Brief Report

Bedside renal ultrasound in the evaluation of suspected ureterolithiasis

James H. Moak MD, RDMSa,⁎, Michael S. Lyons MDb, Christopher J. Lindsell PhDb

aDepartment of Emergency Medicine, University of Virginia, Charlottesville, VA 22908, USA
bDepartment of Emergency Medicine, University of Cincinnati

Received 22 October 2010; revised 10 November 2010; accepted 14 November 2010

Abstract

Objective: To determine whether ultrasound changes emergency physicians’ estimated likelihood of acute ureterolithiasis in patients with flank pain.

Methods: This prospective, observational study enrolled patients awaiting computed tomographic (CT) scan for presumed renal colic. Using a visual analogue scale, treating physicians estimated the likelihood of acute ureterolithiasis based first on clinical findings and urinalysis, then after ultrasound, and finally after CT. A 20% change in estimated likelihood was considered clinically significant. Test characteristics of ultrasound for any ureteral stone and for those greater than or equal to 5 mm in size were determined.

Results: One hundred seven patients were enrolled. Sensitivity, specificity, and negative predictive value of ultrasound for stones observed on CT were 76.3% (95% confidence interval [CI], 59.4%-88.0%), 78.3% (95% CI, 66.4%-86.9%), and 85.7% (95% CI, 74.1%-92.9%) respectively, and for stones ≥5 mm 90.0% (95% CI, 54.1%-99.5%), 63.9% (95% CI, 53.4%-73.2%), and 98.4% (95% CI, 90.3%-99.9%), respectively. Ultrasound significantly impacted the estimated likelihood of disease in 33 of 107 cases (30.8%, 95% CI, 22.5%-40.6%). Computed tomography further significantly changed physicians’ impression of disease in 55 of 107 cases (51.4%, 95% CI, 41.6%-61.1%).

Conclusions: Bedside renal ultrasound had only a limited impact on the physicians’ clinical impression of patients with possible ureterolithiasis. The sensitivity of sonographic hydronephrosis was modest for detecting any ureteral stone, but much better for detecting a large stone. Further study is needed to define the precise role ultrasound should play in evaluating patients with suspected ureterolithiasis.

© 2012 Elsevier Inc. All rights reserved.

1. Introduction

Non-contrast computed tomography (CT) scanning of the abdomen and pelvis is accepted as the most accurate diagnostic modality for ureterolithiasis in emergency department (ED) patients [1-3]. However, CT is time-consuming, costly, and exposes patients to radiation. Bedside renal ultrasound is relatively sensitive and specific for unilateral hydronephrosis, and may be of diagnostic value to emergency physicians evaluating patients with possible ureterolithiasis [4-6]. Although renal ultrasound is a core component of training in emergency ultrasound [7], emergency physicians do not use this modality as commonly as other applications such as the Focused Assessment with...
2. Methods

This was a prospective, observational study involving a convenience sample of patients awaiting CT scan for possible ureterolithiasis between October 2006 and September 2008. The study was approved by the institutional review board. The study was conducted in a large, urban, academic ED with an annual census of about 85,000. Patients were eligible for inclusion if the treating physician had ordered a non-contrast CT scan of the abdomen and pelvis to evaluate for ureterolithiasis, but was unaware of the results and had not looked at the CT images. Patients were enrolled based on the availability of the investigators or a teaching sonographer who identified patients eligible for the study, but did not otherwise participate in the investigation. Patients who were younger than 18 years, in custody, pregnant, or unable to consent were excluded.

Treating physicians were asked to estimate the likelihood of acute ureterolithiasis as the cause of the patient’s symptoms at three points in time. Likelihood was estimated using a Visual Analog Scale from 0% to 100%. The initial estimation was based on clinical findings and urinalysis. Treating physicians were then asked to re-estimate clinical likelihood of disease after an ultrasound scan was performed, and finally after the results of the CT scan were known. The presence or absence of hydronephrosis on ultrasound and of hydronephrosis or ureteral or bladder stones on CT was recorded. Patient age, sex, presence or absence of hematuria, and prior history of ureterolithiasis were recorded.

In most instances, the treating physician was a resident who participated in ultrasound scanning with the attending of record. Twenty-four attending emergency physicians, credentialed in renal ultrasound with at least 25 prior scans, performed and interpreted all sonographic scans. Sonographers selected the scanning plane and probe orientation at their own discretion. No attempt was made to document or control for the hydration status of the patients. The ultrasound examination could be performed before or after CT scanning as long as the CT results were not known to the sonographers. All sonographic studies were performed on a Sonosite Titan (Bothell, WA) ultrasound machine using either a 2 to 4 MHz 15 mm or a 2 to 5 MHz 60 mm curved array transducer. All CT scans were done with a General Electric Lightspeed Ultra Computed Tomography Scanner Eight Slice (Waukesha, Wis) and were read by radiology residents with subsequent attending review.

The primary outcome measure was the treating physician’s estimated likelihood of acute ureterolithiasis before and after sonographic scanning, and after CT scanning. A clinically relevant change in estimated likelihood of disease was specified a priori as 20%. Secondary outcome measures were the test characteristics of hydronephrosis for any ureteral or bladder stone and for a ureteral stone greater than or equal to 5 mm in size. The patient population was characterized using descriptive statistics (means and standard deviations or frequencies and percentages as appropriate), and diagnostic test statistics for ultrasound were computed using CT findings as the criterion standard. Confidence intervals for proportions were estimated using the score method. The mean and 95% confidence intervals (CIs) of the mean estimated likelihood of disease were computed for each time point, and the change in estimated likelihood of disease was computed with 95% CIs. Analyses were conducted using SPSS v16.0 (SPSS Inc, Chicago, Ill) and Microsoft Excel (Microsoft Corporation, Redmond, Wash).

3. Results

One hundred seven patients were enrolled in the study. Mean age was 38 years (SD 14 years); 58.9% were men; 48.6% had a history of prior stones; 75.7% had hematuria. Overall, 35.5% of patients in the study were found to have bladder or ureteral stones on CT. The treating physician who assessed disease likelihood was a resident in 95 cases (88.8%) and an attending in 12 cases (11.2%). The primary investigator was the attending of record for 43.0% of the subjects. Ultrasound changed the estimated likelihood of disease by more than 20% in 33 of 107 cases (30.8%, 95% CI, 22.5% to 40.6%). Among those, the shift was toward the final impression in 69.7% and away from it in 30.3%. After ultrasound, CT scan changed physicians’ impression of disease by more than 20% in 55 of 107 cases (51.4%, 95% CI, 41.6%-61.1%). The test performance of sonographic hydronephrosis for any ureteral or bladder stone and for stones greater than or equal to 5 mm is shown in Table 1. There was no statistically significant difference in the test characteristics of ultrasound performed by the primary investigator versus other attending physicians.

4. Discussion

Prior studies have demonstrated that sonographic hydronephrosis as judged by emergency physicians correlates
relatively well with hydronephrosis on intravenous pyelogram [5] and CT scan [4,9], and that the degree of sonographic hydronephrosis is related to stone size [6]. The purpose of this investigation was to determine the extent to which this sonographic finding impacts physicians’ perceived likelihood of acute ureterolithiasis. Secondarily, our study sought to determine the test characteristics of bedside ultrasound for detecting any ureteral or bladder stone and for detecting a stone greater than or equal to 5 mm in size. Our results reveal that bedside renal ultrasound had a limited impact on physicians’ assessment of disease likelihood. A significant change in the physician’s clinical impression occurred in less than a third of cases. Among these, the direction of change, towards greater or lesser likelihood, was discordant with the post-CT assessment 30% of the time. In our study the sensitivity of hydronephrosis for detecting any ureteral or bladder stone, 76%, was at the lower end of the range reported by other investigators (72%-87%) in studies using hydronephrosis on CT or intravenous pyelogram as the criterion standard [4,5,9]. In this investigation, the sensitivity of ultrasound for large stones, 90%, was comparable to that of a larger, retrospective study also undertaken in the ED setting [6].

An explanation for the limited reliance on sonographic findings in our study, and for the low utilization rates of renal ultrasound among emergency physicians in general [8], may be that clinicians are reluctant to use hydronephrosis as a proxy for the presence or absence of a ureteral stone. Arguably, the sensitivity and specificity of ultrasound is not high enough to provide clinicians with the accuracy they desire in a diagnostic test.

Computed tomography is superior to ultrasound in demonstrating ureterolithiasis [1-3], but this greater degree of accuracy may not always be necessary. Whether to perform a highly accurate test depends upon a number of factors including the consequences of not diagnosing the condition with less accurate means and the test’s potential for harm. The necessity of determining the precise size and location of a stone has not reached consensus. Ureterolithiasis is usually a self-limited disease that can be managed conservatively [10]. Spontaneous passage of a stone is likely when stone size is less than 5 mm [11]. Urgent intervention is rarely necessary. The complication rate from conservative management has been observed to be as low as 7% when symptoms last less than 4 weeks [12]. Cumulative radiation exposure to patients from CT scanning is significant [13-15] and likely to be a public health problem in the future [16]. Patients with a history of ureterolithiasis appear to be among those at greatest risk for excessive radiation from diagnostic imaging [17].

Although ultrasound had only modest sensitivity for detecting ureteral stones in this study, its substantially higher sensitivity for detecting large stones suggests that this modality should play some role in the evaluation of possible ureterolithiasis. Kartal and colleagues [18] prospectively evaluated an algorithm in which patients with hematuria and hydronephrosis were spared further testing; the authors concluded that ultrasound can be safely employed using this diagnostic approach. Catalano et al suggested that CT may be avoided in patients with no signs of ureterolithiasis on ultrasound and plain radiography [19]. In the selective CT arm of their study, hydronephrosis was present in all patients who required intervention. Given its high accuracy rate, CT should continue to serve as the more definitive test in the evaluation of ureterolithiasis, but an expanded role for ultrasound in limiting CT utilization appears warranted. Further studies are needed to delineate which patients, such as the elderly, first time presenters, or those with possible appendicitis, should undergo CT and which ones may be evaluated with ultrasound. Computed tomography may be able to be avoided, for instance, in patients with a prior history of ureterolithiasis and no sonographic hydronephrosis if other concerning processes can be ruled out clinically. Future research should be undertaken to develop a decision rule that would use sonographic and clinical findings to predict the likelihood of identifying a ureteral stone on CT.

Our results must be interpreted in light of several limitations. We were surprised by the limited impact ultrasound had on physicians’ estimated likelihood of

<table>
<thead>
<tr>
<th></th>
<th>CT positive for any stone</th>
<th>CT negative for any stone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydronephrosis</td>
<td>29</td>
<td>15</td>
</tr>
<tr>
<td>No hydronephrosis</td>
<td>9</td>
<td>54</td>
</tr>
<tr>
<td>Sensitivity = 76.3% (95% CI, 59.4-88.0), specificity = 78.3% (95% CI, 66.4-86.9), PPV = 65.9% (95% CI, 50.0-79.1), NPV = 85.7% (95% CI, 74.1-92.9)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>CT positive for stone ≥5 mm</th>
<th>CT negative for stone ≥5 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydronephrosis</td>
<td>9</td>
<td>35</td>
</tr>
<tr>
<td>No hydronephrosis</td>
<td>1</td>
<td>62</td>
</tr>
<tr>
<td>Sensitivity = 90.0% (95% CI, 54.1-99.5), specificity = 63.9% (95% CI, 53.4-73.2), PPV = 20.4% (95% CI, 10.3-35.8), NPV = 98.4% (95% CI, 90.3-99.9)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PPV, positive predictive value; NPV, negative predictive value.
ureterolithiasis. One possible explanation for this finding may have stemmed from our methodology. We arbitrarily selected a 20% change in likelihood as clinically significant. Using this a priori definition for significance, any initial likelihood for ureterolithiasis greater than 80% could not have shifted towards a significantly higher likelihood after ultrasound. In addition, although an attending physician credentialed in renal ultrasound was present for all scans, the treating physician who assessed disease likelihood was a resident in the large majority of cases. At our institution, upper-level residents (ie, second to fourth year) are given latitude to initiate diagnostic measures including ordering CT scans before an attending has had an opportunity to examine the patient. Our choice to query the physician most directly involved with the care of the patient regardless of level of training was intended to maximize the surveyed physician’s familiarity with the details of the patient’s presentation albeit at the expense of clinical experience. Our study may have generated different results had we chosen to survey attending physicians only.

Another limitation of this investigation is that our prevalence of ureterolithiasis, 35.5%, was lower than in other studies [4,5]. A lower disease prevalence would tend to augment the negative predictive value of ultrasound. Our study may have been susceptible to selection bias as it enrolled a convenience sample of patients awaiting CT, rather than a consecutive sample. In addition, a large proportion of patients, 43%, had sonograms performed by the primary investigator who has more experience in ultrasound than other attendings. This may have biased the results towards a better performance for ultrasound. Finally, this study did not seek to incorporate ureteral jets into the sonographic examination. Doing so might have improved the performance of ultrasound and augmented its role in the diagnostic assessment.

In conclusion, our study reveals that bedside renal ultrasound had only a limited impact on physicians’ clinical assessment of patients with suspected ureterolithiasis. This finding is commensurate with the modest overall sensitivity of ultrasound for detecting a ureteral stone. The sensitivity of ultrasound for detecting a large stone, however, was much better. Further studies are needed to define the precise role of bedside ultrasound in the diagnostic evaluation of patients with possible renal colic.

**Acknowledgment**

The authors wish to thank Pattie Smith, RDMS, for her assistance in enrolling patients in this study and Tina Choudhri, BS, for her assistance with data entry.

**References**


