Brief Report

Can the degree of hydronephrosis on ultrasound predict kidney stone size?☆

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Received 7 April 2009; revised 10 June 2009; accepted 10 June 2009

Abstract

Objective: The aim of the study was to determine if the degree of hydronephrosis on focused emergency renal ultrasound correlates with kidney stone size on computed tomography.

Methods: A retrospective study was performed on all adult patients in the emergency department who had a focused emergency renal ultrasound and ureterolithiasis on noncontrast computed tomography. Severity of hydronephrosis was determined by the performing physician. Ureteral stone size was grouped into 5 mm or less and larger than 5 mm based on likelihood of spontaneous passage.

Results: One hundred seventy-seven ultrasound scans were performed on patients with ureteral calculi. When dichotomized using test characteristic analysis, patients with none or mild hydronephrosis (72.9%) were less likely to have ureteral calculi larger than 5 mm than those with moderate or severe hydronephrosis (12.4% vs 35.4%; \( P < .001 \)) with a negative predictive value of 0.876 (95% confidence interval, 0.803-0.925).

Conclusion: Patients with less severe hydronephrosis were less likely to have larger ureteral calculi.

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1. Introduction

Symptomatic renal colic is a common complaint presenting to the emergency department (ED). An estimated 5% to 15% of the population will have a kidney stone during their lifetime with an ED use rate of 126 to 226 per 100,000 visits [1,2]. Diagnosis of renal colic is often made solely on the basis of history, physical examination, and urinalysis, especially in patients presenting with typical complaints of flank pain radiating to the ipsilateral groin, costovertebral angle tenderness, and hematuria [2]. Multiple imaging modalities, including intravenous pyelography, noncontrast computed tomography (CT), and ultrasound, have been used to diagnose renal colic [3-11]. In many EDs, noncontrast CT has become the dominant imaging modality because it allows determination of stone size and location, degree of hydronephrosis, and evaluation of other pathophysiologic processes that may masquerade as renal colic [2,10-12]. Despite the advantages of CT, drawbacks include cost, accessibility, availability, increased length of ED stay, and risks from ionizing radiation [6,13-15].

Focused emergency ultrasound is advantageous because it is nonionizing, inexpensive, and can be performed at the patient’s bedside thereby becoming an integral part of the physical examination [16,17]. Multiple studies using ultrasound in the evaluation of renal colic have demonstrated that
ultrasound is accurate at detecting hydronephrosis and that emergency physicians can accurately determine the presence and degree of hydronephrosis but that ultrasound has limited use in directly detecting calculi or determining stone location [4-9]. Furthermore, the presence of hydronephrosis on focused emergency ultrasound and hematuria on urinalysis is accurate in detecting and sufficient for diagnosing renal colic [18,19]. Despite ultrasound not being as accurate as other modalities in determining stone location, stone size is a more important determinant of likelihood of stone passage and clinical outcome. Ureteral calculi less than 5 mm are likely to pass spontaneously regardless of location in the ureter, whereas those greater than 5 mm have a decreased likelihood of spontaneous passage or an increased likelihood of need for eventual urologic intervention [20-22]. For larger stones, current guidelines recommend a trial of passage with medical expulsion therapy for calculi between 5 and 10 mm; stones larger than 10 mm will require surgical removal in most cases [21].

The objective of our study is to determine if the degree of hydronephrosis on focused emergency renal ultrasound correlates with ureteral calculi size on noncontrast CT and to ascertain if these results would allow for prediction of stone size.

2. Methods

We performed a retrospective chart review using an emergency ultrasound database containing the findings and interpretations of the focused emergency ultrasounds performed in the ED of an academic medical center with an annual census of 70,000. All consecutive adult patients (≥18 years) in the database who had a complete focused emergency renal ultrasound performed and a noncontrast CT documenting ureterolithiasis for a 4-year period from March 2004 to March 2008 were enrolled. Approval for review with a waiver of informed consent was obtained from the institutional review board.

Ultrasounds were performed in the ED by emergency medicine resident or attending physicians using either a GE Logiq 5 ultrasound machine with a 3.5C 2 to 5-MHz curvilinear or 3S 1.5 to 3.5-MHz phased array ultrasound probe (General Electric, Fairfield, Conn) or a SonoSite MicroMaxx ultrasound machine with a C60e 2 to 5-MHz curvilinear or P17 1 to 5-MHz phased array ultrasound probe (SonoSite, Bothell, Wash). All ultrasound examinations were recorded onto S-VHS videotape or onto DVD-R for video quality assurance review. The impression of the performing clinician was concurrently entered into the ultrasound database.

_Hydronephrosis_ was defined as none, mild, moderate, or severe according to standard definitions. _Mild hydronephrosis_ was defined as enlargement of the calices with preservation of the renal papillae, _moderate hydronephrosis_ was defined as rounding of the calices with obliteration of the renal papillae, and _severe hydronephrosis_ was defined as caliceal ballooning with cortical thinning [17]. All ultrasound examinations were subsequently reviewed for quality assurance (QA) by an emergency ultrasound fellowship-trained emergency physician and an independent nonblinded quantification of the degree of hydronephrosis was made using the above standardized definitions. Ureteral stone size was extracted from the CT report in the medical record after QA review.

The performing physician’s interpretation of the degree of hydronephrosis, the degree of hydronephrosis on QA review, and the ureteral stone size on CT were entered into SPSS (version 16.0; SPSS Inc, Chicago, Ill) and analyzed using χ² testing. Ureteral stone size was stratified into 2 groups, those 5 mm or smaller and those larger than 5 mm, based on the likelihood of successfully spontaneous stone passage, and test characteristics were calculated [20-22].

3. Results

One hundred seventy-seven ultrasounds were performed in the ED on patients who had confirmed ureteral calculi on CT. Of these patients, 120 (67.8%) were male, and the mean age was 48.1 years old (range, 18-89 years old). One hundred forty-four patients (81.4%) had ureteral calculi 5 mm or smaller, and 33 patients (18.6%) had ureteral calculi larger than 5 mm. For the ultrasounds performed, there was very good interobserver agreement between the degree of hydronephrosis as determined by the performing emergency physician and QA review.

### Table 1

<table>
<thead>
<tr>
<th>Emergency physician hydronephrosis</th>
<th>QA hydronephrosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>None</td>
<td>22</td>
</tr>
<tr>
<td>Mild</td>
<td>7</td>
</tr>
<tr>
<td>Moderate</td>
<td>0</td>
</tr>
<tr>
<td>Severe</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
</tr>
</tbody>
</table>

κ = 0.847 (95% confidence interval, 0.777-0.918).

### Table 2

<table>
<thead>
<tr>
<th>Hydronephrosis</th>
<th>Calculi ≤ 5 mm</th>
<th>Calculi &gt; 5 mm</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>25</td>
<td>3</td>
<td>28</td>
</tr>
<tr>
<td>Mild</td>
<td>88</td>
<td>13</td>
<td>101</td>
</tr>
<tr>
<td>Moderate</td>
<td>30</td>
<td>13</td>
<td>43</td>
</tr>
<tr>
<td>Severe</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>144</td>
<td>33</td>
<td>177</td>
</tr>
</tbody>
</table>

*P < .001.*
physician and the QA review (Table 1), with $\kappa = 0.847$ (95% confidence interval, 0.777-0.918).

Increasing degree of hydronephrosis on ultrasound was associated with an increasing proportion of ureteral calculi larger than 5 mm as shown in Table 2 ($P < .001$). Analysis of the test characteristics demonstrated best discrimination by dichotomizing the degree of hydronephrosis into none or mild hydronephrosis (less severe hydronephrosis) and moderate or severe hydronephrosis (more severe). When the degree of hydronephrosis was collapsed into these 2 categories, 129 patients (72.9%) had less severe hydronephrosis and 48 patients (27.1%) had more severe hydronephrosis. One hundred thirteen patients (87.6%) with less severe hydronephrosis had ureteral calculi 5 mm or smaller. None of the 16 patients with less severe hydronephrosis and ureteral calculi larger than 5 mm had stones larger than 10 mm, whereas 6 (35.3%) of the 17 patients with more severe hydronephrosis and larger ureteral calculi had stones larger than 10 mm. Of the patients with calculi 5 mm or smaller, 113 (78.5%) had less severe hydronephrosis; 17 patients (51.5%) with calculi larger than 5 mm had more severe hydronephrosis.

As shown in Table 3, patients with none or mild hydronephrosis were less likely to have larger ureteral calculi than those with moderate or severe hydronephrosis ($12.4\%$ vs $35.4\%$; $P < .001$). This dichotomization had a sensitivity of 0.515 (95% confidence interval, 0.339-0.688), a specificity of 0.785 (95% confidence interval, 0.707-0.847), a positive predictive value of 0.354 (95% confidence interval, 0.226-0.506), and a negative predictive value of 0.876 (95% confidence interval, 0.804-0.925).

### Table 3

<table>
<thead>
<tr>
<th>Hydronephrosis categories vs ureteral calculi size</th>
<th>Calculi ≤ 5 mm</th>
<th>Calculi &gt; 5 mm</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>None or mild</td>
<td>113</td>
<td>16</td>
<td>129</td>
</tr>
<tr>
<td>Moderate or severe</td>
<td>31</td>
<td>17</td>
<td>48</td>
</tr>
<tr>
<td>Total</td>
<td>144</td>
<td>33</td>
<td>177</td>
</tr>
</tbody>
</table>

$P < .001$.

4. Discussion

Our study demonstrated a relationship between the degree of hydronephrosis found on focused emergency ultrasound and ureteral stone size on CT. We observed that increasing degree of hydronephrosis on ultrasound was associated with an increasing proportion of ureteral calculi larger than 5 mm. Most patients in this study had less severe (none or mild) hydronephrosis; these patients were less likely to have larger ureteral calculi. The specificity of an ED ultrasound demonstrating none or mild hydronephrosis is 78.5% with a negative predictive value to predict a ureteral calculus sized 5 mm or less of 87.6%. Because calculi less than 5 mm are likely to pass spontaneously, if a CT were not performed on all patients with none or mild hydronephrosis, the need for CT would be decreased by 73% at the risk of missing only 16 patients (9%) with calculi larger than 5 mm. Although this is not insignificant, all had calculi smaller than 10 mm making them eligible for medical expulsion therapy; none had calculi larger than 10 mm, the size at which stones will likely require urologic intervention [20-21]. The sensitivity for detection of stones larger than 5 mm is poor. Of the patients with more severe hydronephrosis, over one third had calculi larger than 5 mm; of those, 35% had calculi larger than 10 mm. Although the poor sensitivity and the small number of patients with larger stones, especially those larger than 10 mm, make it difficult to draw conclusions, current guidelines suggest a trial of passage with medical expulsion therapy for stones sized 5 to 10 mm [21]. This suggests that in the appropriate clinical setting, patients with less severe hydronephrosis on ED ultrasound might be candidates for discharge with a trial of passage with medical expulsion therapy and outpatient urologic follow-up, whereas those with more severe hydronephrosis should have further evaluation to determine stone size and the need for possible emergent urologic consultation or intervention vs discharge with medical expulsion therapy and urgent urologic follow-up.

This study suggests that bedside focused emergency ultrasound may be a method to screen patients and use CT scans more prudently because most patients in our study had neither larger kidney stones nor more severe hydronephrosis. Avoiding unnecessary CT scans could have a significant impact in the ED and on public heath. Emergency department throughput could be significantly enhanced; one study showed an average delay of 147 minutes between the performance of the focused emergency ultrasound and the CT scan [9]. Concerns have been raised about the risk of cancer from exposure to ionizing radiation from CT scans, and recommendations have been made to limit CT scanning to that which is medically justified [14]. Because the recurrence of renal calculi in patients may be as high as 50%, were these patients to have multiple CT scans, the cumulative dose of radiation over their lifetimes becomes critically important [1,14,15]. This study suggests that in an appropriate clinical setting, such as for a patient with symptoms of recurrent renal colic and in whom alternative serious pathologic condition can be ruled out, focused emergency renal ultrasound may be able to obviate the need for CT scanning in the ED. Further study is needed for evaluation and validation of such a diagnostic paradigm.

The major limitations of this study are due to the retrospective nature of the study. Although all consecutive patients identified in the ultrasound database whom had a focused emergency renal ultrasound performed and a CT scan demonstrating ureterolithiasis were included, there were likely other patients presenting with renal colic who either had a CT but no ultrasound or who had no imaging performed in the ED, thereby, raising potential selection bias.
It is unknown if the ultrasounds were performed before the CT or if the performing physician had access to the CT results before performing the ultrasound. The QA review, however, was performed before extracting the CT results from the medical record, and the agreement between the performing physician’s interpretation and the independent QA review was very good, therefore, making it unlikely that that possible nonblinding of the performing physician to the CT results contributed significant bias. We were unable to control for degree of hydration, and we were also unable to determine if the duration of symptoms (as a surrogate for duration of ureteral obstruction) correlated with the degree of hydronephrosis. Furthermore, this study is limited in that we are studying a group of patients with a known diagnosis of ureterolithiasis on CT rather than all patients coming to the ED with a presentation suggestive of renal colic. Variation in presenting complaints such as location or intensity of pain, results of other ED testing such as urinalysis demonstrating hematuria, or in ED management, patient course, and disposition is unknown. Finally, we were unable to follow patient outcomes such as the rate of and time to successful passage of calculi to determine the effects of the degree of hydronephrosis or of stone size.

In conclusion, our results demonstrate a relationship between the degree of hydronephrosis as determined by emergency physicians on focused emergency ultrasound and ureteral calculi size; patients with less severe hydronephrosis were less likely to have larger ureteral calculi. This suggests that ultrasound can help identify many, but not all, patients who are at lower risk for having larger ureteral calculi.

Acknowledgments

Statistical analysis was assisted by Cristina Sison, PhD, Senior Research Statistician, Feinstein Institute for Medical Research. Alexander Tsukerman, MD, Department of Emergency Medicine, Long Island Jewish Medical Center performed data entry.

References