DIR

Diagn Interv Radiol 2025; DOI: 10.4274/dir.2025.253304

ABDOMINAL IMAGING

ORIGINAL ARTICLE

Role of ureteral wall thickness and computed tomography imaging in predicting spontaneous passage of ureteral stones

Özlem Kadırhan[1]
Sonay Aydın[1]
Ercüment Keskin[2]
Mecit Kantarcı[1,3]

[1]Erzincan Binali Yıldırım University Faculty of Medicine, Department of Radiology, Erzincan, Türkiye

[2]Erzincan Binali Yıldırım University Faculty of Medicine, Department of Urology, Erzincan, Türkiye

[3]Atatürk University Faculty of Medicine, Department of Radiology, Erzurum, Türkiye

PURPOSE

Urolithiasis is a common health problem with a high recurrence rate, and effectively balancing follow-up with intervention is important for patient safety. In this context, our study aims to identify criteria that can predict the likelihood of spontaneous passage (SP) of ureteral stones.

METHODS

A retrospective analysis was performed on 2,773 patients who presented to our hospital with renal colic over a 4-year period. The study included 897 patients with unilateral ureteral stones measuring ≤10 mm, identified using non-contrast computed tomography, and inflammatory serum markers assessed through biochemical testing. Variables analyzed to predict the likelihood of SP included stone size, lateralization and location, ureteral wall thickness (UWT) at the stone site, stone density, degree of hydronephrosis (HN), ureteral length, parenchymal thickness and density, and various biochemical parameters.

RESULTS

It was determined that the SP of ureteral stones was considerably affected by larger stone size (right >6.5 mm, left >6 mm), higher stone density (>957 Hounsfield units), increased UWT (>1.7 mm), presence of high-grade HN (grade ≥2), and elevated neutrophil-lymphocyte ratio (NLR) (>2.15) and platelet-lymphocyte ratio (PLR) (>10.28) values in blood. No statistically significant relationship was observed between SP and ureteral length, renal parenchymal thickness, or renal parenchymal density. It was found that when the UWT at the level of the ureteral stone exceeded 1.7 mm, the risk of the stone not passing spontaneously increased by 706.5 times in univariate logistic regression (LR) analysis and by 337.9 times in multivariate LR analysis compared with individuals with a wall thickness below this threshold.

CONCLUSION

Our study demonstrated that, in addition to stone size and location, increased UWT at the stone level, higher stone density, the presence of concomitant high-grade HN, and elevated NLR and PLR values in the blood could be used as criteria to determine the likelihood of SP of ureteral stones. According to our results, UWT was shown to be a stronger risk factor for failure of SP than stone size.

CLINICAL SIGNIFICANCE

The findings indicate that wall thickness around ureteral stones is a risk factor with a higher negative predictive value for SP than the stone size and location.

KEYWORDS

Ureteral stone, spontaneous passage, ureteral wall thickness, stone density, neutrophil-lymphocyte ratio, platelet-lymphocyte ratio, computed tomography, hydronephrosis

Corresponding author: Özlem Kadırhan

E-mail: ozlemkkadirhan@gmail.com

Received 21 February 2025; revision requested 26 March 2025; accepted 02 June 2025.

Epub: 07.07.2025

DOI: 10.4274/dir.2025.253304

You may cite this article as: Kadırhan Ö, Aydın S, Keskin E, Kantarcı M. Role of ureteral wall thickness and computed tomography imaging in predicting spontaneous passage of ureteral stones. *Diagn Interv Radiol.* 07 July 2025 DOI: 10.4274/dir.2025.253304 [Epub Ahead of Print].

Ureteral stones account for approximately 20% of all urinary tract stones. If stones formed in the kidney pass into the ureter, they may cause severe, sudden pain known as renal colic.[1] It has been reported that 5%–12% of individuals in developed countries present to the emergency department with renal colic at least once in their lifetime.[2-4] Urinary tract infection and sudden deterioration in renal function can also occur in the setting of urolithiasis.[1] In such cases, prompt identification of an appropriate treatment regimen based on the likelihood of spontaneous passage (SP) is crucial to prevent the potential development of urosepsis.

According to current guidelines, for patients with uncomplicated distal ureteral stones ≤10 mm, a period of observation or medical expulsive therapy (MET) is recommended. However, in some cases of urolithiasis, individualized treatment may be necessary.[5] This is because long-term observation, based on parameters such as stone size and location, may not be sufficient; if the stone does not pass spontaneously, patients may continue to experience severe colic pain, urosepsis, impaired renal function, or reduced quality of life due to the obstructing stone. To reduce the risk of non-passage and associated complications, additional predictive parameters and multicenter studies are needed to better assess the likelihood of SP.[1,6,7] For example, impacted ureteral stones–regardless of their size or location–may lead to increased ureteral wall thickness (UWT) at the site due to local inflammation, hypertrophy, and edema, thereby preventing SP. Moreover, these changes can increase the risk of acute complications during minimally invasive procedures, such as intraoperative bleeding and ureteral perforation, and may also prolong operative time.[8,9] In this context, informing the operating surgeon of these findings may reduce treatment failure, help better prepare for potential intraoperative complications, and support consideration of alternative treatment protocols. Although there are limited studies investigating the relationship between UWT around the stone, SP, and treatment success using non-contrast computed tomography (CT), the sample sizes in these studies are relatively small, indicating the need for further research in this area.[10-16] Additionally, although some studies examine serum inflammation markers in SP of ureteral calculi, exclusion criteria have not been standardized, particularly regarding the effects of concurrent diseases. In cases where the effects of other variables are assessed simultaneously with MET, the impact of the MET agent on markers used to predict SP remains unclear.

Detecting the probability of SP of a ureteral stone allows for selecting the most appropriate treatment method more quickly, limiting delays in patient management and reducing the risk of complications. Numerous studies in the literature focus on stone size and location to predict the likelihood of SP. In addition to these established parameters, only a few studies have attempted to predict SP based on biochemical indicators and other urinary system factors. However, these studies are insufficient to establish standardized values. Therefore, we aim to identify useful imaging and laboratory parameters that could enhance the predictive accuracy for SP of ureteral stones.

Main points

- Urolithiasis is a common cause of emergency room visits due to renal colic. In the absence of spontaneous passage (SP), urosepsis and sudden loss of renal function may occur. Therefore, appropriate management of the balance between follow-up and intervention is crucial for patient safety.
- The predictive value of the criteria regarding stone size and location, which are frequently used in SP of ureteral stones, is limited in some cases.
- Our study shows that the wall thickness around the ureteral stone is a risk factor with a higher negative predictive rate for the absence of SP than the stone size and location.
- Stone density, increasing degree of hydronephrosis, and elevated platelet-lymphocyte ratio and neutrophil-lymphocyte ratio values can also serve as additional parameters to enhance the predictive accuracy for SP of stones.

Methods

Ethics committee approval

The study was carried out with the permission of Erzincan Binali Yıldırım University Clinical Ethics Committee (decision number: 2023-15/8, date: 07/09/2023). This study was conducted in accordance with the Declaration of Helsinki. Due to its retrospective design, informed consent forms were not acquired as the data collected from patients did not contain any identifiable information.

Scope of the study

Between January 1, 2019, and December 31, 2023, patients with unilateral ureteral stones ≤10 mm who were admitted to our hospital's emergency department and/or urology clinic after their first renal colic episode, underwent non-contrast CT with a stone protocol, and had inflammatory serum markers assessed by biochemical tests were retrospectively screened without age restriction and included in the study. The exclusion criteria are presented in the diagram illustrating the study population (Figure 1). Data on patients' gender, age, treatment protocols, and biochemical test results were obtained from medical records.

Radiological assessment

All participants underwent CT scans using a 128-slice multi-detector CT scanner (Siemens Somatom, Siemens Healthcare, Forchheim, Germany) following a non-contrast stone protocol (kV: 120, mAs: automated current modulation; slice thickness: 1.5 mm). Image assessments were performed using the picture archiving and communication system (PACS) archive with Syngo.via software (Siemens Somatom, Siemens Healthcare, Forchheim, Germany). Soft tissue window settings (width 300; level 40) were applied to axial, coronal, and sagittal plane images.

The ureteral stone's lateralization (right/left), location, maximum axial diameter (mm), average density [Hounsfield units (HU)], UWT (mm), degree of hydronephrosis (HN) (grade 0–4), average renal parenchymal density (HU), and ureter length were assessed by a radiologist with 4 years of experience based on the non-contrast CT scans performed at the time of patients' admission.

The diameter and density of the ureteral stone were measured at the level of its greatest transverse dimension using the freehand region of interest (ROI) method (Figure 2a, b). The location of the ureteral stone was categorized as proximal, mid, or distal by dividing the ureteral length into three equal segments. UWT was determined by measuring the soft tissue density, including the ureteral wall and periureteral edema, at the level where this density was most prominent (Figure 2c). Renal parenchymal thickness was measured at the upper, mid, and lower poles on sagittal plane scans, avoiding areas with space-occupying lesions. The thickest area in each section was measured, and the average of these three measurements was used to determine the parenchymal thickness (Figure 3a). Renal parenchymal density was assessed by obtaining three measurements from the most homogeneous and thickest areas without space-occupying le-

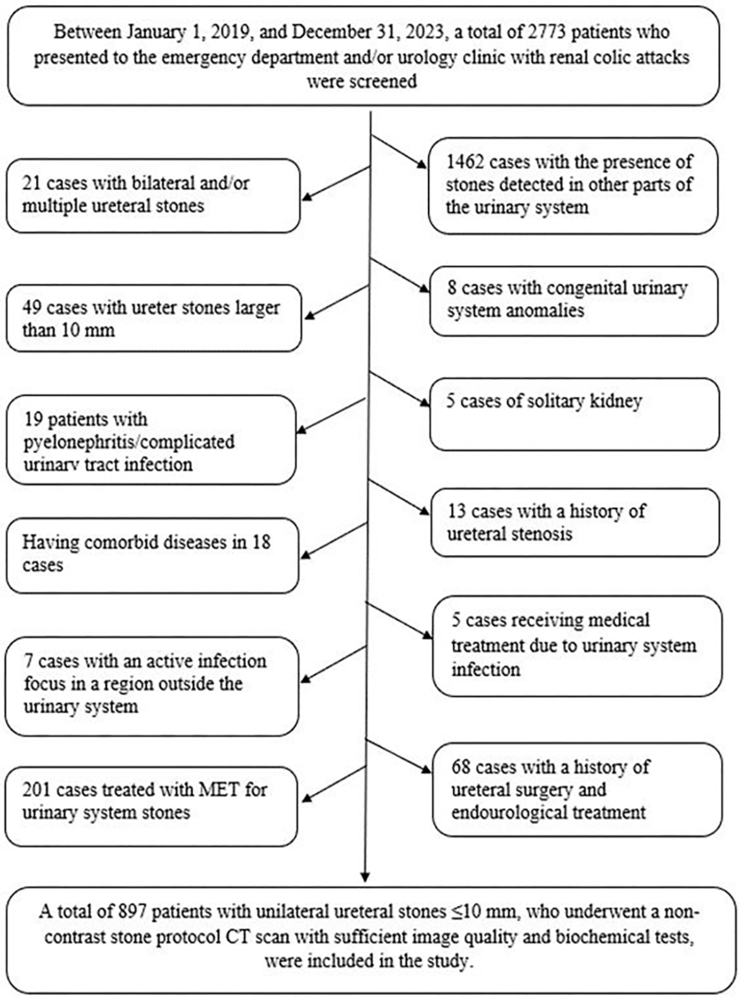

Figure 1. Scheme showing the study population. MET, medical expulsive therapy; CT, computed tomography.

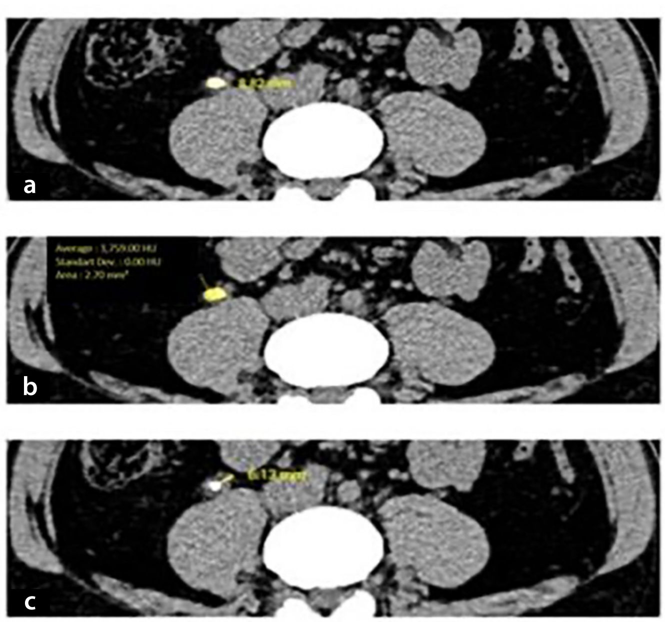

Figure 2. Non-contrast axial plane CT images: the diameter **(a)** and density **(b)** of the ureteral stone are measured at a single level where the stone's diameter is widest. Ureteral wall thickness **(c)** is measured at the level where the soft tissue density, consisting of the ureter wall and periureteral edema surrounding the stone, is highest, using the freehand ROI option. CT, computed tomography; ROI, region of interest.

sions at the upper, mid, and lower pole levels using the freehand ROI method. The average of these values was recorded (Figure 3b). Ureteral length was measured using reformatted CT images, with the ureteropelvic junction and ureterovesical junction as the starting and ending points, respectively. The measurement was based on the number of transverse slices, each represented by a single axial line, multiplied by the slice thickness parameter (Figure 4). The presence and grading of HN in the collecting system, secondary to the ureteral stone, were evaluated based on a commonly used CT grading classification system (Figure 5).

Biochemical assessment

Based on the biochemical tests conducted at the time of the patient's initial presentation, the neutrophil-lymphocyte ratio (NLR) and platelet-lymphocyte ratio (PLR) values were determined.

After applying the exclusion criteria, the SP status of ureteral stones was evaluated using non-contrast CT images accessed via the PACS system, and the mean follow-up durations were recorded based on patient follow-up records. Following the assessment of SP status, the effects of patients' demographic characteristics, initial findings on non-contrast CT, and biochemical test results on SP were analyzed.

Statistical Analysis

The conformity of the data to a normal distribution was verified using the Shapiro–Wilk test and Q–Q plot. Accordingly, parametric tests were used for inferential statistics. The Student's t-test was applied to compare parameters between two independent groups. The Mann–Whitney U test was used to compare median values of parameters that did not follow a normal distribution between two groups, and the chi-square test was employed to evaluate categorical variables expressed as percentages. Descriptive statistics were presented as mean ± standard deviation for normally distributed numerical variables and as number and percentage for categorical variables. In the study, the effects of age, gender, and selected clinical and laboratory characteristics on the risk of spontaneous stone passage were first analyzed using univariate logistic regression (LR). Variables found to be significant were then analyzed using stepwise multivariate LR (enter method). Optimum cut-off values were determined by receiver operating characteristic analysis. Statistical analyses were performed using SPSS version 25.0 (IBM Corporation, Armonk, NY, United States), and P values less than 0.05 were considered statistically significant.

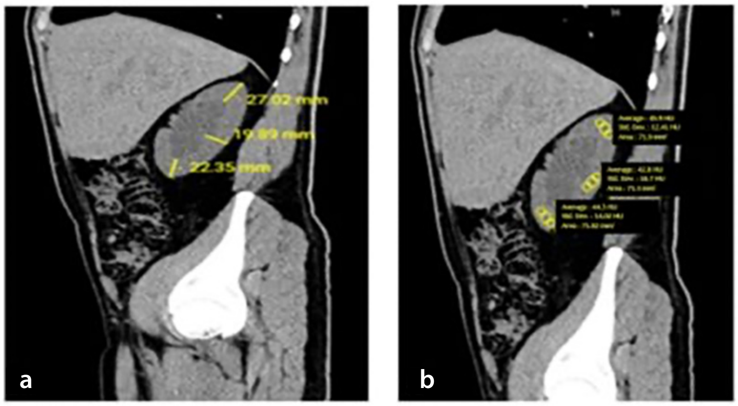

Figure 3. Sagittal non-contrast CT scan: **(a)** parenchymal thickness (mm) and **(b)** parenchymal density (HU) were measured using the freehand ROI option at the three thickest and most homogeneous levels without space-occupying lesions at the upper, middle, and lower poles of the kidney. The mean values of these measurements were calculated. CT, computed tomography; HU, Hounsfield units.

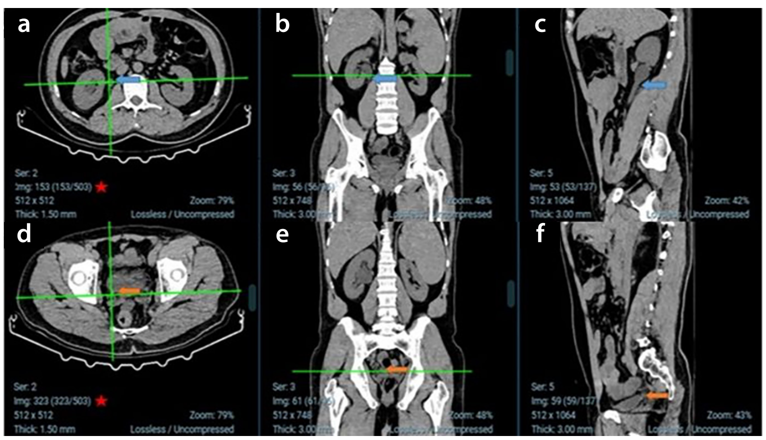

Figure 4. Measurement of ureteral length: The ureteropelvic junction (**a**, transverse; **b**, coronal; **c**, sagittal; blue arrow) and ureterovesical junction (**d**, transverse; **e**, coronal; **f**, sagittal; orange arrow) levels were identified on reformatted CT images. Ureteral length was determined by counting the number of transverse lines (red stars) between the two levels based on the section thickness parameter. CT, computed tomography.

Results

A total of 897 patients who presented to our hospital's emergency department or urology outpatient clinic with renal colic attacks over a 4-year period and met the inclusion criteria were included in the study without any age restriction. The median follow-up duration for SP was 4 weeks (±2 weeks) according to patient medical records.

The study population consisted of 72.9% (n = 654) male and 27.1% (n = 243) female participants, with a mean age of 46.05 ± 13.84 years. Among the 897 cases included, 384 (42.8%) showed SP of the ureteral stone during follow-up, whereas 513 (57.2%) did not experience SP (Table 1). Of the 513 patients without SP of ureteral stones, 88 were managed using extracorporeal shock wave lithotripsy (ESWL), whereas the remaining 425 cases were treated by ureterorenoscopy and ureteroscopic laser lithotripsy.

The clinical parameters of the cases were compared based on SP status. It was found that the average UWT at the stone level in cases without SP (2.41 ± 0.48 mm) was substantially higher than in cases with SP (1.41 ± 0.27 mm). In addition, the mean ureteral stone sizes and stone densities in cases without SP were considerably greater than those in cases with SP. Furthermore, the incidence of SP was substantially higher in distal ureteral stones (n = 195, 50.78%) than in proximal stones (n = 66, 17.18%) based on stone location. The study also observed that PLR and NLR values were considerably higher in cases without SP than in those with SP. Among the cases studied, the frequency of stone SP was substantially higher in patients without HN or with grade 1 HN (14.6% and 57.3%, respectively), and the likelihood of SP decreased considerably as the degree of HN increased (Table 2).

It was also found that mean values of ureter length, renal parenchymal density, and parenchymal thickness were considerably higher in male patients than in female patients. No significant differences between genders were observed for other parameters, including SP (Tables 3, 4).

According to the LR analysis of factors associated with the absence of SP in ureteral stones, UWT, left/right ureteral stone sizes, stone densities, renal parenchymal densities, and the presence of HN were identified as statistically significant risk factors. Patients with UWT values greater than 1.7 mm at the stone level had a 706.5-fold higher risk of absence of SP than those with UWT values less than 1.7 mm (Table 5).

According to the multivariate LR analysis of variables found significant in the univariate analysis, UWT at the stone level, left/right ureter stone size, stone density, PLR, and NLR values were identified as statistically significant risk factors for the absence of stone SP. When all these factors were present simultaneously, patients with UWT values greater than 1.7 mm at the stone level had a 337.98-fold higher risk of not passing stones spontaneously than those with UWT less than 1.7 mm (Table 6).

Discussion

The prevalence of ureteral stones and the frequency of related hospital admissions are increasing. Therefore, to avoid adding to the healthcare burden, conservative treatment should not be overlooked in cases with a likelihood of SP. However, early planning of invasive treatment is crucial in cases without SP probability, as delayed intervention may lead to acute renal failure. In such cases, ureteral stones can be managed using minimally invasive methods, thanks to advances in ESWL and endourological techniques.[17,18] Depending on the location and size of the stone, treatment success rates of 68%–90% have been reported for ESWL and 80%–97% for endourological methods.[5,19]

Despite these high success and stone-free rates, minimally invasive treatments are costly and carry potential risks, including hematoma formation, urinary tract infections, and urinary extravasation. Therefore, accurately predicting the likelihood of SP and avoiding overtreatment remains critical.[20-22] In this context, we aimed to identify certain indicators–and their standardized values–that have not been sufficiently investigated in the literature but may help predict SP of ureteral stones and guide clinical decision-making.

In our study, we demonstrated a statistically significant relationship between SP and several variables: UWT at the stone level, stone size, stone density, stone location, HN grade, PLR, and NLR. Stones located in the upper ureter were less likely to pass spontaneously than those in lower positions. Similarly, high-density stones, low-density stones, and stones accompanied by high-grade HN exhibited a lower rate of SP than stones in patients without HN or with low-grade HN. The likelihood of SP decreased as UWT, stone size, PLR, and NLR increased. No statistically significant relationship was found between SP and age or gender.

Statistically significant predictive values were identified through univariate and multivariate LR analyses for the following variables: UWT >1.7 mm at the stone level, ureteral stone dimensions (right >6.5 mm, left >6 mm), stone density >957 HU, PLR >10.28, NLR >2.15, and high-grade HN (≥ grade 2). These results indicate that the predictive value of UWT at the ureteral stone level may offer a stronger prediction of SP than stone size alone, which is a key factor in the formation of various clinical guidelines.

Stone size and location

Various studies in the literature have examined the effect of ureteral stone size and location on SP.[7,23,24] These studies generally show a positive correlation between smaller, distally located stones and higher SP rates.[25-28] Reported SP rates based on ureteral stone location range from 45%–79% for the lower ureter to 22%–60% for the middle and 12–48% for the upper level.[29,30] In our study group, SP was more likely in lower ureteral calculi and decreased progressively at higher levels (distal: 50.78%, middle: 32.03%, upper: 17.18%), consistent with findings in the literature. Although our SP percentages fall within the reported ranges, they are lower than the average values. This may be attributed to the relatively larger average stone sizes in our cohort (right: 6.29 mm; left: 6.4 mm). Stone size is another key factor often used to predict the SP of ureteral stones. The literature indicates that SP occurs in 68%–98% of ureteral stones ≤4 mm and in 25%–67% of 5–10 mm stones. With MET, SP rates for 5–10 mm stones can reach up to 83%.[30-37] Consistent with these findings, our study showed that the probability of SP decreased as stone size increased. Specifically, stone sizes of 6–6.5 mm in the ureter were identified as statistically significant risk factors for spontaneous non-passage in both univariate and multivariate regression analyses. However, the literature lacks standardization regarding the imaging plane used to measure stone size. One study reported that axial plane measurements–commonly used–can underestimate the actual stone burden by up to 20%.[38,39]

Yoshida et al.[1] and Lee et al.[6] have reported that measuring stone size in the longitudinal plane is more valuable, as it reflects a larger contact surface with the ureteral mucosa. A greater contact area is associated with increased mucosal inflammation and edema, thereby reducing the likelihood of secondary SP. In our study, stone size was defined as the larger of the measurements obtained in the transverse and longitudinal planes; however, a direct comparison between measurements from different planes was not performed. Therefore, although our study incorporates dimensional data in line with previous work, it may be considered relatively limited due to the lack of direct comparison between imaging planes.

Ureteral wall thickness around the ureteral stone

When a ureteral stone is impacted, an increase in UWT develops due to inflammation, periureteral edema, hypertrophy, and fibrosis resulting from stone irritation at the site of impaction.[1,10,16,40] Studies have also shown that increased UWT is associated with higher intraoperative complication rates and lower stone-free rates during ureteroscopic procedures.[11,41]

The effect of UWT at the level of the ureteral stone on SP is controversial, and few studies have investigated this issue. According to the study by Yoshida et al.[1], the probability of a 4-week SP in patients with low UWT at the ureteral stone level (76.4%) was considerably higher than in those with high UWT (14.7%). This research identified a threshold value of 2.71 mm for predicting SP and showed that when UWT is evaluated alongside established parameters such as stone size and location, the accuracy of SP prediction approaches 90%.[1] In our study, the mean UWT at the stone level in cases without SP was found to be 2.41 mm, which was similar to the mean thickness of 2.4 mm reported by Coşkun and Can[42] and lower than the 2.78 mm reported by Selvi et al.[43] This difference may be related to variations in the exclusion criteria and the inclusion of patients with metabolic syndrome who exhibited more heterogeneous characteristics in the study by Selvi et al.[43] However, the common finding across all these studies is that lower UWT values are associated with a higher likelihood of SP at the ureteral stone level.

Table 1. Distribution of socio-demographic and clinical characteristics of all cases

Variables	Mean ± SD	M (min-max)
Age	46.05 ± 13.84	45 (11–81)
Men/women n (%)	654 (72.9%)/243 (27.1%)	
Ureteral wall thickness at stone level (mm)	1.84 ± 0.62	1.7 (0.51–5.12)
Left ureteral stone size (mm)	6.4 ± 1.7	6.5 (3–10)
Right ureteral stone size (mm)	6.29 ± 1.7	6 (3–10)
Stone density (HU)	1,023.04 ± 471.64	957 (235–2068)
Ureteral length (mm)	223.81 ± 15.21	225 (172–264)
Kidney parenchymal density (HU)	38.08 ± 3.81	39 (25–47)
Kidney parenchymal thickness (mm)	18.21 ± 2.75	18 (6–28.77)
PLR	10.09 ± 3.8	
NLR	2.05 ± 0.5	
Accompanying hydronephrosis		
Grade 1	348 (38.8%)	
Grade 2	321 (35.8%)	
Grade 3	138 (15.4%)	
Grade 4	9 (1%)	
No	81 (9%)	
Spontaneous passage		
No	513 (57.2%)	
Yes	384 (42.8%)	

SD, standard deviation; M, median; HU, Hounsfield units; PLR, platelet-lymphocyte ratio; NLR, neutrophil-lymphocyte ratio; min-max, minimum-maximum.

Table 2. Comparison of the quantitative clinical characteristics of cases according to spontaneous stone passage status

Variables	Spontaneous stone passage No (n = 513) Mean ± SD	 Yes (n = 384) Mean ± SD	*P*
Age	46.51 ± 13,53	45.71 ± 14.09	0.620*
Ureteral wall thickness at stone level (mm)	2.41 ± 0.48	1.41 ± 0.27	**<0.001***
Left ureteral stone size (mm)	7.64 ± 1.29	5.44 ± 1.32	**<0.001***
Right ureteral stone size (mm)	7.66 ± 1.39	5.3 ± 1.12	**<0.001***
Stone density (HU)	1,355.29 ± 418.91	774.34 ± 336.89	**<0.001***
Ureteral length (mm)	224.44 ± 17.98	223.35 ± 12.79	0.541*
Kidney parenchymal density (HU)	37.63 ± 4.14	38.42 ± 3.52	0.083*
Kidney parenchymal thickness (mm)	18.14 ± 2.95	18.25 ± 2.60	0.730*
Stone location (%)			**<0.001***
Upper	255 (49.70%)	66 (17.18%)	
Middle	140 (27.29%)	123 (32.03%)	
Lower	118 (23%)	195 (50.78%)	
Accompanying hydronephrosis			
No	6 (1.6%)	75 (14.6%)	**<0.001+**
Grade 1	48 (14.1%)	294 (57.3%)	
Grade 2	195 (50.8%)	126 (24.6%)	
Grade 3 or above	129 (33.6%)	18 (3.5%)	
PLR	11.51 ± 4.79	9.06 ± 2.29	**<0.001****
NLR	2.35 ± 0.53	1.65 ± 0.47	**<0.001****

SD, standard deviation; **P* value obtained from the Student's t-test; +*P* value was obtained from the chi-square test; **Mann–Whitney U test; HU, Hounsfield units; PLR, platelet-lymphocyte ratio; NLR, neutrophil-lymphocyte ratio.

Table 3. Comparison of the quantitative clinical characteristics between female and male patients

Variables	Men (n = 654) Mean ± SD	Women (n = 243) Mean ± SD	*P*
Age	45.5 ± 13.27	47.53 ± 15.24	0.260
Ureteral wall thickness at stone level (mm)	1.83 ± 0.6	1.88 ± 0.67	0.507
Left ureteral stone size (mm)	6.29 ± 1.7	6.67 ± 1.69	0.224
Right ureteral stone size (mm)	6.35 ± 1.74	6.11 ± 1.57	0.466
Stone density (HU)	1,043.85 ± 485.88	967.02 ± 428.82	0.211
Ureteral length (mm)	225.38 ± 14.88	219.59 ± 15.38	**0.003**
Kidney parenchymal density (HU)	38.46 ± 3.64	37.07 ± 4.09	**0.005**
Kidney parenchymal thickness (mm)	18.48 ± 2.73	17.46 ± 2.68	**0.004**

SD: standard deviation; *P* value obtained from the Student's t-test; HU, Hounsfield units.

Table 4. Comparison of the presence of hydronephrosis and spontaneous passage between female and male patients

	Men (n = 654)	Women (n = 243)	*P*
Accompanying hydronephrosis			
No	44 (10.1%)	10 (6.2%)	0.772
Grade 1	164 (37.6%)	68 (42%)	
Grade 2	160 (36.7%)	54 (33.3%)	
Grade 3 or above	66 (15.6%)	30 (18.5%)	
Spontaneous passage			
No	372 (56.9%)	141 (58%)	0.859
Yes	282 (43.1%)	102 (42%)	

The *P* value was obtained from the chi-square test.

Table 5. Examination of factors associated with the absence of spontaneous stone passage using univariate logistic regression analysis

Variables	Odds (95% CI)	*P*
Age > 45	1,193 (0.754–1,888)	0.452
Women	0.954 (0.569–1,599)	0.859
Ureteral wall thickness at stone level (mm) > 1.7	706.500 (157.638–3166.395)	**<0.001**
Left ureteral stone size (mm) > 6.5	6.061 (3,386–10,850)	**<0.001**
Right ureteral stone size (mm) > 6	7,046 (3,826–12,975)	**<0.001**
Stone density (HU) > 957	13,907 (7,841–24,667)	**<0.001**
Ureteral length (mm) > 225	1,375 (0.867–2,179)	0.176
Kidney parenchymal density (HU) < 39	1,646 (1,037–2,661)	0.034
Kidney parenchymal thickness (mm) > 18	1,197 (0.753–1,904)	0.447
Accompanying hydronephrosis		
Grade 1	2,296 (0.499–10,555)	0.286
Grade 2	19,345 (4,353–85,976)	**<0.001**
Grade 3 or above	89,583 (16,788–478.030)	**<0.001**
PLR > 10.28	3.99 (1,317–10,358)	**<0.001**
NLR > 2.15	3,746 (2,473–5,642)	**<0.001**

CI, confidence interval; Odds, odds ratio; PLR, platelet-lymphocyte ratio; NLR, neutrophil-lymphocyte ratio; HU, Hounsfield units.

Table 6. Examination of factors associated with the absence of spontaneous stone passage using multivariate logistic regression analysis

Variables	Odds (95% CI)	*P*
Ureteral wall thickness at stone level (mm) > 1.7	337.977 (58.270–1960.337)	**<0.001**
Left ureteral stone size (mm) > 6.5	5,429 (1,319–22,343)	**0.019**
Right ureteral stone size (mm) > 6	20,657 (3,170–134.609)	**0.002**
Stone density (HU) > 957	4,349 (1,170–16,165)	**0.028**
Kidney parenchymal density (HU) < 39	1,603 (0.452–5,688)	0.465
Accompanying hydronephrosis ref: none	1	0.399
Grade 1	0.536 (0.008–36,147)	0.772
Grade 2	1,858 (0.027–127.253)	0.774
Grade 3 or above	1,536 (0.021–110.372)	0.844
PLR > 10.28	7.49 (4,192–11,983)	**0.004**
NLR > 2.15	2,072 (1,127–3,219)	**<0.001**

CI, confidence interval; Odds, odds ratio; PLR, platelet-lymphocyte ratio; NLR, neutrophil-lymphocyte ratio; HU, Hounsfield units.

In addition, our study demonstrated that a UWT greater than 1.7 mm was a risk factor for non-SP of ureteral stones, with an odds ratio of 706.5 in univariate LR analysis and 337.9 in multivariate LR analysis when combined with other parameters (stone size, density, NLR, and PLR). In light of these findings, UWT appears to offer considerable superiority as a risk factor compared with stone size, which remains an important parameter in current clinical practice. In the study by Yoshida et al.[1], although UWT was an important predictor of non-SP in LR analyses, its risk ratio was low compared with stone size and stone location.[1] In the study by Cumpanas et al.[44], UWT was a considerable risk factor in univariate LR analysis but lost its importance in multivariate analysis, where linear stone dimensions emerged as the strongest predictor of non-SP. Conversely, in studies by Coşkun and Can[42] and Selvi et al.[43], after standardizing stone sizes between SP and non-SP groups, UWT was shown to be the most important predictor of non-SP in both univariate and multivariate LR analyses, outperforming other parameters.[42,43] A review of the current literature reveals that studies exploring the role of UWT in predicting the SP of ureteral stones remain limited, and no standardized criteria have yet been established for patient management. Therefore, further research is warranted to validate our findings and support the development of standardized predictive tools.

Degree of hydronephrosis

When examining the relationship between HN, which can develop due to obstructive ureteral stones, and the SP of the stone, studies have reported that the likelihood of SP decreases as the degree of HN increases.[43] Consistent with the literature, our study observed that the SP rates of ureteral stones decreased in proportion to the degree of HN.

Stone density

In the literature, various studies have investigated the effect of stone density (HU) on SP and the success of ESWL using non-contrast CT.[45] In a study by Coşkun and Can[42], the probability of SP was reported to be high in cases with stones of lower density. In our study group, the mean stone density in cases without SP (1,355.29 ± 418.91 HU) was statistically significantly higher than in those with SP (774.34 ± 336.89 HU). Furthermore, our results showed that a stone density above 957 HU was a statistically significant risk factor for non-SP in both univariate and multivariate

LR analyses. In contrast, Balci et al.[46] reported no statistically significant difference in stone density between cases with and without SP.

Ureter length

To our knowledge, only one study in the literature has investigated the effect of ureteral stone presence on ureter length in relation to SP. In a randomized study by Coşkun and Can[42], which compared groups with and without SP in 50 ureteral stones, the average ureter length in the non-SP group was 199 mm, and the presence of the stone was found to have no statistically significant effect on SP. Our study is the second in the literature to examine the impact of ureter length on the SP of ureteral stones and features a larger sample size than the previously reported study. In our cohort of 897 cases–513 of which did not experience SP–there was no statistically significant difference in ureter length between the SP and non-SP groups. The average ureter length in the non-SP group was 225 mm. In both studies, no statistically significant association between ureter length and SP was found in either univariate or multivariate regression analyses.[42]

Renal parenchymal thickness and density

When evaluating the potential for predicting SP based on renal parenchymal thickness and density, which may be affected by HN secondary to ureteral stones, no statistically significant differences were observed. In cases without SP, the mean parenchymal thickness was 18.14 mm and the mean parenchymal density was 37.63 HU, whereas in cases with SP, these values were 18.25 mm and 38.42 HU, respectively. Our study is the second in the literature to examine the effect of parenchymal thickness and density on the likelihood of SP in ureteral stones and includes the largest sample size to date. In the first published study on this topic, the mean parenchymal thickness in cases without SP was reported as 21.6 mm and the parenchymal density as 33.9 HU.[42] That study included 100 patients with equal gender distribution and SP status. Although it had a smaller sample size than our study, the results were also not statistically significant, consistent with our findings.

Inflammatory serum markers

In the literature, it has been reported that impacted ureteral stones cause a systemic inflammatory response due to obstruction and ureteral trauma, leading to elevated levels of certain blood markers such as white blood cell (WBC) count, neutrophil count, C-reactive protein (CRP), and procalcitonin. Conversely, some studies on similar parameters have shown a statistically significant relationship between these markers and a decreased probability of SP.[7-13,47,48] However, the study by Sfoungaristos suggested that increased WBC and neutrophil levels may stimulate ureteral peristalsis, thereby facilitating SP.[15] In contrast, a study by Cilesiz et al.[49] reported no statistically significant difference between SP and WBC or CRP values.

In contrast to the previously discussed inflammatory serum indicators, the association between NLR and PLR markers and the SP of ureteral stones has been examined in only a limited number of studies.[39,50] In the study by Abou Heidar et al.[48], it was shown that increased NLR (>2.87) and PLR (>10.42) values were associated with decreased SP rates in both univariate and multivariate analyses. In a recent study by Aghaways et al.[51], the NLR and PLR values were measured as 2.63 ± 1.35 and 11.47 ± 4.86, respectively, in patients without SP, and a statistically significant relationship was found between elevated values and a lower probability of SP. In our study, the NLR (2.35 ± 0.53) and PLR (11.51 ± 4.79) values in cases without SP were statistically significantly higher than in those with SP, with cutoff values of 2.15 for NLR and 10.28 for PLR. These results indicate a relationship between high NLR and PLR values and unsuccessful SP of ureteral stones. However, studies by Coşkun and Can[42], Ahmed et al.[52], and Senel et al.[53] reported no statistically significant relationship between SP of ureteral stones and NLR or PLR values.

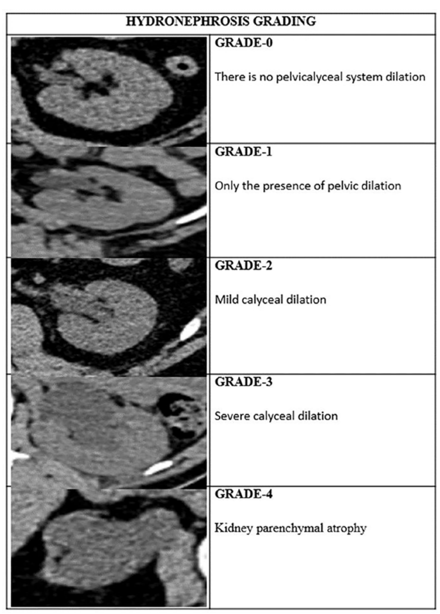

Figure 5. Hydronephrosis grading system.[54]

The incidence of ureteral stones has been reported to be approximately 12% in adult men and 6% in adult women.[33] In our study, a male predominance (n = 654, 72.9%) was observed among patients with ureteral stones, consistent with the literature. However, no statistically significant association was found between the SP of ureteral stones and gender.

Limitations

The limitations of this study include its retrospective design and single-center setting. Another limitation is that all imaging measurements were performed by a single radiologist; therefore, interobserver variability was not assessed. In addition, stone composition was not determined in this study. Patients who received MET, known to facilitate SP, and those who received recent anti-inflammatory treatment, which could affect biochemical results, were excluded from the study. However, more useful results could be obtained from randomized studies comparing the data we obtained regarding SP of ureteral stones with cases who received MET or anti-inflammatory treatment. Among the parameters analyzed in this study, none can be considered entirely novel compared with the existing literature, which may be regarded as a limitation. Nevertheless, the comprehensive evaluation of these parameters within a relatively broad population contributes to the literature by providing a more holistic perspective. Furthermore, by confirming the diagnostic value of UWT, the study offers a distinctive and noteworthy finding.

In conclusion, the accurate prediction of the probability of SP remains debated, and additional criteria are needed for personalized patient-specific follow-up and treatment management. The results of our study indicate that, alongside large stone size and proximal stone location, high stone density, increased UWT, considerable HN at the stone's proximal site, and elevated NLR and PLR values in the blood are statistically significantly and negatively associated with SP.

Footnotes

Conflict of interest disclosure

Sonay Aydın, MD, is Section Editor in Diagnostic and Interventional Radiology. He had no involvement in the peer-review of this article and had no access to information regarding its peer-review. Other authors have nothing to disclose.

References

1. Yoshida T, Inoue T, Taguchi M, Omura N, Kinoshita H, Matsuda T. Ureteral wall thickness as a significant factor in predicting spontaneous passage of ureteral stones of ≤10 mm: a preliminary report. *World J Urol*. 2019;37(5):913-919. [Crossref]
2. Fukuhara H, Ichiyanagi O, Kakizaki H, Naito S, Tsuchiya N. Clinical relevance of seasonal changes in the prevalence of ureterolithiasis in the diagnosis of renal colic. *Urolithiasis*. 2016;44(6):529-537. [Crossref]
3. Hong DY, Kim JW, Lee KR, Park SO, Baek KJ. Epidemiologic and clinical characteristics of patients presenting with renal colic in Korea. *Urol J*. 2015;12(3):2148-2153. [Crossref]
4. Cepeda Delgado M, López Izquierdo R, Amón Sesmero JH, Del Pozo Vegas C, Álvarez Manzanares J. Epidemiological characteristics of renal colic and climate-related causes in a continental area in Spain. *Urol Int*. 2015;95(3):309-313. [Crossref]
5. Türk C, Petrík A, Sarica K, et al. EAU Guidelines on diagnosis and conservative management of urolithiasis. *Eur Urol*. 2016;69(3):468-474. [Crossref]
6. Lee SR, Jeon HG, Park DS, Choi YD. Longitudinal stone diameter on coronal reconstruction of computed tomography as a predictor of ureteral stone expulsion in medical expulsive therapy. *Urology*. 2012;80(4):784-789. [Crossref]
7. Coelho-Souza SA, Jenkins SR, Casarin A, et al. *The* effect of light on bacterial activity in a seaweed holobiont. *Microb Ecol*. 2017;74(4):868-876. [Crossref]
8. Mugiya S, Ito T, Maruyama S, Hadano S, Nagae H. Endoscopic features of impacted ureteral stones. *J Urol*. 2004;171(1):89-91. [Crossref]
9. Deliveliotis C, Chrisofos M, Albanis S, Serafetinides E, Varkarakis J, Protogerou V. Management and follow-up of impacted ureteral stones. *Urol Int*. 2003;70(4):269-272. [Crossref]
10. Sarica K, Kafkasli A, Yazici Ö, et al. Ureteral wall thickness at the impacted ureteral stone site: a critical predictor for success rates after SWL. *Urolithiasis*. 2015;43(1):83-88. [Crossref]
11. Yoshida T, Inoue T, Omura N, et al. Ureteral wall thickness as a preoperative indicator of impacted stones in patients with ureteral stones undergoing ureteroscopic lithotripsy. *Urology*. 2017;106:45-49. [Crossref]
12. Aldaqadossi HA. Stone expulsion rate of small distal ureteric calculi could be predicted with plasma C-reactive protein. *Urolithiasis*. 2013;41(3):235-239. [Crossref]
13. Lee KS, Ha JS, Koo KC. Significance of neutrophil-to-lymphocyte ratio as a novel indicator of spontaneous ureter stone passage. *Yonsei Med J*. 2017;58(5):988-993. [Crossref]
14. Özcan C, Aydoğdu O, Senocak C, et al. Predictive factors for spontaneous stone passage and the potential role of serum C-reactive protein in patients with 4 to 10 mm distal ureteral stones: a prospective clinical study. *J Urol*. 2015;194(4):1009-1013. [Crossref]
15. Sfoungaristos S, Kavouras A, Katafigiotis I, Perimenis P. Role of white blood cell and neutrophil counts in predicting spontaneous stone passage in patients with renal colic. *BJU Int*. 2012;110(8 Pt B):E339-345. [Crossref]
16. Elibol O, Safak KY, Buz A, Eryildirim B, Erdem K, Sarica K. Radiological noninvasive assessment of ureteral stone impaction into the ureteric wall: a critical evaluation with objective radiological parameters. *Investig Clin Urol*. 2017;58(5):339-345. [Crossref]
17. Miller OF, Kane CJ. Time to stone passage for observed ureteral calculi: a guide for patient education. *J Urol*. 1999;162(3 Pt 1):688-690; discussion 690-691. [Crossref]
18. Hermanns T, Sauermann P, Rufibach K, Frauenfelder T, Sulser T, Strebel RT. Is there a role for tamsulosin in the treatment of distal ureteral stones of 7 mm or less? Results of a randomised, double-blind, placebo-controlled trial. *Eur Urol*. 2009;56(3):407-412. [Crossref]
19. Dasgupta R, Cameron S, Aucott L, et al. Shockwave lithotripsy versus ureteroscopic treatment as Therapeutic Interventions for Stones of the Ureter (TISU): a multicentre randomised controlled non-inferiority trial. *Eur Urol*. 2021;80(1):46-54. [Crossref]
20. Skolarikos A, Alivizatos G, de la Rosette J. Extracorporeal shock wave lithotripsy 25 years later: complications and their prevention. *Eur Urol*. 2006;50(5):981-990; discussion 990. [Crossref]
21. Perez Castro E, Osther PJ, Jinga V, et al. Differences in ureteroscopic stone treatment and outcomes for distal, mid-, proximal, or multiple ureteral locations: the Clinical Research Office of the Endourological Society ureteroscopy global study. *Eur Urol*. 2014;66(1):102-109. [Crossref]
22. Drake T, Grivas N, Dabestani S, et al. What are the benefits and harms of ureteroscopy compared with shock-wave lithotripsy in the treatment of upper ureteral stones? A systematic review. *Eur Urol*. 2017;72(5):772-786. [Crossref]
23. Preminger GM, Tiselius HG, Assimos DG, et al. 2007 Guideline for the management of ureteral calculi. *Eur Urol*. 2007;52(6):1610-1631. [Crossref]
24. Keller EX, De Coninck V, Audouin M, Doizi S, Daudon M, Traxer O. Stone composition independently predicts stone size in 18,029 spontaneously passed stones. *World J Urol*. 2019;37(11):2493-2499. [Crossref]
25. Jendeberg J, Geijer H, Alshamari M, Cierzniak B, Lidén M. Size matters: the width and location of a ureteral stone accurately predict the chance of spontaneous passage. *Eur Radiol*. 2017;27(11):4775-4785. [Crossref]
26. Türk C, Knoll T, Seitz C, Skolarikos A, Chapple C, McClinton S; European Association of Urology. Medical expulsive therapy for ureterolithiasis: the EAU recommendations in 2016. *Eur Urol*. 2017;71(4):504-507. [Crossref]
27. Brubaker WD, Dallas KB, Elliott CS, et al. Payer type, race/ethnicity, and the timing of surgical management of urinary stone disease. *J Endourol*. 2019;33(2):152-158. [Crossref]
28. Matlaga BR, Jansen JP, Meckley LM, Byrne TW, Lingeman JE. Treatment of ureteral and renal stones: a systematic review and meta-analysis of randomized, controlled trials. *J Urol*. 2012;188(1):130-137. [Crossref]
29. Skolarikos A, Laguna MP, Alivizatos G, Kural AR, de la Rosette JJ. The role for active monitoring in urinary stones: a systematic review. *J Endourol*. 2010;24(6):923-930. [Crossref]
30. Ramasamy V, Aarthy P, Sharma V, Thakur APS. Role of inflammatory markers and their trends in predicting the outcome of medical expulsive therapy for distal ureteric calculus. *Urol Ann*. 2022;14(1):8-14. [Crossref]
31. Assimos D, Krambeck A, Miller NL, et al. Surgical management of stones: American Urological Association/Endourological Society Guideline, PART I. *J Urol*. 2016;196(4):1153-1160. [Crossref]
32. Preminger GM, Tiselius HG, Assimos DG, et al. 2007 guideline for the management of ureteral calculi. *J Urol*. 2007;178(6):2418-2434. [Crossref]
33. Furyk JS, Chu K, Banks C, et al. Distal ureteric stones and tamsulosin: a double-blind, placebo-controlled, randomized, multicenter trial. *Ann Emerg Med*. 2016;67(1):86-95.e2. [Crossref]
34. Mokhless I, Zahran AR, Youssif M, Fahmy A. Tamsulosin for the management of distal ureteral stones in children: a prospective randomized study. *J Pediatr Urol*. 2012;8(5):544-548. [Crossref]
35. Aydogdu O, Burgu B, Gucuk A, Suer E, Soygur T. Effectiveness of doxazosin in treatment of distal ureteral stones in children. *J Urol*. 2009;182(6):2880-2884. [Crossref]
36. Demehri S, Steigner ML, Sodickson AD, Houseman EA, Rybicki FJ, Silverman SG. CT-based determination of maximum ureteral stone area: a predictor of spontaneous passage. *AJR Am J Roentgenol*. 2012;198(3):603-608. [Crossref]
37. Chau LH, Tai DC, Fung BT, Li JC, Fan CW, Li MK. Medical expulsive therapy using alfuzosin for patient presenting with ureteral stone less than 10mm: a prospective randomized controlled trial. *Int J Urol*. 2011;18(7):510-514. [Crossref]
38. Metser U, Ghai S, Ong YY, Lockwood G, Radomski SB. Assessment of urinary tract calculi with 64-MDCT: the axial versus coronal plane. *AJR Am J Roentgenol*. 2009;192(6):1509-1513. [Crossref]

39. Kadihasanoglu M, Marien T, Miller NL. Ureteral stone diameter on computerized tomography coronal reconstructions is clinically important and under-reported. *Urology*. 2017;102:54-60. [Crossref]

40. Özbir S, Can O, Atalay HA, Canat HL, Çakır SS, Ötünçtemur A. Formula for predicting the impaction of ureteral stones. *Urolithiasis*. 2020;48(4):353-360. [Crossref]

41. Legemate JD, Wijnstok NJ, Matsuda T, et al. Characteristics and outcomes of ureteroscopic treatment in 2650 patients with impacted ureteral stones. *World J Urol*. 2017;35(10):1497-1506. [Crossref]

42. Coşkun A, Can U. Is it possible to predict spontaneous passage of a ureteral stone? An up-to-date comment on the current problem with new concepts concerning the patient and the stone. *Cent European J Urol*. 2022;75(3):305-310. [Crossref]

43. Selvi I, Baydilli N, Tokmak TT, Akinsal EC, Basar H. CT-related parameters and Framingham score as predictors of spontaneous passage of ureteral stones ≤ 10 mm: results from a prospective, observational, multicenter study. *Urolithiasis*. 2021;49(3):227-237. [Crossref]

44. Cumpanas AD, Camp B, Tran CM, et al. Prospective evaluation of ureteral wall thickness as a means to predict spontaneous stone passage: is it beneficial? *J Endourol*. 2024. [Crossref]

45. Nakasato T, Morita J, Ogawa Y. Evaluation of Hounsfield units as a predictive factor for the outcome of extracorporeal shock wave lithotripsy and stone composition. *Urolithiasis*. 2015;43(1):69-75. [Crossref]

46. Balci M, Tuncel A, Aydin O, et al. Tamsulosin versus nifedipin in medical expulsive therapy for distal ureteral stones and the predictive value of Hounsfield unit in stone expulsion. *Ren Fail*. 2014;36(10):1541-1544. [Crossref]

47. Park CH, Ha JY, Park CH, Kim CI, Kim KS, Kim BH. Relationship between spontaneous passage rates of ureteral stones less than 8 mm and serum C-reactive protein levels and neutrophil percentages. *Korean J Urol*. 2013;54(9):615-618. [Crossref]

48. Abou Heidar N, Labban M, Bustros G, Nasr R. Inflammatory serum markers predicting spontaneous ureteral stone passage. *Clin Exp Nephrol.* 2020;24(3):277-283. [Crossref]

49. Cilesiz NC, Ozkan A, Kalkanli A, et al. Can serum procalcitonin levels be useful in predicting spontaneous ureteral stone passage? *BMC Urol.* 2020;20:1-6. [Crossref]

50. Proctor MJ, Morrison DS, Talwar D, et al. A comparison of inflammation-based prognostic scores in patients with cancer. A Glasgow Inflammation Outcome Study. *Eur J Cancer*. 2011;47(17):2633-2641. [Crossref]

51. Aghaways I, Ibrahim R, Bapir R, Salih RQ, Salih KM, Abdulla BA. The role of inflammatory serum markers and ureteral wall thickness on spontaneous passage of ureteral stone < 10 mm: a prospective cohort study. *Ann Med Surg (Lond)*. 2022;80:104198. [Crossref]

52. Ahmed AF, Gabr AH, Emara AA, Ali M, Abdel-Aziz AS, Alshahrani S. Factors predicting the spontaneous passage of a ureteric calculus of ≤10 mm. *Arab J Urol*. 2015;13(2):84-90. [Crossref]

53. Senel C, Aykanat IC, Asfuroglu A, Keten T, Balci M, Aslan Y, Tuncel A. What is the role of inflammatory markers in predicting spontaneous ureteral stone passage? *Aktuelle Urol.* 2022;53(5):448-453. English. [Crossref]

54. Onen A. Grading of hydronephrosis: an ongoing challenge. *Front Pediatr*. 2020;27;8:458. [Crossref]