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Endoscopic treatment of ureteral stones in children: efficacy, safety, and analysis of infectious-inflammatory complications



Khudaybergenov Ulugbek Ataulloyevich

Email: ulugbek0465@gmail.com

<https://orcid.org/0000-0002-0018-8045>

Abdukarimov Olimjon Odiljon ogli

Email: olimjon_uz090@mail.ru

<https://orcid.org/0000-0002-4295-5548>

Isroilov Bekzod Shavkatovich

Email: bekzod.medicaldoctor@gmail.com

<https://orcid.org/0009-0006-1502-0487>

Tashkent State Medical University, Tashkent, Uzbekistan

Rakhimboyev Asqar Akramovich

Email: doctorasqar83@mail.ru

<https://orcid.org/0009-0008-2889-4305>

**Republican Specialized Scientific-Practical Medical Center of Urology, Tashkent,
Uzbekistan**

Abstract. Endoscopic techniques are increasingly used for ureteral stones in children, but data on their safety and on the determinants of postoperative infectious-inflammatory complications (IIC) in the pediatric population remain limited. This study aimed to evaluate the efficacy and safety of endoscopic treatment of ureteral stones in children and to analyze the frequency, severity, and correlates of IIC. We analyzed 85 children (aged 4–17 years) who underwent endoscopic treatment of ureteral stones at a single tertiary urology center; the pediatric cohort was assessed separately



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from adults because of anatomical and physiological differences, and demographic, stone-related, infection-related, and procedural variables were compared between children with and without IIC using univariate methods, with no multivariable modeling undertaken given the small number of complicated cases. The immediate stone-free rate was 98.8% (84/85), with a single residual stone that did not require reintervention; most stones were small (≤ 5 mm in 90.6%) and located in the distal ureter (54.1%), and treatment was delivered mainly by transurethral (retrograde) ureterolithotripsy (55.3%) and percutaneous antegrade ureterolithotripsy (43.5%). IIC occurred in 12 of 85 children (14.1%) and were mild in every case, with no acute obstructive pyelonephritis or urosepsis; on univariate comparison, the only variable that differed significantly between children with and without IIC was the degree of leukocyturia (median 151,250 vs 22,500/mL; $p < 0.001$), whereas sex, age, stone location and size, bacteriuria, blood leukocyte count, preoperative drainage, and type of intervention did not differ significantly. Endoscopic treatment of ureteral stones in children is thus highly effective and safe, achieving a very high stone-free rate with infrequent and uniformly mild infectious complications, and the baseline infectious status of the urinary tract, reflected chiefly by leukocyturia, is the principal correlate of IIC, underscoring the importance of preoperative assessment and correction of urinary infection.

Keywords: pediatric urolithiasis; ureteral calculi; ureteroscopy; children; postoperative complications; urinary tract infection.

Relevance of the topic. The incidence of urolithiasis in children has risen over recent decades, and the surgical management of pediatric stone disease has shifted increasingly toward minimally invasive endoscopic techniques [1, 2, 3]. Advances in miniaturized instruments and laser lithotripsy have made ureteroscopic and percutaneous approaches feasible even in young children, and contemporary series report high stone-free rates with acceptable morbidity [4, 5, 6].

Nevertheless, the pediatric ureter and collecting system differ anatomically and physiologically from those of adults, and children may be more vulnerable to certain perioperative events; treatment strategies and safety data therefore cannot simply be extrapolated from adult cohorts [3, 6, 7]. Systematic reviews have confirmed that ureteroscopy for stone disease is safe and effective across pediatric centers, but they also highlight heterogeneity in reported complication rates and a relative scarcity of dedicated analyses of infectious-inflammatory complications (IIC) in children [7, 8].

Infectious complications — ranging from postoperative fever and urinary tract infection to, rarely, urosepsis — are among the most clinically relevant adverse events after endoscopic stone treatment, and in adults they are driven predominantly by the preoperative infectious status of the urinary tract [9, 10]. Whether the same determinants apply in children, and how frequently and how severely IIC occur after pediatric endoscopic ureterolithotripsy, are questions that merit dedicated study.

Aim of the study. The aim of the present study was to evaluate the efficacy and safety of endoscopic treatment of ureteral stones in children and to characterize the frequency, severity, and correlates of infectious-inflammatory complications in this population.



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Materials and methods. We analyzed 85 children aged 4 to 17 years who underwent endoscopic treatment of ureteral stones at a single tertiary specialized urology center. Each patient was counted once, irrespective of the number of clinical episodes or treatment stages. The pediatric cohort was analyzed separately from a parallel adult cohort, given the anatomical and physiological differences of childhood and the distinct clinical course of pediatric stone disease.

Endoscopic treatment was delivered, according to stone location and ureteral anatomy, by transurethral (retrograde) ureterolithotripsy, percutaneous antegrade ureterolithotripsy, or a combined approach. The immediate stone-free status was assessed after the main treatment stage. Infectious-inflammatory complications were defined and graded using the same clinical and laboratory criteria applied to the adult cohort — postoperative fever without an infectious focus, urinary tract infection, acute pyelonephritis, and urosepsis — in accordance with standard definitions [11].

Recorded variables included sex and age; stone location and maximum diameter; preoperative infection markers (leukocyturia quantified by the Nechiporenko method, bacteriuria, and peripheral-blood leukocyte count); preoperative upper-tract drainage; and the type of endoscopic intervention. Continuous variables are presented as median with interquartile range and categorical variables as counts and percentages. Children with and without IIC were compared using the χ^2 or Fisher exact test and the Mann–Whitney U test, as appropriate; $p < 0.05$ was considered significant. Because of the limited number of complicated cases, the analysis was univariate and descriptive, and no multivariable model was constructed.

Results. The median age was 12 years (interquartile range 9–15; mean 11.7 ± 4.1), with a predominance of school-age and adolescent children. Boys accounted for 57.6% of the cohort and girls for 42.4%, consistent with the higher prevalence of stone disease among boys in this age group. Stones were most often located in the distal ureter, and the great majority were small — 90.6% measured 5 mm or less — which is typical of pediatric ureteral stone disease and favors endoscopic removal (Table 1).

Table 1. Demographic and stone characteristics of the pediatric cohort (n = 85)

Characteristic	n	%
Sex		
Boys	49	57.6
Girls	36	42.4
Stone location (n = 74)*		



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Characteristic	n	%
Upper third	23	31.1
Middle third	11	14.9
Lower third	40	54.1
Stone size (n = 85)		
≤ 5 mm	77	90.6
6–10 mm	6	7.1
> 10 mm	2	2.4

*Note. Age: median 12 years [9–15], mean 11.7 ± 4.1 ; stone size range 3–18 mm. * Location data were unavailable for 11 children (12.9%).*

Endoscopic treatment achieved a very high immediate clinical efficacy. Stone-free status after the main stage was reached in 84 of 85 children (98.8%); a single patient (1.2%) had a residual stone that did not require repeat surgery. Treatment was delivered predominantly by transurethral (retrograde) ureterolithotripsy and by percutaneous antegrade ureterolithotripsy, with a single combined procedure (Table 2).

Table 2. Immediate outcomes and distribution of procedures (n = 85)

Parameter	n	%
Immediate outcome		
Stone-free after main stage	84	98.8
Residual stone	1	1.2
Type of intervention		
Transurethral (retrograde) ureterolithotripsy	47	55.3
Percutaneous antegrade ureterolithotripsy	37	43.5
Combined approach	1	1.2

Infectious-inflammatory complications developed in 12 of 85 children (14.1%), while 73 (85.9%) had an uncomplicated postoperative course. In every affected child the complication was mild; no cases of acute obstructive pyelonephritis or urosepsis occurred, confirming the relative



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safety of endoscopic treatment in this population when principles of preoperative preparation are observed.

A comparison between children with and without IIC is shown in Table 3. Most demographic, anatomical, and procedural parameters did not differ significantly between the groups. The only variable significantly associated with IIC was the degree of leukocyturia, which was markedly higher in affected children and reflects the presence and intensity of a baseline urinary infection. Sex, age, stone location and size, bacteriuria, blood leukocyte count, preoperative drainage, and type of intervention showed no significant association, and the high stone-free rate was independent of the occurrence of IIC.

Table 3. Comparison of children with and without infectious-inflammatory complications

Parameter	IIC (n = 12)	No IIC (n = 73)	p
Girls, n (%)	8 (66.7)	28 (38.4)	0.112
Age, years, Me [Q1–Q3]	13.0 [9.5–14.3]	12.0 [9.0–15.0]	0.934
Lower-third location, n (%)	5 (41.7)	35 (53.8)	0.46
Stone size, mm, Me [Q1–Q3]	4.0 [4.0–4.0]	4.0 [4.0–4.0]	0.513
Leukocyturia, /mL, Me	151,250	22,500	<0.001
Bacteriuria, n/N (%)	11/12 (91.7)	17/25 (68.0)	0.220
Blood leukocytes, $\times 10^9/L$, Me	7.05	6.9	0.895
Preoperative drainage, n (%)	5 (41.7)	19 (26.0)	0.33
Stone-free, n (%)	12 (100)	72 (98.6)	0.71

Note. Me — median; Q1–Q3 — interquartile range. Location and infection-marker denominators reflect available data. Because of the small number of complicated cases, the comparison is descriptive and univariate.



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In this cohort of 85 children, endoscopic treatment of ureteral stones was both highly effective and safe, with a stone-free rate of 98.8% and infectious complications that, although not rare, were uniformly mild. These findings are consistent with systematic-review evidence that ureteroscopy for pediatric stone disease achieves high success rates with acceptable morbidity across centers of varying volume [7, 8, 12], and they reinforce the growing consensus that minimally invasive endoscopy is an appropriate first-line option for most pediatric ureteral stones [4, 5, 6].

The favorable outcomes reflect in part the stone profile of this population: the great majority of stones were small and distally located, characteristics that facilitate endoscopic clearance. Contemporary series using holmium:YAG laser and pneumatic lithotripsy in children report comparably high stone-free rates and low complication rates, whether stones are treated by retrograde ureteroscopy or, for proximal stones, by antegrade percutaneous access [13, 14, 15, 16, 17, 18]. The distribution of procedures in our cohort — roughly balanced between retrograde ureterolithotripsy and percutaneous antegrade ureterolithotripsy — mirrors this individualized, stone-adapted approach, and shock-wave lithotripsy remains an alternative in selected cases [19].

The central observation regarding infectious complications is that, as in adults, the baseline infectious status of the urinary tract was the dominant correlate: leukocyturia was the single variable significantly associated with IIC, whereas demographic and stone-related parameters were not. This parallels adult evidence that preoperative urinary infection, rather than stone anatomy, drives post-endoscopy infectious complications [9, 10, 20], and it supports careful preoperative urinalysis and, where indicated, treatment of urinary infection before endoscopic intervention [20, 21]. The high frequency of bacteriuria in affected children, although not reaching statistical significance in this small sample, is consistent with this interpretation and with the recognized importance of even asymptomatic bacteriuria in stone patients [21].

Importantly, the small number of complicated cases precluded multivariable modeling in children — a limitation, but also a reflection of the safety of the procedure, since severe infectious events were absent. This contrasts with the adult population, in which a sufficient number of events allowed construction of a formal predictive model, and suggests that in children clinical vigilance directed at preoperative urinary infection may be more valuable than complex risk scores.

This study has several limitations. It was a single-center analysis with the inherent constraints of a retrospective design. The number of infectious complications was small and uniformly mild, which precluded multivariable analysis and limits the power to detect modest associations; some non-significant differences (for example, in bacteriuria and preoperative drainage) may therefore represent type II error rather than true absence of effect. Complete data on stone location and infection markers were unavailable for a minority of children. Larger, ideally multicenter, pediatric cohorts will be needed to confirm these findings and to establish whether formal risk stratification adds value in this low-event population.

Conclusion.



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1. Endoscopic treatment of ureteral stones in children is highly effective, achieving a very high immediate stone-free rate (98.8%) with a stone-adapted choice between retrograde and percutaneous antegrade ureterolithotripsy.

2. Infectious-inflammatory complications were infrequent (14.1%) and uniformly mild, with no acute obstructive pyelonephritis or urosepsis, confirming the safety of endoscopic treatment in this population.

3. The baseline infectious status of the urinary tract, reflected principally by leukocyturia, was the only factor significantly associated with IIC, whereas demographic and stone-related characteristics were not.

4. These results support endoscopy as a first-line approach for pediatric ureteral stones and emphasize preoperative assessment and correction of urinary infection as the key measure for further reducing infectious complications.

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