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ORIGINAL RESEARCH

Retrospective Study on Ureteroscopic Lithotripsy in Patients with Ureteral Duplication: Clinical Characteristics and Treatment Outcomes

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Objective: To evaluate the clinical characteristics and treatment outcomes of ureteroscopic lithotripsy (URSL) in patients with ureteral duplication and urinary stones.

Methods: This retrospective study analyzed 18 patients with ureteral duplication and urolithiasis who underwent URSL between January 2020 and December 2024. A control group of 200 patients with normal urinary anatomy who underwent URSL during the same period was randomly selected. Demographic data, clinical features, stone size and location, comorbidities, and surgical outcomes (operative time, postoperative hospital stay, and complications) were collected and compared between groups.

Results: No significant differences were found in age, gender, or BMI between the two groups. The ureteral duplication group had a higher proportion of patients with a history of urinary stones. Stone location differed significantly, with fewer right-sided ureteral stones in the duplication group. Despite anatomical challenges, there were no significant differences in operative time, hospital stay, or complication rates between the groups.

Conclusion: URSL is a safe and effective treatment for patients with ureteral duplication and urinary stones. Surgical outcomes are comparable to those in patients with normal urinary anatomy. Further research with larger sample sizes and long-term follow-up is needed to optimize diagnostic and therapeutic strategies.

Keywords: ureteral duplication, ureteroscopic lithotripsy, surgical outcomes, retrospective study

Introduction

Ureteral duplication is a congenital anomaly of the urinary system, which is defined by a kidney with two distinct renal pelves and ureters. It is reported to be found in around 0.5–3% of the general population,[1] with females being more affected than males, and unilateral duplication being more commonly observed than bilateral duplication.[2,3] This condition is primarily caused by abnormal bifurcation of the ureteric bud during embryonic development, resulting in aberrant partitioning of the renal pelvis and ureter.[4] Ureteral duplication can be categorized into complete duplication and partial duplication, where complete duplication refers to each renal pelvis having a separate ureter draining independently into the bladder, and partial duplication refers to two ureters joining before entering the bladder and sharing a common orifice.

Ureteral duplication is often asymptomatic, but it can lead to various complications, such as urinary tract infections (UTIs), vesicoureteral reflux, and the formation of urinary stones.[5,6] The presence of duplicated ureters may alter the anatomy of the urinary tract, making it more prone to these issues. Ureteroscopic lithotripsy (URSL) is one of the commonly employed treatments for managing urinary stones in patients with ureteral duplication. However, there is

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limited research focusing on the specific challenges and outcomes of URSL in these patients, particularly concerning differences in surgical efficacy and complications compared to those with normal ureters.[7–9]

Therefore, this study aims to evaluate the clinical characteristics and surgical outcomes of URSL in patients with ureteral duplication, comparing them with a control group of patients with normal ureteral anatomy. The findings of this study could provide insights into the safety and efficacy of URSL in this specific patient population and guide future treatment strategies.

Methods

Patients

We retrospectively reviewed hospital records from January 2020 to December 2024 and included patients presenting with URSL. A total of 18 patients with ureteral duplication and concomitant ureteral or renal calculi were enrolled. For comparison, we initially screened 5154 patients with urolithiasis and normal urinary tract anatomy who underwent URSL during the same period. After excluding those with febrile urinary tract infections (UTI), missing medical records or follow-up data, and those who received other surgical procedures such as percutaneous nephrolithotomy (PCNL) or open surgery, a pool of eligible control patients was established. From this pool, 200 patients were randomly selected as the control group using a simple random sampling method (sample() function in R software, version 4.2.2), ensuring equal probability and independence of selection.

This retrospective study was conducted following the principles of the Declaration of Helsinki and was approved by the Ethics Committee of Wuhan Central Hospital (Approval No: WHZXKYL2025-045). The Ethics Committee waived the requirement for informed consent due to the retrospective nature of the study. All patient data were anonymized and de-identified prior to analysis to protect patient privacy and confidentiality.

Operative Technique

All surgeries were carried out under general anesthesia, with the patient positioned in lithotomy for optimal access. Seven experienced urologists, each with more than ten years of experience in endourology, conducted the surgeries. The choice of ureteroscope was based on stone location and ureteral anatomy. A 9.5/8 Fr rigid ureteroscope (Karl Storz) was used for mid and distal ureteral stones, while an 8.4 Fr flexible ureteroscope (Karl Storz) with a 12 Fr ureteral access sheath (Innovex Med) was used for proximal ureteral and renal stones. Holmium laser lithotripsy (Accu-Tech, Beijing, China) was performed with energy settings ranging from 0.6 to 1.0 J and a frequency of 15–20 Hz. Stones were fragmented into particles smaller than 2 mm to facilitate spontaneous passage. A BARD 4.7 Fr ureteral stent was inserted routinely at the termination of the operation, and an 18 Fr Foley catheter was deployed and subsequently removed within 48 hours.

Patient Data and Clinical Information

For this study, we gathered a range of patient data, including demographic details such as gender, age, and BMI. Clinical information was also collected, encompassing presenting symptoms, symptom duration, and any history of urinary stones. Additionally, we recorded pertinent medical histories, such as diabetes mellitus, hypertension, and coronary artery disease. Imaging data, including the size and location of the stones, were obtained from preoperative scans, with stone size measured as the longest diameter. Surgical details, including operative time, hospital stay duration, and any complications, were also documented.

For the purpose of this study, difficult ureters were defined as those in which an 8 Fr ureteroscope could not be inserted due to ureteral narrowing. During the 1-month postoperative follow-up, a KUB imaging study was conducted to check for any remaining stones. Any stones greater than 4 mm were classified as residual stones. The ureter was categorized into three anatomical regions: the proximal ureter, extending from the ureteropelvic junction (UPJ) to the iliac vessels; the mid-ureter, from the iliac vessels to the bladder; and the distal ureter, which encompasses the intramural segment within the bladder wall. Hydronephrosis severity was classified according to the anteroposterior (AP) diameter of the renal pelvis. Mild hydronephrosis was characterized by an AP diameter of less than 3 cm, moderate hydronephrosis by an AP diameter ranging from 3 to 4 cm, and severe hydronephrosis by an AP diameter exceeding 4 cm.

For patients with bilateral ureteral stones, data for each side were recorded separately, including stone size, location, whether the duplication was complete or incomplete, and the site of ureteral fusion. However, the operative time was not recorded separately for each side.

Statistical Analysis

Distribution characteristics of continuous measures were first verified through Kolmogorov–Smirnov testing. Parametric data (mean ± SD) underwent *t*-tests for dual-group comparisons or ANOVA with SNK post-hoc analysis for multi-group contrasts. Non-normal distributions were described using median (IQR) and analyzed via rank-sum approaches (Mann–Whitney/Kruskal–Wallis). Discrete variables, presented as counts and percentages, were assessed via χ^2-tests with Fisher's exact correction for sparse cells.

Results

Demographic and Clinical Characteristics

As shown in Table 1, the study included 18 patients with ureteral duplication. Among these, 10 patients (55.6%) were male and 8 patients (44.4%) were female, with a median age of 61.5 years (IQR: 10.5 years) and a median BMI of

Table 1 Basic Demographics of Patients with Ureteral Duplication

No.	Gender	Age (Years)	BMI(kg/m²)	Presenting Symptoms	Onset Duration (Days)	Comorbidities	History of Urolithiasis	History of Ipsilateral Stone Surgery
1	Male	32	19.6	Flank pain	14	No	No	No
2	Male	49	24.2	Flank pain	7	No	No	No
3	Male	64	27.5	Flank pain	2	No	Yes	No
4	Male	71	20	Flank pain	90	Hypertension	No	No
5	Male	42	23.7	Asymptomatic	N/A	No	Yes	PCNL
6	Male	58	22.5	Flank pain	1	Hypertension	No	No
7	Female	68	23.8	Flank pain	60	Diabetes	No	No
8	Female	62	25.5	Flank pain	2	No	Yes	URSL
9	Male	63	27.7	Asymptomatic	N/A	Hypertension	Yes	PCNL
10	Male	53	22.9	Flank pain	120	No	No	No
11	Female	61	18.8	Flank pain	30	No	Yes	URSL
12	Female	64	22.5	Flank pain	4	No	No	No
13	Male	55	21.1	Flank pain	2	Hypertension	No	No
14	Female	62	26.4	Urinary frequency	7	Hypertension	No	No
15	Female	35	24.6	Flank pain	150	No	No	No
16	Female	64	20.6	Flank pain	5	No	Yes	URSL
17	Female	60	25.8	Flank pain	90	Hypertension	No	No
18	Male	70	23.7	Flank pain	3	Hypertension	Yes	URSL
Total	Male (n=10) Female (n=8)	Median (IQR) 61.5 (10.5)	Median (IQR) 23.7 (3.8)	Flank pain (n=15) Asymptomatic (n=2) Urinary frequency (n=1)	Median (IQR) 7.0 (64.8)	Hypertension (n=7) Diabetes (n=1) No=(10)	Yes (n=7) No (n=11)	URSL (n=4) PCNL (n=2) No=(12)

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23.7 kg/m² (IQR: 3.8 kg/m²). The most common presenting symptom was flank pain, reported by 15 patients (83.3%), while 1 patient (5.6%) presented with urinary frequency, and 2 patients (11.1%) were asymptomatic, with their stones incidentally detected during routine ultrasound. The median duration of symptoms before diagnosis was 7.0 days (IQR: 64.8 days). Regarding comorbidities, 7 patients (38.9%) had a history of hypertension, and 1 patient (5.6%) had a history of diabetes mellitus. Of the 18 patients, 7 (38.9%) had a history of urinary tract stones, including 4 patients (22.2%) who had previously undergone ureteroscopic lithotripsy (URSL) and 2 patients (11.1%) with a history of percutaneous nephrolithotomy (PCNL).

During the period from January 2020 to December 2024, a total of 5172 patients underwent URSL at our institution. Of these, 18 patients had ureteral duplication and concomitant stones, representing 0.35% of the total URSL procedures performed. This indicates the low prevalence of ureteral duplication among all patients undergoing URSL during this period.

Stone Characteristics and Ureteral Duplication Features

As shown in Table 2, the stone characteristics of patients with ureteral duplication are presented. Among the 18 patients, 11 patients (61.1%) had left-sided duplication with concomitant stones, 4 patients (22.2%) had right-sided duplication, and 3 patients (16.7%) had bilateral duplication. Since the 3 patients with bilateral stones were recorded separately for each side, a total of 21 records were included, although the analysis is based on 18 patients. 3 patients (16.7%) had complete duplication, including 1 bilateral case, while 15 patients (83.3%) had incomplete duplication. The median stone size was 8.0 mm (IQR: 7.0 mm). Stone locations were as follows: 9 stones (42.9%) were located in the proximal ureter, 2 stones (9.5%) in the mid-ureter, 7 stones (33.3%) in the distal ureter, and 3 stones (14.3%) in the renal pelvis. Preoperative CT scans identified ureteral duplication in 13 cases (61.9%), while the remaining 8 cases (38.1%) were diagnosed intraoperatively.

During surgery, the fusion point of the duplicated ureters was assessed in 13 cases with unilateral incomplete duplication and 2 cases with bilateral incomplete duplication. Among these, 10 cases (58.8%) showed fusion in the proximal ureter, 6 cases (35.3%) in the mid-ureter, and 1 case (5.9%) in the distal ureter. In total, 9 stones were located above the fusion point, while 8 stones were found below it. Regarding hydronephrosis, 3 cases (14.3%) had severe hydronephrosis, 2 cases (9.5%) had moderate hydronephrosis, and 16 cases (76.2%) had mild hydronephrosis. Due to difficult ureteral access, 4 cases (19.0%) required pre-stenting for ureteral dilation. The median operative time was 49.0 minutes (IQR: 30.3 minutes), and the median postoperative hospital stay was 2.0 days (IQR: 0.0 days). At the 1-month follow-up, 1 case (4.8%) had residual stones greater than 4 mm, as confirmed by KUB imaging.

Comparison with Control Group

As illustrated in Table 3, no notable differences were found in age, gender, or BMI between the patients with ureteral duplication and the 200 randomly selected control patients who underwent URSL for normal ureters. Detailed demographic and clinical characteristics of the control group are provided in Supplementary Table 1. However, the incidence of a previous history of urolithiasis was greater in the duplicated ureter group. While no significant difference in stone size was observed between the two groups, there was a notable difference in the distribution of stone locations. Specifically, the proportion of stones located in the right ureter was significantly lower in the ureteral duplication group compared to the normal group.

Although the rate of difficult ureters seemed higher in the ureteral duplication group, statistical analysis showed no significant difference between the two groups. Additionally, surgical duration, postoperative hospital stays, and complication rates were comparable between the two groups, with no statistically significant differences detected.

Table 2 Characteristics of Stones in the Ureteral Duplication Group

Stone Side	Complete Duplication or Incomplete Duplication	Stone Size (mm)	Stone Location	Detection Method	Site of Ureteral Confluence	The stone is located Inferior/Superior to the Ureteral Confluence	Hydronephrosis	Difficult Ureter	Duration of Surgery (Minutes)	Postoperative Hospitalization Day (Days)	Complication
Left	Incomplete	11.2	Distal ureter	CT	Middle ureter	Inferior	Mild	No	26	2	No
Left	Incomplete	15	Renal	CT	Proximal ureter	Superior	Mild	No	19	2	No
Left	Incomplete	5.2	Proximal ureter	Intraoperative	Distal ureter	Superior	Mild	Yes	135	5	No
Left	Incomplete	11	Middle ureter	CT	Middle ureter	Inferior	Severe	No	77	2	No
Bilateral	Both, Complete	Left: 5, Right: 8	Right: Middle ureter, Left: Distal ureter	Both, CT	N/A	N/A	Both, Mild	No	65	2	No
Bilateral	Both, Incomplete	Left: 6, Right: 20	Both, Proximal ureter	Both, CT	Both, Proximal ureter	Both, Inferior	Left: Mild; Right: Moderate	Both, Yes	60	2	No
Right	Incomplete	5.8	Distal ureter	CT	Middle ureter	Inferior	Severe	No	20	2	No
Left	Incomplete	6	Proximal ureter	Intraoperative	Middle ureter	Superior	Moderate	No	31	2	No
Left	Incomplete	11	Distal ureter	CT	Middle ureter	Inferior	Mild	No	45	2	No
Left	Complete	7	Distal ureter	Intraoperative	N/A	N/A	Mild	No	48	2	No
Right	Incomplete	7	Distal ureter	Intraoperative	Middle ureter	Inferior	Mild	No	40	4	No
Left	Complete	13	Proximal ureter	Intraoperative	N/A	N/A	Mild	Yes	121	2	No
Bilateral	Both, Incomplete	Left: 14, Right: 24	Both, Proximal ureter	Both, CT	Both, Proximal ureter	Both, Superior	Both, Mild	No	180	2	Residual stones
Right	Incomplete	8	Renal	CT	Proximal ureter	Superior	Mild	No	45	2	No
Left	Incomplete	22	Proximal ureter	Intraoperative	Proximal ureter	Superior	Mild	No	72	2	No
Left	Incomplete	4.6	Proximal ureter	CT	Proximal ureter	Superior	Mild	No	40	3	No
Right	Incomplete	5	Distal ureter	Intraoperative	Proximal ureter	Inferior	Severe	No	50	2	No
Left	Incomplete	10	Renal	Intraoperative	Proximal ureter	Superior	Mild	No	62	2	No
Left (n=11) Right (n=4) Bilateral (n=3)	Incomplete (n=17) Complete (n=4)	Median (IQR) 8.0 (7.0)	Renal (n=3), Proximal ureter (n=9), Middle ureter (n=2), Distal ureter (n=7)	CT (n=13) Intraoperative (n=8)	Proximal ureter (n=10) Middle ureter (n=6) Distal ureter (n=1)	Inferior (n=8) Superior (n=9)	Mild (n=16) Moderate (n=2) Severe (n=3)	Yes (n=4) No (n=17)	Median (IQR) 49.0 (30.3)	Median (IQR) 2.0 (0)	Residual stones (n=1)

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Table 3 Comparison of URSL Outcomes Between Ureteral Duplication and Normal Patients

BMI (kg/m²)	**n=18 Median (IQR): 23.7 (3.8)**	**n=200 Median (IQR): 24.2 (3.8)**	**0.6215**
History of urolithiasis	7/18 (38.9%)	30/200 (15%)	0.01781
Stone Side			< 2.2e-16
Left	11/18 (61%)	102/200 (51%)	0.5646
Right	4/18 (22%)	90/200 (45%)	0.03658
Bilateral	3/18 (17%)	8/200 (4%)	0.05145
Stone Size (mm)	n=21 Median (IQR): 8.0 (7.0)	n=208 Median (IQR): 7.0 (3.6)	0.07017
Stone Location			0.1037
Renal	3/21 (14.3%)	7/208 (3.4%)	
Proximal ureter	9/21 (42.9%)	112/208 53.8%	
Mid ureter	2/21 (9.5%)	37/208 (17.8%)	
Distal ureter	7/21 (33.3%)	52/208 (25%)	
Difficult Ureter Encountered	19.0% (n=4/21)	16/208 (7.7%)	0.09533
Duration of surgery (minutes)	n=18 Median (IQR): 49.0 (30.3)	n=200 Median (IQR): 42.0 (30.0)	0.1011
Postoperative hospitalization day (days)	n=18 Median (IQR): 2.0 (0)	n=200 Median (IQR): 2.0 (1.0)	0.4882
Complication			1
Postoperative infection and fever	0	3/208 (1.4%)	
Postoperative urinary tract bleeding	0	3/208 (1.4%)	
Postoperative stone residue	4.5% (n=1)	4/208 (1.9%)	

Discussion

Ureteral duplication is a common urinary tract anomaly, but clinical reports of patients with this condition combined with urinary stones may be underestimated, and the characteristics of its incidence remain unclear. A review of the literature revealed that only Chertack N et al conducted a retrospective analysis of 50 patients in 2018,[10] with other available literature mainly consisting of case reports.[5,11] In our institution, over the past 5 years, 5172 cases of URSL were performed, of which only 18 involved patients with ureteral duplication, further highlighting the rarity of such cases. Therefore, conducting this research is of significant clinical importance and provides valuable insights for the treatment of these special patients.

Although ureteral duplication is more common in females,[6] our study found a higher proportion of male patients with stones. This discrepancy may reflect the overall higher incidence of urinary stones in males.[12,13] The symptoms of stone onset are similar to those of the general population, primarily presenting as flank pain. The lower proportion of complete duplications compared to previous reports may reflect ethnic variations or sampling bias.[10] For patients suspected of having urinary stones, we routinely perform preoperative CT scans to confirm the location and size of the stones, rather than using intravenous pyelography (IVP). However, this study found that the diagnostic rate of CT for ureteral duplication was only 61.9%. This suggests that the diagnostic accuracy of CT for such anomalies needs improvement, and future studies may benefit from utilizing advanced imaging techniques such as 3D reconstruction to further enhance diagnostic accuracy.

We also performed the first multi-sample statistical analysis of the location of the ureteral junction in cases of ureteral duplication. The results revealed that in incomplete duplications, the two ureters most commonly fused at the proximal segment, followed by the mid-ureter, with the least fusion occurring at the distal ureter. Additionally, we recorded the

relative position of stones to the junction, and the results showed that the number of stones located both above and below the junction was similar, suggesting that the junction does not significantly hinder the downward movement of stones.

Our findings align with those of Chertack N et al.[10] When comparing our results to those of the normal ureter stone group, we observed no significant differences in age, gender, or BMI between the two groups. However, the proportion of patients with a history of stones was significantly higher in the ureteral duplication group, suggesting that patients with this anomaly are more prone to developing urinary stones. Interestingly, we found that the incidence of stones in the upper urinary tract on the right side was relatively lower in patients with ureteral duplication. The cause of this phenomenon is not fully understood and could be attributed to anatomical variations or limitations in sample size. Further research with larger sample sizes is needed to verify this finding.

Although the incidence of difficult ureters appeared to be higher in the ureteral duplication group, statistical analysis showed no meaningful distinction between the two arms. This suggests that while anatomical challenges may increase in duplication cases, these difficulties do not significantly affect total surgical result relative to patients with a healthy ureter. Furthermore, there were no significant differences between the two groups in terms of operative time, hospital stay, or postoperative complication rates. These results underscore the practical utility of URSL in treating patients with complex anatomical conditions, such as ureteral duplication, without significantly increasing the risk of complications or prolonging operative time, thus providing valuable clinical guidance.

Although this study provides preliminary evidence of the clinical benefit and associated safety of URSL in patients with ureteral duplication, there are several limitations. First, due to the rarity of these cases, the sample size of this study is small, and larger, multicenter prospective studies are needed to improve the generalizability of the findings. Second, the specific mechanisms of stone formation in this unique anatomical structure are not fully understood. Future basic research can further explore the mechanisms of stone formation in patients with ureteral duplication, including the effects of urinary flow dynamics and anatomical variations. Lastly, although this study demonstrates good short-term outcomes for stone treatment in ureteral duplication patients, long-term follow-up research remains an important direction for future studies. Understanding postoperative stone recurrence rates, urinary tract infection occurrences, and other long-term outcomes will help provide a more comprehensive assessment for clinical treatment.

Conclusion

This study investigated the application of URSL in patients with ureteral duplication and confirmed its safety and efficacy in this patient group. Although the procedure showed good results in respect of surgical duration, hospital stay and postoperative complications, additional investigations are required to optimize diagnostic methods, to investigate the mechanisms of stone formation and to improve the individualized treatment strategies. The emphasis of future research should be on larger multicenter studies, long-term follow-up data, and the optimization of comprehensive treatment approaches to provide more comprehensive clinical guidance.

Data Sharing Statement

The data is provided in the manuscript or supplementary information file.

Ethical Approval

This retrospective study was conducted following the principles of the Declaration of Helsinki and was approved by the Ethics Committee of Wuhan Central Hospital (Approval No: WHZXKYL2025-045). The Ethics Committee waived the requirement for informed consent due to the retrospective nature of the study. All patient data were anonymized and de-identified prior to analysis to protect patient privacy and confidentiality.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no potential conflicts of interest in this work.

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