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PREDICTIVE ROLE OF NON-CONTRAST SPIRAL COMPUTERIZED TOMOGRAPHY ON SPONTANEOUS PASSAGE OF URETERAL STONES

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ABSTRACT

Purpose: We assessed the role of non-contrast spiral computerized tomography (CT) for prediction of a favorable clinical outcome in patients with ureterolithiasis, presenting with acute flank pain.

Materials and Methods: Consecutive 185 patients having acute flank pain were prospectively evaluated with physical examination, urinalysis and hemogram, and non-contrast spiral CT. Size (greatest width in mm), location, perinephric fat stranding, the degree of hydronephrosis, tissue rim sign and perinephric fluid were assessed with spontaneously passed and unpassed stones.

Results: Urinary stone disease was investigated in 173 (93.5%) patients out of 185 (mean age = 41.1 years) by non-contrast spiral CT in whom ureterolithiasis was diagnosed in 96 (94 unilateral, 2 bilateral). Spontaneous passage was assumed in 79 patients with ureterolithiasis. Only 38 patients spontaneously passed ureteral stones with less than 7.4mm diameter. The greatest width difference was statistically significant between passed and unpassed group [(2.0-7.4mm; mean 4.37±1.63) vs. (4.0-10.0mm; mean 7.35±1.81), p<0.05].

Conclusions: Spiral CT seems to be a sensitive imaging modality for the detection of ureteral calculi. In addition, size and location of the ureteral stones and its effects on ureteral wall, as periureteral inflammation and edema, demonstrated by the rim sign, present an important predictive value on spontaneous passage of uretreral stones.

Key words: ureteral calculi; diagnosis; tomography, X-ray computed; therapeutics
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INTRODUCTION

The value of unenhanced spiral computerized tomography (CT) for demonstrating urinary tract stones has been well established since its first report (1-4). In spite of the valuable results, obtained using unenhanced CT in the evaluation of patients with acute renal colic, the use of non-contrast CT has not been accepted fully by clinicians accustomed to findings shown on intravenous urography (IVU). In the evaluation of renal colic, IVU has an important role to delineate urinary structures and its functional features, along with the localization and degree of any obstruction. In spite of its advantages, the use of contrast material, the difficulty to perform the test properly during acute pain, and the time needed for test completion are limiting factors for its choice. Radiolucent stones, lack of bowel preparation or tiny stones superimposed over bony pelvis are also problems.

On therapeutic approach, smaller stone size, location of the stone, especially in the distal ureteral part, and presence or perinephric fluid extravasation, might be correlated with spontaneously stone passage (5,6). Based on these facts related in IVU, and in the literature about the use of spiral CT in recent years, we have studied in our series of renal colic the diagnostic role of non-contrast spiral CT scanning. In addition, we assessed the using of spiral CT in patients with ureterolithiasis for predicting a favorable clinical outcome and the impact of stone diameter and localization.

MATERIAL AND METHODS

One hundred and eighty five consecutive patients (average age=41.1±15.1 years) presenting acute, severe flank pain in emergency rooms and urology outpatient clinics were included into the study. Patients with fever or other features suggestive of septicemia, and those who are likely, or known, to be pregnant were excluded from the study group. All patients were initially evaluated in emergency room and outpatient settings through history, physical examination, and laboratory tests (white blood cell level and urine analysis), and were subsequently submitted to spiral CT scan without contrast material.

Imaging was performed with a CT scanner (Siemens Somatom Plus 40) using spiral technique, with table speed of 7mm/sec, 5mm collimation (pitch 1.2), and 5mm reconstruction interval covering the urinary tract without contrast application. Areas with small opaque calculi or undetermined findings were additionally reviewed at 3mm intervals. The scan time was between 40 and 50 sec, with suspended respiration during inspiration. All patients were able to hold their breath for at least the first half of the scan sequence. The greatest width was measured in all patients having ureterolithiasis after computerized magnification of images (Figure-1).

All CT images were jointly reviewed by a radiologist and an urologist for the presence of opaque calculi, tissue rim sign, hydronephrosis or hydroureter, perirenal fluid, and perinephric fat stranding. A positive tissue rim sign was defined as a 1 to 2mm rim of soft-tissue attenuation (20-40H) surrounding the intraureteral stone. The presence or absence of this tissue rim sign could be determined only when we observed a clear fat plane around a stone or calcification. When the outer ureteral wall could not be observed due to the lack of such a fat plane at the level of the stone, the sign was categorized as indeterminate. In addition, we measured the size of each

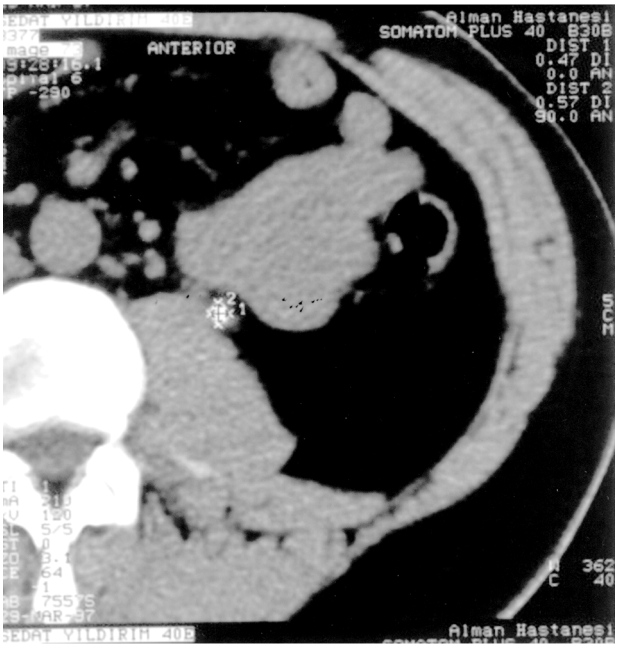

Figure 1 *- Greatest width of the mid-ureteral stone was measured (5.7mm).*

stone (in millimeters) as the greatest dimension within the axial plane of the CT section. Stone location in the ureter was classified as proximal (when above the level of the top of the sacro-iliac joint), mid (when at the level of the sacro-iliac joint), and distal (when below of the sacro-iliac joint, at the ureterovesical junction).

In patients found to have urolithiasis by this method, the spontaneous passage of stone, its eradication by retrograde ureteroscopy or surgery, or resolution of the findings during follow-up after an ESWL, were considered as evidence of a defined diagnosis. For the purposes of this study, we defined spontaneous passage, which was patient-dependent, due to many factors such as pain tolerance and presence of infection, as occurring if no intervention was performed. The follow-up of all positive cases for non-obstructive or obstructive stones was performed by 2 authors (TE and TK). Patients with ureterolithiasis were separated into 2 groups, with less and more than 7mm stone diameters, according to Takahashi et al. (6), to determine a cut-off value in the spontaneous passage of the stones. All patients were followed utmost 3 weeks for spontaneous stone passage, determined by patient's report and control X-ray studies.

Non paired Student *t* test and the Mann-Withney *u* test were used for statistical analysis for determining correlation of ureteral stone diameter and the associated secondary findings, especially ureteral tissue rim sign, with the clinical outcome (patient with documented passage of stones versus patients in whom conservative treatment failed).

RESULTS

In 173 patients with urinary tract stone disease (51 females, 122 males), 94 had unilateral ureter stone (48 on the right, 51 on the left), and 2 bilateral ureteral stones.

Six unilateral stones were found in the proximal ureter, 14 in the mid, and the remaining 74 in the distal portion. Of 2 patients with bilateral ureteral stones, one had stones in both distal ureters, whereas in the other case the stones were in the distal ureter and in the mid-portion on the contralateral side.

In patients with ureteral stones, spontaneous passage occurred in 38 (40%), and ESWL therapy was performed in 16 (16.8%). Retrograde ureteroscopic stone extraction was successful in the remaining 41 (43.2%), including one patient with bilateral stones. Considering the high mortality risk, no intervention was possible for one patient with bilateral ureteral stones, anuria and multiorgan failure, managed in the intensive care unit, who expired during hemodialysis. In 3 patients with ureteral stones, spontaneous passage of stone into the bladder was detected during spiral CT scanning, with dramatic decrease in pain.

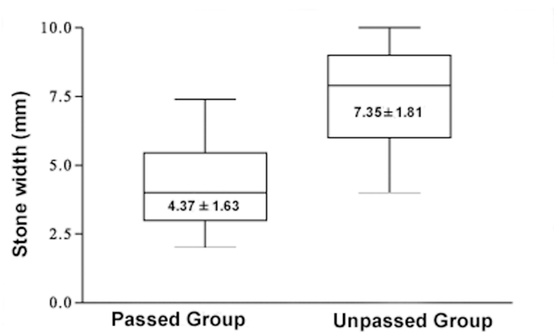

Figure 2 *- Distribution of stone widths for passed (n=38) and unpassed (n=41) groups. Mean stone diameters were 4.37 and 7.35mm, for spontaneously passed and unpassed groups, respectively.*

In 33 cases with ureteral stones, there was no obstruction on spiral CT images. The other 63 patients showed obstructive signs – hydroureter, hydronephrosis, perinephric fluid or fat stranding.

Spontaneous passage of the ureteral stone was assumed in 79 patients with ureterolithiasis. These patients were divided into 2 subgroups, according to the stone diameter as less than 7.0mm diameter and more than 7.0mm diameter (6). In 32 (66.7%) out of 48 patients, spontaneous stone passage was observed, with mean 4.38±1.35mm stone diameter (3.0-6.9mm). On the other hand, only in 6 (19.3%) patients out of 31, ureteral stone passed spontaneously, with a mean 8.23±0.89mm stone diameter (7.0–10.0mm). Retrograde ureteroscopic stone extraction was performed in the remaining 16 and 25 patients, of the former and later groups, respectively. All passed stones (n=6) were smaller than 7.4mm stone diameter in the later group.

The difference of mean stone diameter between successfully passed (n=38) and unpassed (n=41) group was statistically significant [(2.0-7.4mm; mean 4.37±1.63) vs. (4.0-10.0mm; mean 7.35±1.81), $p<0.05$] (Figure-2). In addition, the distribution of treatment modalities and the outcome of assumption of spontaneous passage in unilateral ureterolithiasis dependent on its location in 94 patients are shown in Table-1. In addition, the presence or absence of the ureteral wall tissue rim sign around the stone can also impact on predicting the spontaneous passage of ureteral stones. The tissue rim sign was present in 38 (37%) of patients with ureterolithiasis, whilst a negative, or indeterminate, tissue rim sign was observed in 23 (22%) and 41 (40%) patients, respectively. All spontaneously passed mid-ureteral stones (n=5) and distal ureteral stones (n=33) did not have ureteral tissue rim sign (Figure-3). Although ureteral tissue rim sign was observed in 4 (80%) out of 5 mid-ureteral unpassed stones (Figure-4A), this ratio was 23 (67%) of 34 for distal ureteral unpassed stones (Figure-4B).

DISCUSSION

Due to its high accuracy, and the short time needed to perform it without contrast, spiral CT has

__Table 1__ - Distribution of treatment modalities and outcome of assumption of spontaneous passage of unilateral ureterolithiasis depending on its localization in 94 patients.

Location of Ureteral Stones (n=94)	Follow-up for Spontaneous Passage	Follow-up for Spontaneously Passed Stones (stonediameter-mm)	Interventions for Ureteral Stones	
			URS	ESWL
Proximal ureter (n=6; 6%)	n=2	-	n=1	n=5
Mid-ureter (n=14; 15%)	n=10	5 (50%) 4.6 - 7.0 (5.6 ± 0.8)	n=7	n=2
Distal ureter (n=74; 79%)	n=67	33 (49%) 2.0 - 7.4 (4.2 ± 1.6)	n=32	n=9
Total	n=79	38 (48%)	n=40	n=16

URS = uretererenoscopy, ESWL = extracorporeal shock wave lithotripsy

emerged as a preferable alternative to IVU for the diagnosis of urolithiasis in clinical practice. The series of Fielding et al. (7) reporting 100% sensitivity and 97% specificity of spiral CT support this argument, as well as the results of our study, which revealed 98% specificity with 100% sensitivity. Besides the presence and localization of stones, further information can be obtained with spiral CT of urinary tract, such as size and density of stones, obstructive parameters (hydronephrosis, hydroureter, or perinephric fluid as a result of rupture of fornices), and degree of obstruction (6). Combination of unilateral ureteral dilatation and perinephric stranding was reported as presenting 97% positive predictive value for stone disease. Conversely, the absence of both signs has 93% negative predictive value for excluding stone disease (8). However, the frequency of all CT secondary signs of ureteral obstruction peaks at 8 hours of pain duration. It seems therefore reasonable to obtain scans in patients with flank pain and suspected renal colic within this window of time to maximize findings of secondary signs of obstruction. Similarly, if the scanning is performed much earlier, the CT secondary findings might be entirely negative. Varanelli et al. (9), found that perinephric stranding remained nearly constant over time at about 25%, and nephromegaly reached a peak of 65% at 5-6 hours. Additionally, in the same study, periureteral stranding was present in 35% of patients with pain during 2 hours, and reached a peak of 76% at 7-8 hours. On the other hand, collecting system dilation was present in only 68% of patients with pain during 2 hours or less. All CT secondary signs of ureteral obstruction showed a significant increase in frequency as duration of flank pain increased, regardless of stone size, with ureteral tissue rim sign being the only known exception (9). This may explain why CT studies in 30% of the patients with acute ureteral obstruction due to ureterolithiasis show negative findings for some or all CT secondary signs of obstruction.

***Figure 3** - Spontaneously passed distal ureteral stone without ureteral wall tissue rim sign.*

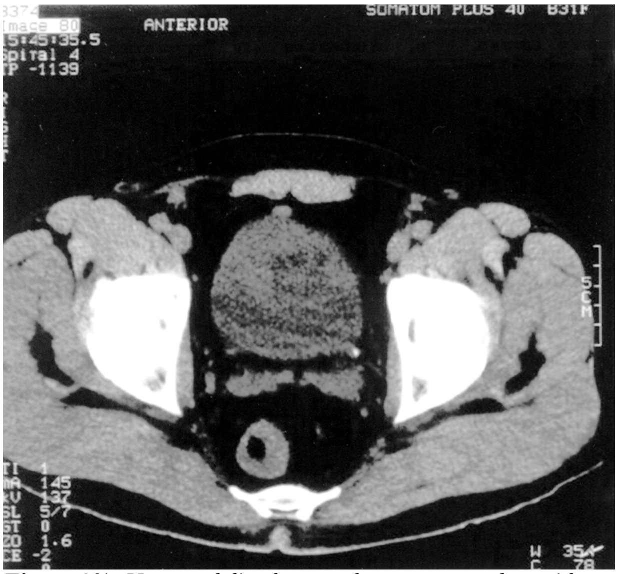

Figure 4A)- *Unpassed distal ureteral stone wrapped up with periureteral edema (ureteral wall tissue rim sign) in spite of its width less than 5mm.*

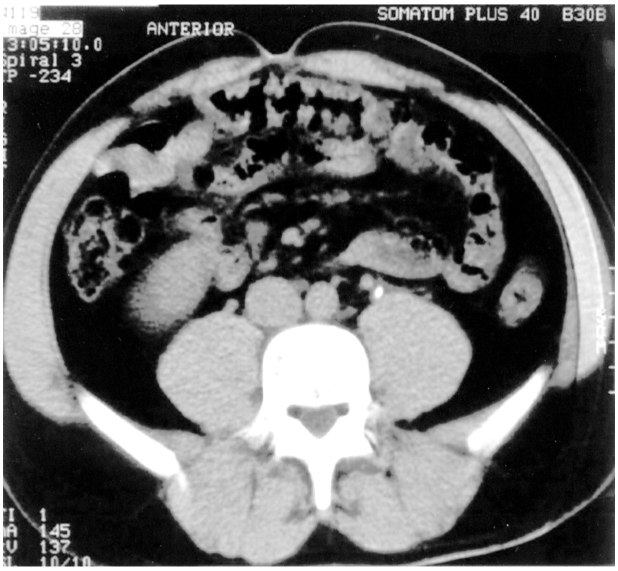

Figure 4B)- *Left mid-ureteral calculi surrounded by tissue rim sign, which could not be passed spontaneously in spite of its width was less than 5mm.*

Non-contrast spiral CT can be used to predict a favorable outcome, especially for ureteral stones. In our series, mean diameter was significantly larger in patients with unsuccessful conservative treatment than in those with spontaneous stone passage. Also, spontaneous passage of ureteral stones with less than 7mm diameter, without ureteral rim sign, can be observed in 67% of patients. Nevertheless, the successfully passed ratio was 19% in ureteral stones with more than 7mm diameter. All passed stones (n=6) were smaller than 7.4mm diameter in the later group. In Dalrymple series (8), the average size of the stones that passed spontaneously is 4.6mm, whereas those requiring interventional approach are 6.0mm ($p<0.002$). They pointed out that 80% of stones 4mm or less passed spontaneously. On the other hand, this cut-off value was given as 7mm in Boulay's & Takahashi's series (5,6), which is confirmed by our series as less than 7.4mm stone diameter in spontaneously passed group. Due to the fact that the size of the stone has great importance for therapy, and not determining the diameter may cause an inappropriate therapeutic approach, stone greatest width measurement is crucial for the assessment. In Boulay's series (5), stone size was the only variable associated with conservative versus interventional treatment, while stone location and degree of ureteral dilation did not appear to affect the treatment choice. It was shown that spiral CT offers significantly improved accuracy in determining stone size compared to traditional imaging techniques, such as plain radiography and nephrotomography (10). In the present study, according to the findings obtained with non-contrast spiral CT, it can be suggested that not only ureteral stone location and diameter, but also periureteral tissue rim sign, might help for prediction. Spontaneous passage did not succeed in 67% and 80% of the stones wrapped with periureteral edema (ureteral wall tissue rim sign) localized in mid and distal ureter, respectively. Although the results of Takahashi et al. series (6) including ureteral tissue rim sign was not predictive for spontaneous passage of ureteral stones, this sign, representing edema of the ureteral wall at the level of obstruction, impact moving down of stones over time in our study.

As a diagnostic work-up tool taking less than 10 minutes, without the need for bowel cleaning and intravenous or intestinal contrast, the non-contrast spiral CT is a rapid and comfortable initial approach to patients in acute flank pain, especially in the emergency room. However, the inability to assess the renal function and the urinary mucosa are main disadvantages of non-contrast spiral CT. Although pelvic phleboliths are common, the confusion with ureteral stones on spiral CT rarely creates need for contrast studies such as IVU (2.1%). The “tail sign”, which has been recently reported with its 100% specificity and 65% sensitivity in differentiating phleboliths from ureteral calculi at unenhanced spiral CT, might decrease the requirement of IVU in the assessment of distal ureteral stones (11). In spite of its limited role regarding renal function and in non-obstructive distal ureteral stones, Teh et al. claimed that non-contrast spiral CT can be used as the method of choice without need for other tests (12).

In conclusion, non-contrast spiral CT of the urinary tract appears as a method of choice in the emergency room to evaluate acute flank pain, with its high specificity and sensitivity.

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