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DOI: http://dx.doi.org/10.31584/jhsmr.20261530

Received: 29 April 2026

Accepted: 29 June 2026

Published online: 27 November 2026

Please cite this article as: Boonyapalanant C, Guptashthira W, Chuntanaparb N, Chamnarnprai S, Sinsophonphap A. Impact of prior shockwave lithotripsy on outcomes of ureterorenoscopic lithotripsy for ureteric stones: a retrospective cohort study. J Health Sci Med Res 2026 doi: http://dx.doi.org/10.31584/jhsmr.20261530

Early Version — Uncorrected: This accepted manuscript has not been typeset or proofread. Content and formatting may change prior to final publication and should not be regarded as the final Version of Record.

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Original Article

Impact of Prior Shockwave Lithotripsy on Outcomes of Ureterorenoscopic Lithotripsy for Ureteric Stones: A Retrospective Cohort Study

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Running title Prior SWL and URS Outcomes in Ureteric Stones

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Abstract

Objective: Shockwave lithotripsy (SWL) and ureterorenoscopic lithotripsy (URSL) are common treatment options. When SWL fails, URSL is frequently performed as a salvage procedure. Prior SWL may induce ureteral mucosal edema, inflammation, or stone impaction that could affect subsequent URSL outcomes. This study evaluated the impact of prior SWL on outcomes of URSL in patients with ureteric stones.

Material and Methods: This retrospective cohort study included adult patients who underwent URSL for ureteric stones at Panyananthaphikkhu Chonprathan Medical Center between July 2016 and January 2026. Patients were categorized according to history of prior SWL before URSL. Demographic data, stone characteristics, and operative outcomes were analyzed. Univariate and multivariate analyses were performed to identify factors associated with operative time, hospital stay, stone-free rate, and postoperative complications.

Results: Eighty-seven patients were included, with 23 (26%) having prior SWL. Operative time was longer in the prior SWL group (41.1 ± 25.0 vs 28.7 ± 14.0 minutes, p = 0.005), although prior SWL was not an independent predictor after multivariable analysis. The overall stone-free rate was 92%, with no significant differences in stone-free rate or hospital stay between groups. Postoperative infectious complications occurred more frequently in patients with prior SWL (30% vs 6%, p = 0.003) and remained independently associated with prior SWL (adjusted OR 18.27, p = 0.006).

Conclusion: Prior SWL did not significantly affect most URSL outcomes but was associated with an increased risk of postoperative infectious complications.

Keywords: endourology, shockwave lithotripsy, ureteric stone, ureterorenoscopy

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Introduction

Urolithiasis is a common urological condition with a rising global incidence and recurrence rate.[1] Ureteric stones are a significant proportion of symptomatic urinary tract stone disease and frequently require active intervention.[2,3] The choice of treatment depends on multiple factors, including stone size, location, symptom severity, patient factors, and patient preference. According

to current international standard guidelines, minimally invasive approaches have become the standard of care for ureteric stones.[2-4] Among available treatment modalities, shockwave lithotripsy (SWL) and ureterorenoscopic lithotripsy (URSL) are widely used options for the management of ureteric calculi. SWL is a non-invasive treatment that fragments stones using acoustic shock waves, whereas URSL provides direct endoscopic visualization and fragmentation of stones using intracorporeal fragmentation.[3,4]

In clinical practice, although SWL is often considered a first-line therapy for selected ureteric stones due to its non-invasive nature, its stone-free rate remains lower than URSL, particularly in patients with larger stones, high stone density, or unfavorable stone characteristics.[5-7] When SWL fails, URSL is commonly performed as a secondary or salvage procedure. However, prior exposure to SWL may theoretically induce ureteral mucosal edema, inflammation, stone impaction, or fibrosis, potentially increasing procedural difficulty and perioperative morbidity during subsequent URSL.[8-10] The extent to which previous SWL influences operative parameters, stone-free rates, and postoperative complications remains unclear.

Several studies have investigated the outcomes of URSL performed after failed SWL, but the available evidence remains limited and inconsistent. While some reports suggest prolonged operative time or increased complication rates, others have demonstrated comparable efficacy and safety.[11-15] Clarifying the impact of prior SWL on URSL outcomes is clinically relevant for patient counseling, operative planning, and perioperative risk assessment. Therefore, this retrospective cohort study evaluated the impact of prior SWL on perioperative and postoperative outcomes in patients undergoing URSL for ureteric stones.

Material and Methods

Study design and population

This single-center retrospective cohort study was approved by the Ethics Committee of Panyananthaphikkhu Chonprathan Medical Center, Srinakharinwirot University, Thailand (protocol number EC 013/68). Written informed consent was obtained from all participants. The

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study was carried out in accordance with the principles of the Declaration of Helsinki, and patient confidentiality was strictly maintained.

The medical records of consecutive adult patients (≥18 years) who underwent URSL for ureteric stones at Panyananthaphikkhu Chonprathan Medical Center between July 2016 and January 2026 were retrospectively reviewed. Patients were included if they had postoperative follow-up of at least 1 month, and patients with incomplete medical records were excluded. The study population was subsequently divided into two groups according to the history of prior SWL before URSL. Data collection was categorized into three domains: (1) patient characteristics, including sex, age, comorbidities, history of prior stone treatment other than SWL (URSL or open surgery), and previous urinary tract infection; (2) operative data, including operative time, stone characteristics (size, number, and location), and ureteral stent placement after URSL; and (3) postoperative outcomes, including length of hospital stay, stone-free rate, and postoperative complications. Stone-free status was defined as no visible stone fragment detected on postoperative imaging at 1 month after surgery. Postoperative infectious complications, including fever and sepsis, were evaluated within 24 hours after URSL. Fever was defined as an axillary temperature >38°C. Sepsis was diagnosed according to the international consensus definitions.[11]

Surgical technique

All URSL procedures were performed by experienced urologists at our institution. Patients were placed in the lithotomy position under spinal or general anesthesia, depending on the anesthesiologist's clinical assessment and the location of the stone. URSL was performed using a semi-rigid ureterorenoscope (URS) with a 6.5-Fr distal tip and 7-Fr shaft (Karl Storz, Tuttlingen, Germany), and a holmium:yttrium aluminum garnet laser was used for stone fragmentation. Any residual fragments were retrieved using a stone basket. A 6-Fr double-J ureteral stent was inserted when clinically indicated, including in the presence of ureteral edema, mucosal trauma, significant residual fragments, or bleeding. The operative time was recorded from the insertion of the URS until completion of the operation. In patients who required a postoperative ureteric stent, the stent was removed approximately 2 weeks after URSL. All patients underwent follow-up imaging 1 month after operation to assess stone-free status. The imaging modality included plain film, ultrasonography, or computed tomography, and it was selected based on the radiopacity of the initial stone.

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Statistics or analysis

Statistical analysis was conducted using Stata version 19 software. Demographic data, stone characteristics, intraoperative data, and postoperative data were presented as mean ± standard deviation or percentages. The independent t-test and Pearson chi-square test were used to compare data between the two groups. A binary logistic regression model for multivariate analysis was used to identify factors affecting the perioperative and postoperative outcomes. A p-value less than 0.05 was defined as having statistical significance.

Results

A total of 87 patients were included in this study and divided into two groups depending on their history of SWL prior to URSL; 23 patients (26%) had a history of prior SWL, and 64 patients (74%) had no previous SWL before URSL. The patients' demographic data and stone characteristics were comparatively analyzed and are presented in Table 1. The overall mean age was 59.6 ± 12.4 years, and 39% of the patients were male. Patients in the prior SWL group had significantly larger stones (11.1 ± 6.3 mm vs 8.4 ± 3.7 mm, $p = 0.016$) and a higher number of stones (1.6 ± 0.9 vs 1.0 ± 0.2, $p < 0.001$). A history of urinary tract infection was more common in the prior SWL group (74% vs 44%, $p = 0.013$). No significant differences were observed between the groups regarding age, sex, underlying diseases, previous management, and stone location.

The mean operative time was significantly longer in patients with prior SWL (41.1 ± 25.0 minutes) compared with those without prior SWL (28.7 ± 14.0 minutes, $p = 0.005$). The rate of post-operative stent placement was not significantly different between the two groups (74% in the prior SWL group vs 56% in the non-prior SWL group, $p = 0.136$). The length of hospital stay tended to be longer in the prior SWL group (4.1 ± 10.8 days vs 1.5 ± 1.3 days), although this difference did not reach statistical significance ($p = 0.052$). The overall postoperative stone-free rate was 92% with no statistically significant difference between the two groups (83% in the prior SWL group vs 95% in the non-prior SWL group, $p = 0.055$). All recorded complications were infectious in nature. No cases of significant bleeding or major ureteric injury were found. Most of the infectious events were postoperative fever, with only one case of sepsis, which occurred in the

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prior SWL group. Infectious complications occurred more frequently in patients with prior SWL (30% vs 6%, p = 0.003). All operative outcomes and complications are presented in Table 2.

In univariate analysis of operative time, larger stone size (β = 1.83, 95% CI 1.08–2.58, p < 0.001), lower ureteral location (β = −12.54, p = 0.016), and prior SWL (β = 12.42, 95% CI 3.94–20.89, p = 0.005) were associated with operative time. However, in multivariate analysis, only stone size remained independently associated with operative time (β = 1.57, 95% CI 0.72–2.42, p < 0.001). Prior SWL was no longer significant after adjustment (Table 3). For length of hospital stay, the multivariate analysis showed increasing age was independently associated with longer hospital stays (β = 0.08, 95% CI 0.01–0.15, p = 0.031) (Table 4). From multivariate analysis for postoperative infectious complications, prior SWL was independently associated with postoperative complications (adjusted OR 18.27, 95% CI 2.35–142.10, p = 0.006). History of urinary tract infection showed borderline significance after adjustment (p = 0.055) (Table 5). For post-operative stone-free status, stone size was identified as an independent predictor (adjusted OR 0.70, 95% CI 0.50–0.99, p = 0.043) (Table 6).

Discussion

The management of ureteric stones has evolved substantially over the past decades with the development of minimally invasive technologies. According to current international standard guidelines, both SWL and URSL are recommended treatment options for ureteric stones, with the choice of modality depending on stone characteristics, anatomical factors, patient factors, and patient preference.[2–4] Historically, SWL was widely used as a first-line treatment because it is non-invasive, can be performed without general anesthesia, and is associated with a favorable safety profile. However, improvements in endoscopic equipment, including the development of smaller-diameter URS, improved digital visualization, and more effective intracorporeal lithotripsy systems such as the holmium laser, have significantly expanded the role of ureteroscopy. Therefore, URSL has increasingly become a preferred treatment option in many centers due to its ability to achieve higher stone-free rates with immediate stone clearance.[6]

Despite this trend, SWL remains an important treatment modality, particularly for patients with small stones or those who prefer a non-invasive approach. However, when SWL fails to

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achieve adequate stone fragmentation or clearance, URSL is commonly performed as a secondary or salvage procedure. In these situations, concerns have been raised regarding whether prior exposure to SWL may affect subsequent ureteroscopic procedures. Experimental and clinical studies have demonstrated that SWL may induce morphological changes within the urinary tract, including urothelial injury, mucosal edema, inflammation, and tissue microtrauma. These changes may theoretically promote stone impaction or mucosal adhesion, making the procedure more challenging or associated with less favorable outcomes. The effects may vary depending on the number of SWL sessions, energy levels used, and individual patient response, which may help explain the variation in outcomes reported across studies.[8-10]

In this study, operative time was significantly longer in patients with prior SWL on univariate analysis, but it did not remain significant after adjustment for confounding factors. This finding suggests that the longer operative time observed in the prior SWL group was likely related to greater stone burden rather than a direct effect of previous SWL treatment. This may be because patients with prior SWL tended to have more complex stones, which may explain the differences in operative outcomes. These findings are consistent with previous studies evaluating salvage URSL after failed SWL. Demirelli et al. and Philippou et al. reported comparable operative times between primary and salvage URSL, and a systematic review by Wang et al. similarly found no significant difference in operative duration.[15,17,18] However, several studies have reported longer operative times in patients undergoing URSL after failed SWL, including reports by Tugcu et al., Irer et al., Kilinc et al., and Yao et al.[11-14]

The overall stone-free rate in this cohort did not significantly differ between patients with and without prior SWL. Multivariate analysis further confirmed that stone size, rather than previous SWL exposure, was the only independent predictor of postoperative stone-free status. These findings are consistent with previous studies that showed comparable treatment success rates between primary and salvage URSL. Almost all the studies reported similar stone-free rates between the two approaches, and the meta-analysis by Wang et al. also found no significant difference in treatment success.[12,13,15-20] Some studies have reported lower stone-free rates after SWL failure.[14,21]

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One possible explanation for the variability in operative time and stone-free outcomes reported in previous studies is differences in baseline stone characteristics, particularly stone size and the presence of stone impaction, which are more frequently observed in patients undergoing salvage URSL after failed SWL. In addition, several earlier studies included heterogeneous populations consisting of both renal and ureteric stones. Because renal stones often require flexible URSL or retrograde intrarenal surgery, variations in stone location and surgical technique may influence the operative time and treatment outcomes reported in the literature. In contrast, the present study focused specifically on ureteric stones, allowing a more homogeneous evaluation of the impact of prior SWL on ureteroscopic outcomes.

In our study, patients with prior SWL tended to have longer hospital stays, although the difference did not reach statistical significance. Multivariate analysis identified increasing age as the only independent factor associated with prolonged hospitalization. These findings are consistent with several previous studies that reported no significant differences in hospital stay between patients undergoing primary URSL and salvage URSL after failed SWL.[20-21] Taken together, the current evidence suggests that previous SWL exposure does not affect postoperative recovery following URSL.

A notable finding of this study was the significantly higher rate of postoperative infectious complications in patients with prior SWL. Most cases were limited to postoperative fever, although one episode of sepsis occurred in the prior SWL group. Multivariate analysis confirmed prior SWL as an independent predictor of infectious complications. Several mechanisms may explain this association. Shockwave exposure may cause urothelial injury, microvascular damage, and local inflammatory changes, potentially leading to mucosal edema or bacterial colonization around the stone surface.[8,11] During URSL, fragmentation of colonized stones may release bacteria into the urinary tract or bloodstream, increasing the risk of postoperative infection. In addition, patients in the prior SWL group in our cohort had a higher prevalence of previous urinary tract infection, which may further contribute to this risk. Several previous studies have reported comparable overall complication rates between primary and salvage URSL, including the meta-analysis by Wang et al.[13,15,18–21] However, some studies have reported higher complication rates in patients undergoing URSL after failed SWL, such as those by Yao et al. and Irer et al.[12,14] The discrepancy

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between our findings and previous reports may be related to differences in study populations, sample size, or definitions of postoperative complications.

Another important clinical consideration is the optimal timing of URSL following unsuccessful SWL. Irer et al. investigated this issue and suggested that performing URSL several days after SWL may allow mucosal edema and inflammatory changes to subside, thereby facilitating safer endoscopic access and potentially reducing operative difficulty. The authors reported that delaying URSL for approximately 2-3 weeks after SWL may provide more favorable operative conditions.[12] Although our study did not specifically evaluate the interval between SWL and URSL, this factor may represent an important variable influencing surgical outcomes and should be explored in future prospective studies.

This study has several limitations. First, the retrospective design may cause selection bias and limit the ability to control for all potential confounders. Second, the study was conducted at a single center with a relatively limited sample size, particularly in the prior SWL group. Third, it could not be definitively confirmed whether all cases of postoperative fever were directly related to the procedure. Postoperative fever can result from other causes or other sources of infection. Lastly, detailed information regarding the number of SWL sessions and the interval between SWL and URSL was not consistently available. To our knowledge, the present study provides additional evidence specifically evaluating ureteric stones, whereas many previous studies included mixed cohorts of renal and ureteric calculi.

Conclusion

In this retrospective cohort study, prior SWL was not significantly associated with most operative outcomes of URSL, including operative time after adjustment for confounding factors, length of hospital stay, or stone-free rate. However, a history of SWL was associated with a higher risk of postoperative infectious complications. As infection is a common complication following endoscopic stone surgery, heightened awareness and careful perioperative and postoperative monitoring may be particularly important in patients with prior SWL. Further prospective studies with larger patient populations are needed to confirm these results and figure out the mechanisms linking prior SWL to infectious complications after URSL.

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Acknowledgement

The authors thank Mr. Sadiporn Phuthomdee for his assistance with the statistics.

Funding sources

None.

Conflicts of interest statement

There are no conflicts of interest to declare.

Abbreviations

SWL	Shockwave lithotripsy
URS	Ureterorenoscopy
URSL	Ureteroscopic lithotripsy
UTI	Urinary tract infection

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Table 1: Baseline Characteristics

	No prior SWL 64 (74%)	**Prior SWL 23 (26%)**	**p-value**
Age (years)	58.6±13.0	62.7±10.3	0.177
Sex			0.614
Male	24 (38)	10 (43)	
Female	40 (62)	13 (57)	
Underlying diseases	43 (67)	20 (87)	0.069
Previous stone management (URSL or open surgery)	7 (11)	4 (17)	0.424
History of UTI	28 (44)	17 (74)	0.013
Positions			0.757
Upper	12 (19)	4 (17)	
Middle	12 (19)	6 (26)	
Lower	40 (62)	13 (57)	
Stone size (mm)	8.4±3.7	11.1±6.3	0.016
Number of stones	1.0±0.2	1.6±0.9	<0.001

SWL, Shockwave Lithotripsy; URSL, Ureteroscopic Lithotripsy; UTI, Urinary Tract Infection

Table 2: Operative Outcomes and Complications

	No prior SWL 64 (74%)	**Prior SWL 23 (26%)**	**p-value**
Operative time (minutes)	28.7±14.0	41.1±25.0	0.005
Post-operative ureteric stent	36 (56)	17 (74)	0.136
Hospital Stay (days)	1.5±1.3	4.1±10.8	0.052
Infectious complication	4 (6)	7 (30)	0.003
Stone-free status (1 month)	61 (95)	19 (83)	0.055

SWL, Shockwave lithotripsy

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Table 3: Results of Univariable and Multivariable Analyses of Operative Time

	Univariate analysis		Multivariate analysis	
	Coeff. (95% CI)	**p-value**	**aCoeff. (95% CI)**	**p-value**
Age (years)	0.01 (-0.31 to 0.33)	0.945	-0.06 (-0.37 to 0.24)	0.673
Sex: Female	-1.38 (-9.41 to 6.65)	0.734	1.53 (-5.93 to 8.99)	0.684
Underlying diseases	2.41 (-6.35 to 11.17)	0.586	-1.74 (-10.23 to 6.76)	0.685
Previous stone management	-1.72 (-13.51 to 10.08)	0.773	-6.98 (-18.88 to 4.92)	0.246
History of UTI	3.09 (-4.73 to 10.91)	0.435	3.40 (-4.43 to 11.23)	0.390
Positions				
Upper	Reference (1)		Reference (1)	
Middle	-6.49 (-18.67 to 5.69)	0.292	-10.41 (-22.39 to 1.57)	0.088
Lower	-12.54 (-22.65 to -2.43)	0.016	-9.25 (-18.82 to 0.33)	0.058
Stone size (mm)	1.83 (1.08 to 2.58)	<0.001	1.57 (0.72 to 2.42)	<0.001
Number of stones	6.24 (-0.67 to 13.14)	0.076	5.80 (-2.26 to 13.87)	0.156
Prior SWL	12.42 (3.94 to 20.89)	0.005	4.42 (-5.19 to 14.03)	0.362

UTI, Urinary Tract Infection; SWL, Shockwave Lithotripsy; CI, Confidence Interval; Coeff., Coefficient; aCoeff., Adjusted Coefficient

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Table 4: Results of Univariable and Multivariable Analyses of Hospital Stay

	Univariate analysis		Multivariate analysis	
	Coeff. (95% CI)	**p-value**	**aCoeff. (95% CI)**	**p-value**
Age (years)	0.05 (-0.04 to 0.15)	0.273	0.08 (0.01 to 0.15)	0.031
Sex: Female	-1.72 (-4.19 to 0.76)	0.171	-1.08 (-3.62 to 1.47)	0.402
Underlying diseases	1.37 (-1.34 to 4.08)	0.317	0.63 (-2.31 to 3.58)	0.669
Previous stone management	-1.33 (-4.99 to 2.33)	0.472	-2.03 (-6.13 to 2.07)	0.327
History of UTI	1.46 (-0.96 to 3.88)	0.233	1.05 (-1.67 to 3.77)	0.445
Positions				
Upper	Reference (1)		Reference (1)	
Middle	-2.83 (-6.64 to 0.98)	0.143	-1.30 (-5.45 to 2.86)	0.536
Lower	-3.70 (-6.86 to -0.54)	0.022	-2.93 (-6.00 to 0.14)	0.061
Stone size (mm)	0.001 (-0.26 to 0.27)	0.985	-0.09 (-0.36 to 0.18)	0.494
Number of stones	-0.21 (-2.39 to 1.98)	0.852	-0.76 (-3.31 to 1.79)	0.556
Prior SWL	2.68 (-0.03 to 5.38)	0.052	2.71 (-0.49 to 5.90)	0.096

UTI, Urinary Tract Infection; SWL, Shockwave Lithotripsy; CI, Confidence Interval; Coeff., Coefficient; aCoeff., Adjusted Coefficient

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Table 5: Results of Univariable and Multivariable Analyses of Infectious Complications

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	**p-value**	**aOR (95% CI)**	**p-value**
Age (years)	1.04 (0.98 to 1.10)	0.180	0.99 (0.94 to 1.03)	0.495
Sex: Female	0.74 (0.21 to 2.65)	0.644	0.22 (0.03 to 1.45)	0.115
Underlying diseases	4.34 (0.52 to 35.90)	0.173	1.02 (0.09 to 11.65)	0.988
Previous stone management	Not estimable*	-	Not estimable*	-
History of UTI	11.71 (1.43 to 96.10)	0.022	9.17 (0.96 to 87.89)	0.055
Positions				
Upper	Reference (1)		Reference (1)	
Middle	2.00 (0.31 to 12.75)	0.463	11.25 (0.49 to 259.77)	0.131
Lower	0.73 (0.13 to 4.17)	0.723	0.70 (0.08 to 5.81)	0.739
Stone size (mm)	1.04 (0.91 to 1.18)	0.579	0.91 (0.78 to 1.06)	0.219
Number of stones	1.30 (0.52 to 3.26)	0.580	0.16 (0.02 to 1.08)	0.060
Prior SWL	6.56 (1.71 to 25.23)	0.006	18.27 (2.35 to 142.10)	0.006

UTI, Urinary Tract Infection; SWL, Shockwave Lithotripsy; CI, Confidence Interval; OR, odds ratio; aOR, adjusted odds ratio

*Odds ratio could not be calculated because no patients with postoperative complications had a history of previous stone management.

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Table 6: Results of Univariable and Multivariable Analyses of Stone-Free Status

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	**p-value**	**aOR (95% CI)**	**p-value**
Age (years)	0.99 (0.93 to 1.05)	0.714	1.04 (0.96 to 1.13)	0.297
Sex: Female	2.22 (0.47 to 10.62)	0.317	2.67 (0.29 to 24.57)	0.385
Underlying diseases	0.41 (0.05 to 3.62)	0.425	0.53 (0.02 to 13.11)	0.696
Previous management	0.86 (0.09 to 7.88)	0.892	2.33 (0.06 to 97.87)	0.657
History of UTI	1.47 (0.31 to 7.01)	0.626	1.93 (0.12 to 30.95)	0.642
Positions				
Upper	Reference (1)		Reference (1)	
Middle	1.15 (0.20 to 6.74)	0.874	1.07 (0.05 to 21.79)	0.963
Lower	12.00 (1.15 to 124.99)	0.038	6.92 (0.35 to 135.40)	0.202
Stone size (mm)	0.70 (0.57 to 0.87)	0.001	0.70 (0.50 to 0.99)	0.043
Number of stones	0.76 (0.26 to 2.23)	0.622	11.89 (0.11 to 1,317.55)	0.303
Prior SWL	0.23 (0.05 to 1.14)	0.072	0.09 (0.00 to 2.15)	0.137

UTI, Urinary Tract Infection; SWL, Shockwave Lithotripsy; CI, Confidence Interval; OR, odds ratio; aOR, adjusted odds ratio

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