Diagn Interv Radiol 2006; 12:147-150

Unenhanced multidetector CT evaluation of urinary stones and secondary signs in pediatric patients

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PURPOSE
This retrospective study evaluated the unenhanced multi-detector computed tomography (MDCT) findings of urinary system calculi and the secondary signs associated with ureteral stones in children.

MATERIALS AND METHODS
The study included 87 children (54 boys, 32 girls) with a mean age of 89 months (range: 5 months to 16 years) who were referred to us from various departments and were evaluated with unenhanced MDCT between January 2004 and June 2005. The patients were retrospectively evaluated by 2 radiology specialists by means of PACS (picture archiving and communication systems) with regard to the presence of stones, and localization and secondary signs associated with ureteral stones, such as hydronephrosis, proximal ureteral dilatation, unilateral renal enlargement, perinephric edema, tissue rim sign, decreased renal density, and periureteral edema. Patients were scanned by 4- and 16-slice MDCT.

RESULTS
Urinary system calculi were detected in 47 (54%) children. An isolated stone in the urinary bladder was detected in one patient. In the remaining 46 children, 43 of the detected stones were renal stones and 23 of them were ureteral stones. Secondary signs associated with ureteral stones were detected in 69.6% of children who had ureteral stones.

CONCLUSION
MDCT provided evaluation of the secondary signs associated with ureteral stones as well as the direct visualization of the stones in cases with urinary stone disease. The ability of MDCT to detect the secondary signs associated with ureteral stones supported the diagnoses and may aid in diagnosis when difficulties are present.

Key words: • multi-detector, computerized tomography • pediatric patients • urinary tract, calculi

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Received 16 March 2006; revision requested 18 April 2006; revision received 24 April 2006; accepted 26 April 2006.

The incidence of urinary stone disease in the pediatric population is less than in adults (1). While renal colic is the main finding in adults, it is observed in only 15% of children (2). While childhood stone disease is continuing to decrease in developed countries, it remains endemic in some parts of the world (2). Radiological imaging has a very important role in the evaluation of stone patients. For this reason, direct urinary system graphy, ultrasonography, intravenous pyelography, computed tomography (CT), and magnetic resonance imaging (MRI) might be used (3). All of these imaging methods have some advantages and disadvantages. Unenhanced spiral CT was first used by Smith et al. in 1995 to evaluate urinary stones (4). Unenhanced spiral CT is more sensitive and specific in defining ureteral stones compared to other imaging methods. In diagnosis of ureteral stones in adults, findings secondary to the urinary system obstruction may be used as contributory (5).

In our study, urinary system stones and the incidence of findings secondary to ureteral stones were retrospectively evaluated with unenhanced multi-detector CT (MDCT) in a pediatric population.

Materials and methods

The study included 87 pediatric patients (33 girls: 37.9%; 54 boys: 62.1%) with a mean age of 89 months (rang: 5 months to 16 years) that were scanned with MDCT, utilizing stone protocols, between January 2004 and June 2005 after referral from various departments in our hospital. One of the patients had a solitary kidney. Two radiology specialists retrospectively performed the evaluations of the CT investigations using PACS (picture archiving and communication systems). In CT investigations, the presence and localization of the stones, secondary signs associated with the ureteral stones, and the presence of concomitant urinary system and extraurinary pathologies were evaluated. Secondary signs associated with the ureteral stones, such as hydronephrosis, ureteral dilatation proximal to the stone, renal enlargement, perinephritic edema, tissue rim sign, decreased renal density, and periureteral edema, were evaluated.

In CT, a stone was recognized by visualization of the calcific densities in the kidneys and ureter (6-7). In diagnosis of hydronephrosis, in order to exclude extrarenal pelvis situations, dilation of the upper and lower pole calices were taken into consideration (6). Proximal ureteral dilatation was distinguished by visualization of the ureter distal to the stone with normal caliper, which was dilated proximally, and by visualization of the continuation of the proximally-dilated ureter with the renal pelvis. For enlarged kidneys, parenchymal thickness of both kidneys, in the sections traversing mid zone planes, and the length of the kidneys were measured and asymmetrical increases were not-

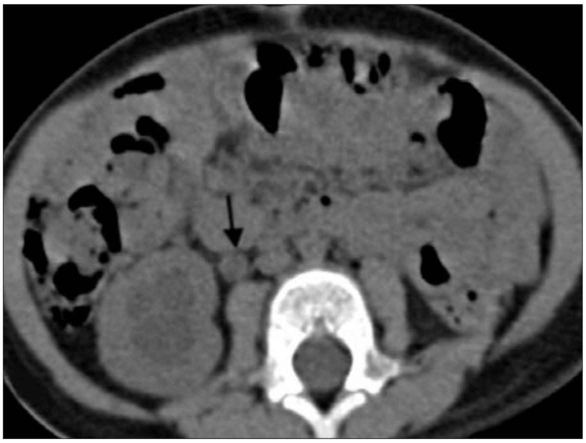

Figure 1. In a one-year-old male patient, hydronephrosis in the right kidney and proximal ureteral dilatation secondary to a stone in the mid 1/3 of the right ureter is seen.

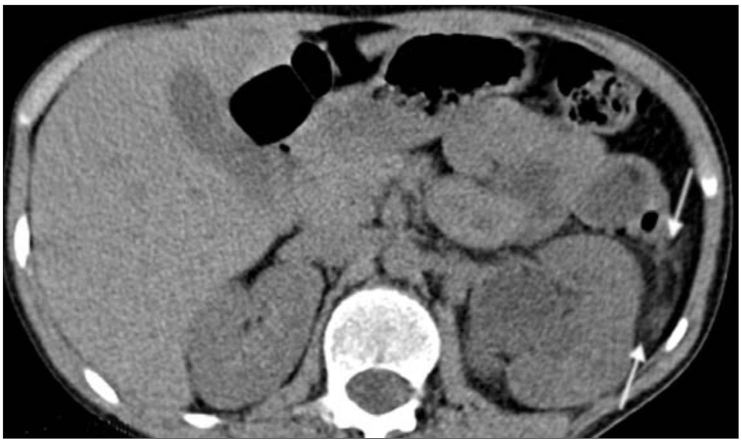

Figure 2. In a 13-year-old male patient, left perinephritic edema *(arrows)* secondary to a left ureteral stone is seen. Additionally, on the ipsilateral side, hydronephrosis is observed.

ed. Perinephritic edema was defined as the stranding of the adipose tissue around the kidney. Tissue rim sign was recognized as the visualization of the annular soft tissue caused by the edematous ureteral wall surrounding the stones (5). Periureteral edema was distinguished by the presence of stranding in the surrounding adipose tissue as a result of the inflammation secondary to ureteral stones. Comparison with the periureteric area on the opposite side facilitated the diagnosis (6). Decreased renal density was visually evaluated as the asymmetric density decrease between the two kidneys (5).

Examinations were performed with a 4-slice MDCT (Somatom, Volume Zoom, Siemens, Germany) (n = 52) and a 16-slice MDCT (Somatom Sensation, Siemens, Germany) (n = 35). Stone protocols were as follows; 4-slice MDCT: collimation 2.5 mm; table movement 10 mm; pitch 1, 120 kV, 60-100 mAs; 16-slice MDCT: collimation 1.5 mm; table movement 24 mm; pitch 1, 120 kV; CareDose option providing an effective mAs of 60-120, without oral or intravenous contrast medium administration; 3 mm slices from the suprarenal region to the symphysis pubis were obtained.

Results

In 47 of the 87 patients (54%), urinary stones were detected in the urinary system. While in one patient there was an isolated urinary bladder stone, in the remaining 46 patients, 23 ureteral and 43 renal stones were present. In 20 patients, stones were detected in both kidneys and ureters. The localization of stones in the 23 patients with ureteral stones were as follows; proximal ureter (n = 6; 26%), distal level (n = 10; 43.4 %), mid level (n = 5; 21.7%), both mid and distal levels (n = 2; 8.6%). Secondary signs associated with ureteral stones were detected in 16 of 23 patients (69.6%) who had ureteral stones. Of the 23 patients with ureteral stones, there was hydronephrosis in 14 (60.9%), proximal ureteral dilatation in 13 (56.5%) (Figure 1), renal enlargement in 9 (39.1%), perinephritic edema in 6 (26.1%) (Figure 2), tissue rim sign in 6 (26.1%) (Figure 3), decreased renal density in 4 (1.4%) (Figure 4), and periureteric edema in 3 (13%) (Figure 5) of the patients.

There was hematuria in 16 of the children who had urinary system stones, hematuria and abdominal pain in 11, abdominal pain in 7, family history and hematuria in 4, hematuria and previous urinary stone history in 4 and recurrent urinary tract infections. Four of these patients had hypercalciuria, 1 had ornithine transcarbamylase deficiency, 1 had glycogen deposition disorder, and 1 had familial Mediterranean fever.

In 7 of the patients, additional urinary system pathologies was detected. These pathologies were neurogenic bladder due to operated lumbosacral meningocele, double collecting duct in one kidney and dysplasia in the other kidney, obstruction of ureteropelvic junction, angiomyolipoma, horseshoe kidney, pelvic kidney, and simple renal cyst.

In 14 of the patients, accompanying extraurinary pathologies were detected. There were 7 with accessory spleens, 2 with pleural effusions, 1 with parauterine fluid, 1 with fluid in the inguinal channel, 1 with splenomegaly, and 1 with hepatosplenomegaly in whom there was glycogen deposition disorder.

Discussion

Many studies investigating the sensitivity and specificity of unenhanced CT in urinary system stone disease in comparison with other radiological modalities have been published. According to these studies, the sensitivity of unenhanced CT in the detection of urinary system stone disease in adults is higher compared to other imaging methods (7-11). Its most important disadvantage is its high radiation dose and its high cost (12). However, two important advantages of CT are short duration of examination and the absence of contrast medium administration (7). Additionally, by measuring the density of detected stones, CT provides information useful in treatment

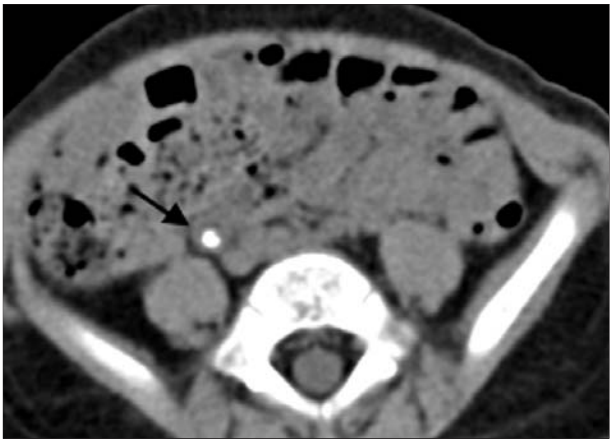

Figure 3. In a one-year-old male patient, tissue rim sign *(arrow)* caused by an edematous ureteral wall surrounding a stone in the ureter is seen.

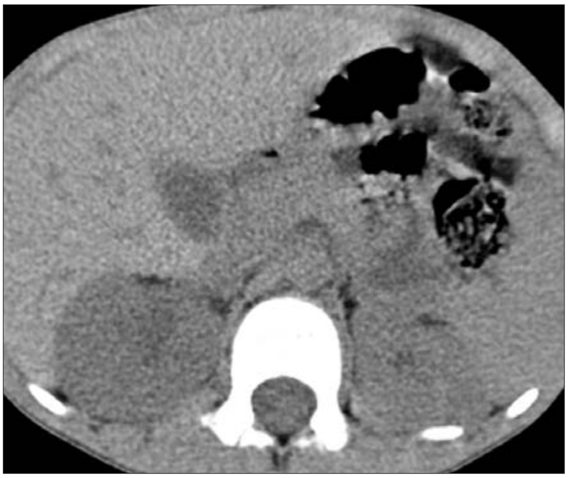

Figure 4. In a 7-year-old male patient, minimal increase in renal size, and decreased renal density in the right kidney secondary to a proximal ureteral stone is seen.

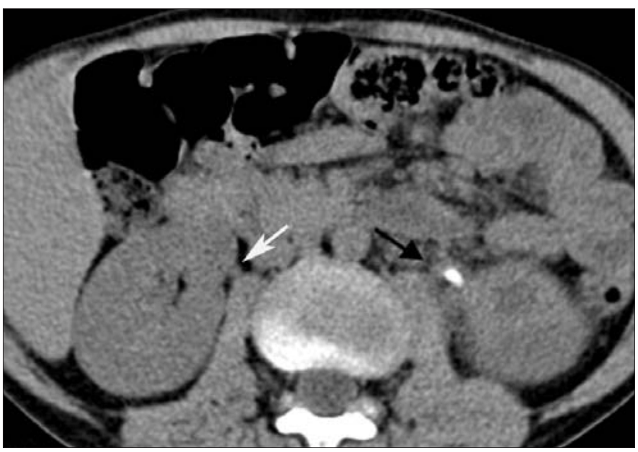

Figure 5. In a 13-year-old male patient, normal periureteric adipose tissue *(white arrow)* is seen. However, ureteral wall thickening *(tissue rim sign)* secondary to a stone in the proximal left ureter and fat stranding secondary to periureteric edema *(black arrow)* is observed.

planning (13). Detection of secondary signs associated with obstruction in CT examination also provides data regarding the importance of the ureteral stone (7).

Since Smith et al. defined urinary system stones with CT in 1995, there have been many other studies of the detection of stone disease with CT using 5 mm and thinner sections (6-7). In our study, section thickness was 3 mm.

Flank pain or abdominal pain (with or without hematuria), nausea, vomiting, dysuria and urinary system infection are the most commonly encountered symptoms in children; however, in children younger than 5 years, classical flank pain may not be present (14). Özokutan et al. reported that symptoms of flank or abdominal pain are the most common in pediatric urinary stone patients (12). In our study, the most common symptom was hematuria and abdominal pain.

Secondary signs associated with ureteral stones have provided new contributions to diagnosis. Among the secondary signs, hydronephrosis, perinephritic edema, unilateral renal enlargement, unilateral absence of dense pyramids, prominence of laterconal fascia, and tissue rim sign were evaluated by investigators (5-6). In our study, hydronephrosis, proximal ureteral dilatation, renal enlargement, perinephritic edema, tissue rim sign, decrease in renal density, and periureteral edema were evaluated.

Secondary signs are indicators of urinary system obstruction. When no stone is detected in the presence of secondary signs, then previously extracted stones, pyelonephritis, and causes of obstruction other than stones should be considered (6).

Hydronephrosis, which is one of the secondary signs of ureteral stones, has been detected with CT in 69%-83% of adult patients (6, 12, 15). Smergel et al., in their study of children with ureteral stones, hydronephrosis was detected in 45% of the cases (5). Strouse et al., in their study of a pediatric population, detected hydronephrosis in 73% of the study group (7). In our study, hydronephrosis as a secondary sign was detected in 60.9% of patients.

In their study of an adult sample, Ege et al. reported that proximal ureteral dilatation was found in 82.3%, accounting for the most common secondary sign (6). Most commonly detected secondary signs among pediatric patients observed by Smergel et al. were renal enlargement and proximal ureteral dilatation, both of which occurred in 50% of cases (5). In our study, proximal ureteral dilatation was seen in 56.5% of the patients and it was the most common secondary sign after hydronephrosis.

In stone disease, renal enlargement may be caused by edema secondary to acute obstruction. This entity has been reported to occur in between 36%-71% of cases in different studies (5-7). In our study, similar to studies among adults, renal enlargement was detected in 39.1% of the patients.

Perinephritic edema has been found in 36%-82% of adult patients. Ege et al. found perinephritic edema in 47.2% of patients (6). In the pediatric population, it is observed in a lower rate than adults, 5%-41% of patients (5-7). In our study, in parallel to the literature, perinephritic edema was found in 26.1% of our patients.

Tissue rim sign appears as a result of edema in the ureteral wall surrounding the stones. It has been reported to have high specificity in distinguishing ureteral stones from phlebolites. Strousse et al. reported a frequency of tissue rim sign of 34% (7). In our study, tissue rim sign was present in 26.1% of patients.

In stone disease, a decrease in renal density may be observed secondary to obstruction. Strousse et al. reported a decreased renal density prevalence rate of 24% (7); in our study, this rate was 17.4 %.

Periureteral edema may develop secondary to inflammatory reaction and obstruction by neighboring ureteral stones. Ege et al. found a periureteral edema frequency rate in adults of 59%, whereas Strousse et al. reported it to be 41% in children (6,7). In our study, periureteral edema was noted in 13% of the patients, which is significantly lower compared to the literature. However, the mean age of the patients that we evaluated was significantly lower than in the literature. The lower frequency we observed may have been related to the fact that abdominal fatty tissue is lower in this age group, which may have made it more difficult to determine periureteral edema in our patients.

In conclusion, while CT in urinary stone disease shows stones directly, it also permits evaluation of the secondary signs associated with stones. Identification of secondary signs supports the diagnosis of ureteral stones and contributes to the diagnosis when there is difficulty in stone diagnosis.

References

1. Eshed I, Witzling M. The role of unenhanced helical CT in the evaluation of suspected renal colic and atypical abdominal pain in children. Pediatr Radiol 2002; 32:205-208.
2. Ozokutan BH, Kucukaydin M, Gunduz Z. Urolithiasis in childhood. Pediatr Surg Int 2000; 16:60-63.
3. Rao PN. Imaging for kidney stones. World J Urol 2004; 22:323-327.
4. 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.
5. Smergel E, Greenberg SB, Crisci KL, Salwen JK. CT urograms in pediatric patients with ureteral calculi: do adult criteria work? Pediatr Radiol 2001; 31:720-723.
6. Ege G, Akman H, Kuzucu K, Yildiz S. Acute ureterolithiasis: incidence of secondary signs on unenhanced helical CT and influence on patient management. Clin Radiol 2003; 58:990-994.
7. Strouse PJ, Bates DG, Bloom DA, Goodsitt MM. Non-contrast thin-section helical CT of urinary tract calculi in children. Pediatr Radiol 2002; 32:326-332.
8. Pfister SA, Deckart A, Laschke S, et al. Unenhanced helical computed tomography vs intravenous urography in patients with acute flank pain: accuracy and economic impact in a randomized prospective trial. Eur Radiol 2003; 13:2513-2520.
9. Olcott EW, Sommer FG, Napel S. Accuracy of detection and measurement of renal calculi: in vitro comparison of three-dimensional spiral CT, radiography, and nephrotomography. Radiology 1997; 204:19-25.
10. Ketelslegers E, Van Beers BE. Urinary calculi: improved detection and characterization with thin-slice multidetector CT. Eur Radiol 2006 16; 161-165.
11. Wang LJ, Ng CJ, Chen JC, Chiu TF, Wong YC. Diagnosis of acute flank pain caused by ureteral stones: value of combined direct and indirect signs on IVU and unenhanced helical CT. Eur Radiol 2004; 14:1634-1640.
12. 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.
13. Gupta NP, Ansari MS, Kesarvani P, Kapoor A, Mukhopadhyay S. Role of computed tomography with no contrast medium enhancement in predicting the outcome of extracorporeal shock wave lithotripsy for urinary calculi. BJU Int 2005; 95:1285-1288.
14. Walther PC, Lamm D, Kaplan GW. Pediatric urolithiases: a ten-year review. Pediatrics 1980; 65:1068-1072.
15. 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.