Emergency Ultrasound and Urinalysis in the Evaluation of Flank Pain

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Abstract

Objectives: To determine the sensitivity and specificity of limited emergency ultrasonography of the kidney in diagnosing renal colic. **Methods:** This was a prospective observational trial from December 2001 to December 2003 at a suburban emergency department. Patients who presented with flank pain suspicious for renal colic were enrolled. Exclusion criteria included fever, trauma, known current kidney stone, unstable vital signs, and inability to provide consent. All patients underwent sequential emergency ultrasonography and computed tomography of the kidneys and bladder. Data were analyzed using chi-square analysis. The primary outcome was the sensitivity and specificity of ultrasonography. Results were also stratified for presence of hematuria. **Results:** Fifty-eight of the 104 patients enrolled in the study were diagnosed with renal colic. The overall sensitivity and specificity of bedside ultrasonography for the detection of hydronephrosis were 86.8 (95% confidence interval [CI] = 78.8 to 92.3) and 82.4 (95% CI = 74.1 to 88.1), respectively. In patients with hematuria, hydronephrosis by emergency ultrasonography demonstrated a sensitivity and specificity of 87.8 (95% CI = 80.3 to 92.5) and 84.8 (95% CI = 73.7 to 91.9), respectively. In 55 of the cases, the initial computed tomograph was read by a resident and later re-read by an attending physician. Using the reading of the attending physician as the criterion standard resulted in a sensitivity and specificity of 83.3 (95% CI = 73.2 to 88.0) and 92.0 (95% CI = 79.9 to 97.6), respectively. **Conclusions:** Emergency ultrasonography of the kidneys shows very good sensitivity and specificity for diagnosing renal colic in patients with flank pain and hematuria. **Key words:** emergency ultrasonography; bedside ultrasonography; limited ultrasonography; renal colic; kidney stones; flank pain. ACADEMIC EMERGENCY MEDICINE 2005; 12:1180–1184.

Kidney stones occur in 2%–3% of the general population,[1] and patients commonly present to the emergency department (ED) with pain. The classic presentation of renal colic is the acute onset of unilateral flank pain with radiation to the groin, dysuria, and hematuria.[2] Kidney stones are commonly diagnosed by history, physical examination, and urinalysis, with or without direct imaging of the stone.[3] Intravenous urography, computed tomography (CT), and ultrasonography have all shown utility in diagnosing renal colic.[4–7]

A CT scan is the most accurate method to diagnose a kidney stone,[8] but this increased accuracy costs both time and money. Requesting a CT scan often means adding hours to a patient's stay in the ED.[9] In contrast, emergency ultrasonography (EUS) is a bedside procedure that can be performed quickly. EUS also has the benefit of a lack of radiation exposure. EUS of the kidney involves a limited imaging protocol, looking for hydronephrosis as a surrogate marker for kidney stones.[10] We sought to determine the sensitivity and specificity of hydronephrosis on EUS of the kidneys, compared with CT scan findings of renal stone disease, in patients presenting with symptoms consistent with renal colic.

METHODS

Study Design. This was a prospective observational trial involving a convenience sample of patients with flank pain. During the study, a clinician with experience in EUS was on call from 8 AM to 11 PM to enroll patients. In addition, patients who were encountered overnight but still in the ED the next morning without CT scan results were also considered for enrollment. The study was approved by the medical center institutional review board, and written informed consent was required before participating in the study.

Study Setting and Population. The study was conducted in the ED of a suburban teaching hospital in central Massachusetts with an annual census of approximately 75,000 visits. Patients were prospectively enrolled over a two-year period, from December 2001 to December 2003. ED residents and attending physicians were asked to notify study personnel when any patient with flank pain was encountered. Patients were eligible for enrollment if the treating physician

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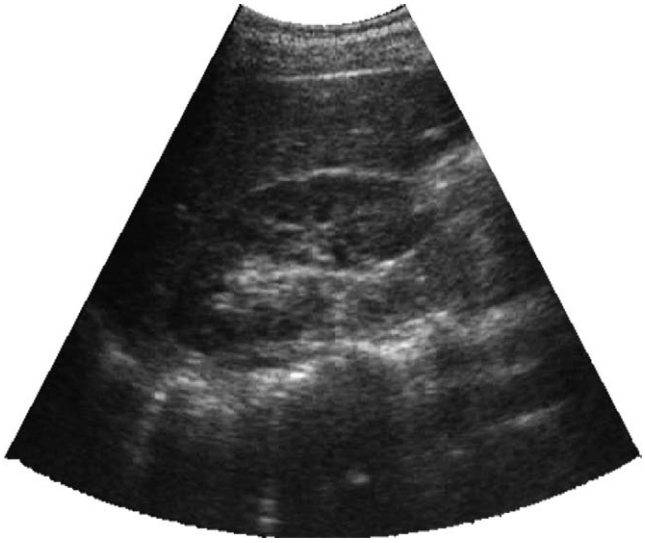

Figure 1. Normal renal ultrasonograph.

believed that the flank pain was consistent with renal colic. Exclusion criteria included fever, trauma, known current kidney stone, unstable vital signs, and inability to provide consent.

Study Protocol. The EUS of the kidney consisted of a limited imaging protocol performed at the patient's bedside. The protocol consisted of both long- and short-axis views of each kidney and a long and transverse view of the bladder. The main goal of this EUS was to identify hydronephrosis by documenting dilatation of the kidney's central collecting system (Figures 1 and 2). We made no attempt to identify the actual kidney stone and considered any EUS with unilateral hydronephrosis to be positive for renal colic.

Measurements. All ultrasonographic images were obtained with a Sonosite Titan (Bothell, WA) ultrasound machine using one of two ultrasonographic probes. The sonographer used either a curved microconvex 2- to 4-MHz array or a larger curved 2- to 5-MHz array. The ultrasonographic images were recorded on high-quality digital tape for later review. CT scans were performed on a General Electric Lightspeed Ultra Computed Tomography Scanner Eight Slice (Waukesha, WI).

Figure 2. Renal ultrasonograph with hydronephrosis.

TABLE 1. Patient Characteristics

	All Patients	No Renal Colic ($n = 38$)	Renal Colic ($n = 63$)
Gender (% female)	55.4	73.0	41.2*
Age, yr (SEM)	40.1 (1.36)	38.1 (2.31)	41.4 (1.66)
Nausea/vomiting (%)	58.3	51.4	64.1
Dysuria (%)	30.7	37.8	28.1
Polyuria (%)	11.9	13.5	10.9
History of stones (%)	36.6	40.5	34.4
Flank tenderness (%)	73.3	73.0	73.4
Abdominal tenderness (%)	46.5	56.8	43.7

*$p < 0.05$.

All patients underwent identical initial workups, including urinalysis, EUS, CT scan, and a follow-up interview at least one month later. Ultrasonographic images were obtained by credentialed emergency ultrasonographers blinded to the CT scan results. Most ultrasonographies were performed by two emergency physicians with extensive ultrasonography experience; however, a significant minority were performed by four physicians who had completed at least 25 renal ultrasonographies (the minimum required to be eligible to enroll patients). All ultrasonography results were reviewed by the most experienced physician.

All CT scans were eventually read by a board-certified radiologist. During nights and weekends, a radiology attending physician was not available to immediately read the CT scan. These CT scans were initially read by a radiology resident and re-read by a radiology attending physician 12–36 hours later.

Data Analysis. The sensitivity and specificity of the EUS for hydronephrosis were determined using the initial interpretation of the EUS and the final CT reading for hydronephrosis only. The initial CT reading was compared with the final CT reading using chi-square analysis, with the final CT reading as the criterion standard. Final diagnosis was determined at one-month follow-up, after review of all patient records and a patient telephone interview. A patient was determined to have renal colic if 1) the CT scan showed a kidney stone or signs of passage of a kidney stone (hydroureter, hydronephrosis, bladder stone), 2) the patient passed a kidney stone in a urine strainer, or 3) surgical intervention for a kidney stone was performed.

During the study, the attending physician was blinded to the results of the EUS and patient decisions were made using the findings of the CT scan. The imaging results are stratified by urinalysis (hematuria or not).

All data were entered into an Excel spreadsheet (Microsoft Corp, Redmond, WA). Statistical analysis

TABLE 2. Sensitivity and Specificity of EUS for Hydronephrosis

	CT (+)	CT (−)
EUS (+)	46	9
EUS (−)	7	42

Positive findings refer to the presence of hydronephrosis.

was performed using a Web-based statistical package (http://www.statistics.com). Sensitivity and specificity were calculated using chi-square test with 95% confidence intervals (95% CI). Agreement of CT readings was performed using a κ test.

RESULTS

A total of 104 subjects with symptoms suspicious for renal colic were enrolled. Of these, 58 were diagnosed with renal colic by CT scan and 62 were determined to have had renal colic at one-month follow-up. The diagnosis at one-month follow-up was determined by a combination of chart review and a follow-up telephone call to the patient (or primary care physician if the patient was unable to be reached). Thirty-one patients were unavailable for telephone follow-up, and therefore a review of their records and discussion with the patient's primary physician or urologist provided follow-up. Characteristics of all enrolled patients are provided in Table 1. The only difference between the groups of patients with renal colic and those without renal colic was the percentage of female patients.

The overall sensitivity and specificity of EUS for detection of hydronephrosis were 86.8 (95% CI = 78.8 to 92.3) and 82.4 (95% CI = 74.1 to 88.1), respectively (Table 2). Stratification of the data by urinalysis results revealed that EUS in patients with hematuria ($n = 47$) demonstrated a sensitivity and specificity of 87.8 (95% CI = 80.3 to 92.5) and 84.8 (95% CI = 73.7 to 91.9), respectively (Table 3). Hematuria alone demonstrated a sensitivity and specificity for the diagnosis of renal colic of 93.1 (95% CI = 86.7 to 97.1) and 33.3 (95% CI = 24.5 to 38.9), respectively (Table 4).

Although a CT scan was performed for all patients, some of these scans (during nights and weekends) were interpreted first by radiology residents and only later (12–36 hours) reinterpreted by radiology attending physicians. With the interpretation of the attending physician taken as the criterion standard, the sensitivity and specificity were 83.3 (95% CI = 73.2 to 88.0) and 92.0 (95% CI = 79.9 to 97.6), respectively (Table 5).

TABLE 4. Sensitivity and Specificity of Hematuria by Urinalysis for Kidney Stones

	CT (+)	CT (−)
Urinalysis (+)	54	28
Urinalysis (−)	4	14

Urinalysis (−) = less than five red blood cells per high-power field.

All patients enrolled in this study presented with flank pain and underwent a CT scan for suspected renal colic, but another diagnosis was discovered in 38% ($n = 40$). Despite an extensive workup, 19 of the patients did not receive a definitive diagnosis. Three patients were admitted with appendicitis, diverticulitis, and metastatic cancer. One patient required methotrexate for an ectopic pregnancy. Six additional patients required antibiotics in the ED for pneumonia ($n = 3$), urinary tract infection ($n = 2$), and diverticulitis. The rest had a variety of diagnoses, including hemorrhagic renal cyst, ovarian cyst, hepatitis, and others.

Six individuals performed the bedside ultrasonographies. Sixty-nine percent were performed by two emergency physicians with registered diagnostic medical sonography credentialing and extensive experience in ultrasonography. Thirty-one percent were performed by four additional ED physicians credentialed in ultrasonography. Comparison of the less experienced with the more experienced sonographers demonstrated an increased sensitivity (94 vs. 83) and a decreased specificity (73 vs. 86). The only difference between the two groups was a lower percentage of female patients in the group with the less experienced sonographers.

DISCUSSION

Patients with symptoms consistent with renal colic underwent urinalysis, EUS, and CT scan during their evaluation in the ED. The overall sensitivity and specificity of EUS for the detection of hydronephrosis approximated that reported in the literature for traditional ultrasonography.[11–14] In fact, the resident-read CT scan (using the final read as the criterion standard) compared with EUS (using hydronephrosis on final CT reading as the criterion standard) revealed a greater sensitivity for EUS but less specificity. EUS is not perfect, and invariably some patients who

TABLE 3. Sensitivity and Specificity of EUS for Hydronephrosis in Patients with Hematuria

	CT (+)	CT (−)
EUS (+)	43	5
EUS (−)	6	28

Positive findings refer to the presence of hydronephrosis.

TABLE 5. Sensitivity and Specificity of Resident-read CT Scan

	Attending CT (+)	Attending CT (−)
Resident CT (+)	25	2
Resident CT (−)	5	24

Positive findings refer to radiographic diagnosis of renal colic.

undergo ultrasonography by an emergency physician will be sent home with the incorrect diagnosis, but this also happens when the emergency physician relies on less experienced radiologists reading CT scans.

The CT scan is considered the criterion standard in the imaging of the renal system for patients with suspected renal colic,[8] but it is not without its problems. It is more expensive and takes longer than EUS. EUS also has the benefit of a lack of radiation exposure. The greatest advantage of the CT scan is its ability to identify a wider range of alternative diagnoses, many of which have considerable morbidity.

In some EDs, young patients with symptoms consistent with a kidney stone and hematuria on urinalysis may never undergo imaging. However, prior studies demonstrate that urinalysis alone is not sensitive or specific enough to diagnose renal stones.[15–17] Deciding whether a patient requires a CT scan, EUS, or neither for the workup of suspected renal colic should be based on the accuracy of the test and the consequences of missing a potential diagnosis. The potential for disease states with a high degree of morbidity or mortality that masquerade as renal colic, such as abdominal aortic aneurysm, are higher in older patient populations.

There has been limited research on bedside ultrasonography or EUS in patients with flank pain. A study by a urologist found that limited bedside ultrasonography of the kidney was useful in establishing the diagnosis in patients with flank pain.[18] We are unaware of any previous studies looking at limited bedside ultrasonography in the evaluation of renal colic. There are many studies looking at ultrasonography performed in the radiology suite, but these imaging protocols differ from what is used in EUS.

Urinalysis, EUS, and CT scan all have a role in the diagnosis of renal stones. The results from EUS and urinalysis are rapid, while a CT scan can sometimes take hours in a busy ED. EUS of the kidneys shows very good sensitivity and specificity for diagnosing renal colic in patients presenting with flank pain and hematuria.

LIMITATIONS

One limitation of our study was the lack of randomization between EUS and CT scan. All patients underwent CT imaging because this is considered the criterion standard at our institution. We attempted to compensate for this by blinding the clinician to the EUS results and the ultrasonographer to the CT results.

The effect of hydration status on the ability of ultrasonography to detect hydronephrosis has been noted by a number of investigators.[19,20] Hydration status was not recorded for the patients in this study, and it is possible that the delay in obtaining the CT scan allowed increased hydration and hydronephrosis that was not present during the initial ultrasonography. This would cause a decrease in the sensitivity for EUS.

Although an attempt was made to capture the majority of patients presenting with renal colic, many patients may have been missed. One of the sonographers who enrolled patients into this trial was on call to come in and perform the ultrasonography, but this was not a routine occurrence and no patients presenting between midnight and 8 AM were enrolled unless the attending physician for that period was credentialed to perform renal ultrasonography.

Most of the ultrasonographies in this study were performed by individuals with extensive experience in EUS. It may be that less experienced sonographers will not be able to match these results. We have examined the results from the less experienced sonographers separately to demonstrate that these results are applicable to sonographers who have completed ultrasonography credentialing.

CONCLUSIONS

Emergency ultrasonography of the kidneys showed very good sensitivity and specificity for diagnosing renal colic in patients presenting with flank pain and hematuria.

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