Medical Ultrasonography
2010, Vol. 12, no. 3, 188-197

The sensitivity of transabdominal ultrasound in the diagnosis of ureterolithiasis

Călin Moş[1], Gineta Holt[1], Ştefan Iuhasz[1], Doina Moş[1], Ile Teodor[2], Monica Hălbac[2]

[1] University of Oradea, Faculty of Medicine and Pharmacy, Romania
[2] County Hospital, Beiuş, Romania

Abstract

Objectives: The echographic diagnosis of renal lithiasis colic is suggested by the existence of hydronephrosis, but the certainty is given by the direct visualization of the ureteral calculus. The aim of this study is to assess the performance of ultrasound in identifying ureteral calculi compared to other imaging methods (abdominal X-ray, urography and computed tomography). **Material and method:** We performed ultrasonographic examination (one or multiple examinations) in 217 patients with renal colic and ureterolithiasis. The calculus was identified by abdominal radiography, urography, computed tomography or by eliminating the calculus. **Results:** Ureteral calculi were ultrasonographically identified in 159 of the examined patients: 121 in the initial examination, 38 in the additional reexaminations (73.27% sensitivity as compared to other imaging techniques: 48.39% for X-ray, 68.37% for urography, and 91,11% CT). Hydronephrosis was identified in 193 patients (88.94%). Four of the patients (1.84%) were diagnosed retrospectively, based on the elimination of one calculus, but none of the imaging methods had managed to identify it previously. 12.58% of the ultrasonographically identified ureteral calculi were located in the pelviureteric junction, 10.69% in the proximal ureter, 6.91% in the mid ureter, 28.93% in the distal ureter, and 40.88% in the pelviureteric junction. **Conclusions:** Ultrasound is a sensitive method of detecting UL in/during a renal colic and may be used as the initial imaging method in investigating these patients. The presence or absence of hydronephrosis can not be considered as a discriminatory factor for the diagnosis of ureterolithiasis.

Keywords: ureterolithiasis, renal colic, ultrasound

Rezumat

Obiective: Diagnosticul ecografic al colicii renale litiazice este sugerat de existența hidronefrozei dar certitudinea este dată de vizualizarea directă a calculului ureteral Scopul studiului este evaluarea performanței ecografiei în identificarea calculilor ureterali în comparație cu alte metode imagistice (radiografia abdominală pe gol, urografia şi tomografia computerizată). **Material şi metodă:** Au fost examinați ecografic (examinare unică sau în repetiție) un număr de 217 pacienți cu colică renală prin litiază ureterala identificată radiografic, prin urografie, tomografie computerizată, sau prin eliminarea calculului. **Rezultate:** Ecografic s-au identificat calculii ureterali la 159 dintre pacientii examinati: 121 la prima examinare, 38 la examinări suplimentare (sensibilitate 73,27% comparativ cu radiografia pe gol - 48,39%, urografia - 68,37%, tomografia computerizată – 91,11%). Hidronefoza a fost identificată la 193 (88.94%) dintre pacienții examinați. La 4 pacienti (1,84%) nici una dintre metodele imagistice nu a identificat calculul ureteral, diagnosticul făcându-se retrospectiv, pe baza eliminării urinare a calculului. Calculii ureterali identificați ecografic au fost localizați 12,58% la nivelul joncțiunii bazineto-ureterale, 10,69% la nivelul ureterului proximal, 6,91% la nivelul ureterului mijlociu, 28,93% la nivelul ureterului distal şi 40,88% la nivelul joncțiunii bazineto-ureterale. **Concluzii:** Ecografia este o metodă sensibilă în vizualizarea UL în colicile renale litiazice şi poate fi folosită ca metodă imagistică de primă intenție în investigarea acestor pacienți. Prezența sau absența hidronefozei nu poate fi considerată element discriminator pentru diagnosticul litiazei ureterale.

Keywords: litiază ureterală, colică renală, ecografie

Received 15.04.2010 Accepted 02.06.2010
Med Ultrason
2010, Vol. 12, No 3, 188-197
Address for correspondence: Dr. Călin Moş
1 Andrei Şaguna Street
415200, Beiuş,
Bihor County, România
e-mail: drcalinmos@yahoo.com

Introduction

Lithiasis is the most frequent cause of renal colic, which is a common disease, approximately 10% of the general population having it at least once during their lifetime [1,2,3]. Ureterolithiasis is more frequent in men than in women (ratio 3:1) [1,4].

The clinical symptoms and lab tests do not always es-

tablish the diagnosis, renal colic has to be distinguished from other renal diseases, female genital pathology, obstructive, inflammatory and tumoral conditions of the digestive tract, thoracic diseases, neurological or testicular disorders etc. The accidental echographic detection of hydronephrosis, without typical clinical symptoms of renal colic, requires the identification of its etiology [4].

The ultrasonographical (US) examination has several advantages: it is a low cost technique, non-irradiating, does not require contrast administration, it does not depend on the renal function, and allows for multiple reexaminations. Its disadvantages reside in the difficulty to examine the ureter in obese patients, as well as the need for an appropriate technique and expertise, particularly in viewing calculi located in the mid ureter.

The universal opinion is that US is the main technique to use in suspected renal colic in children and pregnant women. For the rest of the patients, the opinions are divided, but most authors agree that US should be the initial method in all cases of renal colic, as it gives accurate answers for both positive and differential diagnosis [5-8]. Although US is considered a high sensitivity imaging method in visualizing hydronephrosis, it is appreciated to be less sensitive in visualizing ureterolithiasis [8, 9].

Medical literature data on this subject is quite heterogeneous, with big differences between studies, and that is why the aim of this study was to assess the sensitivity and specificity of US in ureteral calculi identification, as compared to other imaging techniques.

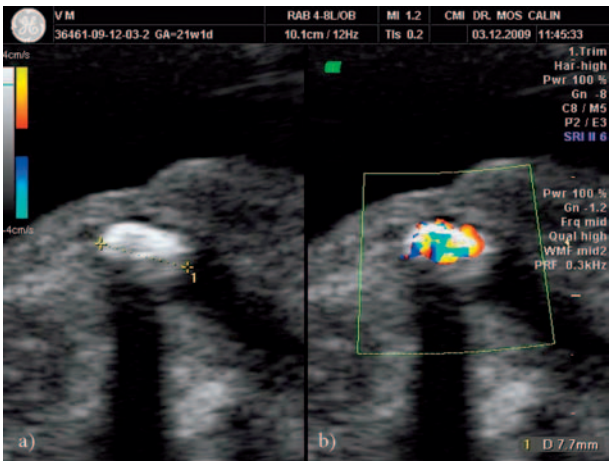


Fig 1. Typical UL image a) gray scale, b) Color Doppler. Accurate image of the intramural ureteral calculus, with a very good definition of rear acoustic shadow, of the edges of the calculus and of the twinkling artifact.



Fig 2. Hydronephrosis with proximal hydroureter (arrows).

Material and method

217 patients (136 men and 81 women, aged 5-91) with clinically diagnosed renal colic were ultrasonographically investigated between January 2008 and December 2009. Ureterolithiasis had been initially identified by a method other than US or by the urinary elimination of the calculus. Plain abdominal x-ray (X-ray) was performed in all patients. Those without ureteral calculus underwent urography (URO). Patients with negative urographic exam for ureterolithiasis and those with contraindication for urography underwent computed tomography (CT). Informed consent was obtained from all patients. The study was approved by the local Ethics Committee.

The transabdominal ultrasound examination was performed with a Voluson 730 Pro ultrasound machine (General Electric, Kretz Technik) using two convex transducers with variable 1.5 - 4.5 MHz, 4.0 - 8.5 MHz frequency, depending on the patient's body weight. The transducer with the highest frequency was preferred for the examination, in order to better define the rear acoustic shadow, the limits of the calculus and the twinkling artifact (fig 1). The patients were required to have a full bladder.

The examination technique assessed the following: kidney (the presence/absence of hydronephrosis was recorded); the pelvi-ureteric junction and the proximal ureter (fig 2), the ureterovesical junction and the distal ureter; the mid ureter (using color Doppler in order to identify the iliac vessels) (fig 3-6).

The ultrasonographic diagnosis of ureterolithiasis (UL) was established upon detection of the ureteric calculus, regardless of the presence or absence of hydronephrosis. The result was considered to be true positive for UL when an intensely hypoechogenic structure was observed inside the ureter, with calculus features. The false

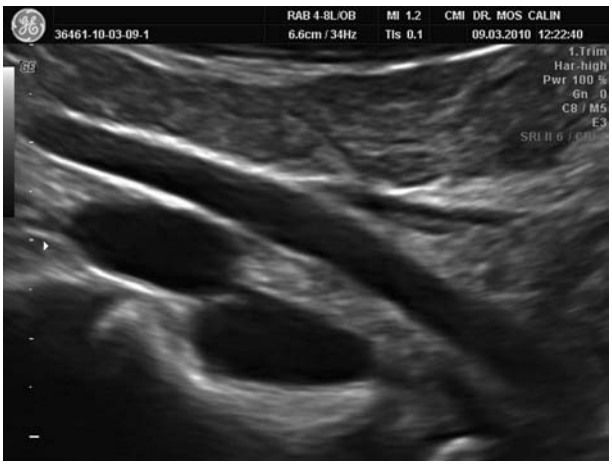


Fig 3. Visualization of hydroureter (longitudinal section) above the iliac vessels.

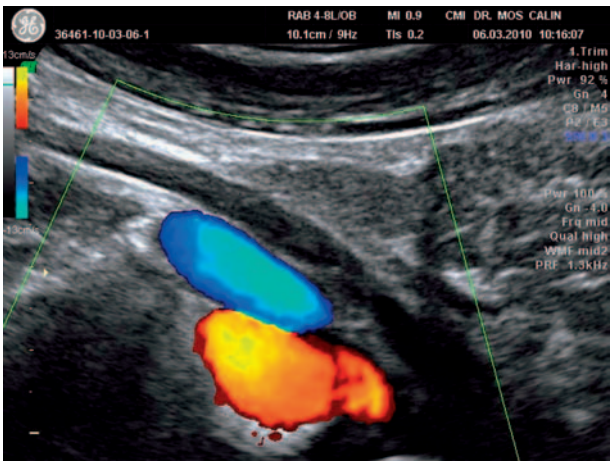


Fig 4. Longitudinal section through the hydroureter anterior to the iliac vessels (cross-section/oblique view, Color Doppler).

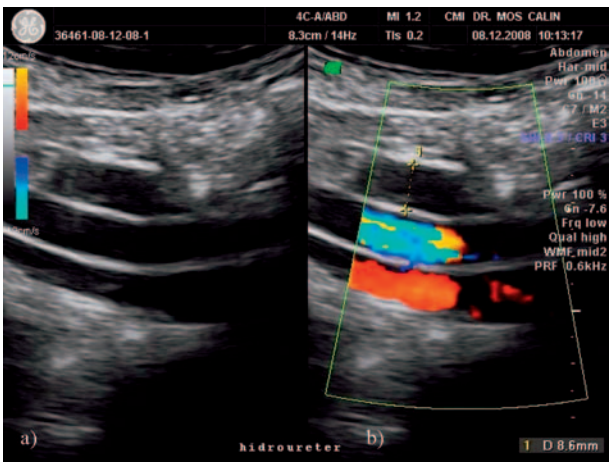


Fig 5. The iliac vessels visualized on longitudinal section and hydroureter on oblique/horizontal section a) gray scale, b) Color Doppler.

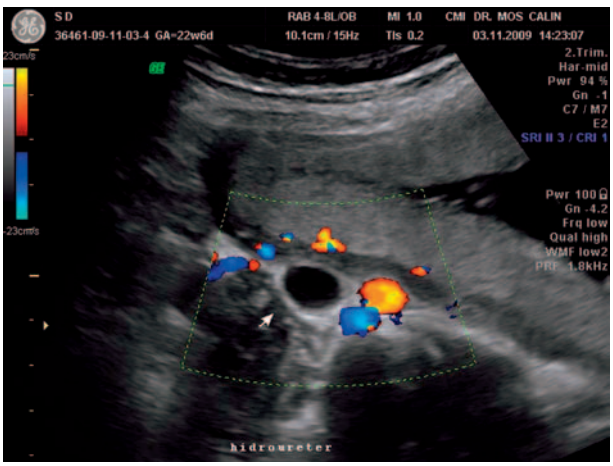


Fig 6. Pregnancy week 23 changed the relationship between the iliac vessels and hydroureter: the ureter is pushed sideways, becoming for a short period of time parallel with the iliac vessels; the hydroureter and the iliac vessels are viewed in cross section. Anterior to the iliac vessels and the ureter – the uterus with placental insertion.

negative results occurred when UL could not be ultrasonographically assessed (nu mi se pare că se înțelege sensul frazei). A 2x2 table was used for the evaluation of the results. The sensitivity of every imaging method was determined, with a 95% confidence interval.

Results

Of the 217 patients included in the study, UL was diagnosed by X-ray in 105 patients (48.39%). Of the 112 patients with negative radiological aspects for UL, 98 underwent urography. This examination identified UL in 67 of the investigated patients (68.37%). 31 patients with negative urographic exam for UL and 14 patients who could not undergo urography (45 patients in total), underwent CT. UL was identified in 41 of these patients (91.11%). For the 4 patients with negative CT exam for UL, the diagnosis was confirmed by the urinary elimination of the calculus (table I).

US was performed in all 217 patients. UL was detected in 121 patients (55.76%) during the initial examination, and in 38 patients during the additional reexamination (73.27% of the examined patients). Of all the examined patients, 193 (88.94%) had hydronephrosis, and in 111 of them UL was identified during the initial examination (table II).

Table I. Comparison of the sensitivity of different imaging methods (X-rays, URO, CT and US) in detecting UL.

Imaging technique	X-rays	URO	CT	US
Number of patients	217	98	45	217
Patients with identified lithiasis	105	67	41	159
Sensitivity	48,39%	68,37%	91,11%	73,27%

Table II. Results obtained by US.

Ureterolithiasis (UL)	Renal colic and UL	UL with hydronephrosis	UL without hydronephrosis
Number of patients	217 100%	193 88,94%	24 11,06%
Identified during the initial ultrasonographic examination	121 55,76%	111 57,51%	10 41,67%
Identified during additional reexaminations	38 17,51%	34 17,61%	4 16,67%
Total identified ureterolithiasis	159 73,27%	145 75,12%	14 58,33%

Table III. Results obtained by US compared to X-rays, URO and CT.

	X-rays 217 patients		URO 98 patients		CT 45 patients	
	Visualized calculus	Non-visualized calculus	Visualized calculus	Non-visualized calculus	Visualized calculus	Non-visualized calculus
Visualized calculus ECO	76	83	49	22	28	1
Non-visualized calculus ECO	29	29	18	9	13	3
Total	105	112	67	31	41	4

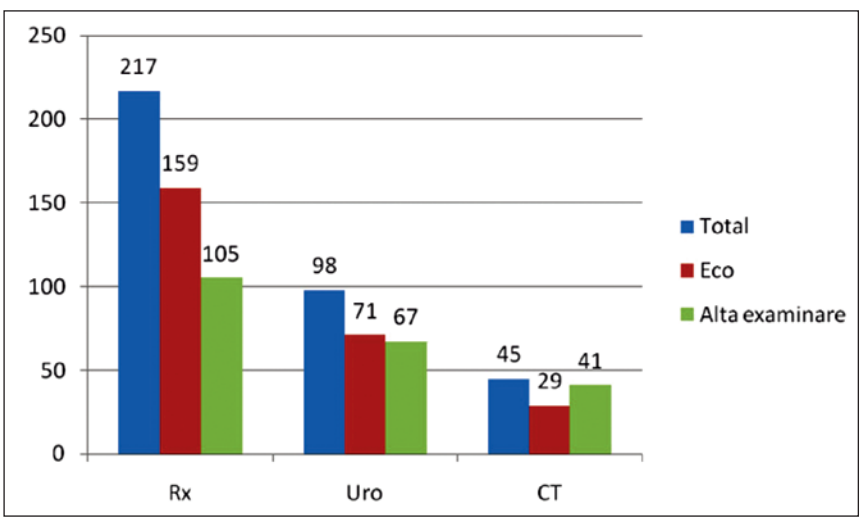


Fig 7. Comparison between US, X-rays, URO and CT results.

The sensitivity of the ultrasound was assessed by reference to the confirmed UL diagnosis obtained through other diagnostic imaging methods, as well as through the elimination of the calculus. After the first ultrasonographic examination, the sensitivity of US was of 55.76%, but after the additional reexaminations of the 96 patients who initially did not present calculus, the sensitivity of the method increased to 73.27%.

Table 3 and fig 7 compare the results of US with those of other imaging techniques. If we consider only the patients who underwent both ultrasound and other imaging methods we obtain the following sensitivities: 48.39% for X-rays and 73.27% for US, 68.37% for URO and 72.45% for US, 91.11% for CT and 64.44% for US.

The ureteral location of the calculi identified through US was the following: 20 patients had calculi in the pelviureteric junction (12.58%) (fig 8, fig 9), 17 in the proximal ureter (10.69%) (fig 10-12), 11 in the mid ureter (6.91%) (fig 13-16), 46 in the distal ureter (28.93%) (fig 17-20), and 65 in the ureterovesical junction (40.88%) (fig 21-24).



Fig 8. Calculus at the level of the ureteropelvic junction producing pelvis expansion.



Fig 9. Hydronephrosis caused by two calculi located in the ureteropelvic junction.



Fig 10. Calculus in the proximal ureter, just below the ureteropelvic junction.



Fig 11. Large calculus in the proximal ureter.



Fig 12. Mixture of four small calculi in the ureter producing hydronephrosis and hydroureter.



Fig 13. Large calculus (over 1.5 cm) in the mid ureter.



Fig 14. Calculus in the middle third of the ureter, viewing the suprajacent hydroureter at a large distance.



Fig 15. View of an ureteral calculus anterior to the left ovary.

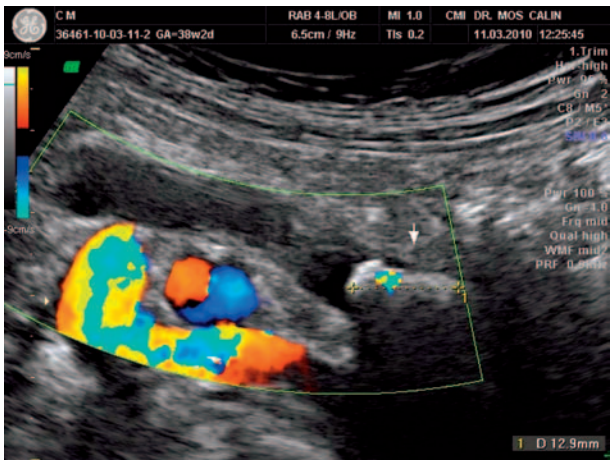


Fig 16. Hydroureter and large ureteral calculus anterior to the iliac vessels identified by Color Doppler. The twinkling artifact can be observed in the calculus.



Fig 17. Calculus in the distal, juxtavesical ureter.



Fig 18. Distal ureteral calculus and hydroureter.



Fig 19. 3-4 mm small intramural ureteral calculus, with discrete rear acoustic shadow and hydroureter.



Fig 20. Small-sized twin intramural calculi with rear acoustic shadow.

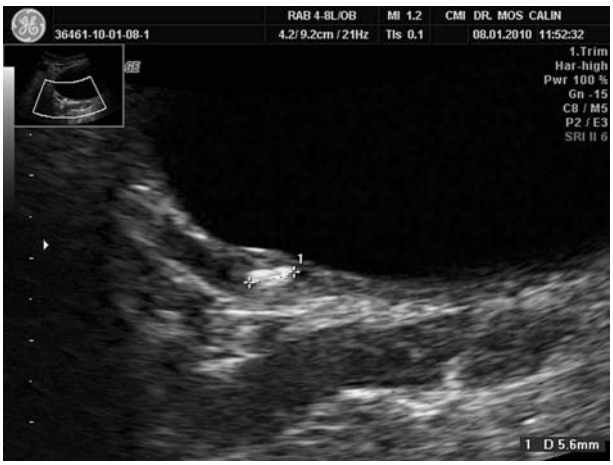


Fig 21. Calculus in the ureteropelvic junction, with hydroureter but without rear acoustic shadow.



Fig 22. 3 mm calculus in the ureteropelvic junction, without rear acoustic shadow and without hydroureter. The presence of hypoechogenic ureteral edema with acoustic amplification given by the urine from the bladder which enables the identification of this small-sized ureteral calculus.



Fig 23. Calculus in the ureteropelvic junction, inside the ureter which prolapsed in the bladder.

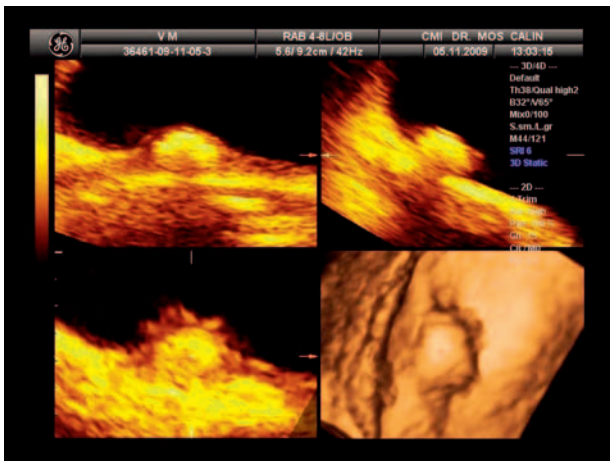


Fig 24. 3D examination in three orthogonal planes visualizes the ureter's prolapse in the bladder. Note that the perilithiasic ureteral edema is best viewed in plane C, which is not possible in case of 2D ultrasound. 3D reconstruction in surface mode demonstrates the bulging of the ureter in the bladder.

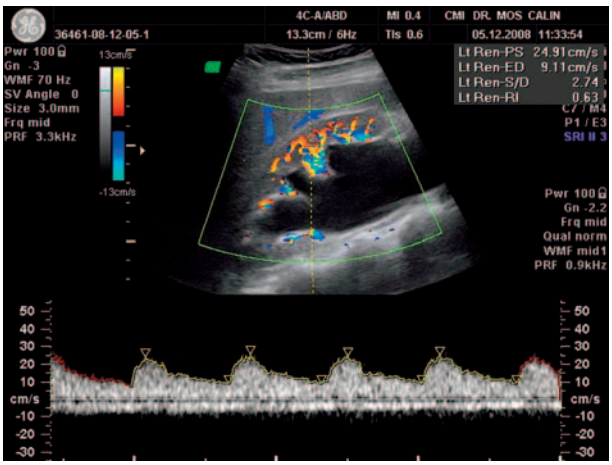


Fig 25. Significant hydronephrosis, impedance indices in normal interlobular arteries (IR=0.63).

Discussions

The order in which the imaging methods should be used in medical practice for the diagnosis of UL differs according to the autor: initially X-rays and URO, using US in order to monitor the evolution of hydronephrosis; association of X-rays or URO with US; initially CT; initially US and other imaging methods if US is negative [5,7,8,10,11]. We believe that US must be used as the initial imaging method, as it detects most of the ureteral calculi, thus avoiding the irradiation of the patients.

UL usually determines the complete or partial obstruction of the ureter, which dilates above to the obstruction involving the renal pyelocaliceal system. Therefore, UL may be suspected upon identification of hydronephrosis, especially when accompanied by renal colic. Other helpful diagnosis criteria are the presence of a hydroureter (diameter of the ureter exceeding 6 mm) and by the identification of a perirenal collection (urinoma caused by the breaking of a chalice) [11]. Besides UL, unilateral or bilateral hydronephrosis may have other causes (ureteral stricture, obstructions, papillary necrosis, acute pyelonephritis, renal transplantation, renal, ureteral or vesical tumors, ureteral valves, congenital mega-chalices, pregnancy, ureteral reflux, prostatic or neurogenic causes, hyperhydratation, diabetes insipidus, retroperitoneal conditions, adenopathies, tumors, fibrosis, etc) which require careful differential diagnosis [12].

There are also cases of UL without associated hydronephrosis. In non-obstructive UL, without hydronephrosis, sometimes even with atypical symptoms, the differential diagnosis must be extended: acute appendicitis, gynecological and obstetrical pathology (ovarian cysts**,** ectopic pregnancy**,** hydrosalpinges), epididymitis, testicular torsion, biliary colic, pancreatitis, gastric or duodenal ulcer, intestinal occlusion, intestinal infarction or necrosis, gastrointestinal foreign bodies, aortic dissection, pneumothorax etc [4]. In some cases, not even Doppler examination can provide sufficient diagnostic proof. In case of a non-obstructive UL, the impedance indices in the interlobar arteries are usually normal. The resistivity indices exceeding 0,70 in the renal interlobar arteries initially seemed useful for the diagnosis of the ureteral obstructive syndrome [13], but subsequent studies brought no conclusive results [14,15] (fig 25). The ureteral jets also proved to be obviously diminished or continuous and of low intensity only in obstructive UL (fig 26), while they are usually normal in partially obstructive or non-obstructive UL [16] (fig 27).

For these reasons, only direct visualization of ureteral calculus has diagnostic value for reno-ureteral colic and lithiasis. Regarding the echographic identification of UL, there are numerous studies, with quite contradictory results, and with a very wide range of values, the sensitivity of the method ranging between 19% and 96% [5,8, 3, 17-22]. In our study, the sensitivity of the method was of 73.27%.

The examination technique that we used had some peculiarities. If hydronephrosis and hydroureter were present, we tried to track the hydroureter from the kidney downstream for as long as we could. If no calculus was identified, we continued to track the ureterovesical junc-

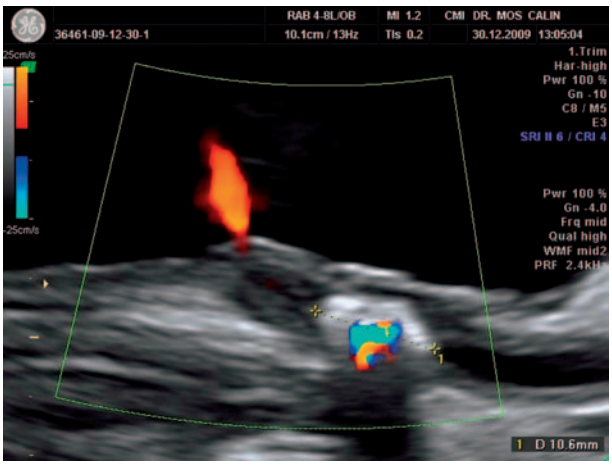


Fig 26. 1cm calculus in the intramural distal ureter producing calculus, proximal hydroureter, calculus distal edema. Maintaining the ureteric jet indicates a partially obstructive lithiasis.

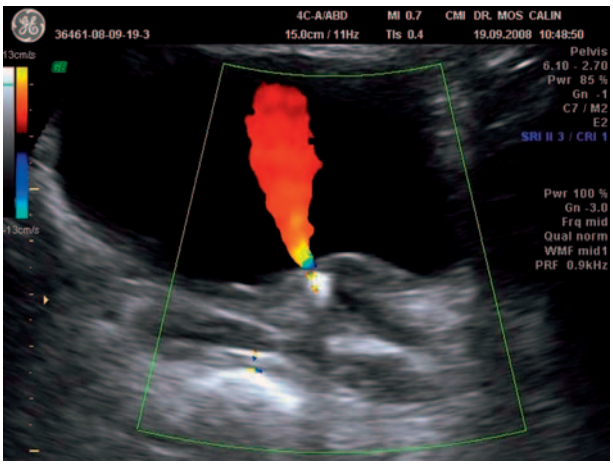


Fig 27. Non-obstructive ureteral lithiasis: normal ureteric jet intensity in the presence of a small ureteral calculus associated with perilithiasic edema.

tion and the distal ureter because most ureteral calculi are echographically identified at this level. If no calculus was identified here either, we tried to view the mid ureter, which is the most difficult part to examine because of its deep location and due to the presence of intestinal gas anterior to this part of the ureter. The displacement of the intestinal gas was acheived by the compression of the region with the transducer (similar to Puylaert technique of graduated compression in acute appendicitis) [23]. We also tried to combine the compression with the patients' change in position, by placing them in lateral position, on the opposite side of the colic.

To our knowledge, to this day there is no literature data regarding the sensitivity of ultrasonographic reexaminations in identifying UL. In our opinion, the ultrasonographic reexamination is very important. If the initial examination visualizes the calculus, the reexamination may determine whether it had moved or not. If the initial examination could not view the calculus, the reexamination may visualize an ureteral calculus that moved in a place with a better ultrasonographic view. The processing of the statistical data considered both the identification of ureteral lithiasis during the initial examination as well as the identification of several calculi only during the reexaminations. Due to calculi migration, the reexaminations increased the chance of detection of ureteral calculus in case it had reached the ureteral distal portion, more accessible for the echographic view, regardless of the presence of hydroureter. Therefore, the reexaminations proved to be useful and increased the overall sensitivity of US in identifying UL from 55.76% to 73.27%.

We have sometimes identified several ureteral calculi in the same part of the ureter (fig 8,11,19). The presence of hydronephrosis favors the visualization of UL (75.12% sensitivity with hydronephrosis and 58.33% without). UL without hydronephrosis has also been detected (8.8%). Hydronephrosis and hydroureter may not be present immediately after the onset of renal colic (due to the short time since the onset of obstruction) or in case of low-grade obstruction ureterolithiasis (especially in poor hydration condition). Even without hydroureter, especially in the juxtavesical ureter, calculi can still be detected due to the very good acoustic window provided by a full bladder. The optimal conditions for the examination of the intramural ureter could highlight very small calculi, even 3 mm in diameter calculi which would have been difficult or impossible to assess in the renal sinus.

Similar to other studies [8,24,25], our study has also identified the largest number of ureteral calculi in the distal third of the ureter, especially in the ureterovesical junction. Distal locations (distal ureter and ureterovesical junction) sum up 72.6% of all the ultrasonographically identified calculi.

Even without an ultrasonographical visualization of the ureteric calculus, US is able to determine the degree of hydronephrosis, the renal parenchymal thickness, the impedance indices in interlobular arteries, the absence or presence of ureteral jets, as well as their intensity. Most of the times, these clinically integrated data and lab tests may allow a physician to decide whether it is necessary to use another imaging method or ultrasonographic reexamination. We believe that ultrasonographic reexamination is useful, mainly due to a higher sensitivity than that of plain X-ray examination (72.27% to 48.39%) and urography (72.45% to 68.37%). Ultrasound proved to be

inferior to CT (64.44% to 91.11%), CT being the most sensitive method in detecting UL.

The limitations of the study are due to the lack of uniformity in the interval between the appearance of the symptoms and the ultrasonographic examination-reexamination, this period varying according to the moment of the examination, the intensity of the symptoms, and the evolution under specific treatment. Establishing a systematic methodology for the use of US in renal colic could be beneficial for the increase of US sensitivity in this pathology. Additionally, the association between transabdominal and transvaginal or transrectal ultrasound could increase the number of identified distal UL, especially in obese patients.

Conclusions

US is a sensitive technique in viewing UL during the renal colic and may be used as the initial imaging method in investigating these patients. The presence or absence of hydronephrosis cannot be considered a discriminatory element for the diagnosis of ureterolithiasis, but only for the identification of the ureteral calculus.

Competing interest

No conflict of interest.

Bibliography

1. Stamatelou KK, Francis ME, Jones CA, Nyberg LM, Curhan GC. Time trends in reported prevalence of kidney stones in the United States: 1976–1994. Kidney Int 2003; 63:1817–1823.
2. Delvecchio FC, Preminger GM. Medical management of stone disease. Curr Opin Urol 2003; 13:229–233.
3. Pearle MS, Calhoun EA, Curhan GC; Urologic Diseases of America Project. Urologic diseases in America project: urolithiasis. J Urol 2005; 173:848–857.
4. Menon M, Resnick MI. Urinary lithiasis: etiology, diagnosis, and medical management. In: Campbell MF, Walsh PC, Retik AB, eds. Campbell's Urology. 8th ed. Philadelphia, Pa.: Saunders, 2002.
5. Erwin BC, Carroll BA, Sommer FG. Renal colic: the role of ultrasound in initial evaluation. Radiology 1984; 152:147–150.
6. Middleton WD, Dodds WJ, Lawson TL, Foley WD. Renal calculi: sensitivity for detection with US. Radiology 1988; 167:239–244.
7. 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.
8. 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; 74:901904.
9. Aslaksen A, Gothlin JH. Ultrasonic diagnosis of ureteral calculi in patients with acute flank pain. Eur J Radiol 1990; 11:87–90.
10. Tamm EP, Silverman PM, Shuman WP. Evaluation of the patient with flank pain and possible ureteral calculus. Radiology 2003; 228:319–329.
11. Jindal G, Ramchandani P. Acute flank pain secondary to urolithiasis: radiologic evaluation and alternate diagnoses. Radiol Clin North Am 2007; 45:395–410.
12. Dudea SM. The kidney and the ureter. In: Badea R, Dudea S, Mircea P, Stamatian F. Clinical ultrasound handbook. Vol I, Medical Publishing House 2000:440–490.
13. Platt JF, Rubin JM, Ellis JH. Acute renal obstruction: evaluation with intrarenal duplex Doppler and conventional US. Radiology 1993; 186:685–688.
14. Tublin ME, Dodd GD3rd, Verdile VP. Acute renal colic: diagnosis with duplex Doppler US. Radiology 1994; 193: 697–701.
15. Cronan JJ, Tublin ME. Role of the resistive index in the evaluation of acute renal obstruction. AJR Am J Roentgenol 1995; 164: 377–378.
16. Burge HJ, Middleton WD, McClennan BL, Hildebolt CF. Ureteral jets in healthy subjects and in patients with unilateral ureteral calculi: comparison with color Doppler US. Radiology 1991; 180:437–442.
17. 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.
18. Middleton WD, Dodds WJ, Lawson TL, Foley WD. Renal calculi: sensitivity for detection with US. Radiology 1988; 167:239–244.
19. Laing FC, Jeffrey RB Jr, Wing VW. Ultrasound versus excretory urography in evaluating acute flank pain. Radiology 1985; 154:613–616.
20. Ripolles B, 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.
21. Fowler KA, Locken JA, Duchesne JH, Williamson MR. US for detecting renal calculi with nonenhanced CT as a reference standard. Radiology 2002; 222:109–113.
22. 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.
23. Puylaert JB. Acute appendicitis: US evaluation using graded compression. Radiology 1986; 158:355–360.
24. 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; 47:333–336.
25. Svedstrom E, Alanen A, Nurmi M. Radiologic diagnosis of renal colic: the role of plain film, excretory urography and sonography. Eur J Radiol 1990; 11:180–183.