Original Research Paper Medical Science

Study of Role of Ultrasonography Towards Early Diagnosis of Ureteric Stone in Central India

Dr Aruna Pawar	Professor, Department of Radiology Shree Vasantrao NaikGovernment Medical College (SNVNGMC), Yavatmal
Dr Suhas D Alone	Assistant Commissioner,Government Veterinary Minipolyclinic, Ghatangi (Dist-Yavatmal)
*** Dr Nilesh Agrawal**	Assistant Superintendent ,Government Medical College & Hospital, Nagpur * Corresponding Author

ABSTRACT

Objective. The purpose of this study was to evaluate the usefulness of ultrasonography as an initial diagnostic tool in patients with suspected ureterolithiasis. **Methods.** We performed a prospective study of 318 patients with suspected ureteral stones over a 2 year period. If no cause of the flank pain was found by sonography, computed tomography was performed immediately to confirm the absence of ureteral stones. **Results.** We found urolithiasis with sonography in 291 of 296 patients with confirmed urolithiasis. The 5 remaining cases were identified after non–contrast-enhanced computed tomography (n = 5). **Conclusion.** Sonography can be used as an initial diagnostic tool in patients with suspected ureterolithiasis.

KEYWORDS Ultrasonography, ureteric stone.

INTRODUCTION

Acute flank pain caused by urolithiasis is a common condition in patients visiting emergency departments or outpatient urology clinics.1,2 Radiologic studies always have had important roles in the workup of these patients. Plain radiography has been done traditionally. In the past several years, thin-section non–contrast-enhanced CT has been the reference standard for diagnosing urinary tract calculi in adults.1–3 Non–contrast-enhanced CT has higher sensitivity and specificity than either sonography or IVU for detecting ureteral stones. In many studies, the sensitivity, specificity, and accuracy rates of CT for detecting urolithiasis have been reported as 96% to 100%, 95.5% to 100%, and 96% to 98%, respectively.1,4–10 Sonography has been shown to be effective in the diagnosis of renal calculi1 but limited in the diagnosis of ureteral calculi.11–14 Additional useful information for diagnosing ureteral calculi by sonography has been reported lately, such as twinkling artifacts and the application of endocavitary and high-frequency transducers for small calculi.15,16

In recent years, new sonographic equipment and technologies have been developed that improve image resolution and lessen artifacts. To our knowledge, only 1 study has reported the sensitivity and specificity of sonography, 93% and 95%, respectively, by definite demonstration of stone with new sonographic equipment and technologies.17 We have recently improved our ability to visualize ureteral calculi by using a specific technique for preparing the patient before scanning, new sonographic equipment, and compression. Consequently, this study was intended to evaluate the value of sonography as a first-line diagnostic tool for ureterolithiasis.

MATERIALS AND METHODS

Among all patients with acute flank pain who visited the OPD/ emergency department, 318 consecutive patients with clinically suspected urinary tract calculi underwent sonography (215 male and 103 female). Inclusion criteria were: (1) acute flank pain & (2) costovertebral angle tenderness. Patients with fever, who were clinically suspected of having acute pyelonephritis, were excluded. The patients' ages ranged from 15 to 76 years (mean, 42.2 years). A definitive diagnosis of urolithiasis was made when the patient passed a stone either naturally or after extracorporeal shock wave lithotripsy, when a stone was extracted by urologic procedures or when a stone was clearly seen within a markedly dilated ureter on sonography or CT.

Sonography was performed with the patients in the supine position. Our criteria for diagnosis of ureterolithiasis on sonography only included calcific echogenicity that appeared to be within the ureter lumen associated with or without hydronephrosis. Color Doppler imaging was used in 214 of the 313 calculi shown by sonography to determine the presence or absence of a twinkling artifact from ureteral calculi. We used the grading system proposed by Ellenbogen et al18 to determine the degree of hydronephrosis associated with ureteral calculi. The sonographic findings of distal ureteral calculi were vague on transabdominal sonography in 5 patients, so we performed transrectal or transvaginal sonography to increase the diagnostic confidence. We were unable to identify any cause of the flank pain in 15 patients, and we immediately performed non–contrast-enhanced CT. We defined the criteria for diagnosis of ureteral calculi on CT as the presence of calcific density appearing within the ureter lumen with visualization of the continuing proximal and distal ureter to the level of the calculus, including a tissue rim sign.19 We evaluated the sensitivity, specificity, and accuracy of sonography for detecting ureteral calculi and compared the final diagnoses obtained from the results of the clinical course and CT.

The Institutional Ethics Board approved the study. All patients provided written informed consent for the study.

RESULTS

Urolithiasis was confirmed in 296 of 318 patients. It was seen on sonography in 291 patients but was missed in 5 patients; however, the urolithiasis in these cases was identified after non–contrast-enhanced CT (n = 5). The 291 patients with urolithiasis diagnosed by sonography included 285 patients with ureterolithiasis, 5 patients with stone in the urinary bladder, and 1 patient with urethrolithiasis. In the 5 cases that sonography missed, the clinical symptoms and signs were typical, and swelling of a unilateral ureteral orifice was present. We confirmed that the stones in the urinary bladder and urethra were passed from the ureter. We detected 313 calculi in the 291 patients identified by sonography, including 307 ureteral calculi in the 285 patients with ureteral stone, 5 urinary bladder calculi in 5 patients, and 1 urethral calculus. We logically suspected that these 6 calculi found in the urinary bladder and urethra were passed from the ureter because the patients had renal colic within 1 hour, which was relieved just before sonography. The overall sensitivity, specificity, and accuracy of sonography for detecting ureteral calculi were 98.3%, 100%, and 98.4%, respectively. We found that 274 patients had a single ureteral calculus, whereas 17 patients had 2 to 5 ureteral calculi.

In the case of failed stone detection on sonography, urolithiasis (n = 5) was confirmed by CT. Stones were found in the left proximal ureter (n = 1), right UVJ (n = 1), urinary bladder (n = 1) and in the right distal ureter (n = 1). Computed tomography showed the absence of urolithiasis in 14 patients who underwent non–contrast-enhanced CT (n = 14). Five patients who underwent contrast-enhanced CT were found to have acute pyelonephritis (n = 3), renal infarction with renal arterial occlusion (n = 1), and ureteral cancer (n = 1). The remaining 3 patients were found to have pelvic inflammatory disease (n = 1), enteritis (n = 1), and transitional cell carcinoma in the urinary bladder (n = 1).

The 313 calculi identified by sonography in the 291 patients included 21 in the UPJ, 96 in the proximal half of the ureter, 69 in the distal half of the ureter, 121 in the UVJ, 5 in the urinary bladder, and 1 in the urethra. In the 285 patients with ureteral stone, it involved the left ureter in 126 cases, right ureter in 154 cases, and both ureters in 5 cases.

(TABLE 1 COMES HERE)
The ureteral calculi ranged in diameter from 1 to 22 mm as follows (mean ± SD, 7.5 ± 0.16 mm): 5 mm or less in 83 patients (26.5%), 6 to 10 mm in 194 patients (62%), 11 to 15 mm in 29 patients (9.3%), and greater than 15 mm in 7 patients (2.2%).

(TABLE 2 COMES HERE)
A total of 184 of the 214 calculi (86%) examined by color Doppler sonography showed a twinkling artifact. These findings helped confirm that this artifact was consistently present with tiny calculi.

We detected multiple calculi (≥2) in 17 patients on sonography. Real-time sonography and the presence of a twinkling artifact aided in the determination that multiple calculi were present.

We performed transrectal or transvaginal sonography to enhance the diagnostic confidence in 5 patients who had vague findings of distal ureteral calculi on transabdominal sonography. We could detect calculi that were 1 mm in diameter with transvaginal sonography.

The 31 8 patients had the following grades of hydronephrosis: grade 0 in 113 patients, grade 1 in 46, grade 2 in 119, and grade 3 in 40. Of the 291 patients with stones identified with sonography, the hydronephrosis grades were as follows: grade 0 in 91 patients, grade 1 in 45, grade 2 in 115, and grade 3 in 40. A total of 200 of the 291 patients had hydronephrosis (68.7%). Two of the 5 patients with confirmed stone not shown on sonography had grade 2 hydronephrosis. One patient with acute pyelonephritis and another without evidence of stone on sonography or CT had grade 1 and 2 hydronephrosis, respectively.

From treatment point of view, immediate ureteroscopic lithotripsy was performed in 123 of 296 patients, which confirmed the presence of ureteral calculi. Extracorporeal shock wave lithotripsy was performed in 62 patients, and stone fragments were passed in all of these patients. Conservative treatment including pain control and hydration was implemented in 88 patients. In 76 of these 88 patients, natural passage of ureteral calculi was confirmed by the patients. We could not confirm the passage of stones in 34 patients because 22 were lost to follow-up and 12 stated that they did not see passage of a stone. However, urolithiasis could be diagnosed in these 12 patients by the presence of a stone on more than 2 image modalities, their clinical status, and laboratory findings.

DISCUSSION
Many studies have compared the efficacy of different radiologic modalities for evaluating acute flank pain. Since the mid-1990s, non–contrast-enhanced CT has been considered the most precise imaging technique[10,20–24] and the reference standard for diagnosis of urolithiasis. Non–contrast-enhanced CT can detect extraurologic diseases and is fast and relatively easy to learn.[10,21,22] Nevertheless, CT has limitations: it is not available outside hospital facilities and is costly.[25] The amount of radiation in non–contrast-enhanced helical CT is approximately 10 times that of plain radiography of the abdomen and pelvis.[26] Moreover, many patients may receive an additional radiation dose with follow-up studies (if a calculus is not expelled) or with new episodes of colic (75% of patients).27 Sonography is a radiation-free diagnostic tool that can be very accurate. In this study, the overall diagnostic sensitivity, specificity, and accuracy of sonography were 98.3%, 100%, and 98.4%, respectively. Previous articles reported sensitivity rates of sonography for detecting stone of 12% to 93%[17,19,21,28,29] and a recently published article reported that the sensitivity and specificity of sonography for stone were 78.6% and 100%, which were better than in previous reports, and those for obstruction were both 100%.2 Several studies have been performed with low-dose CT protocols to detect ureteral stones; the sensitivity was reported to be 89.5% to 97%, and the specificity was found to be 94.7% to 100%.30–32 Consequently, the diagnostic efficacy of sonography in our study was better than that of low-dose CT but did not reach the sensitivity of normal-dose CT. Although low-dose CT has many advantages, including simple preparation, objective information, and easy application, sonography also has great advantages; it is radiation free, universally available, easily applicable, and inexpensive compared with CT, and it allows for repeated follow-up examinations.[17] The higher sensitivity and accuracy of sonography for detecting stone might have been due to the development of new sonographic equipment, appropriate preparation for tracing the entire ureter, and the relatively thinner body habitus of Asian patients.

Usually, transabdominal sonography can easily identify the renal pelvis, proximal ureter, distal ureter, and bladder and can be used to determine the level of obstruction, but its ability to show pathologic conditions in the mid ureter is limited.We divided the ureter into proximal and distal portions fromthe UPJ to the UVJ based on the level of crossing the iliac vessels because no appreciable difference exists in the sensitivity, specificity, and diagnostic accuracy of sonography for detecting urolithiasis based on location. The locations of the 313 calculi in the 291 patients with a sonographic diagnosis consisted of the UPJ in 21 cases, proximal half of the ureter in 96 cases, distal half of the ureter in 69 cases, UVJ in 121 cases, urinary bladder in 5 cases, and urethra in 1 case. In 285 patients with ureteral stone, the calculi were seen in the left ureter in 126 cases, right ureter in 154 cases, and both ureters in 5 cases.

Compression can remove bowel gas anterior to the ureter and help with tracing the ureter between the level of the iliac wing and the dome of the urinary bladder.

Although the distal ureter can be readily identified with transabdominal sonography because the urinary bladder provides a good sonic window,[36] an overdistended bladder may interfere with identification of a small stone in the distal ureter. On these occasions, intracavitary sonography is helpful for confirming the presence of a stone in the ureter and distinguishing between other causes of ureteral obstruction such as a urothelial tumor, blood clot, or fungus ball.[37] In our experience, when transabdominal sonographic findings of distal ureteral calculi are vague, transrectal or transvaginal sonography can enhance the diagnostic confidence.

We detected multiple ureteral calculi in 17 patients. Sonography operates in real time, and separate twinkling artifacts helped identify the presence of multiple calculi in individual ureters. We observed the separation of 2 or more calculi in the ureteral lumen by peristaltic movement in 14 patients.

Detecting secondary signs of a ureteral stone, including hydronephrosis, a perirenal fluid collection, and a change in the resistive index of an interlobar artery, is important. In one study, the authors achieved 95% sensitivity and 67% specificity when they included definite ureteral stones and hydronephrosis38 and in another report, the sensitivity jumped from 12% to 81% when secondary signs of ureteral obstruction were included in the diagnosis of urolithiasis.[2] In this study, we could detect hydronephrosis in 68.7% of ureteral calculi, which was a relatively lower incidence of hydronephrosis in ureteral colic.

When calculi are shown in the distal ureter, hydroureter without dilatation of the renal pelvis might be seen and considered in the absence of hydronephrosis. We applied strict criteria for diagnosing hydronephrosis in this study, which may explain the lower incidence of hydronephrosis.

In summary, sonography is an excellent modality with many advantages for detecting ureteral stones; it is radiation free, relatively inexpensive, universally available, and easily applicable, and it has high diagnostic efficacy. Specific techniques for preparing the patient before scanning, new sonographic equipment, compression techniques, and additional intracavitary scanning can enhance the diagnostic accuracy for detecting ureteral calculi on sonography.

TABLE 1.
Locations of stones

Location	Stone, n (%)
UVJ	121 (38.7)
Proximal Ureter	96 (30.7)
Distal Ureter	69 (22)
UPJ	21 (6.7)
Urinary Bladder	5 (1.6)
Urethra	1 (0.3)
Total	313 (100)

TABLE 2.
Diameters of stones measured by USG

Diameter (mm)	Stone, n (%)
≤ 5	83 (26.5)
6-10	194 (62)
11-15	29 (9.3)
>15	7 (2.2)
Total	313 (100)

REFERENCES

1. Tamm EP, Silverman PM, Shuman WP. Evaluation of the patient with flank pain and possible ureteral calculus. Radiology 2003; 228:319–329.
2. Ripollés T, Agramunt M, Errando J, Martinez MJ, Coronel B, Morales M. Suspected ureteral colic: plain film and sonography vs unenhanced helical CT. A prospective study in 66 patients. Eur Radiol 2004; 14:129–136.
3. Palmer JS, Donaher ER, O'Riordan MA, Dell KM. Diagnosis of pediatric urolithiasis: role of ultrasound and computerized tomography. J Urol 2005; 174:1413–1416.
4. Boulay I, Holtz P, Foley WD, White B, Begun FP. Ureteral calculi: diagnostic efficacy of helical CT and implications for treatment of patients. AJR Am J Roentgenol 1999; 172: 1485–1490.
5. Dorio PJ, Pozniak MA, Lee FT Jr, Kuhlman JE. Non-contrast-enhanced helical computed tomography for the evaluation of patients with acute flank pain. WMJ 1999; 98:30–34.
6. Chen MY, Zagoria RJ. Can noncontrast helical computed tomography replace intravenous urography for evaluation of patients with acute urinary tract colic? J Emerg Med 1999; 17:299–303.
7. Chen MY, Zagoria RJ, Saunders HS, Dyer RB. Trends in the use of unenhanced helical CT for acute urinary colic. AJR Am J Roentgenol 1999; 173:1447–1450.
8. Vieweg J, Teh C, Freed K, et al. Unenhanced helical computerized tomography for the evaluation of patients with acute flank pain. J Urol 1998; 160:679–684.
9. Fielding JR, Fox LA, Heller H, et al. Spiral CT in the evaluation of flank pain: overall accuracy and feature analysis. J Comput Assist Tomogr 1997; 21:635–638.
10. Smith RC, Verga M, McCarthy S, Rosenfield AT. Diagnosis of acute flank pain: value of unenhanced helical CT. AJR Am J Roentgenol 1996; 166:97–101.
11. Aslaksen A, Gothlin JH. Ultrasonic diagnosis of ureteral calculi in patients with acute flank pain. Eur J Radiol 1990; 11:87–90.
12. Erwin BC, Carroll BA, Sommer FG. Renal colic: the role of ultrasound in initial evaluation. Radiology 1984; 152:147–150.
13. Laing FC, Jeffrey RB Jr, Wing VW. Ultrasound versus excretory urography in evaluating acute flank pain. Radiology 1985; 154:613–616.
14. Hill MC, Rich JI, Mardiat JG, Finder CA. Sonography vs. excretory urography in acute flank pain. AJR Am J Roentgenol 1985; 144:1235–1238.
15. Lee JY, Kim SH, Cho JY, Han D. Color and power Doppler twinkling artifacts from urinary stones: clinical observations and phantom studies. AJR Am J Roentgenol 2001; 176: 1441–1445.
16. Laing FC, Benson CB, DiSalvo DN, Brown DL, Frates MC, Loughlin KR. Distal ureteral calculi: detection with vaginal US. Radiology 1994; 192:545–548.
17. Patlas M, Farkas A, Fisher D, Zaghal I, Hadas-Halpern I. Ultrasound vs CT for the detection of ureteric stones in patients with renal colic. Br J Radiol 2001; 74:901–904.
18. Ellenbogen PH, Scheible FW, Talner LB, Leopold GR. Sensitivity of gray scale ultrasound in detecting urinary tract obstruction. AJR Am J Roentgenol 1978; 130:731–733.
19. 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; 8:212–217.
20. Smith RC, Rosenfield AT, Choe KA, et al. Acute flank pain: comparison of non-contrast-enhanced CT and intravenous urography. Radiology 1995; 194:789–794.
21. Sommer FG, Jeffrey RB Jr, Rubin GD, et al. Detection of ureteral calculi in patients with suspected renal colic: value of reformatted noncontrast helical CT. AJR Am J Roentgenol 1995; 165:509–513.
22. Katz DS, Lane MJ, Sommer FG. Non-contrast spiral CT for patients with suspected renal colic. Eur Radiol 1997; 7: 680–685.
23. Dalrymple NC, Verga M, Anderson KR, et al. The value of unenhanced helical computerized tomography in the management of acute flank pain. J Urol 1998; 159:735–740.
24. Sourtzis S, Thibeau JF, Damry N, Raslan A, Vandendris M, Bellemans M. Radiologic investigation of renal colic: unenhanced helical CT compared with excretory urography. AJR Am J Roentgenol 1999; 172:1491–1494.
25. Grisi G, Stacul F, Cuttin R. Cost analysis of different protocols for imaging a patient with acute flank pain. Eur Radiol 2000; 10:1620–1627.
26. Liu W, Esler SJ, Kenny BJ, Goh RH, Rainbow AJ, Stevenson GW. Low-dose nonenhanced helical CT of renal colic: assessment of ureteric stone detection and measurement of effective dose equivalent. Radiology 2000; 215:51–54.
27. Levine JA, Neitlich J, Verga M, Dalrymple N, Smith RC. Ureteral calculi in patients with flank pain: correlation of plain radiography with unenhanced helical CT. Radiology 1997; 204:27–31.
28. 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; 217:792–797.
29. Catalano O, Nunziata A, Altei F, Siani A. Suspected ureteral colic: primary helical CT versus selective helical CT after unenhanced radiography and sonography. AJR Am J Roentgenol 2002; 178:379–387.
30. Poletti PA, Platon A, Rutschmann OT, Schmidlin FR, Iselin CE, Becker CD. Low-dose versus standard-dose CT protocol in patients with clinically suspected renal colic. AJR Am J Roentgenol 2007; 188:927–933.
31. Tack D, Sourtzis S, Delpierre I, de Maertelaer V, Gevenois PA. Low-dose unenhanced multidetector CT of patients with suspected renal colic. AJR Am J Roentgenol 2003; 180:305–311.
32. Kluner C, Hein PA, Gralla O, et al. Does ultra-low dose CT with a radiation dose equivalent to that of KUB suffice to detect renal and ureteral calculi? J Comput Assist Tomogr 2006; 30:44–50.
33. Hadas-Halpern I, Farkas A, Patlas M, Zaghal I, Sabag-Gottschalk S, Fisher D. Sonographic diagnosis of ureteral tumors. J Ultrasound Med 1999; 18:639–645.
34. Voet D, Mareels S, Oosterlinck W, Afschrift M. Sonographic diagnosis of a nonobstructive tumor in the mid-ureter. J Clin Ultrasound 1997; 25:459–460.
35. Liu JB, Bagley DH, Conlin MJ, Merton DA, Alexander AA, Goldberg BB. Endoluminal sonographic evaluation of ureteral and renal pelvic neoplasms. J Ultrasound Med 1997; 16:515–521.

36. Holm HH, Torp-Pedersen S, Larsen T, Dorph S. Transabdominal and endoluminal ultrasonic scanning of the lower ureter. Scand J Urol Nephrol Suppl 1994; 157: 19–25.
37. Kim HJ, Lim JW, Lee DH, Ko YT. Differentiation of malignant from benign distal ureteral obstructions: assessment using transrectal and color Doppler ultrasonography. J Ultrasound Med 2007; 26:1129–1136.
38. Dalla Palma L, Stacul F, Bazzocchi M, Pagnan L, Festini G, Marega D. Ultrasonography and plain film versus intravenous urography in ureteric colic. Clin Radiol 1993; 47: