Routine Ultrasonic Assessment of the Middle Third of the Ureter: Prompt Diagnosis of Significant Calculi with Minimal Radiation Exposure

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Abstract

Purposes
To verify the value of ultrasound in the diagnosis of significant calculi in the middle third of the ureter in terms of difficulty and time consumption.

Methods
This study was a retrospective chart review of patients who had received extracorporeal shock wave lithotripsy for calculi in the middle third of the ureter over a period of 36 months from July 2006 to June 2009. Clinical data and reports of imaging studies were collected for analysis. Primary ultrasound with routine assessment of the middle third of the ureter was performed in 63 cases. Extra time spent in detection of calculi was calculated from the records of the sonograms. Statistical analysis was performed to determine the factors which may have influenced the time spent in detection of calculi.

Results
Routine ultrasonic assessment of the middle third of the ureter detected 90% (57/63) of significant calculi. The extra time spent in detection of calculi was 71.98 seconds on average. Most of the significant calculi were detected in two minutes (85.7%). Extra time spent in detection of calculi was significantly less in patients with high grade hydroureter.

Conclusions
With routine ultrasonic assessment of the middle third of the ureter, most patients with significant calculi can be diagnosed promptly. Excretory urography and CT can be avoided in most patients and radiation exposure can be reduced to a minimum.

Keywords: ultrasound, ultrasonography, ureter, ureteral calculi
Introduction

The diagnosis of ureteral calculi with ultrasound by direct detection of intraluminal hyperechoic foci has been thought to be time consuming and less sensitive than other methods. Obese patients with small calculi and calculi situated in the middle third of the ureter were considered limitations on the use of ultrasonic detection [1,2]. For these situations, unenhanced computerized tomography yields the highest sensitivity [3,4] but is accompanied by exposure to a high dose of radiation.

Due to the widespread utilization of CT, the level of exposure to radiation in the general population is rapidly increasing [5,6]. Brenner called attention to the fact that the risk of radiation related cancer may leap 4 fold in the near future and emphasized the need for the reduction of CT before it becomes a public health issue [5]. Several efforts have been made to reduce the dose of radiation related to CT. Some authors have reported good results in the detection of urolithiasis with low dose CT [7-9]; however, for patients with urolithiasis, the main concern is the overall exposure to radiation during surgical interventions and repetitive radiologic imaging for both acute episodes and lifelong follow-up [10]. John et al advocated monitoring and reduction of radiation exposure for all patients presenting with urolithiasis [11]. Nadler suggested that both urologists and radiologists have a responsibility to make greater efforts to reduce the radiation exposure to patients with urolithiasis and “KUB and ultrasound need to be used more for following stones” [12].

We have performed extracorporeal shock wave lithotripsy (SWL) for ureteral calculi with ultrasound localization for more than 10 years and have experience in the ultrasonic depiction of ureteral calculi. Over the last 5 years, we have determined that the diagnosis of calculi in the middle third of the ureter with direct ultrasonic visualization of intraluminal hyperechoic foci is not as difficult or as time consuming as previously thought. With routine ultrasonic assessment of the middle third of the ureter, most surgically significant calculi can be diagnosed without the need for computerized tomography or excretory urography.

Patients and Methods

This study was a retrospective chart review of patients who had received extracorporeal shock wave lithotripsy (SWL) for calculi in the middle third of the ureter during the 36 month period from July 2006 to June 2009. A total of 76 patients (81 sessions) were enrolled. Clinical data, imaging studies, and records of SWL treatment were collected for analysis. SWL is the first line treatment for surgically significant calculi in the middle third of the ureter in our department. Ureteroscopic surgery is reserved for patients with severe infection or when SWL treatment has failed.

The primary reports of plain radiographs were positive for calculi in 14.8% of patients, and a second inspection of these was performed by a senior radiologist and two urologists.

Initial sonography of the urinary tract was performed in the outpatient clinic with routine assessment of the middle third of the ureter on the obstructed side. The procedure for detection of a suspected calculus in the middle third of the ureter begins with renosonographic assessment of the degree of hydronephrosis; the ultrasound probe is then placed on the lower abdomen to identify the common iliac vessels. Overlying bowel gas can usually be compressed away in a few seconds after applying the ultrasound probe. Typically, there is a segment of dilated ureter cephalic to (Figure 1a) or crossing the iliac vessels (Figure 1b, 1c). A ureteral calculus could then be visualized as an intraluminal hyperechoic focus over the distal end of the dilated ureteral segment (Figure 1a, 1b, 1d). Identification of the iliac vessels is the priority since the fastest way to find the ureter and calculi in this sonographically noisy area is by using the iliac vessels as a reference.
Extra time spent in ultrasonic detection of ureteral calculi was calculated by subtracting the time record of the first picture showing ureteral calculi from the preceding picture (kidney or urinary bladder). Stone size was determined by the longitudinal length of the calculi measured electronically either on plain radiograph or on sonogram.

High grade hydroureter was defined as a persistently dilated proximal ureter more than 5mm in diameter.

The relationship between findings on plain radiography and findings on sonogram were assessed by using the Pearson chi-square test. Factors which influenced the extra time spent in detection of calculi were evaluated by the t-test for Equality of Means.

Results

From July 2006 to June 2009, a total of 76 patients (55 males and 21 females) with a mean age of 49.0 (Range 23-79) received 81 sessions of extracorporeal shock wave lithotripsy (SWL) for calculi in the middle third of the ureter. Clinical data are shown in Table 1.

Primary reports of plain radiographs were positive for calculi in 12, equivocal in 10, and negative in 59. Reports of the second inspection of plain radiographs were positive for calculi in 28, equivocal in 26, and negative in 27. Focusing on the middle third of the ureter, reports turned positive in 40 % (4/10) of primary equivocal radiographs and 20.3% (12/59) of primary negative radiographs, even though the overall positive rate was still lower than 50 % (34.5%, 28/81) (Table 2).
Initial ultrasound of the upper urinary tract was performed in the outpatient clinic with routine assessment of the middle third of the ureter in 63 cases. Calculi were detected in 57 and were missed in 6. Initial ultrasound detected 90.4% of significant calculi in the middle third of the ureter. There were 18 cases without initial ultrasound assessment of the middle third of the ureter; plain radiographs were positive for calculi in 10 and equivocal in 4 (Table 2). All calculi were detected with ultrasound before ESWL treatment.

The extra time spent in detection of calculi in the middle third of the ureter was 24 to 260 seconds in 57 cases (≤ 60 seconds in 49.2%, 60-120 seconds in 36.5%, >120 seconds in 14.2%), and the average was 71.98 seconds. Most (85.7% 54/63) of the significant calculi were detected in two minutes.

Every patient had a second ultrasonic examination performed before SWL treatment. Sonograms showed high grade hydronephrosis in 46 and low grade hydronephrosis in 35, and high grade hydroureter in 45 and low grade hydroureter in 36 (Table 2).

Table 2. Reports of findings on radiograph and sonogram

<table>
<thead>
<tr>
<th>Stone size</th>
<th>Negative</th>
<th>Equivocal</th>
<th>Positive</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 5mm</td>
<td>21</td>
<td>12</td>
<td>0</td>
<td>81</td>
</tr>
<tr>
<td>&gt; 5mm</td>
<td>15</td>
<td>6</td>
<td>25</td>
<td>46</td>
</tr>
</tbody>
</table>

Table 3. Stone size and findings on radiograph and sonogram

<table>
<thead>
<tr>
<th>Stone size</th>
<th>KUB finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 5mm</td>
<td>12</td>
</tr>
<tr>
<td>&gt; 5mm</td>
<td>15</td>
</tr>
</tbody>
</table>

Statistics analysis:

The positive rate for detection of calculi in the middle third of the ureter on plain radiographs was low (34.5%). Findings on plain radiographs were significantly related to the size of the stone (p=0.016). The degrees of hydronephrosis and hydroureter were significantly related to stone size (p=0.001, 0.001) (Table 3) but not related to the findings on plain radiographs (p=0.708, 0.436) (Table 2).

Extra time spent in detection of calculi in the middle third of the ureter was less in patients who had larger calculi, high grade hydronephrosis, high grade hydroureter, or BMI less than 27. The time difference between high grade and low grade hydroureter (58.3±24.0 vs. 90.7±10.9 seconds) was statistically significant (p=0.009). The time difference between larger calculi and smaller calculi (63.9±4.3 vs. 99.3±18.1 seconds) was only marginally significant (p=0.078) (Figure 2).

There were no significant differences in terms of grade of hydronephrosis (p=0.124), BMI (<27 vs. >27:...
Figure 2. Extra time spent in the detection of calculi

Discussion

Good imaging is the cornerstone for the successful treatment of ureteral calculi. In this study, 65.4% of patients with significant calculi in the middle third of the ureter had been reported to be negative or equivocal on the initial reading of their plain radiographs.

Imaging modalities for the definitive diagnosis of ureteral calculi may include excretory urography, the combination of plain radiography and ultrasonography, and unenhanced helical computerized tomography.

Excretory urography had been the main modality for the diagnosis of ureteral calculi; however, it is rarely utilized now because it is time consuming and there are potential adverse effects including contrast agent induced renal function deterioration and serious allergic reactions. [3] The diagnosis of ureteral calculi has been largely replaced by unenhanced helical CT or the combination of plain radiography and ultrasonography.

Unenhanced helical CT has excellent sensitivity and specificity in the detection of urolithiasis. Over the last decade, it has been widely accepted as the gold standard for detecting urinary tract calculi; [4,13,14] however, its high radiation dose created concern about expanding its use on patients with urolithiasis. Katz et al. pointed out that patients with nephrolithiasis are at greater risk for repetitive CT studies [10]. Ferrandino and Bagrodia's study showed that 20% of patients with an acute stone event received a substantial dose of radiation (mostly from CT scans) within a year of the event. When diagnostic and intraoperative exposure (from fluoroscopy) is combined, the dose of radiation may exceed 50mSv (the recommended yearly dose limit for occupational exposure by the International Commission on Radiological Protection). They suggested that alternative methods of imaging should be considered provided that they do not compromise patient care [15].

Ultrasound is sensitive for the detection of hydronephrosis [1-3], but its sensitivity in the detection of ureteral calculi is much lower than that of unenhanced helical CT [4]. Catalano et al. [16] and Ripolles et al. [17] showed that most significant ureteral calculi can be diagnosed with the combination of plain radiography and ultrasonography. Tracing down from the renal pelvis, most significant calculi in the upper third of the ureter are
readily diagnosed with ultrasound (Figure 3). Calculi in the lower third can be visualized after the urinary bladder is distended [1,18] (Figure 4). Calculi in the middle third of the ureter are difficult to detect by ultrasound, [1,18,19] and excretory urography or CT is usually required. This means that exposure to high dose radiation is inevitable for most patients with calculi in the middle third of the ureter.

For 5 years, we have performed ultrasonography with routine assessment of the middle third of ureters of hydronephrotic kidneys. Using iliac vessels as a reference makes the depiction of calculi in the middle third of the ureter simple and results in a higher rate of detection. Initial ultrasound detected 90.4% of our surgically significant calculi. The extra time spent in detection of calculi was short, 71.98 seconds on average. About half of the significant calculi were promptly visualized with ultrasound (49.2% in less than 1 minute). Most significant middle third calculi were detected in two minutes (85.7%). Ultrasonic assessment of the middle third of the ureter adds only a modest load to the ultrasound examination.

Extra time spent in the detection of calculi was less in high grade hydroureter and reached statistical significance (p=0.009); time was less in detecting larger calculi but was of only marginal significance (p=0.078). Our case number was relatively small and we were unable to show the significance of other factors that might have influenced the detection time.

In our experience, factors which may have an impact on the ultrasonic detection of ureteral calculi include smaller calculi, a minimally-dilated ureter, obesity, copious bowel gas, tortuous iliac vessels, and an unusual course of the ureter. Smaller calculi with a minimally-dilated ureter are of less significance because spontaneous passage is expected [16,17,20]. Obesity is an important detrimental factor, but there were few obese patients in our population. Bowel gas is not a major problem and can be compressed away by the ultrasound probe in a few seconds. Because the middle third of the ureter lies closer to the anterior abdominal wall, there are fewer bowel loops interposed between the ureter and the anterior abdominal wall. Tortuous iliac vessels and an unusual course of the ureter are rare.

Through more intense use of ultrasound and routine assessment of the middle third of the ureter, our results showed that most patients with significant calculi in the middle third of the ureter can be diagnosed promptly with
ultrasound. Excretory urography and CT can be avoided in most patients and exposure to radiation can be reduced to a minimum.

It is well known that ultrasound has a valuable role in the serial evaluation of chronic stone formers [21]. For practicing urologists, getting information about hydronephrosis from time to time is very important in the management of ureteral calculi. Ultrasound is more practical than CT for the serial follow up of hydronephrosis.

Notably, some authors report that ultrasound can also be used as an initial diagnostic tool in patients with suspected ureterolithiasis [22-24]. To the best of our understanding, no previous paper has focused on the ultrasonic diagnosis of calculi in the middle third of the ureter. Our study showed that ultrasound can be used as the main initial diagnostic modality for patients with these calculi. We agree with the opinion of Ripellés et al that "US can achieve a high rate of diagnosis with similar practical value as CT. CT should be reserved for complicated cases" [18].

"Sonography is an operator-dependant technique requiring expertise, experience, and adequate imaging equipment for satisfactory results" [21]. There are different limitations for the ultrasonic depiction of ureteral calculi in individual hospitals; however, in this era of expanding application of CT and increasing concerns about CT induced malignancy [25,26], ultrasonography may still have an important position in the algorithm for the diagnosis and follow up of ureteral calculi.

Conclusions

Ultrasonic detection of calculi in the middle third of the ureter is not difficult and not time consuming. With routine ultrasonic assessment of the middle third of the ureter, most patients with significant calculi can be diagnosed promptly. Excretory urography and computerized tomography can be avoided in most patients and exposure to radiation reduced to a minimum.

Acknowledgement

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References
超音波常規檢視中段輸尿管：
快速診斷中段輸尿管結石及大幅減少輻射暴露

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摘要

目的

驗證超音波檢查中段輸尿管結石的診斷價值。超音波檢查中段輸尿管結石被認為是困難和費時的。然而，我們發現如果我們作常規超音波檢查中段輸尿管，這將有不同的結果。

方法

本研究是蒐集中段輸尿管結石接受體外震波碎石的患者，進行回顧性研究。收集臨床資料和影像學報告進行分析，最初的超音波檢查含常規檢查中段輸尿管。在36個月中（從2006年7月至2009年6月）有63例。記錄檢測中段輸尿管結石所花費的額外時間。進行統計分析，找出哪些因素會影響結石檢測花費的額外時間。

結果

常規超音波檢查中段輸尿管，可檢出90％（57/63）的中段輸尿管結石。平均檢測結石花費的額外時間為71.98秒，大多數在兩分鐘內（85.7％）。花費的額外時間在中高度輸尿管積水患者明顯較短。

結論

常規超音波檢查中段輸尿管，可以快速診斷中段輸尿管結石。大多數患者可避免靜脈腎臟攝影和電腦斷層掃瞄。這些患者受到的輻射照射，可以減少到最低限度。

關鍵詞：超音波、超音波檢查、輸尿管、輸尿管結石