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PREDICTIVE FACTORS FOR IMPACTED URETER STONES IN CHILDREN: A RETROSPECTIVE ANALYSIS

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ABSTRACT

Aim: This study aimed to ascertain predictive indicators for the occurrence of impacted ureteral calculi in pediatric patients.

Methods: A retrospective investigation of 68 pediatric cases that underwent ureteroscopy (URS) for ureteral calculi between March 2012 and July 2022 was undertaken. Within this cohort, 19 patients were diagnosed with impacted calculi. Non-contrast thin-section abdominal computed tomography (NCCT) scans were utilized to assess stone dimensions, density, the incidence of hydronephrosis, and calculi positioning. The cohort was segregated into two groups: Group 1, comprising patients with impacted stones, and Group 2, those without. A statistical evaluation was performed to identify the significant predictors of calculi impaction.

Results: In the impacted stone cohort, a higher mean calculi diameter was noted (p=0.053). A higher incidence of calculi impaction was observed in the proximal ureter, and a positive correlation was found between the severity of hydronephrosis and the detection of impacted calculi. For proximal ureteral stones, a diameter exceeding 8.5mm demonstrated increased propensity for impaction. Logistic regression analysis revealed that the occurrence of calculi in the proximal ureter was associated with a 3.195-fold increased risk of impaction compared to the distal ureter, while severe hydronephrosis corresponded with a 39-fold elevated likelihood of calculi impaction compared to low-grade or absent hydronephrosis.

Conclusion: In pediatric patients with proximal ureteral stones, severe hydronephrosis and stone diameters surpassing 8.5mm were indicative of calculi impaction, thereby advocating endoscopic stone surgery as the primary therapeutic intervention.

Keywords: pediatric, hydronephrosis, ureteral calculi, ureteral obstruction

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INTRODUCTION

Urinary stone disease incidence in the pediatric demographic represents almost 1% of such cases within Turkey[1]. Over the past decade, the prevalence of this condition has surged, particularly among children below 15 years of age[2]. As per the EAU/ESPU guidelines, ureterorenoscopic laser lithotripsy (URS) is endorsed as the primary therapeutic strategy for pediatric lower ureteric stones, while it serves as an alternate modality for upper ureteric stones. Notwithstanding, shockwave lithotripsy (SWL) persists as the principal intervention for upper ureteric stones [3].

Impacted ureteric stones, however, exhibit a decreased responsiveness to SWL treatment[4]. Pathological alterations such as edema, hypertrophy, and the excretion of fibrinous exudate adhere to the ureteric segment housing the impacted stones [5]. This obstructive lesion in the ureter impedes stone clearance, even following SWL-induced fragmentation. Additionally, it can engender renal impairment via proximal stasis induced by the impacted stone, and can potentially incite an infection within the enclosed system. A ureterorenoscopic approach presents a compelling alternative to SWL for managing impacted stones, providing direct stone access, diagnosing impacted stones intraoperatively, and facilitating post-fragmentation JJ stent placement. With the advent of flexible ureterorenoscopes, this method has gained further reliability through enabling a safe retrograde approach to treating upper ureteric stones.

Given the ability to predict the impaction status of stones, especially those situated in the proximal ureter, ureterorenoscopy could be favored as the initial treatment choice over SWL. Prior research has primarily focused on forecasting impacted ureteric stones in adults, thereby leaving a knowledge gap in the pediatric population[6]. Hence, this study aims to identify predictive factors for impacted ureteric stones in the pediatric cohort prior to surgical intervention.

METHODS

Following the procurement of ethical approval from the localethics committee (2023-15/27), this study incorporated a total of 68 pediatric patients who had undergone ureteroscopic laser lithotripsy for ureteric stones within the period of March 2012 to July 2022. All subjects were included, with no exclusions. Prior to the procedure, non-contrast thin-section abdominal computed tomography (NCCT) scans were conducted on all patients.

CT images were appraised by two experienced urologists, examining stone dimensions, density, the incidence of hydronephrosis, and stone localization. Patient data, including age, height, weight, stone-free status post-single-session URS, and any developed complications, were documented. Patients diagnosed with impacted stones during ureterorenoscopy were classified as Group 1, while those with non-impacted stones formed Group 2. Postoperative complications were categorized per the modified Clavien-Dindo system (CDS)[7]. Children with Society for Fetal Urology (SFU) grade 3 and 4 kidney hydronephrosis were classified as severe hydronephrosis cases.

Pre-procedure urinalysis and urinary cultures were obtained. In patients with sterile urinary cultures, URS was performed, whereas those with non-sterile cultures received antibiotic treatment. URS was performed on patients exhibiting obstructive ureteral stones and non-sterile urine cultures after administering prophylactic antibiotics. All procedures were conducted under general anesthesia, with all patients receiving perioperative prophylactic antibiotics. Postoperative follow-up entailed a first-day X-ray Kidney Ureter Bladder (KUB), succeeded by ultrasound and X-ray KUB one-month post-procedure. Subsequently, ultrasound examinations were performed every three months during the first year, with subsequent specialized follow-ups customized according to the individual patient characteristics.

URS Procedure:

URS was executed on all subjects utilizing a semi-rigid ureteroscope (Karl Storz, Tuttlingen, Germany, 6.5 French) and a Holmium:Yttrium-Aluminum-Garnet (Ho:YAG) laser set to both high-frequency and low-frequency dusting settings. For challenging proximal ureter stone access or fragmentation scenarios, a transition was made to a flexible ureteroscope (FURS) (Karl Storz, Flex 2, Tuttlingen, Germany). Guidewire placement preceded URS, followed by the introduction of the ureteroscope into the ureter. If the guidewire could not traverse the proximal stone segment, it was safely advanced along the stone edge. Passive hydrodilation was performed on all subjects via a manual pump to facilitate ureterorenoscope insertion from the bladder into the ureter. When secure ureteral access was not achievable or when pyuria was observed emanating from the upper system during catheterization, a double J stent was placed, and the URS procedure was deferred to the subsequent session. Upon successful ureteral access and fragmentation completion, a double J stent was placed and removed under general anesthesia within the first month.

STATISTICAL ANALYSIS:

IBM SPSS Statistics version 22.0 (IBM Corp., Armonk, NY, USA) facilitated statistical analyses. Normality was determined via the Shapiro-Wilk test. Continuous data were reported as mean ± standard deviation (SD) for normally distributed data and as median (range) for non-normally distributed data. Categorical variables were represented as frequencies and percentages. Student's t-test was utilized for normally distributed continuous variables, and the Mann-Whitney U (MWU) test was employed for non-normally distributed continuous variables. Categorical variables were analyzed using Fisher's exact test. Pearson correlation analysis was used for normally distributed variables, while

Spearman's correlation analysis was used for non-normally distributed variables. The receiver operating characteristic (ROC) curve analysis determined continuous variable cutoff values. Logistic regression analyses were conducted to identify significant variables influencing the presence of impacted ureteric stones, with $p < 0.05$ considered statistically significant.

RESULTS

The sample included 42 boys and 26 girls, with a mean age of 6.9 ± 4.3 years and a mean ureteral stone size of 8.5 ± 3.1 mm. Stone-free rates were 85.3% the day after surgery, increasing to 94.1% by the end of the first postoperative month. There were no significant differences between groups concerning variables such as age, gender, side, body mass index, stone density, pre-stenting rates, stone-free rates on the first day and first month postoperatively, history of urinary tract infection (UTI), and previous treatments for urinary system stones on the same side (table 1). The rate of ureter kinking was significantly higher in Group 1 at 36.8%, compared to Group 2 at 6.1% (p=0.004).

The rate of impacted stones was 22.2% in the distal ureter, 16.7% in the mid-ureter, and 63.6% (7 out of 11 cases) in the proximal ureter. The rate of impacted stones was significantly higher in the upper ureter compared to the middle and lower ureter (p=0.021) (table 1).

The mean size of impacted stones was 9.8±3.6 mm, while that of non-impacted stones was 7.9±2.7 mm (p=0.013). The cutoff value for stone size was determined to be 8.5 mm using ROC analysis (AUC=0.651), and there was no significant difference between the groups based on this threshold value (p=0.59) (table 1). Subgroup analysis found no significant difference between the groups in terms of stone size being smaller or larger than 8.5 mm for distal and mid-ureter stones. However, in upper ureter stones, the impaction rate was 33.3% (2/6) for small stones and 100% (5/5) for large stones (p=0.045).

The stone impaction rate varied according to the degree of hydronephrosis. In cases without hydronephrosis, the impaction rate was 7.7% (1/13). In grade 1 hydronephrosis, the impaction rate was 26.1% (6/23), in grade 2 it was 17.4% (4/23), in grade 3 it was 83.3% (5/6), and in grade 4, it was 100% (3/3) (p<0.001). Severe hydronephrosis was observed in 42.1% of patients in Group 1, compared to only 2% in Group 2 (p<0.001) (table 1).

Table 1: Univariate comparison of variables between children with and without impacted stones.

		Group 1 (n= 19)	Group 2 (n=49)	p
Age (year)		7.8± 4.7	6.6±4.2	0.321[a]
Gender (Girl/Boy)		7/12	19/30	1[b]
Side (Right)		57.9%	40.8%	0.279[b]
BMI (kg/m²)		19.3±5.5	18.6±6.2	0.685[a]
Stone size (mm)		10 (6-21)	8 (4-21)	0.053[c]
Stone size >8.5 mm		57.9%	46.9%	0.590[b]
Stone density		800±289	654±424	0.307[a]
Stone location (proximal/ mid/distal)		7/2/10	4/10/35	**0.021[b]**
Hydronephrosis	**None**	1	12	**<0.001[b]**
	Grade 1	6	17	
	Grade 2	4	19	
	Grade 3	5	1	
	Grade 4	0	1	
Severe Hydronephrosis (SFU grade 3-4)		8 (42.1%)	1 (2%)	**<0.001[b]**
Preoperative UTI		26.3%	26.5%	1[b]
Pre-stenting		10.5%	14.3%	1[b]
Previous stone surgery		31.6%	26.5%	0.766[b]
Ureter kinging		36.8%	6.1%	**0.004[b]**
Fluoroscopy time (sec)		23.0±7.1	20.1±10.5	0.725[a]
Operative time (min)		60.8±31.2	53.4±25.3	0.315[a]
Stone-free in first day		73.7%	89.8%	0.128[b]
Stone-free in first month		89.5%	95.9%	0.310[b]
Postoperative complication (CDS)		1 Grade 2 (FUTI)	5 Grade 2 (febrile UTI)	0.459[b]
Ureter long-term complication		1 ureter stricture	0	0.279[b]

(N represents the number of cases, CDS: Clavien-Dindo system, SFU: Society of Fetal Urology, sec: seconds, min: minutes, UTI: Urinary tract infection, FUTI: Febrile urinary tract infection, mm: millimeter, a: Student-t test was used, b: Fisher exact test, c: MWU)

The stone size was marginally significant (p=0.070) in predicting the presence of impacted stones. For each unit (mm) increase in stone size, the likelihood of having an impacted stone increased by a factor of 1.297. The presence of severe hydronephrosis significantly increased the likelihood of having an impacted stone by approximately 39.008 times (p=0.002). The odds of having an impacted stone in the proximal ureter were approximately 3.195 times higher than in the distal ureter (p=0.008) (table 2).

During a median follow-up period of 14 months, one child in Group 1 developed a ureteral stricture.

Table 2: Independent variables in predicting impacted ureter Stones

	reference	P value	Odds ratio	95% Confidence Interval
Stone size		0.70	1.297	0.979- 1.718
Stone location	distal	0.008	3.195	1.354-7.537
Hydronephrosis	None, Grade 1 or 2	0.001	39.008	3.819- 398.397

DISCUSSION

In this study, a stone-free rate of 94.1% by the end of the first postoperative month following a single session of URS aligns with previous literature, indicating the high efficacy of URS for stone clearance in pediatric patients with ureter stones[8]. Of the children, 19 had impacted stones, with the presence of hydronephrosis being the strongest predictor. While stone size may have alimited influence, stone location also effectively predicts the presence of impacted stones.

Medical expulsive therapy (MET) is often the first treatment of choice for pediatric ureter stones. However, MET is ineffective and can potentially lead to renal damage when stones are impacted[9]. This observation is consistent with the adult study by Sarıca et al., which found a significant association between the degree of hydronephrosis and the presence of impacted stones, particularly in patients with proximal ureter stones unresponsive to spontaneous passage for at least two months[10]. Since a two-month observation period is not viable in children, particularly when hydronephrosis is present, ureter stones in pediatric patients are not left untreated for such an extended period in our setting. Instead, the diagnosis of impacted stones is based on intraoperative findings during URS, providing a more definitive diagnosis. Similarly, Samir et al. observed a significant association between the degree of hydronephrosis and the presence of impacted stones in adult patients with distal ureter stones of 5-10 mm following a 4-week follow-up[11]. Hence, in pediatric patients with a presumed diagnosis of impacted stones, MET is not a feasible therapeutic approach. Tuerxun et al. found no association between the presence of hydronephrosis and predictive failure of MET in identifying impacted stones, differing from our findings[9]. This divergence could be due to the proactive approach our clinic adopts, prioritizing interventional management like JJ stenting or URS over MET in children with moderate and severe hydronephrosis.

Our study found that the presence of the stone in the proximal ureter was statistically significant in multivariate analysis, whereas a study involving adult patients by Yoshida et al. found that the presence of the stone in the middle ureter was significantly associated with impacted stones[6]. Other studies involving adult cases report different findings about the predictive value of the proximal ureter for impacted stones[12,13]. The varying results might be due to our inclusion of a pediatric patient group. It should be noted that beyond natural narrowing points in the ureter, such as the ureteropelvic junction, iliac crossing, and ureterovesical junction, stones that remain fixed during follow-up could be impacted stones. The lack of a natural narrowing region in the upper ureter may account for the association between stone location in this area and impacted stones.

In children, the occurrence of stones in the proximal ureter poses a greater risk for complications during semirigid ureterorenoscopy with laser lithotripsy compared to other ureteral areas[8]. Consequently, in cases where medical expulsive therapy (MET) isn't the preferred approach, shock wave lithotripsy (SWL) is generally recommended as the primary treatment for children with proximal stones according to the 2023 EAU/ESPU guidelines.However, due to the high incidence of impacted stones in the proximal ureter, an initial assessment for the presence of these stones is crucial. This study suggests that, alongside the degree of hydronephrosis, stone size also plays an integral role in predicting the presence of impacted stones in the proximal ureter. When a decision for ureterorenoscopy (URS) for proximal ureteral stones is made, it may be beneficial to perform the procedure with flexible ureterorenoscopy or utilize it as necessary to avoid potential complications.

Our study found that children with impacted ureteral stones had larger stone sizes, a finding that aligns with recent research by Abdrabuh et al., indicating a similar trend in adults[13]. Other studies have also shown a correlation between large stone size and the presence of impacted stones[6], [14]. Particularly in the proximal ureter, a stone diameter exceeding 8.5 mm was significantly linked with impacted stones. This data might be critical for clinicians when deciding on the treatment option.

LIMITATIONS OF THE STUDY

This study has limitations, including its retrospective nature, which impacted the number of patients we could include. However, given the scarcity of research on impacted stones in the pediatric age group, this study still offers valuable insights. A key strength of this study is that all procedures were conducted by the same pediatric urologist in a well-experienced center, where ureterorenoscopic laser lithotripsy was also performed for kidney stones.

CONCLUSION

The presence of severe hydronephrosis in pediatric ureteral stones, particularly when localized in the proximal ureter, strongly indicates the existence of an impacted stone. SWL is considered as the first-line treatment option for proximal ureteral stones in active management. However, in cases where there is advanced hydronephrosis and the stone size is larger than 8.5mm, these should be regarded as warning signs for the presence of impacted stones. This indicates that endoscopic stone surgery should be prioritized as the primary treatment option for these children.

Conflicts of interest: The authors have nothing to disclose.

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