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Keywords: *children, ureteral stones, contact ureterolitho- tripsy.*

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Endoscopic Treatment of Children with Impacted Ureteral Stones

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Abstract- Ureteroscopy is the method of choice for treating children with impacted ureteral stones. In this study, ureterolithotripsy were used to assess the treatment outcomes for pediatric patients with impacted ureteral stones. The treatment results of 73 children aged 5 to 18 years were retrospectively evaluated. The average stone size was 10.0 ± 0.6 mm in length and 5.5 ± 0.7 mm in width. Complete stone removal was achieved in 71 patients (97.2%). The total number of intraoperative complications was 24 (33.8%). Conversion from endoscopic intervention to open surgery was required in two cases (2.8%) (Grade III). Ureteral mucosal injury was observed in 6.8% of children (Grade I), and ureteral perforation in 1.4% of cases (Grade II-a). Ureteral mucosal burns occurred in 4.1% of patients (Grade II-a) during laser lithotripsy. Deformation of the tip of the metal guidewire during an attempt to pass it retrogradely into the kidney occurred in 16.4% of cases (Grade I). Postoperative complications were observed in 23 patients (31.5%). Elevated body temperature was noted in 8.2% of cases (Grade I), and hematuria in 9.6% (Grade I). Urinoma (Grade III-b) and steinstrasse (Grade II-a) were each observed in one child (1.4%). Systemic inflammatory response syndrome was also reported in one case. Ureteroscopic contact lithotripsy for impacted ureteral stones in children is an effective and safe treatment method.

Keywords: children, ureteral stones, contact ureterolithotripsy.

I. Introduction

Urolithiasis is very common in some parts of the world, like Central Asia, the Middle East, South Asia, and North Africa. Treating it is very important for pediatric patients who have it. However, epidemiological studies have shown that the incidence of pediatric urolithiasis is increasing even in developed countries [2]. It should be noted that stone formation in children tends to recur, so minimally invasive surgical methods that can be reused if necessary should be preferred. These methods also allow for stone removal without disrupting the anatomical structure of the urinary tract and reducing the potential adverse effects of surgery on the growing body.

In cases where stones are located in the ureter, spontaneous passage is unlikely, and the risk of complications is high. Therefore, active surgical intervention is recommended in children [11]. Although guidelines from the European Association of Urology and the European Society for Paediatric Urology suggest that both minimally invasive and traditional approaches can be used to remove ureteral stones, only a small subset of pediatric patients require open surgery. Nevertheless, every effort should be made to completely remove the stones, as postoperative residual fragments pass spontaneously in only 20–25% of cases [5].

Ureteroscopy is considered the method of choice in treating children with ureteral stones, particularly when the disease duration exceeds 2-3 months and the calculus is tightly adherent to the ureteral mucosa (i.e., impacted). In adults, impacted stones are defined as those that have remained in the exact ureteral location for at least two months. In such cases, intravenous urography typically fails to demonstrate contrast distal to the stone, and it is generally impossible to pass a metal guidewire into the renal pelvis [7]. It is important to emphasise that ureterolithotripsy for impacted stones requires a high level of surgical skill, as there is a significant risk of ureteral wall injury and subsequent stricture formation.

This study sought to evaluate the efficacy of antegrade and transurethral ureterolithotripsy (TUULT) in resolving the challenging clinical scenario of impacted ureteral stones in pediatric patients, with a specific focus on treatment outcomes.

II. Materials and Methods

Between January 2019 and December 2024, we embarked on a retrospective journey through the medical records of 73 children, their ages ranging from 5 to 18, each grappling with the challenge of ureteral obstruction. Our aim was to illuminate the landscape of their treatment outcomes, casting light on the paths to recovery and the shadows of adversity they faced. The study included patients who experienced their first episode of renal colic 30-40 days before presentation, but for various reasons had not undergone surgical intervention. Multislice computed tomography (CT) with contrast of the urinary tract confirmed the presence of ureteral stones in all cases, with preserved renal function.

All patients exhibited ureterohydronephrosis, and tortuosity of the ureter was observed proximal to the stone. Patients with congenital anomalies of the urinary tract or strictures of the ureteropelvic junction,

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ureterovesical junction, or ureter were excluded from the study.

Before the surgical intervention, each patient was subjected to a comprehensive clinical and laboratory workup. This included meticulous urine and blood analyses, with bacteriological studies conducted as indicated. The diagnostic process was further augmented by ultrasonography and detailed radiographic imaging of the urinary tract, painting a complete picture of the patient's condition. If pyuria or bacteriuria were detected in a urinalysis, and further confirmed by a positive urine culture, a specific antibiotic treatment was initiated to effectively cleanse and restore the urinary tract to its normal, healthy state. Parents or guardians were thoroughly informed about the planned surgical procedures, possible complications, and additional interventions. Following this detailed discussion, their informed consent was obtained, signifying their agreement with the proposed course of action. The study protocol was approved by the Ethics Committee of the Republican Scientific and Practical Medical Centre of Urology, where the study was conducted (Protocol No. 1, January 23, 2023).

All procedures were performed under general anaesthesia. Transurethral ureterolithotripsy (TUULT) was performed with the patient in the supine position, whereas antegrade ureterolithotripsy was performed in the prone position. During the procedures, TUULT employed a 7 Fr rigid ureteroscope manufactured by Karl Storz® (Germany). Antegrade interventions were performed percutaneously, accessing the posterior calyx of the lower renal pole through a 14 Fr rigid endoscope also produced by Karl Storz® (Germany). Ureteral orifice dilation was not performed in any case. Before lithotripsy, a flexible guidewire was inserted into the ureter, ideally advanced into the renal pelvis and calyceal system; if not feasible, it was positioned at the level of the stone. Stone fragmentation was achieved using either a pneumatic lithotripter (LithoClast® Master, EMS, Switzerland) or a thulium laser (Cyber Ho®, Quanta System, Italy). To reduce the risk of damage to the ureteral mucosa due to heat, fragmentation of the stone began from its central part. This approach allowed for a gradual reduction in stone volume, minimizing the contact time between the laser fiber and the ureteral wall. Furthermore, the resulting smaller fragments were more easily extracted, further decreasing the potential for trauma to the delicate lining of the ureter. The power settings were carefully adjusted to achieve effective fragmentation while minimizing thermal energy dissipation. After the calculus had shattered into smaller fragments, the lithotripsy continued, relentlessly grinding the remnants until only granules resembling fine sand remained. Fragments larger than 4-5 mm were extracted using forceps; in cases with only smaller fragments, the procedure was concluded, assuming spontaneous passage with urine flow. At the end of the procedure, a Double J stent was inserted into the ureter and removed on postoperative days 7–10 under general anaesthesia. The stent placement aimed to ensure adequate drainage and prevent ureteral stricture formation during the healing process. Its removal, performed under general anaesthesia for patient comfort and to minimize potential discomfort or trauma, was uneventful in all cases. Post-removal, patients were monitored for any signs of urinary obstruction or flank pain, and discharged home with instructions on increased fluid intake and reporting any concerning symptoms. Nephrostomy drainage was additionally established in patients who underwent antegrade ureterolithotripsy. Intraoperative complications were classified using the modified Satava system, and postoperative complications were assessed according to the Clavien–Dindo classification [4].

The outcomes were compared using Fisher's exact test and Student's t-test. The descriptive statistics were calculated, and data processing was performed using Microsoft Office Excel 2007, Stat Soft Statistica 8.0, and statistical formulas.

III. Results

The mean age of the patients was 13.3 ± 2.7 years (range: 5–18 years). Demographic characteristics are summarised in Table 1. Among the 73 children, 48 (65.8%) were boys and 25 (34.2%) were girls. The mean stone size was 10.0 ± 0.6 mm in length and 5.5 ± 0.7 mm in width. Stone location was distributed as follows: distal ureter in 35 children (47.9%), mid-ureter in 24 (32.9%), and proximal ureter in 14 (19.2%). Stones were located in the right ureter in 45 patients (64.6%) and in the left ureter 28 (35.4%). One patient had previously undergone an unsuccessful attempt at extracorporeal shock wave lithotripsy (ESWL), and in another, stone extraction via ureteroscopy had failed.

TUULT was used for stones located in the distal and mid-ureter, while antegrade ureterolithotripsy was performed for proximally located stones. Complete stone clearance, including large fragments, was achieved in 71 patients (97.2%). Due to severe edema and hypertrophy of the mucous membrane, which made endoscopic visualization of the stone difficult, in two cases (2.8%) it was necessary to switch to open surgery (Table 2).

Resection of the ureter at the site of the stone was performed in one case, and a uretero-ureteroanastomosis was created; in another child, a ureterocystoanastomosis was performed (Grade III). Ureteral mucosa injury was observed in 6.8% of children (Grade I), and ureteral perforation in 1.4% of cases (Grade II-a), with the stone migrating extraureterally. These complications occurred in the group of children under 7 years of age. Ureteral mucosal burns were observed in 4.1% of patients (Grade II-a) when using a laser for lithotripsy. In 16.4% of cases (Grade I),

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deformation of the tip of the metal guidewire occurred during an attempt to retrogradely pass it beyond the stone, and it was replaced with another one. This complication was primarily attributed to excessive force applied during manipulation, leading to a loss of tactile feedback and potential damage to the guidewire's integrity. The replacement procedure, while successful in most instances, contributed to a slight increase in procedural time and resource utilization. Thus, the total number of intraoperative complications was 24 (33.8%) cases.

After surgery, the children stayed in the intensive care unit for 6–8 hours; once their condition stabilised, they were transferred to the general ward.

Table 1: Some Demographic Data and Clinical Characteristics of Patients (N=73)

Characteristic	Age (years)			
	5-7	8-10	11-14	15-18
Numberofpatients	11 (15%)	26 (36%)	24 (33%)	12 (16%)
Boys/Girls	6/5	19/7	16/8	7/5
Duration of disease (days, mean±SD)	41,9±6,8	42,7±7,2	41,9±6,9	41,3±7,4
Unsuccessful ESWL	1 (1,4%)	-	2 (2,7%)	-
Unsuccessful TUULT		1 (1,4%)		
Stone length (mm, mean±SD)	9.3±1,0	9,9±1,3	10,4±0,8	10,5±0,7
Stone width (mm, mean±SD)	5,3±0,9	5,4±0,8	5,5±0,7	5,6±0,7
Lengthofhospitalstay	4,1±0,8	4,2±0,9	4,3±0,8	4,0±0,7

Complications in the postoperative period were observed in 23 cases (31.5%). Increased body temperature without signs of sepsis after surgery occurred in 8.2% of cases (Grade I); in these patients, growth of microorganisms was detected during bacteriological examination of urine before the intervention. After intensification of antibacterial therapy, body temperature returned to normal. Hematuria without blood clots was observed in 9.6% of patients (Grade I) who underwent antegrade ureterolithotripsy. The use of hemostatic drugs and increased diuresis made it possible to eliminate the bleeding.

Table 2: Intraoperative Complications from the Perspective of the Modified Satava Classification (N=73)

Grade	Injury	Number of patients
Grade I	– Minimal mucosal injury of the ureter (mucosal tears);	5 (6,8%)
	– Malfunctioning or breakage of instruments;	12 (16,4%)
Grade II-a	– Mucosal injury (thermal injury);	3 (4,1%)
	– Extraureteral stone migration requiring stent insertion;	1 (1,4%)
	– Ureteral perforation requiring stent or nephrostomy insertion and secondary ureteroscopy;	1 (1,4%)
Grade III	– Inability to access the ureter or reach the stone requiring conversion to open surgery;	2(2,8%)

All children after endoscopic intervention were prescribed non-steroidal anti-inflammatory drugs during the first two days. However, in 9.6% of cases (Grade IIa), the use of these drugs was required for more than three days due to discomfort caused by nephrostomy drainage. A small urinoma (Grade IIIb) in the region of the lower pole of the kidney was detected by ultrasonography in one child (1.4%) after percutaneous access to the ureter. Without any additional interventions, the urinoma resolved by the fifth day after the operation. Steinstrasse (Grade IIa) located in the lower section of the ureter was observed in one child (1.4%). The reason for this was that, during pneumatic lithotripsy, fragments of the calculus located in the middle section migrated into the renal cavity and, after the operation, moved to the ureter. The use of an alpha-blocker made it possible to eliminate the fragments. Systemic inflammatory response syndrome (hyperthermia up to 38^{o}C, chills, pulse 120 per minute, respiratory rate 28 per minute, leukocyte count in peripheral blood 16,000 per ml) was observed in one child, who was transferred to the intensive care unit. Appropriate treatment (infusion therapy, additional antibiotics) allowed sepsis to be controlled.

Of the 73 patients, 70 were re-examined within 12 months. No patient experienced recurrent stone formation. However, in one case, a clinically insignificant narrowing of the mid-ureter (where the calculus had been located) was detected via intravenous urography. The thickness of the renal parenchyma was consistent with age norms, and its function remained preserved.

IV. Discussion

Ritchey M. et al. first described a case of stone removal in a child using ureteroscopy with a laser lithotripter in 1988 [10]. Due to the lack of small-caliber endoscopes at the time, pediatric urologists remained skeptical about the use of lithotripsy for ureteral stones

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for many years. The inherent anatomical differences in the pediatric urinary tract, particularly the smaller diameter of the ureters, presented significant technical challenges. Concerns were raised regarding the potential for trauma, perforation, and incomplete stone fragmentation when using instruments designed for adult anatomy, leading to a preference for more established, albeit often more invasive, surgical techniques. Over the past decade, however, concerns about urinary tract injury when using endoscopes to treat ureteral and renal pathology have been largely overcome. Small-calibre devices have been developed and introduced into practice, making laser stone fragmentation feasible and establishing ureterolithotripsy as a first-line treatment for children with ureteral stones.

Table 3: Distribution of Patients Depending on the Degree of Postoperative Complications According to the Modified Clavien-Dindo Classification (N=73)

Grade	Complication	Number of Patients
Grade I	Hyperthermia Blood in the urine requires the use of hemostatic agents, additional infusion therapy and diuretics	6 (8,2%) 7 (9,6%)
Grade IIa	The need for non-steroidal anti-inflammatory drugs is more than 48 hours after surgery. Steinstrasse	7 (9,6%) 1 (1,4%)
Grade IIIb	Urinoma	1 (1,4%)
Grade IVb	Urosepsis (including SIRS)	1 (1,4%)

Despite these advances, the optimal treatment approach for impacted stones remains a challenge. Ghoneim I. A. et al. [6] consider extracorporeal shock wave lithotripsy (ESWL) to be effective for impacted proximal ureteral stones less than 2 cm. However, ESWL is often ineffective when there is limited space for stone expansion after fragmentation within the ureteral lumen [9]. Bres-Niewada E. points out that ESWL rarely eliminates stones in a single session, often requiring repeated interventions or additional procedures, which can negatively impact the patient's quality of life [3]. In our study, ESWL was attempted in one patient but failed to clear the stone. During ureteroscopy, the stone was found to be fragmented, but oedema of the ureteral mucosa prevented its migration through the lumen.

While numerous studies address the treatment of impacted stones in adults, we found only one report describing ureterolithotripsy in similar cases in children. Adanur S. et al. [1] achieved complete stone clearance in 93.75% of pediatric cases using a semirigid endoscope and laser lithotripsy, with a complication rate of 15.6%. ESWL was additionally used for stones that migrated into the renal pelvis. In our practice, we did not employ ESWL. However, in two cases, traditional surgery was required to remove the stones. The Clavien-Dindo classification was used by Adanur et al. to assess intraoperative complications; we utilised the Satava classification instead. According to our data, a stone-free status was achieved in 71 (97.2%) children, though complication rates were higher: intraoperative complications occurred in 33.8%, while postoperative complications were observed in 31.5%. These higher rates may be attributed to longer durations of obstruction, the use of larger-calibre rigid endoscopes, and the application of a pneumatic lithotripter.

The endoscope's calibre is paramount in surgical interventions, proving crucial not only for delicate pediatric procedures but also in navigating the challenging terrain of impacted stones in adults. Nagata M. et al. reported successful treatment using rigid and flexible 6.9 Fr ureteroscopes in patients with obstruction due to ureteral stones lasting from 14 months to 10 years [8]. Complete stone removal via ureteroscopy was achieved in 96.2% of cases; with adjunctive ESWL, the stone-free rate reached 100%. Small-calibre endoscopes enabled surgery without significant complications. The authors noted that chronic obstruction leads to inflammatory oedema of the ureteral mucosa and formation of fibroepithelial polyps, which require laser removal. We also observed hypertrophy of the ureteral mucosa in the area surrounding the stone, which hindered visualisation and lithotripsy. An attempt to use a laser to remove the hypertrophied mucosa resulted in thermal injury, leading us to discontinue that technique.

In conclusion, ureteroscopic contact lithotripsy is an effective and safe treatment for impacted ureteral stones in children. For stones in the middle and lower ureter, transurethral ureterolithotripsy (TUULT) is recommended. For stones in the upper ureter, antegrade ureterolithotripsy is preferable.

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