) could identify hydronephrosis with an accuracy of 96% compared with certified ultrasonographers.[30] Other studies have also observed favourable results after short intensive training.[9 14 15]

BUS has several strengths: it has a low marginal cost, it can be performed rapidly (2–3 min) and concurrently with other management, and it can obviate the need to wait for imaging in the radiology department, which can be lengthy even in developed urban settings.[8]

At least eight published studies have shown how BUS might be used to inform renal colic management and to assess its accuracy.[9 10 13–17 30]

Table 1 shows five studies that measured the accuracy of BUS for detecting hydronephrosis or stone disease. In these studies the sensitivity for detecting hydronephrosis ranges from 72% to 97% and specificities from 73% to 83% compared with either CT or IVPU as a gold standard.

Interestingly, the study by Henderson and colleagues had a higher sensitivity than the others for detecting hydronephrosis.[10] Part of their protocol was the administration of 500 ml of intravenous fluid prior to scanning. Often the patient with renal colic can be mildly dehydrated due to vomiting or decreased oral intake. This may transiently collapse the pelvic collecting system and the administration of a fluid bolus may therefore unmask a previously obscured hydronephrosis, which could account for improved sensitivity in these patients.[10 12]

Two prospective studies measured the accuracy of using hydronephrosis and other sonographic findings at BUS to diagnose an obstructing stone. Other studies reviewed did not use imaging as the reference for stone diagnosis,[14 30] were retrospective[16] or only reported findings of hydronephrosis on gold standard and did not correlate this with the presence of stones.[9 13 15]

Some authors have combined KUB plain films with ultrasound in order to improve diagnostic accuracy. In the study by Henderson and colleagues, 108 cases of suspected nephrolithiasis

Table 1 Accuracy of bedside ultrasound for detecting hydronephrosis or stones in patients with flank pain compared with CT or IVPU

Reference	Std	Year	N†	Prevalence of disease % (95% CI)	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV % (95% CI)	NPV % (95% CI)
Hydronephrosis								
Rosen	IVP	1998	83	69 (58 to 78)	72 (59 to 83)	73 (52 to 88)	85 (71 to 94)	54 (37 to 71)
Henderson‡	IVP	1998	108	58 (49 to 67)*	97 (89 to 99)*	73 (59 to 84)*	84 (73 to 90)*	94 (81 to 98)*
Gaspari and Horst	CT	2005	101	51 (42 to 60)*	87 (79 to 92)	82 (74 to 81)	84 (72 to 91)*	86 (73 to 94)*
Watkins	CT	2007	57	68 (56 to 79)	80 (65 to 89)	83 (61 to 94)	91 (75 to 98)	65 (43 to 83)
Stones								
Henderson‡	IVP	1998	108	64 (54 to 72)*	88 (79 to 94)*	69 (54 to 81)*	84 (73 to 90)*	77 (69 to 88)*
Moak	CT	2012	107	36 (27 to 45)	76 (59 to 88)	78 (66 to 87)	66 (50 to 79)	86 (74 to 92)

*Our calculation.
†Cases that were checked against another gold standard imaging technique.
‡All patients received a 500 ml N saline bolus prior to scan which may have improved sensitivity. Six cases showed calcifications or filling defect on IVP. These were counted as no-hydro for calculations.
IVP, intravenous pyelography; NPV, negative predictive value; PPV, positive predictive value.

were assessed with BUS and KUB plain films.[10] Using this approach, they found that they were able to detect 67/69 cases of nephrolithiasis confirmed by IVPU (98% sensitive, CI 92% to 99%). Sixty-one of these patients had hydronephrosis detectable at the bedside and, of the remaining eight, six were able to be confirmed by KUB (75%, CI 41% to 93%)*.

Other studies using formal radiology ultrasound have also shown that complementary KUB improved the sensitivity of detecting stones and had acceptable specificity when compared with either modality alone.[31 32]

Although the role of plain film KUB is controversial, the fact remains that approximately 90% of stones are radio-opaque, consisting of calcium oxalate, calcium phosphate and struvite.[26] While KUB may be comparatively insensitive for stones <4 mm and those in the mid and distal ureters,[33] its use may improve stone detection rates at the margins where obstruction is not readily demonstrated with ultrasound.

It is also important to consider if BUS allows effective risk stratification of patients with renal colic and whether high-tech imaging strategies may be justified due to improved clinical outcomes. Nephrolithiasis is commonly a self-limiting disease with few serious complications. The need for specialist intervention is determined by clinical features and not the presence of a stone per se. Persistent pain and the presence of severe obstruction are primary indications for intervention or admission,[34] both of which are related to the inability of an obstructing stone to spontaneously pass. Superimposing infection is also an indication for emergency intervention.[34]

It is generally thought that most stones <5 mm will ultimately pass, stones 5–9 mm will likely pass (and may be candidates for expectant medical therapy) and stones ≥10 mm will likely require extraction.[16 34–36] Coll and colleagues prospectively recruited 172 individuals with a solitary stone undergoing CT.[37] They detailed the proportion of stones that passed by each millimetre increase in stone size, as measured on CT. Their data are categorised in table 2 and support the rule of thumb that stones ≥5 mm may warrant different management. However, there is no real consensus among practitioners on this, probably due to a lack of large observational studies. The 2007 European and American Urological Associations' consensus paper made its recommendations based on five studies with a combined 224 patients, of which the study by Coll and colleagues constituted more than three-quarters.[35]

Moak and colleagues investigated whether hydronephrosis on BUS could identify potentially troublesome stones and their results are reproduced in table 3.[17] They found that BUS was able to identify hydronephrosis in 29/38 cases of stone disease and identified no hydronephrosis in 54/69 patients without stones (see table 1). They further stratified their data by stone size and revealed that patients with hydronephrosis were significantly more likely to have a stone ≥5 mm (OR 15.9, $p<0.01$)* than those without hydronephrosis. They concluded that ultrasound was sensitive for detecting clinically relevant stones; however, the overall prevalence of stones (35.5%) was lower than in other studies of patients with flank pain and the number of larger stones was small (10 stones), making definitive conclusions difficult. Furthermore, they considered those without stones and those with stones <5 mm as a single group for comparisons. If we consider only patients with proven stone disease, the relationship between stone size and hydronephrosis is weaker and not statistically significant (OR 3.6, $p=0.24$)*.

Goertz and colleagues had earlier investigated whether stone size might be predicted based on the degree of hydronephrosis found on BUS in the initial assessment.[16] Using a simple definition of hydronephrosis (none, mild, moderate, severe) defined elsewhere in the literature (figure 1),[12] they retrospectively reviewed 177 cases of stones confirmed on CT where BUS had been recorded and stored. In their results (table 4) it was shown that patients with moderate and severe hydronephrosis had a significantly higher proportion of stones ≥5 mm than those with mild or no hydronephrosis (35.4% vs 12.4%, χ^2 test, $p<0.001$). Furthermore, of patients with moderate or severe hydronephrosis, 6/48 had stones 10 mm or larger (12.5%, CI 23% to 50%)* compared with 0/129 (0%, CI 0% to 3%)* of patients with mild or no hydronephrosis.

Table 2 Proportion of stones spontaneously passing depending on size identified at CT (from Coll *et al*[37])

Stone size (mm)	N	% Passing spontaneously*	95% CI
1–4	99	76.7	(67.5 to 83.9)
5–9	62	58.1	(45.7 to 69.5)
≥10	11	27.2	(9.7 to 56.5)
Total	**172**		

$p=0.001$ for χ^2 distribution of 3×2 table.
*Our calculations.

Some clinicians are reluctant to diagnose stone disease without evidence of obstruction. Thus, if we are conservative and exclude cases of 'no hydronephrosis' from Goertz and colleagues' data, the significance of the stone size relationship remains: 87%* of patients with mild hydronephrosis had stones <5 mm (CI 79% to 92%)* compared with 65%* of patients with moderate or severe hydronephrosis (CI 50% to 77%)* (OR 3.7, $p=0.001$)*.

To phrase it in clinically meaningful terms, in Goertz's study the odds of having a stone <5 mm with mild hydronephrosis is 6.8:1 compared with 1.8:1 with moderate/severe hydronephrosis. The implication of this is that, in patients with stone disease and only mild hydronephrosis at BUS, we may need eight CT scans to identify one patient with a stone ≥5 mm in whom we *might* change our management. In those with moderate to severe hydronephrosis this number is closer to three. This suggests that mild hydronephrosis may indicate patients for conservative ED management when stones are considered the likely diagnosis, without the need for further imaging. However, these findings will need to be validated prospectively before the stronger conclusions can be drawn.

Goertz and colleagues and Moak and colleagues provide evidence that contrasts with other conclusions in the literature that stone size and degree of obstruction are unrelated.[8]

Unfortunately there have been few published algorithms for rational management strategies in stone disease, but one

Table 3 Distribution of stone sizes (confirmed by CT) depending on presence of hydronephrosis at bedside ultrasound in suspected renal colic (from Moak *et al*[17])

	Stone ≥5 mm	Stone <5 mm*	No stone*	Total
Hydronephrosis	9	20	15	44
%*	20.5	45.5	34.0	100.0%
(95% CI)*	(11.1 to 34.5)	(31.7 to 59.9)	(21.9 to 48.9)	
No hydronephrosis	1	8	54	63
%*	1.6	12.7	85.7	100.0%
(95% CI)*	(0.3 to 8.5)	(6.6 to 23.1)	(75.0 to 92.31)	
Total	10	28	69	107

*$p<0.001$ for χ^2 distribution of 3×2 table (our calculations).
*$p=0.24$ for χ^2 distribution of 2×2 table with only stone disease considered (our calculations).
*OR for stone disease with hydronephrosis is 11.6 (95% CI 4.1 to 33.5) (our calculations).

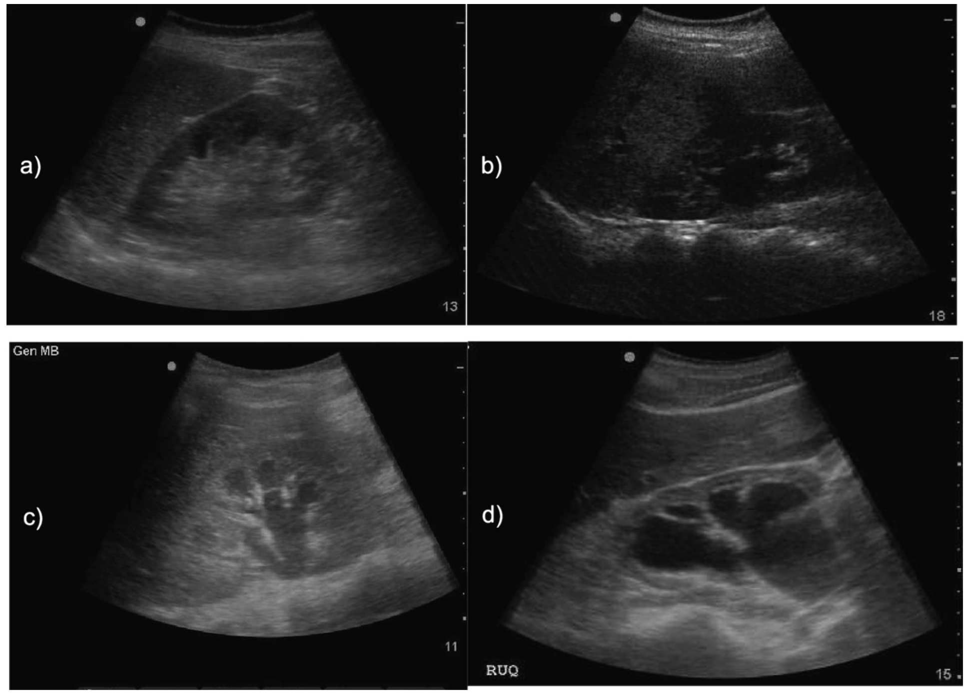

Figure 1 Grades of hydronephrosis. (A) Normal kidney: collecting system is collapsed and hyperechoic. (B) Mild hydronephrosis: pelvis is open and filled with hypoechoic urine. (C) Moderate hydronephrosis: calyces are open with blunting. (D) Severe hydronephrosis: calyces 'ballooned' out, pyramids/ medulla obliterated, cortex remains. (Images courtesy of Massachusetts General Hospital Emergency Ultrasound Division.)

approach is outlined in figure 2.[38] An earlier iteration of this algorithm was adapted by Noble and Brown[12] and this was used by Kartal and colleagues in an attempt to validate a clinical algorithm.[14] They demonstrated that, by using this approach, they were able to discharge up to 50% of patients with renal colic to urology follow-up with no further imaging in the ED other than ultrasound. There were no serious adverse effects at 2 months of follow-up in this group.

A review of the literature by Manthey and Teichman suggested that, even in patients with severe hydronephrosis, permanent damage to the kidneys may only occur after 2–4 weeks.[21] Thus, even if moderate to severe hydronephrosis is detected on BUS, there may be no great urgency in imaging and managing these patients further in the ED. In these cases, swift serial outpatient imaging and urology referral may be sufficient. Furthermore, the immediate complication of calyceal or pelvic rupture is self-limiting and requires no specific management.

Table 4 Proportion of stones <5 mm depending on degree of hydronephrosis at bedside ultrasound in suspected renal colic (from Goertz *et al*)

Degree of hydronephrosis	Stone ≥5 mm	Stone <5 mm	Total
None	3	25	28
%*	10.7	89.3	100.0%
(95% CI)*	(3.7 to 27.2)	(72.8 to 96.3)	
Mild	13	88	101
%*	12.9	87.1	100.0%
(95% CI)*	(7.7 to 20.8)	(79.2 to 92.3)	
Moderate	13	30	43
%*	30.2	69.8	100.0%
(95% CI)*	(18.6 to 45.1)	(54.9 to 81.4)	
Severe	4	1	5
%*	80.0	20.0	100.0%
(95% CI)*	(37.6 to 96.4)	(3.6 to 62.4)	
Total	33	144	177

*Our calculations.
$p<0.001$ for χ^2 distribution of 2×4 table.

ALTERNATIVE DIAGNOSES

The possibility of other pathological processes in the patient with renal colic or flank pain is not trivial and anecdotal evidence suggests that it drives many decisions to pursue CT imaging. Many disease processes involving the urinary tract, bowel and ovaries can present with flank pain. Also, CT may reveal important 'incidentalomas'. While aortic aneurysm/ dissection may be the only acutely life-threatening alternative diagnosis in flank pain, there are also the important acute surgical

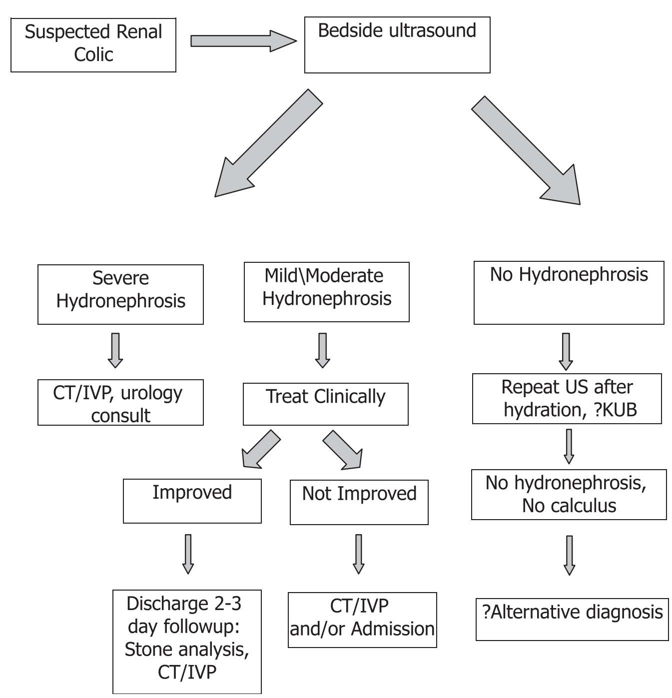

Figure 2 An algorithm for the management of renal colic patients in the emergency department (adapted from Swadron and Mandavia[38]). IVP, intravenous pyelography; KUB, kidney–ureter–bladder x-ray; US, ultrasound.

Table 5 Proportion of alternative pathology found at CT in patients with suspect renal colic in five studies

	Principal author (year)				
	Smith (1996)[24]	Yilmaz (1998)[39]	Nachman (2000)[40]	Catalano (2002)[32]	Cullen (2008)[27]
No of subjects	210	97	281	239	500
Findings†	% of Total cases (95% CI)*				
Stones overall	49.5 (42.5 to 56.2)	66.0 (56.1 to 74.6)	32.7 (27.5 to 38.4)	52.7 (46.3 to 59)	55.8 (52.4 to 60.1)
Total non-stone pathology on CT	14.8 (10.6 to 20.2)	6.2 (2.8 to 12.8)	21.4 (17.0 to 26.5)	13.0 (9.3 to 17.8)	22.4‡ (19.0 to 26.3)
No pathology Found on CT	35.7 (29.5 to 42.4)	23.7 (16.5 to 33.1)	45.9 (40.2 to 51.7)	34.3 (28.6 to 40.5)	27.8 (24.1 to 31.9)
Other pathology diagnosed clinically	2.4 (1.0 to 5.5)	4.1¶ (1.6 to 10.1)	None Reported	None Reported	None Reported
Non-stone pathology found on CT	% of Total cases (95% CI)*				
Abdominal Aortic Aneurysm	0.5 (0.1 to 2.6)	None reported	0.4 (0.1 to 2)	0.4 (0.1 to 2.3)	0.8 (0.3 to 2.0)
Appendicitis	2.4 (1.0 to 5.5)	3.1 (1.1 to 8.7)	2.1 (0.1 to 4.6)	2.1 (0.9 to 4.8)	0.8 (0.3 to 2.0)
Diverticulitis	1.9 (0.7 to 4.8)	None reported	1.4 (0.6 to 3.6)	0.4 (0.1 to 2.3)	0.8 (0.3 to 2)
Biliary stones	1.4 (0.7 to 4.8)	1.0 (0.2 to 5.6)	2.5 (1.2 to 5.1)	0.4 (0.1 to 2.3)	1.0 (0.4 to 2.3)
Pyelonephritis	1.4 (0.7 to 4.8)	None reported	None reported	0.8 (0.2 to 3.0)	1.2 (0.6 to 2.6)
Urinary neoplasm	1.0 (0.3 to 3.4)	None reported	4.6 (2.7 to 7.8)	0.8 (0.2 to 3.0)	2.0 (1.1 to 3.6)
Other neoplasm	0.5 (0.1 to 2.6)	2.1 (0.6 to 7.2)	5.3 (3.3 to 8.6)	0.8 (0.2 to 3.0)	1.2 (0.6 to 2.6)
Misc	5.7§ (3.3 to 9.7)	None reported	5.0** (3.0 to 8.2)	7.1†† (4.5 to 11.1)	14.6‡‡ (11.7 to 17.9)

Renal scarring (5), PUJ obstruction (2), persistent urachus, pancreatitis (4), fatty liver (4), liver cyst (6), diverticular disease (8), ovarian cyst (15), fibroids (3).
*Our calculations.
†NB: subjects may be categorised in more than one group for example, Stones and other pathology (therefore sum >100%). Pathology referred to as a 'mass' and not later defined was counted as neoplastic. Neoplasm includes benign lesions. Diagnoses were presumed to be evident on CT scan unless stated otherwise.
‡Includes pathology of 'low clinical significance', excluding these 12.6% (CI 10.0 to 15.8)* had pathology requiring referral, further investigation or surgery.
§Twelve cases: Ovarion dermoids (2), hydrosalpinx, paratubal cyst, urinary haematoma, hemorrhagic/emphysematous cystitis (2), hemorhagic ovarian cyst (3), megaureter, bladder oulet obstruction.
¶Includes one case of diverticulitis not found on any imaging but confirmed at surgery.
**Fourteen cases: Ovarian cysts (8), ureteral stricture (5) splenic infarct.
††Seventeen cases: hemorrhagic ovarian cyst (5), adnexal torsion (3), hydrosaplinx, epididymitis, pleuritis, renal abscess, omental infarct, papillary necrosis, renal vein thrombosis, tubo-ovarian abcess. And one case not specified.
‡‡Seventy-three cases: renal cyst: simple (10), complex (10), hemorrhagic (3), polycystic kidney (2), Renal scarring (5), PUJ obstruction (2), persistent urachus, pancreatitis (4), fatty liver (4), liver cyst (6), diverticular disease (8), ovarian cyst (15), fibroids (3).

pathologies of appendicitis, diverticulitis and ovarian torsion. These may require urgent laparotomy and many clinicians would be loath to miss them.

In studies reviewed that reported alternative findings in patients with suspected renal colic, the proportion of noteworthy alternative findings was between 7.2% and 14.8% (table 5).[24 27 39 40] In addition, the rate of neoplastic revelation is small; Westphalen and colleagues report that, on a national level in the USA, the diagnosis of neoplasm in those with flank pain is between 0.2% and 0.8% although the low number of these diagnoses in the survey made precise statistics unstable.[3]

Given the generally low rate of other findings that require emergency management, clinicians using BUS may potentially be reassured that adverse outcomes due to missed diagnoses are unlikely in the immediate setting. Furthermore, clinically significant alternative diagnoses will likely have or develop other 'red flags' in the examination and history.

FOR THE FUTURE

Enough evidence now exists to define a rational approach to imaging and management of suspected renal colic. Clinical findings and BUS may help to establish the probability of stone disease, differentiate the likelihood of clinically important stones, indicate the probability of intervention and estimate the likelihood of an alternative diagnosis. Unfortunately, there is no such prospectively validated scoring system or algorithm widely in use and this should be a priority moving forward.

A simple prospectively validated diagnostic imaging strategy could greatly improve the management of patients with suspected renal colic by reducing unnecessary imaging, saving money to the health system and reducing the radiation dose to patients who will not benefit from it.

Based on this review of the literature, there is compelling evidence that the easily learnt skill of BUS may be helpful in managing patients with renal colic. While this technique has been supported by research in emergency medicine, there is no obvious reason why it cannot be learnt by other specialty groups that may be confronted with the renal colic patient, such as practitioners in nephrology, urology, family practice or general surgery.

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REFERENCES

1. **Kirpalani A,** Khallli K, Lee S, *et al*. Renal colic: comparison of use and outcomes of unenhanced helical CT for emergency investigation in 1998 and 2002. *Radiology* 2005;**236**:554–8.
2. **Hyams E,** Korley FK, Pham JC, *et al*. Trends in imaging use during the emergency department evaluation of flank pain. *J Urol* 2011;**186**:2270–4.
3. **Westphalen A,** Hsia RY, Maselli JH, *et al*. Radiological imaging of patients with suspected urinary tract stones: national trends, diagnoses, and predictors. *Acad Emerg Med* 2011;**18**:700–7.
4. **Fowler KA,** Locken JA, Duchesne JH, *et al*. US for detecting renal calculi with nonenhanced CT as a reference standard. *Radiology* 2002;**222**:109–13.
5. **Sheafor DH,** Hertzberg BS, Freed KS, *et al*. Nonenhanced helical CT and US in the emergency evaluation of patients with renal colic: prospective comparison. *Radiology* 2000;**217**:792–7.
6. **Colistro R,** Tollegiani WC, Lyburn ID, *et al*. Unenhanced helical CT in investigation of acute flank pain. *Clin Radiol* 2002;**57**:435–41.
7. *American College of Emergency Physicians Policy Statement: Ultrasound Guidelines 2008*. http://www.acep.org/workarea/downloadasset.aspx?id=32878 (accessed 15 Mar 2012).
8. **Brown DFM,** Rosen CL, Wolfe RE. Renal ultrasonography. *Emerg Med Clin North Am* 1997;**15**:877–93.
9. **Rosen C,** Brown DFM, Sagarin MJ, *et al*. Ultrasonography by emergency physicians in patients with suspected ureteral colic. *J Emerg Med* 1998;**16**:865–70.
10. **Henderson S,** Hoffner R, Aragona J, *et al*. Bedside emergency department ultrasonography plus radiography of the kidneys, ureters, and bladder vs intravenous pyelography in the evaluation of suspected ureteral colic. *Acad Emerg Med* 1998;**5**:666–71.
11. **Hedrenreich A,** Desgrandschampsb F, Terrier F. Modern approach to diagnosis and management of acute flank pain: review of all imaging modalities. *Eur Urol* 2002;**41**:351–62.

12. **Nobel V,** Brown DF. Renal ultrasound. *Emerg Med Clin North Am* 2004;**22**:641–59.
13. **Gaspari R,** Horst K. Emergency ultrasound and urinalysis in the evaluation of flank pain. *Acad Emerg Med* 2005;**12**:1180–4.
14. **Kartal M,** Eray O, Erdogru T, *et al*. Prospective validation of a current algorithm including bedside US performed by emergency physicians for patients with acute flank pain suspected for renal colic. *Emerg Med J* 2006;**23**:341–4.
15. **Watkins S,** Bowra J, Sharma P, *et al*. Validation of emergency physician ultrasound in diagnosing hydronephrosis in ureteric colic. *Emerg Med Australas* 2007;**19**:188–95.
16. **Goertz JK,** Lotterman S. Can the degree of hydronephrosis on ultrasound predict kidney stone size? *Am J Emerg Med* 2010;**28**:813–16.
17. **Moak J,** Lyons MS, Lindsell CJ. Bedside renal ultrasound in the evaluation of suspected ureterolithiasis. *Am J Emerg Med* 2012;**30**:218–21.
18. **Broder J,** Bowen J, Lohr J. Cumulative CT exposures in emergency department patients evaluated for suspected renal colic. *J Emerg Med* 2007;**33**:161–8.
19. **Smith-Bindman R,** Lipson J, Marcus R, *et al*. Radiation dose associated with common computed tomography examinations and the associated lifetime attributable risk of cancer. *Arch Intern Med* 2009;**169**:2078–86.
20. **Katz SI,** Saluja S, Brink JA, *et al*. Radiation dose associated with unenhanced CT for suspected renal colic: impact of repetitive studies. *Am J Roentgenol* 2006;**186**:1120–4.
21. **Manthey D,** Teichman J. Nephrolithiasis. *Emerg Med Clin North Am* 2001;**19**:633–54.
22. **Pearle MS,** Lotan Y. Urinary lithiasis: etiology, epidemiology, and pathogenesis. In: Wein AJ, Kavoussi LR, Novick AC, eds. *Campbell-Walsh Urology*. 10th edn. Philadelphia: Elsevier Saunders, 2012:1257–86.
23. **Smith RC,** Rosenfield AT, Kyuran AC. Acute flank pain: comparison of non-contrast enhanced CT and intravenous urography. *Radiology* 1995;**194**:789–94.
24. **Smith RC,** Verga M, McCarthy S, *et al*. Diagnosis of acute flank pain: value of unenhanced helical CT. *AJR Am J Roentgenol* 1996;**166**:97–101.
25. **Smith RC,** Varanelli M. Diagnosis and management of acute ureterolithiasis: CT is truth. *AJR Am J Roentgenol* 2000;**175**:3–6.
26. **Ferrandino MN,** Pietrow P, Preminger P. Evaluation and medical management of urinary lithiasis. In: Wein AJ, Kavoussi LR, Novick AC, eds. *Campbell-Walsh Urology*. 10th edn. Philadelphia: Elsevier Saunders, 2012:1288–332.
27. **Cullen I,** Cafferty F, Oon SF, *et al*. Evaluation of suspected renal colic with non-contrast CT in the emergency department: a single institution study *J Endourol* 2008;**22**:2441–5.
28. **Bruce T,** Falcone RE, Vasquez D, *et al*. Ultrasound evaluation of blunt abdominal trauma: program implementation, initial experience, and learning curve. *J Trauma* 1997;**42**:384–90.
29. **Scalea T,** Rodriguez A, Chiu WC, *et al*. Focused assessment with sonography for trauma (FAST): results from an international consensus conference *J Trauma* 1999;**46**:466–72.
30. **Mandavia DP,** Aragona J, Chan L. Ultrasound training for emergency physicians—a prospective study. *Acad Emerg Med* 2000;**7**:1008–14.
31. **Haddad M,** Sharif HS, Shahed MS, *et al*. Renal colic diagnosis and outcome *Radiology* 1992;**184**:83–8.
32. **Catalano O,** Nunziata A, Altei F, *et al*. Suspected ureteral colic: primary helical CT versus selective helical CT after unenhanced radiography and sonography. *AJR Am J Roentgenol* 2002;**178**:379–87.
33. **Levine J,** Neitlich J, Verga M, *et al*. Ureteral calculi in patients with flank pain: correlation of plain radiography with unenhanced helical CT. *Radiology* 1997;**204**:27–31.
34. **Papa L,** Steill IG, Wells GA, *et al*. Predicting intervention in renal colic patients after emergency department evaluation. *Can J Emerg Med* 2005;**7**:78–86.
35. **Preminger GM,** Tiselius HG, Assimos DG, *et al*. Guideline for the management of ureteral calculi. *J Urol* 2007;**178**:2418–34.
36. **Matlaga B,** Lingeman JE. Surgical management of upper urinary tract calculi. In: Wein AJ, Kavoussi LR, Novick AC, eds. *Campbell-Walsh Urology*. 10th edn. Philadelphia: Elsevier Saunders, 2012:1359–10.
37. **Coll D,** 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**:101–3.
38. **Swadron S,** Mandavia DP. Renal ultrasound. In: Ma OJ, Mateer JR, eds. *Emergency Ultrasound*. 2nd edn. New York: McGraw-Hill Professional, 2008:229–54.
39. **Yilmaz S,** Sindel T, Arslan G, *et al*. Renal colic: comparison of spiral CT, US and IVU in the detection of ureteral calculi. *Eur Radiol* 1998;**8**:212–17.
40. **Nachman M,** Harkaway R, Summerton S, *et al*. Helical CT scanning: the primary imaging modality for acute flank pain. *Am J Emerg Med* 2000;**18**:649–52.

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