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Evaluation of the Impact of Waist Circumference and Other Predictors on Shock Wave Lithotripsy Outcomes in Ureteral Calculi: A Retrospective Analysis

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Abstract

BACKGROUND/AIMS: In this study, our aim was to evaluate the impact of waist circumference (WC) along with other patient- and stone-related factors on the success of extracorporeal shock wave lithotripsy (SWL) in the treatment of ureteral calculi.

MATERIALS AND METHODS: A retrospective analysis was performed on patients who underwent SWL for a single-radio-opaque ureteral stone (5-15 mm) in our center. Stone-free (SF) status after the treatment was defined as having <4 mm residual fragment on radiography and/or ultrasonography after 4 weeks following the last SWL session. Patient- and stone-related factors were compared.

RESULTS: A total of 200 patients were included in this study. Compared to the SF group, body mass index (BMI) ($p<0.05$), WC ($p<0.05$), Hounsfield unit (HU) ($p<0.05$), stone volume (SV) ($p<0.05$), skin-stone distance ($p<0.05$), grade of hydronephrosis ($p<0.05$), and proximal ureteral diameter (PUD) ($p<0.05$) were higher in the non-SF group. During the evaluation of the parameters with respect to their impact on the prediction of SWL success, univariate analysis did show that BMI ($p<0.05$), WC ($p<0.05$), SV ($p<0.05$), HU ($p<0.05$), and PUD ($p<0.05$) were the significant factors in this aspect. On the other hand, in multivariate analysis, none of these factors have shown statistically significant importance for the development of non-SF status after SWL.

CONCLUSION: Patient- and stone-related factors such as BMI, HU, skin to stone distance, mean SV, grade of hydronephrosis, PUD, have been shown to be associated with SF rates after SWL in accordance with previous studies. On the other hand, according to our results, WC may be a novel predictor of SWL outcomes in ureteral stones.

Keywords: Ureteral calculi, extracorporeal shockwave lithotripsy, waist circumference, success

INTRODUCTION

Urolithiasis is a prevalent urological pathology, affecting approximately 4-20% of the population in developed countries.[1] Ureteral calculi form a significant portion of urinary stone disease and are one of the most common urological presentations in the emergency department. Nearly 65% of all ureteral stones have been shown to pass spontaneously; distal stones have a higher chance of passage compared to proximal ones.[2] While observation can be preferred in asymptomatic and small stones (especially <5 mm), active treatment may be needed in case of urinary obstruction, renal colic pain, or renal insufficiency.[3] Regarding the management of such stones, medical expulsive therapy, extracorporeal

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shock wave lithotripsy (SWL), and ureteroscopy are among the available treatment options. SWL is the recommended treatment option in both proximal and distal ureteral stones less than 10 mm.[4]

Although SWL offers the advantages of safety and non-invasiveness, its lower success rate compared to other treatment modalities remains a major limitation.[5] The identification of predictive factors for SWL outcomes is essential to optimize success rates and minimize complications. In previous studies, high body mass index (BMI), Hounsfield unit (HU), stone density, skin to stone distance (SSD), ureteral wall thickness (UWT), stone volume (SV)/area, proximal ureteral diameter (PUD), and hydronephrosis have been shown to be associated with SWL success in both renal and ureteral stones.[6-8] But, to our knowledge, no study has ever evaluated the effect of waist circumference (WC) on SWL for ureteral calculi. In this study, our aim was to demonstrate the patient- and stone-related factors affecting SWL success in ureteral calculi.

MATERIALS AND METHODS

This study was approved by University of Health Sciences Türkiye, Sancaktepe Şehit Prof.Dr. İlhan Varank Training and Research Hospital Ethics Committee (approval number: 138, date: 30.04.2025), data of the patients treated for single opaque ureteral stone with SWL from January 2023 to April 2025 in our clinic were retrospectively evaluated. A total of 285 patients were identified initially. The exclusion criteria were: patients who are <18 or >65 years old, active urinary infection, radiolucent stones, multiple stones, patients with indwelling ureteral stent, solitary kidney, inflammatory and/or malignant diseases, and patients with urinary anatomical disorders. Patient-related factors such as age, sex, BMI, WC, comorbidities, anticoagulant use, and previous treatment were recorded for each patient. Stone characteristics (stone side, level, volume, density, SSD) were derived by non-contrast computed tomography (NCCT) of the patients. SV was calculated by using the following formula: (long axis × short axis × depth × 0.52). UWT was measured at the stone site, and PUD was the diameter, which is the ureteral lumen right above the stone in the ureter. All measurements were in millimeters. A successful outcome was defined as being completely stone-free (SF) on radiography and ultrasonography at 4 weeks after the last SWL session. Success rates were evaluated in a comparative manner based on the measurement values assessed, as longest diameter and volume of the stone treated. Patients with residual fragments <4 mm were considered SF. After applying the exclusion criteria, a total of 200 patients were included in the final analysis (Figure 1).

The treatment was performed using the electromagnetic lithotripter, Modulith SLX- F2- FD21 (Storz Medical AG, Tägerwilen, Switzerland) under fluoroscopy in all patients. The standard pulse frequency was 60 shockwaves per minute, with a maximum of 3000 shocks applied at each session. All patients received oral anti-inflammatory therapy before every session for pain management. A minimum interval of one week was applied between consecutive SWL sessions. If the stone or residual fragments could not be identified in fluoroscopy, confirmatory radiography and ultrasonography were performed. Patients with no symptoms and residual stones were re-evaluated 4 weeks after the last SWL session with radiography and ultrasonography.

Statistical Analysis

Statistical analysis was performed with Jamovi (version 2.6.0, for Mac OS). Distribution of the variables was measured by Kolmogorov-Smirnov test. Mann-Whitney U test was used for continuous variables and chi-square test was used for categorical variables. Univariate analysis and multivariate analysis (stepwise logistic regression) were used to determine parameters that influence SF status. A p-value <0.05 was considered statistically significant.

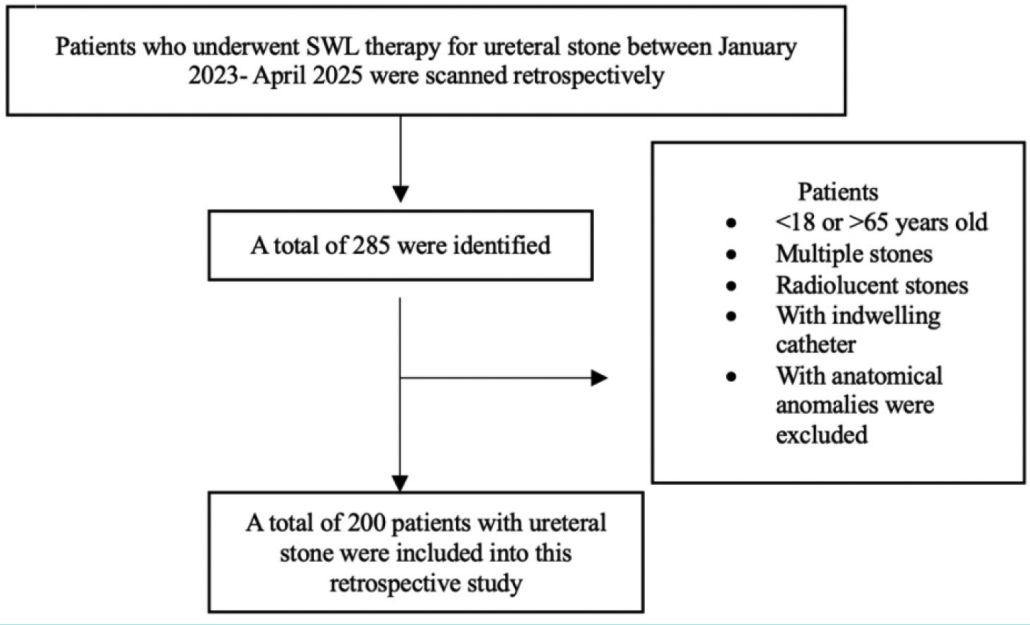

Figure 1. PRISMA diagram showing the selection of the patients.

SWL: Shock wave lithotripsy, PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

RESULTS

A total of 200 patients (male/female: 135/65) were included in this study. Median BMI and WC of the patients were 25.5 (18.3-38.06) and 94 (71-120) cm, respectively. While 149 had no comorbidity, 28 had diabetes mellitus and 23 had coronary artery disease (CAD). Although 148 patients had no previous stone treatment history, 20 patients had a history of SWL, 27 patients had undergone ureterorenoscopy; 3 patients had percutaneous nephrolithotomy, and 2 patients had undergone open surgery.

Our findings revealed that, while 139 patients (70%) were completely SF after SWL, 61 patients (30%) had residual fragments larger than 4 mm at four weeks. Patients in the non-SF group tended to have a higher median BMI (26.8 vs. 25.3, $p<0.05$) and WC (98 vs. 91, $p<0.05$) compared to those in the SF group. There was no statistically significant difference between the two groups regarding age, family history, and previous stone treatment history. No statistically significant difference was found also in stone side, stone level, and the mean UWT values between the two groups. On the other hand, PUD was significantly higher in the non-SF group (8.6 mm) compared to the SF group (7.4 mm) ($p<0.05$). Median SV was higher in non-SF group patients than in SF patients, with values of 149.6 mm^3 and 104.9 mm^3, respectively ($p<0.001$). HU ($p<0.001$), SSD ($p<0.05$), and hydronephrosis grade ($p<0.05$) were significantly higher in non-SF group cases compared to those in the SF group. Complication rate ($p<0.001$) and need for auxiliary intervention ($p<0.001$) were also found to be higher in the non-SF group than in the SF group. All of our findings were summarized in Table 1. Careful univariate analysis of the parameters with respect to their impact on the prediction of SWL success showed that BMI ($p<0.05$), WC ($p<0.05$), SV ($p<0.05$), HU ($p<0.05$), and PUD ($p<0.05$) were the significant parameters in this analysis. On the other hand, in multivariate analysis (logistic stepwise regression), we were not able to show statistical significance in any of these factors. Results of the univariate and multivariate analysis are shown in Table 2. In Figure 2, we illustrate the receiver operating characteristic curve of the multivariate logistic regression model used to predict SF status after SWL. The model yielded an area under the curve of 0.70, indicating moderate predictive accuracy.

DISCUSSION

SWL can be the treatment of choice in the majority of kidney and ureteral stones. Success rates after SWL in ureteral calculi have been reported to vary from 82-90% for proximal-mid and from 58-67% for distal stones.[9] To overcome this considerable range in SWL success rate, vigorous efforts have been made by endourologists to identify predictive factors that may influence the outcomes of SWL.

A proportion of patients fail to achieve SF status after SWL due to either suboptimal stone fragmentation, or impaired clearance of residual fragments. These treatment failures not only lead to repeated sessions, increased cumulative radiation exposure, and complication rates, but may also cause a higher financial burden on the healthcare system. As a result, the ability to accurately predict SWL success using objective and measurable parameters has become a key focus in the optimization of stone management strategies. Various radiological and anthropometric factors are now being incorporated into clinical decision-making algorithms to improve patient selection and success rates.

Both patient-related variables-including age, sex, BMI, WC, and comorbidities-and stone-related factors -including volume, density (HU), composition, anatomical location, and SSD- have been investigated for their potential roles in determining SWL efficacy.

In terms of stone-related factors, SV and HU are among the most extensively investigated parameters associated with the success rates of SWL. SV directly affects the likelihood of effective stone fragmentation; lower fragmentation rates and reduced stone-free rates (SFRs) following SWL.[10] The HU, which is a radiological measure of stone density assessed by NCCT, correlates closely with stone composition and predicts resistance to fragmentation. Stones with higher HU values typically exhibit decreased fragmentation efficiency, resulting in poorer SWL outcomes.[11,12] Our results are in accordance with the literature: higher SV and HU were detected in the non-SF group compared to the SF group, and univariate analysis also demonstrated the significant roles of these parameters.

In addition to SV and density, other factors have been implicated as important predictors of treatment success. The SSD has emerged as another critical factor influencing SWL success. Shock waves must pass multiple tissues (skin, muscle, and fat) before reaching the stone. With longer SSD, the distance covered by the shock waves increases and the final energy that reaches the stone decreases; longer SSD values negatively affect shock wave energy delivery, thereby diminishing fragmentation effectiveness and subsequent stone clearance.[13] In our study, SSD was found to be statistically higher in the non-SF group compared to the SF group.

The UWT, PUD, and grade of hydronephrosis, which often represent stone impaction and ureteral obstruction, have also been studied, particularly regarding ureteral calculi. Increased UWT, dilated PUD, and higher-grade hydronephrosis indicative of chronic obstruction or ureteral inflammation, have been linked to lower SFRs and decreased likelihood of spontaneous passage following SWL.[14,15] In our study, higher PUD and hydronephrosis are associated with lower SF rates after SWL.

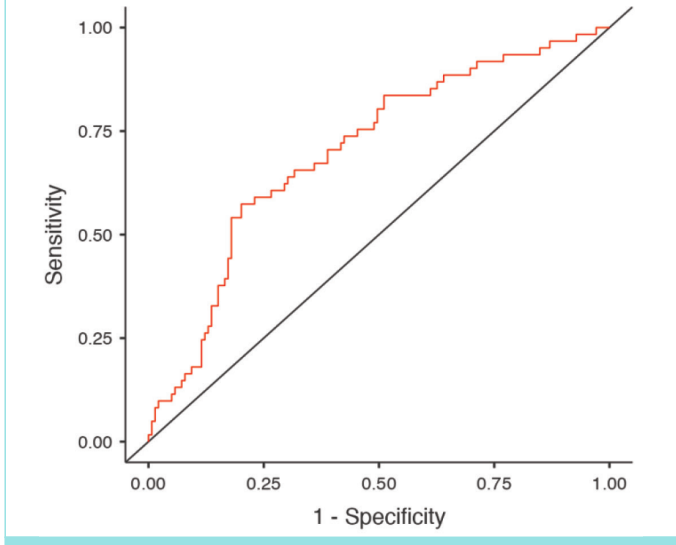

Figure 2. ROC curve of the multivariate logistic regression model predicting stone-free status after SWL.

ROC: Receiver operating characteristic, SWL: Shock wave lithotripsy.

Table 1. Patient- and stone- related characteristics of both groups				
	All patients	**Stone-free group**	**Non-stone-free group**	**p-value**
Number	200	139 (70%)	61 (30%)	
Age (median, min-max)	40 (17-68)	39 (20-68)	41 (17-66)	0.132[a]
Sex				
Male Female	135 65	96 43	39 22	
BMI (median, min-max)	25.5 (18.3-38.06)	25.3 (18.3-35.6)	26.8 (19.5-38.06)	**0.01**[a]
Waist circumference (median, min-max) (centimeter)	94 (71-120)	91 (71-118)	98 (71-120)	**0.001**[a]
Anticoagulant use				
Yes No	18 182	8 131	10 51	**0.01**[b]
Comorbidity				
None Diabetes mellitus Coronary artery disease	149 28 23	112 12 15	37 16 8	**<0.005**[b]
Previous treatment				
None Shock wave therapy Ureteroscopy PNL Open surgery	148 20 27 3 2	99 17 21 1 1	49 3 6 2 1	0.2[b]
Ureteral localization				
Upper Middle Lower	98 53 49	62 39 38	36 14 11	0.1[b]
Side of ureter				
Right Left	86 114	63 76	23 38	0.3[b]
Hounsfield unit (median, min-max)	670 (260-1781)	650 (260-1781)	750 (300-1510)	**<0.001**[a]
Stone volume (median, min-max) (mm^3)	124.4 (33.4-542.04)	104.9 (33.4-440.3)	149.6 (59.5-542.04)	**<0.001**[a]
Skin-stone distance (median, min-max) (millimeters)	124 (55-175)	120 (72-175)	130 (55-174)	**0.003**[a]
Hydronephrosis				
Grade 1-2 Grade 3-4	133 67	99 40	34 27	**0.01**[b]
Ureteral wall thickness (median, min-max)	2.7 (1.1-5.9)	2.6 (1.1-5.9)	2.8 (1.2-5.9)	0.4[a]
Proximal ureteral diameter (median, min-max)	7.8 (3.5-19.2)	7.4 (3.5-15.6)	8.6 (4.7-19.2)	**0.01**[a]
Number of SWL sessions				
Single Multiple	65 135	51 88	14 47	**0.05**[b]
Complications				
None Hematuria Pain Steinstrasse	106 11 63 20	101 9 22 7	5 2 41 13	**<0.001**[b]
Auxiliary intervention				
None Medical expulsive therapy JJ insertion Ureteroscopy	126 42 3 29	124 14 1 0	2 28 2 29	**<0.001**[b]

[a]Mann-Whitney U test.
[b]chi- square test.
BMI: Body mass index, min-max: Minimum-maximum, PNL: Percutaneous nephrolithotomy, SWL: Shock wave lithotripsy.

Table 2. Uni- and multi-variate analysis of the factors

	Univariate analysis			Multivariate analysis	
	95% Confidence interval	OR	p-value	OR	p-value
BMI	0.82-0.97	0.89	**0.007**	1.04	0.5
Waist circumference	0.92-0.98	0.95	**0.002**	1.04	0.1
Stone volume	0.99-0.99	0.99	**0.01**	1.00	0.5
Hounsfield unit	0.99-0.99	0.99	**0.005**	1.00	0.06
SSD	-0.01-0.02	1.01	0.247		
PUD	0.79-0.98	0.88	**0.02**	1.08	0.2

BMI: Body mass index, SSD: Skin to stone distance, PUD: Proximal ureteral diameter, OR: Odds ratio.

Additionally, patient-related factors also significantly impact the outcomes of SWL. Among these factors, BMI has been extensively studied and is consistently associated with reduced success rates following SWL. Elevated BMI often corresponds to greater SSD, potentially impairing shock wave energy transmission, stone fragmentation, and ultimately stone clearance.[16] In addition, the accuracy of stone localization via imaging techniques may be reduced in obese patients, further compromising SWL efficacy.[17] Nevertheless, BMI may not always serve as a reliable indicator for adiposity distribution or body composition. Individuals with similar BMI values can exhibit significantly different body types depending on their relative proportions of lean muscle mass and adipose tissue, leading to variations in treatment outcomes.

Consequently, WC, which specifically measures central obesity and visceral fat deposition, may provide a more clinically relevant assessment of patient-related factors influencing SWL outcomes. Elevated WC is strongly associated with various metabolic and cardiovascular comorbidities, including metabolic syndrome, diabetes mellitus, hypertension, and CAD.[18] Although there are currently limited data specifically investigating WC as a predictor of SWL success, the known associations between central obesity, increased SSD, and adverse clinical outcomes in related urological procedures strongly support the rationale for its evaluation in this context.[19] The potential for WC to more accurately reflect factors that negatively influence shock wave penetration and stone clearance underscores its utility in predicting SWL outcomes beyond conventional BMI measurements.

In our study, both BMI and WC were significantly higher in patients who failed to achieve SF status compared to those who did. This observation was supported by univariate analysis, suggesting a meaningful association between body composition and SWL outcomes. However, in multivariate analysis, these parameters did not retain statistical significance. This may be due to the limited sample size, retrospective design, or collinearity with other stone-related parameters such as SV, stone density, and SSD. Although our findings regarding WC are promising, they should not be interpreted as evidence of WC being an independent predictor of SWL success at this stage. Rather, WC may represent a parameter with potential predictive value that needs confirmation in larger prospective and multicenter studies.

Study Limitations

The small number of cases and the retrospective design are the major limitations of this study. In addition, its single-center nature may limit the generalizability of our findings. Measurements such as WC, SSD, and PUD were operator-dependent and subject to interobserver variability. Stone composition was not confirmed by stone analysis, but only inferred by stone density values. Moreover, SF status was evaluated after four weeks, and longer-term outcomes were not evaluated; longer-term outcomes were not considered. Finally, potential collinearity among predictive variables may have influenced the results of multivariate analysis.

CONCLUSION

With this study, we demonstrated the significance of stone-related parameters-including SV, stone density, SSD, PUD, and hydronephrosis grade- along with patient-related factors, including BMI and WC, in predicting SFRs following SWL. BMI has long been recognized as a relevant anthropometric predictor. Our findings suggest that WC, as a marker of central obesity, may also influence SWL success as a new serve as a predictor of SWL success. While WC was not an independent predictor in multivariate analysis, its association with poorer outcomes in univariate analysis indicates its potential value in patient selection and pre-treatment evaluation.

MAIN POINTS

- Stone volume, stone density, skin to stone distance, proximal ureteral diameter, and hydronephrosis were associated with shock wave lithotripsy (SWL) outcomes, but none were independent predictors in multivariate analysis.
- Waist circumference (WC) was associated with SWL outcomes in univariate analysis, but was not an independent predictor.
- WC may represent a potential predictive parameter for SWL outcomes in ureteral stones, but it requires validation in larger, prospective studies.

ETHICS

Ethics Committee Approval: This study was approved by University of Health Sciences Türkiye, Sancaktepe Şehit Prof.Dr. İlhan Varank Training and Research Hospital Ethics Committee (approval number: 138, date: 30.04.2025).

Informed Consent: This study was designed retrospectively, so no written consent was obtained from the patients.

Footnotes

Authorship Contributions

Surgical and Medical Practices: Y.K., K.C.G., K.S., Concept: D.İ.K., K.S., Data Collection and/or Processing: Y.K., K.C.G., Analysis and/or

Interpretation: Y.K., D.İ.K., Literature Search: K.C.G., Writing: Y.K., D.İ.K., K.C.G., K.S.

DISCLOSURES

Conflict of Interest: No conflict of interest was declared by the authors.

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