Received: 08 Aug 2024 | **Accepted:** 14 Nov 2024 **Genel Tıp Derg. Volume** 34/**Issue** 6 (December), 832-838
DOI: 10.54005/geneltip.1529192

ORIGINAL ARTICLE

Efficacy of Different Surgical Methods in the Treatment of Pediatric Urolithiasis: Retrograde Intrarenal Surgery, Extracorporeal Shock Wave Lithotripsy, and Open/Laparoscopic Surgery Approaches

Pediatrik Ürolitiyazis Tedavisinde Farklı Cerrahi Yöntemlerin Etkinliği: Retrograd İntrarenal Cerrahi, Ekstrakorporeal Şok Dalga Litotripsi ve Açık/Laparoskopik Cerrahi Yaklaşımları

[1]Çiğdem ARSLAN ALICI, [2]Berkay TEKKANAT, [2]Umut ALICI, Baran TOKAR

[1]Pediatric Urology, Eskisehir City Hospital, Eskisehir, Türkiye
[2]Pediatric Surgery, Eskisehir City Hospital, Eskisehir, Türkiye
[3]Pediatric Surgery, Eskisehir Yunus Emre State Hospital, Eskisehir, Türkiye
[4]Department of Pediatric Surgery, Division of Pediatric Urology, Eskisehir Osmangazi University, Faculty of Medicine, Eskisehir, Türkiye

Correspondence

Çiğdem ARSLAN ALICI, Dr.
Pediatric Urology, Eskisehir City Hospital, Eskisehir, Türkiye

E-Mail: lakapies26@gmail.com

How to cite ?

Arslan Alıcı Ç, Tekkanat B, Alıcı U, Tokar B. Efficacy of Different Surgical Methods in the Treatment of Pediatric Urolithiasis: Retrograde Intrarenal Surgery, Extracorporeal Shock Wave Lithotripsy, and Open/Laparoscopic Surgery Approaches. Genel Tıp Derg. 2024;34(6):832-838

ABSTRACT

Background/Aims: To evaluate in which cases Retrograde Intrarenal Surgery (RIRS) should be combined with other techniques in pediatric patients undergoing retrograde intraluminal endoscopic surgery, RIRS combined with extracorporeal shock wave lithotripsy, and RIRS combined with open/laparoscopic surgery for urolithiasis in our clinic.
Materials and Methods: This study conducted a retrospective analysis of data from 302 pediatric patients undergoing RIRS, this technique in conjunction with extracorporeal shock wave lithotripsy (ESWL), open stone surgery, and laparoscopic stone surgery for urolithiasis at our clinic from January 2013 to October 2020. The patient's demographic data, the position, and size of the stones discovered using imaging techniques, surgical interventions for stone extraction, stone-free results, and the condition of postoperative hydronephrosis were evaluated.
Results: A total of 302 pediatric patients were included in this study. The mean age was 89.719 months (SD 51.447, range 6–216). 160 patients (53%) were male, whereas 142 patients (47%) were female. The mean size of the treated stones was 7.964 mm (SD 3.516, range 2.2-25 mm). Stone-free rate was achieved in 262 (86.75%) of the patients during surgical follow-up. Imaging indicated the absence of stones in 235 participants (77.81%). In the follow-up, it was shown that hydronephrosis completely resolved in 278 (92.05%) patients.
Conclusion: Choosing minimally invasive surgical procedures is advisable, particularly for pediatric patients. It is essential to acknowledge that open or laparoscopic surgery, particularly laparoscopy, is significant in certain instances, depending upon the surgeon's expertise.

Keywords: Endoscopic shock wave lithotripsy, Laparoscopy, Pediatric urinary tract calculi, Retrograde intrarenal surgery

ÖZ

Amaç: Kliniğimizde ürolitiazis nedeniyle retrograd intraluminal endoskopik cerrahi, ekstrakorporeal şok dalga litotripsi ile kombine RIRS ve açık/laparoskopik cerrahi ile kombine RIRS uygulanan pediatrik hastalarda RIRS'in hangi durumlarda diğer tekniklerle kombine edilmesi gerektiğini değerlendirmeyi amaçladık.
Gereç ve Yöntemler: Bu çalışmada kliniğimizde Ocak 2013-Ekim 2020 tarihleri arasında ürolitiyazis nedeniyle RIRS ve RIRS ile kombine ESWL, açık taş cerrahisi, laparoskopik taş cerrahisi uygulanan 302 çocuk hastanın verileri retrospektif olarak analiz edildi. Hastaların demografik verileri, görüntüleme yöntemleri ile tespit edilen taşların tarafı ve boyutu, cerrahi taş girişimleri, taşsızlık sonuçları ve ameliyat sonrası hidronefroz durumu değerlendirildi.
Bulgular: Çalışmaya 302 çocuk olgu dahil edildi. Ortalama yaş 89.719 ay (SD 51.447, dağılım 6-216) idi. Dahil edilen hastaların 160'ı (%53) erkek, 142'si (%47) kızdı. Tedavi edilen taşların ortalama boyutu 7.964 mm (SD 3.516, dağılım 2.2-25) idi. Ameliyat sonrası takiplerde hastaların 262'sinde (%86,75) taşsızlık sağlandı. Bu hastaların 235'inde (%77,81) görüntülemede taşa rastlanmadı. Takiplerde 278 (%92.05) hastada hidronefrozun tamamen düzeldiği gözlendi.
Sonuç: Sonuç olarak, özellikle pediatrik olgularda minimal invaziv cerrahi yöntemlerin tercih edilmesi uygundur. Açık veya laparoskopik cerrahinin, özellikle laparoskopinin, seçilmiş olgularda, cerrahın deneyimine göre yeri olduğu unutulmamalıdır.

Anahtar kelimeler: Endoskopik şok dalga litotripsi, Laparoskopi, Pediatrik üriner sistem taşı, Retrograd intrarenal cerrahi

Introduction

The incidence of urinary system stone illness in pediatric patients has risen in recent years (1). The incidence of urinary tract stones in children in low- and middle-income countries, including Turkey, ranges from 5% to 15% (2).

Advancements in technology have led to improvements in stone treatment for pediatric patients. Extracorporeal shockwave lithotripsy (ESWL) and retrograde intrarenal surgery (RIRS) utilizing rigid or flexible ureterorenoscopy (URS) are favored over open or laparoscopic surgical techniques due to superior outcomes and patient advantages. Nonetheless, open or laparoscopic stone therapy is warranted in some anatomical situations, during procedures like pyeloplasty, or when endourological therapies have proven unsuccessful (3).

Peer-Review: Double anonymized - Two External
Plagiarism Checks: Yes - intihal.net
Complaints: geneltip@selcuk.edu.tr

This study aims to evaluate in which cases RIRS should be combined with other techniques in pediatric patients undergoing retrograde intraluminal endoscopic surgery, RIRS combined with extracorporeal shock wave lithotripsy, and RIRS combined with open/laparoscopic surgery for urolithiasis in our clinic.

Material and Methods

This study retrospectively examined the data of 302 pediatric patients who underwent RIRS, RIRS combined with ESWL, open stone surgery, and laparoscopic stone surgery for urolithiasis at our clinic from January 2013 to October 2020.

Before the procedure, patients had preoperative urinalysis, urine culture, serum biochemistry, coagulation assessments, plain abdomen X-ray, and urinary system ultrasound (USG) to determine the existence, size, and position of the stones. In necessary cases, abdominal non-contrast computed tomography (CT) was requested due to suspected stones, and the findings of patients referred from an external facility with prior CT results were also incorporated into the study. The stone length was determined using USG measurements or the longest stone measurement obtained from plain abdominal X-ray or CT scans. Patients with urinary tract infections, coagulation issues, and those who failed to attend regular follow-up were excluded from the study.

Patients were categorized into four groups: those who underwent RIRS with a JJ stent, RIRS without a JJ stent, RIRS in combination with ESWL, and open/laparoscopic stone surgery combined with RIRS. The decision to use a JJ stent in patients who underwent URS was based on the stone's location, size, the dimensions and quantity of stone fragments retrieved through lithotripsy, and the condition of mucosal edema. The decision was made to combine URS and ESWL; if initial treatment commenced with ESWL and subsequent follow-up revealed stone migration to the ureter resulting in obstruction, or if stone-free rates were not attained after three sessions of ESWL, URS treatment was initiated. However, there were renal stones that were inaccessible via URS. Individuals who underwent URS in conjunction with open or laparoscopic surgery, those from whom stones were excised during pyeloplasty, those with substantial staghorn-like stones obstructing the URS that was attempted but unsuccessful, or those who developed a significant obstructive stone tract in various locations within the ureter.

The Extracorporeal shockwave lithotripsy (ESWL) Technique

According to the patient's age, size, and location of the stones, a JJ stent was inserted in chosen patients scheduled for combination treatment with ESWL during URS. During the ESWL session, general anesthesia was delivered to the pediatric patients involved in the study who underwent URS in conjunction with ESWL. The Electromagnetic Shock Wave Lithotripter (ELMED Multimed Classic) was employed for lithotripsy. Fluoroscopy was employed to ascertain the position and breakup of the stone during lithotripsy. The supplied shock wave commenced at 13-14 kV and was elevated to a maximum power level of 20 kV. The highest number of shocks administered per session ranged from 5000 to 5500 beats. The ESWL session concluded when the stone shattered to an acceptable size, no visible stone persisted, or sufficient shocks were administered. The patients underwent follow-up with a plain abdomen X-ray and ultrasound. The JJ stent was extracted one-month post-ESWL session. Postoperative data included age, gender, stone-free rates, and the presence of hydronephrosis.

The Retrograde Intrarenal Surgery (RIRS) Technique

A semirigid 4.5 Fr ureterorenoscope (URS) (Richard Wolf, Germany) was introduced into the pelvicalyceal system under general anesthesia while the patient was in the lithotomy posture. A 0.038 hydrophilic guidewire was first placed. A JJ stent was inserted when access to the upper urinary tract via URS was unachievable, when a stone in the proximal ureter was inaccessible when a stone in the proximal ureter or the reachable pelvicalyceal tract was displaced to the lower pole during laser lithotripsy, when the procedure duration overtook one hour without complete fragmentation of the stone, and when edema likely to induce ureteral obstruction had been expected. Following three weeks, the patients had re-evaluation via ultrasound, the JJ stent was removed, and a second session of retrograde intrarenal surgery (RIRC) was scheduled. In every instance, the pelvicaliceal system was accessed using semirigid or flexible ureteroscopes under general anesthesia. Lithotripsy was conducted utilizing Holmium laser lithotripsy (30 W, Sphinx) with a 365 nm laser probe (Accu Max, Boston, USA), applying suitable power and frequency until the stone was entirely fragmented or diminished to a size amenable to drainage. A JJ stent was reinserted post-procedure due to edema, suspected injury from an enclaved stone, and potential obstruction from a fragmented stone. The stent was extracted within one month.

The Open Surgery Technique

Pediatric patients scheduled for open surgery owing to urinary system stones were selected based on the presence of renal structural defects, significant stone burden, and prior unsuccessful minimally invasive procedures. The case was sterilely stained and draped suitably under general anesthesia. A flank incision was

performed using blunt dissection to access the right/left external oblique muscle, internal oblique muscle, transverse abdominal muscle, and fascia, according to the stone's position. The retroperitoneal space was accessed. The renal pelvis and ureter were identified and elevated. Subsequently, pyelolithotomy, nephrolithotomy, or ureterolithotomy was executed. A JJ stent was inserted following the removal of the stone(s). The JJ stent was extracted after one month. The patients underwent follow-up with simple abdominal X-ray and ultrasound imaging. The postoperative data reported were age, gender, stone clearance rate, and the occurrence of hydronephrosis.

The Laparoscopic Surgery Technique

Laparoscopic surgery may be favored in expert clinics for its minimally invasive nature in a specific patient group initially designated for open surgery. Pediatric cases were subjected to sterile staining and managed under general anesthesia. Laparoscopic pyelolithotomy (LPL) was conducted under general anesthesia in the right or left lateral decubitus posture, contingent upon the side of the kidney stone. A 5-mm port was introduced into the umbilicus via the open-access technique. Subsequently, two 5-mm working ports were introduced under direct visualization along the midclavicular line, parallel to the umbilicus, and 5 cm inferior to the umbilicus in the para-rectal area. Following the establishment of the pneumoperitoneum, the colon was medially mobilized by locating and incising the line of Toldt. Upon identification of the ureter and renal pelvis, the pelvis and ureteropelvic junction were revealed. Following the ureterostomy or pyelotomy incision, the calculi were removed utilizing a laparoscopic grasper. A double-J stent was subsequently inserted antegradely into the bladder. The pelvis was sutured closed using running stitches with 5/0 or 6/0 polyglactin. A drain was not inserted, and the Foley catheter was extracted three days later. The Double J stent was extracted four weeks post-operation.

Patients in the groups underwent plain abdominal radiography and ultrasonography at regular intervals for a minimum duration of one year. Children without stones or with stones measuring less than 4 mm on simple abdominal radiography or ultrasound were considered stone-free. Follow-up intervals were established based on the imaging conducted during the initial month. Patients clear of calculi on simple abdominal radiography or ultrasound were monitored at six-month or year intervals. Patients with stones measuring less than 5 mm were monitored at three-month intervals. In patients with stones above 5 mm, the follow-up or suitable treatment technique was determined based on the location and dimensions of the stone(s).

Statistical analysis

Continuous data are given as mean ± standard deviation. Categorical data is given as a percentage (%). Shapiro Wilk's test was used to investigate the suitability of data for normal distribution. In the comparison of groups with normal distribution, one-way variance analysis (one-way ANOVA) was used for cases with three or more groups. Pearson Chi-Square and Pearson exact Chi-Square analyses were used in the analysis of the created cross-tables. IBM SPSS Statistics 21.0 (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). A value of $p<0.05$ was accepted as a criterion for statistical significance.

Results

A total of 302 pediatric patients were included in this study. This study categorized patients into four groups: Group 1, the URS group without JJ stent; Group 2, the URS group with JJ stent; Group 3, patients who underwent ESWL combined with URS; and Group 4, patients who underwent open or laparoscopic surgery combined with URS. Demographic characteristics, stone size, side, position, stone-free rates, and postoperative hydronephrosis status of the patients according to the groups are reported in Table 1.

For all the patients in the study, the average age of the patients was 89.719 months (Standard deviation: 51.447, range 6–216). Statistical analysis showed a significant correlation between group age and outcome variables ($p=0.010$). This was attributed to the inherent challenges associated with the use of RIRS and ESWL procedures, particularly in cases of obstructive stone formation, and was observed to be more pronounced with decreasing patient age. Our results demonstrate the efficacy of open surgical and laparoscopic techniques, which offer a minimally invasive alternative, as adjunctive approaches in the management of patients with multiple obstructive stones and hard stones such as cystine stones.

Of the patients included in the study, 160 (53%) were male and 142 (47%) were female. Although there was no difference between the groups in terms of gender, it was found that male patients constituted a significantly larger proportion of those who underwent open or laparoscopic surgery. However, the number of patients in the group was small, which limits the reliability of this finding. In consideration of the anatomical challenges specific to the male gender, it may be necessary to supplement the RIRS technique with auxiliary techniques. It was hypothesized that male patients were more prevalent in laparoscopic and open surgical techniques for this reason.

Table 1. Demographic data, stone dimensions, stone characteristics, stone-free rates, and postoperative hydronephrosis status of patients categorized by groups (n=Number of patients, n*=Number of stones)Table 1. Demographic data, stone dimensions, stone characteristics, stone free rates, and postoperative hydronephrosis status of patients categorized by groups (n: number of patients, n*: number of stones)

URS			URS&ESWL	URS & Open/ Laparoscopic Surgery	p	
		JJ stentfree n=49 (16.23 %)	JJ stent n=185 (61.25%)	n=57 (18.87 %)	n=11 (3.65 %)	
Age (month)	**Mean±SD**	90.351±52.234	95.898±54.004	92.263±45.045	39.909±37.176	0.010
Gender	**Female n (%)**	27 (55.10)	83 (44.87)	31 (54.39)	2 (18.18)	0.089
	Male n (%)	22 (44.90)	102 (55.13)	26 (45.61)	9 (81.82)	
Stone size		7.92±3.17	7.50±2.70	11.24±3.27	11.75±3.86	<0.001
Stone side	**Right n* (%)**	36 (8.80)	116 (28.36)	32 (7.83)	10 (2.45)	0.993
	Left n* (%)	27 (6.60)	131 (32.03)	46 (11.24)	11 (2.69)	
Stone-free rate	**n (%)**	44 (89.80)	167 (90.27)	43 (75.44)	7(63.64)	<0.001
Hydronephrosis	**None n (%)**	46 (15.23)	168 (55.62)	54 (17.88)	9 (2.98)	0.457
	Continued n (%)	3 (0.99)	17 (5.62)	3 (0.99)	2 (0.66)	

Table 2. Stone-free rates based on stone localization in groups (n: number of stones)

	URS		URS & ESWL	URS & Open/ Laparoscopic Surgery
	JJ stent-free n=63	JJ stent n=247	n=78	n=21
Lower pole	2	19	9	
Pelvis renalis	3	26	38	6
Ureteropelvic junction	5	52	6	5
Distal ureter	29	80	6	1
Ureterovesical junction	16	40	1	
Stone-free rates n (%)	55 (87.30)	217 (87.85)	60 (76.92)	12 (57.14)

A standard abdomen X-ray was conducted in 299 instances involving urinary system calculi. Stones were identified as non-opaque in 95 (30.46%) instances and opaque in 202 (66.89%) instances (p<0.01). Urinary system stones were identified in 25 instances (8.25%) with non-contrast abdomen CT (p<0.001). Diagnostic ultrasound of the urinary system was conducted in 284 patients (94.03%) (p<0.001). Given that the patients were children, efforts were made to minimize the dose of ionizing radiation. However, in selected cases, a non-contrast abdominal CT was performed to visualize the location, size, and even the presence of the stone.

The average size of the treated stones was 7.964 mm (SD 3.516, range 2.2-25 mm). Patients who underwent open or laparoscopic surgery had significantly larger stone sizes compared to the other groups (p<0.001). In our opinion, these techniques should not be forgotten as an additional treatment modality for difficult and big stones when age and gender are taken into account.

Radiological scans revealed the presence of stones in 409 renal units. The lateral distribution of stones was 194 (47.43%) on the right and 215 (52.57%) on the left. There was no difference between the groups in terms of the side of the stone. We have shown that the techniques can be applied regardless of the side. The three sites with the highest incidence of stones were the distal ureter, ureteropelvic junction, and lower pole of the kidney, respectively.

Stone-free rates were attained in 262 (86.75%) of the patients throughout surgical follow-up. Stone-free rates based on stone localization in the groups are shown in Table 2. The RIRS method, whether used alone or in conjunction with ESWL, represents a viable option for the treatment of urolithiasis in children. While open and laparoscopic surgeries are not the preferred approaches in the majority of cases, they may be considered in patients who have not responded

to these stone-directed techniques, particularly in younger patients with large, tissue-inclusive, and multiple stones. In instances where the desired stone-free rates cannot be achieved with these surgical techniques, surgical intervention can be continued with RIRS.

Imaging revealed no stones in 235 patients (77.81%). During the follow-up, it was noted that hydronephrosis fully resolved in 278 (92.05%) individuals. The result of no difference between the groups in terms of regression of hydronephrosis indicates that rapid intervention in stone-related obstruction is a crucial factor in maintaining renal health.

Discussion

The advantages of minimally invasive techniques for the treatment of urolithiasis in children have been widely reviewed in the literature, especially with new technological developments (8-10). However, while age is an important advantage in some techniques, it is a disadvantage in others. Notably, several significant disadvantages are identified in the studies. Access to RIRS is challenging due to the narrow caliber of ureters, particularly in young children. In instances where access is unavailable, the ureter remains narrow at the ureteral orifice, iliac vessels, or ureteropelvic junction. The dilatation of a narrow ureteric orifice may result in ureteral ischemia, perforation, vesicoureteric reflux, and stricture formation. (11-12). A study reported that ESWL was more successful in young children. The author also found that age was the only independent predictor of surgical success when multivariate analysis was performed (13). It can be used as a combined treatment modality for stones that cannot be reached by RIRS. Open surgery has been used for many years to treat urinary system stones, but its indications are limited even in guidelines. Experience with laparoscopy has also increased among surgeons and it has become the preferred alternative to open surgery (14). The smaller instruments of modern laparoscopy have made this procedure a good alternative for the treatment of urolithiasis in children. Endoscopic and laparoscopic techniques can be combined under guidance to ensure successful treatment. Laparoscopy enables the surgeon to examine the entire collecting system and to fragment and remove all stones in a single surgical procedure (15). By the findings of previous studies, our investigation revealed that age may be a determining factor in the selection of surgical techniques. It is important to note that laparoscopic surgery can be employed as an alternative approach in cases where RIRS, either as a standalone procedure or in conjunction with other techniques, has proven ineffective in the management of urolithiasis, particularly in younger patients.

The findings revealed that male patients were significantly more prevalent in the group that underwent open or laparoscopic surgery. However, the limited sample size of the patient group limits the reliability of this finding. Given the anatomical difficulties specific to the male gender, it can be hypothesized that the RIRS technique can be supported by auxiliary techniques, particularly in younger and more complex cases. However, there is insufficient data in the literature to support this hypothesis.

The size and location of the stone are crucial factors in determining the optimal surgical technique. In the literature, RIRS is recommended as a treatment option for upper ureter and renal stones measuring ≤2 cm (16). ESWL is the recommended initial treatment for pediatric renal stones with a diameter of 1.0 cm, irrespective of the Hounsfield unit (HU) value. Furthermore, ESWL is also indicated for renal stones other than those situated in the lower calyx with a HU value of 750 and a diameter between 1.0 and 2.0 cm. ESWL may also be the preferred initial treatment for renal stones with a diameter of 1.5 cm located in the upper ureter (17, 18). The EAU guidelines strongly advise that the indications for open surgery should be limited to the cases where the child is very young, large stones are present, congenital problems require surgical correction, and/or the presence of severe orthopedic deformities that cannot be positioned for endoscopic procedures (19). Furthermore, the EAU guidelines published in 2021 indicated that laparoscopic or robot-assisted surgery may be a potential option for children with complex renal anatomy (retrorenal or ectopic colon), UPJO or calice diverticulum, megaureter, or a history of endoscopic surgical failure. As previously documented, laparoscopic pyelolithotomy has been demonstrated to achieve a 100% stone-free rate in the treatment of a single stone measuring ≥1 cm in the extrarenal pelvis or ureteric stones refractory to ESWL or RIRS (20). The present study revealed that surgical techniques varied according to the size and location of the stone, a finding that is consistent with the literature. While RIRS and ESWL are two effective stone treatment modalities, it is important to note that laparoscopy also has a role in complex cases and challenging stones.

The literature provides numerous examples of studies evaluating the stone-free success of various methods applied in the treatment of urinary system stones. In a study conducted by Resorlu et al., 84% of children who underwent RIRS achieved a stone-free rate (21). In a study by Demirkesen et al., a stone-free rate of up to 90% was demonstrated in both localisations with ESWL in stones located in the renal pelvis and upper ureter (22). Gupta et al. evaluated the laparoscopic technique and reported a stone-free

rate of 79% with the laparoscopic approach alone (23). Zargooshi reported that 310 children underwent open surgery for the treatment of kidney stones, with a total postoperative stone-free rate of 95.4% (24). The results of our study align with those of previous research, indicating that RIRS and ESWL techniques result in a higher stone-free rate compared to open and laparoscopic techniques. This demonstrates the efficacy of minimally invasive techniques in achieving a stone-free rate. Consequently, these techniques should be the preferred approach for the management of urinary tract stones in children.

The retrospective nature of the study, the unavailability of all requested data from the patients, and the limited number of patients in the open and laparoscopic surgery group represent the limitations of this study. The results of open and laparoscopic surgery performed within limited indications can be obtained with multicentre studies, which provide a more comprehensive overview of the subject matter.

Conclusion

In conclusion, the study was conducted to evaluate the most appropriate techniques for the management of urinary tract stones in children, taking into account the specific clinical circumstances. It is important to note that open and laparoscopic surgical techniques, which have become less prevalent in recent years, should not be overlooked as potential adjunctive procedures in complex cases and challenging stones when indicated. The findings of this study suggest that these techniques, particularly when combined with RIRS, may offer a viable solution in challenging cases.

References

1.Ishii H, Griffin S, Somani BK. Ureteroscopy for stone disease in the pediatric population: a systematic review. BJU Int. 2015 Jun;115(6):867-73. doi: 10.1111/bju.12927. Epub 2015 Jan 21. PMID: 25203925.

2.Barreto L, Jung JH, Abdelrahim A, Ahmed M, Dawkins GP, Kazmierski M. Reprint – Medical and surgical interventions for the treatment of urinary stones in children: A Cochrane Review. Can Urol Assoc J 2019;13(10):334-41. http://dx.doi.org/10.5489/cuaj.5787

3.Kane CJ, Bolton DM, Stoller ML. Current indications for open stone surgery in an endourology center. Urology. 1995 Feb;45(2):218-21. doi:10.1016/0090-4295(95)80008-5. PMID: 7855969.

4.Esposito C, Masieri L, Bagnara V, Tokar B, Golebiewski A, Escolino M. Ureteroscopic lithotripsy for ureteral stones in children using holmium: YAG laser energy: results of a multicentric survey. J Pediatr Urol. 2019 Aug;15(4):391.e1-391.e7. doi: 10.1016/j.jpurol.2019.05.004. Epub 2019 May 8. PMID: 31182399.

5.Rizvi SA, Naqvi SA, Hussain Z, Hashmi A, Hussain M, Zafar MN, Sultan S, Mehdi H. Pediatric urolithiasis: developing nation perspectives. J Urol. 2002 Oct;168(4 Pt 1):1522-5. doi: 10.1097/01.ju.0000028601.63446.51. PMID: 12352448.

6.Tasian GE, Kabarriti AE, Kalmus A, Furth SL. Kidney Stone Recurrence among Children and Adolescents. J Urol. 2017 Jan;197(1):246-252. doi: 10.1016/j.juro.2016.07.090. Epub 2016 Aug 10. PMID: 27521691; PMCID: PMC5161588.

7.Alsagheer G. A., Mohamed O., Abdel-Kader M. S., Hasan A. M., Abdel Razek M., Fathi A., Mahmoud O.,Abolyosr A. (2018). Extracorporeal shock wave lithotripsy (ESWL) versus flexible ureteroscopy (F-URS) for management of renal stone burden less than 2 cm in children: A randomized comparative study. African Journal of Urology, 24(2), 120–125.doi:10.1016/j.afju.2018.02.001

8.Peng T, Zhong H, Hu B, Zhao S. Minimally invasive surgery for pediatric renal and ureteric stones: A therapeutic update. Front Pediatr. 2022 Aug 18;10:902573. doi: 10.3389/fped.2022.902573. PMID: 36061394; PMCID: PMC9433542.

9.Schulz C, Becker B, Netsch C, Herrmann TRW, Gross AJ, Westphal J, Knoll T, König HH. Outcomes and costs of ureteroscopy, extracorporeal shockwave lithotripsy, and percutaneous nephrolithotomy for the treatment of urolithiasis: an analysis based on health insurance claims data in Germany. World J Urol. 2022 Mar;40(3):781-788. doi: 10.1007/s00345-021-03903-2. Epub 2021 Dec 15. PMID: 34910235; PMCID: PMC8948106.

10.Quhal F, Al Faddagh A, Silay MS, Straub M, Seitz C. Paediatric stone management: innovations and standards. Curr Opin Urol. 2022 Jul 1;32(4):420-424. doi: 10.1097/MOU.0000000000001004. Epub 2022 Jun 9. PMID: 35674672.

11.Komori M, Izaki H, Daizumoto K, Tsuda M, Kusuhara Y, Mori H, Kagawa J, Yamaguchi K, Yamamoto Y, Fukumori T, Takahashi M, Kanayama HO, Sakaki M, Nakatsuji H, Hamao T, Miura H. Complications of Flexible Ureteroscopic Treatment for Renal and Ureteral Calculi during the Learning Curve. Urol Int. 2015;95(1):26-32. doi: 10.1159/000368617. Epub 2015 Mar 27. PMID: 25833730.

12.Corcoran AT, Smaldone MC, Mally D, Ost MC, Bellinger MF, Schneck FX, Docimo SG, Wu HY. When

is prior ureteral stent placement necessary to access the upper urinary tract in prepubertal children? J Urol. 2008 Oct;180(4 Suppl):1861-3; discussion 1863-4. doi: 10.1016/j.juro.2008.03.106. Epub 2008 Aug 21. PMID: 18721946.

13.Alsagheer G, Abdel-Kader MS, Hasan AM, Mahmoud O, Mohamed O, Fathi A, Abass M, Abolyosr A. Extracorporeal shock wave lithotripsy (ESWL) monotherapy in children: Predictors of a successful outcome. J Pediatr Urol. 2017 Oct;13(5):515.e1-515.e5. doi: 10.1016/j.jpurol.2017.03.029. Epub 2017 Apr 18. PMID: 28457667.

14.Fahlenkamp D, Winfield HN, Schönberger B, Mueller W, Loening SA. Role of laparoscopic surgery in pediatric urology. Eur Urol. 1997;32(1):75-84. PMID: 9266236.

15.Landa-Juárez S, Rivera-Pereira BM, Castillo-Fernández AM. Management of Pediatric Urolithiasis Using a Combination of Laparoscopic Lithotomy and Pyeloscopy. J Laparoendosc Adv Surg Tech A. 2018 Jun;28(6):766-769. doi: 10.1089/lap.2016.0652. Epub 2018 Feb 6. PMID: 29406799.

16.Xiao J, Wang X, Li J, Wang M, Han T, Zhang C, Du Y, Hao G, Tian Y. Treatment of upper urinary tract stones with flexible ureteroscopy in children. Can Urol Assoc J. 2019 Mar;13(3): E78-E82. doi: 10.5489/cuaj.5283. Epub 2018 Aug 30. PMID: 30169147; PMCID: PMC6395106.

17.Barreto L, Jung JH, Abdelrahim A, Ahmed M, Dawkins GPC, Kazmierski M. Medical and surgical interventions for the treatment of urinary stones in children. Cochrane Database Syst Rev. 2019 Oct 9;10(10): CD010784. Doi: 10.1002/14651858.CD010784.pub3. PMID: 31596944; PMCID: PMC6785002.

18.Elkholy MM, Ismail H, Abdelkhalek MA, Badr MM, Elfeky MM. Efficacy of extracorporeal shockwave lithotripsy using Dornier SII in different levels of ureteral stones. Urol Ann. 2014 Oct;6(4):346-51. doi: 10.4103/0974-7796.141003. PMID: 25371614; PMCID: PMC4216543.

19.EAU Guidelines. Pediatric Urology Guideline, Summary of evidence and recommendations for the management of urinary stones. Edn. Presented at the EAU Annual Congress Paris 2024. ISBN 978-94-92671-23-3. https://uroweb.org/guidelines/paediatric-urology/chapter/the-guideline

20.Agrawal V, Bajaj J, Acharya H, Chanchalani R, Raina VK, Sharma D. Laparoscopic management of pediatric renal and ureteric stones. J Pediatr Urol. 2013 Apr;9(2):230-3. doi: 10.1016/j.jpurol.2012.03.001. Epub 2012 Apr 10. PMID: 22498008.

21.Resorlu B, Oguz U, Resorlu EB, Oztuna D, Unsal A. The impact of pelvicaliceal anatomy on the success of retrograde intrarenal surgery in patients with lower pole renal stones. Urology. 2012 Jan;79(1):61-6. doi: 10.1016/j.urology.2011.06.031. PMID: 21855968.

22.Demirkesen O, Onal B, Tansu N, Altintaş R, Yalçin V, Oner A. Efficacy of extracorporeal shock wave lithotripsy for isolated lower caliceal stones in children compared with stones in other renal locations. Urology. 2006 Jan;67(1):170-4; discussion 174-5. doi: 10.1016/j.urology.2005.07.061. PMID: 16413356.

23.Gupta CR, Khan NA, Sengar M, Mohta A. Laparoscopic Surgery in Pediatric Upper Tract Urolithiasis: An Alternate Modality. J Indian Assoc Pediatr Surg. 2021 Nov-Dec;26(6):401-403. Doi: 10.4103/jiaps.JIAPS_233_20. Epub 2021 Nov 12. PMID: 34912136; PMCID: PMC8637995.

24.Zargooshi J. Open stone surgery in children: is it justified in the era of minimally invasive therapies? BJU Int. 2001 Dec;88(9):928-31. doi: 10.1046/j.1464-4096.2001.01544.x. PMID: 11851615.