

Comparison of extracorporeal shockwave lithotripsy and retrograde intrarenal surgery in the treatment of renal pelvic and proximal ureteral stones ≤ 2 cm in children

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ABSTRACT

Introduction: We aimed to compare extracorporeal shockwave lithotripsy (ESWL) and retrograde intrarenal surgery (RIRS) in pediatric patients with ≤ 2 cm renal pelvis and proximal ureteral stones.

Methods: Medical records of 165 pediatric patients who underwent shockwave lithotripsy (SWL) or RIRS for upper urinary system stones up to 2 cm between January 2014 and December 2018 were retrospectively reviewed. After exclusions, the remaining 130 patients included 73 in the SWL group and 57 in the RIRS group. The groups were compared for demographic features, stone characteristics, operative data, success, and complications.

Results: The mean stone volume was 308 ± 85 (54–800) and 336 ± 96 (60–720) mm³ in SWL and RIRS groups, respectively ($P = 0.46$). There were no significant differences in success rates (60% vs. 70%, SWL and RIRS), auxiliary treatment rates (16.4% vs. 14%), and complication rates (26% vs. 24.5%). The number of active procedural sessions and number of anesthesia sessions was higher in the RIRS group ($P < 0.001$ and $P < 0.001$, respectively), while the procedural time and anesthesia time were higher in the SWL group ($P < 0.001$ and $P < 0.001$, respectively). Stone size was found to be an independent success predictive factor for both the treatment modalities.

Conclusions: Both SWL and RIRS have similar success, complication, and auxiliary treatment rates. RIRS was superior in terms of total procedure and anesthesia durations, while SWL was superior in terms of numbers of anesthesia sessions and active procedure sessions. As both have similar success rates, the more minimally invasive SWL should be chosen for pediatric upper urinary system stones of less than 2 cm size.

INTRODUCTION

Stone disease in the pediatric age group is known to have recurrence rates of approximately 30%–50% at later ages.^[1] It is important to ensure complete stone clearance during the treatment of these children because residual stones may result in more frequent stone recurrences. When choosing the appropriate treatment approach for urolithiasis, the number, size, composition and location of stones, presence or degree of hydronephrosis, and anatomic factors such as ureteric anomalies, solitary kidney, pelviureteric

junction obstruction, ureteral stricture, and morbid obesity should be noted.^[2]

Due to the short length of the ureter, and its greater flexibility and distensibility, it is known that stones fragmented with extracorporeal shockwave lithotripsy (SWL) pass more easily in children. SWL is easy to perform as an outpatient procedure with satisfactory stone-free (SF) rates. The main disadvantages of SWL are that it may require multiple sessions and each session would need anesthesia. Steinstrasse

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may form after SWL for large stones. In addition, it has a lower chance of success for cystine stones, lower pole stones, and stones larger than 2 cm.^[3,4] With the development of the flexible endoscope and laser technology, retrograde intrarenal surgery (RIRS) may be applied to upper urinary tract stones with high success and low complication rates. After an initial experience in adult population, RIRS has also been successfully used for the pediatric age group. Park *et al.* reported that the application rate of SWL remained stable, while RIRS increased from 15% to 31% in the period between 2007 and 2014.^[4,5]

In the present study, we aimed to compare SWL and RIRS in pediatric patients with ≤ 2 cm upper urinary tract stones and to determine the predictive factors for success of both treatment modalities.

METHODS

Study design

Data usage approval for the current study was obtained from the authorized hospital management. Parents or legal guardians of the patients gave written informed consent for inclusion in the study and to undergo the procedures described. The study was conducted in accordance with the ethical guidelines of the Declaration of Helsinki and its amendments. The authors confirm the availability of, and access to, all original data reported in this study.

Medical records of 165 pediatric patients who underwent SWL or RIRS for upper urinary system stones up to 2 cm between January 2014 and December 2018 were retrospectively reviewed. Of these, patients with bilateral upper urinary system stones, urinary system anomaly, a previous history of SWL or urinary system surgery and those with missing data were excluded from the study. After exclusions, among the remaining 130 patients, 73 were in the SWL group while 57 were in the RIRS group. The groups were compared with regard to demographic features, stone characteristics, operative data, treatment success, and complications.

Stone dimension is reported by measuring the stone volume on computed tomography. Success was assessed with kidney-ureter-bladder (KUB) radiography and ultrasonography (USG) taken in the 3rd month after the end of the treatment. Success was defined as complete stone clearance. Complications were evaluated according to the modified Clavien–Dindo classification system.^[6]

Extracorporeal shockwave lithotripsy procedure

SWL was performed under ketamine/midazolam sedation anesthesia (Midazolam/0.005 mg/kg, Ketamine/0.1 mg/kg), administered as IV bolus 10 min before the procedure. SWL was performed using an electrohydraulic lithotripter (Stonelith-V3, PCK Medical, Turkey) device under

fluoroscopy guidance. Shock waves were delivered at 50–60 shocks/min and energy of 8–10 kV. Each session was completed either after application of a total of 3000 shock waves or when the stone was completely disintegrated. Patients were evaluated 1 week after each session with (KUB) radiography and USG and repeat treatment was performed if there was a residual stone fragment.

Retrograde intrarenal surgery procedure

Before RIRS, as per institutional protocol, a double-J (DJ) stent was inserted in all patients. The RIRS procedure was performed 2 weeks after DJ placement. Under general anesthesia, with the patient in dorsal lithotomy position, the DJ stent was removed with a rigid ureterorenoscope (URS) (Karl Storz, Tuttlingen, Germany). Under fluoroscopy guidance, a 0.038 inch hydrophilic guidewire was advanced to the kidney. Whenever possible, a 9.5/10.5 F ureteric access sheath (UAS) was inserted. In patients where the UAS could not be placed due to tight ureter, a 7.5 F flexible URS (Karl Storz Flex-X2, Tuttlingen, Germany) was advanced directly over the hydrophilic guidewire. The stones were fragmented using Holmium: YAG laser device (Quanta System, Milan, Italy) and 272 μ m laser fibers (energy level: 0.8–1.2 J and frequency: 12–15 Hz) until they were deemed small enough to pass spontaneously. In patients with ureteral access sheath, larger fragments were extracted using a stone basket. Each patient again had a DJ stent inserted at the end of the procedure which was removed in the 4th postoperative week.

Statistical analysis

Statistical comparison of the groups used the SPSS 22.0 (IBM, NY, USA) program. Quantitative values are given as mean \pm standard deviation qualitative variables are stated as number and %. When comparing categorical or quantitative variables with the Chi-square method and categorical variables with the independent *t*-test, values with $P < 0.05$ were accepted as significant. The binary logistic regression analysis method was used to assess the predictive value of variables for procedure success with values of $P < 0.05$ accepted as significant. Significant predictive parameters were investigated with receiver operating curve analysis and the cut off, sensitivity, specificity, and area under the curve (AUC) values were obtained for these variables.

RESULTS

The mean age of the patients was 6.6 ± 4.2 years (10 months–15 years) and 7 ± 4.4 years (1–15 years) in SWL and RIRS group, respectively [Table 1]. There was no difference between the groups in terms of age, sex, body mass index, stone volume, stone side, stone localization, and stone Hounsfield unit. While the number of patients with single stone was higher in the SWL group, RIRS group had more patients with multiple calculi ($P = 0.007$).

The number of active procedural sessions and number of anesthesia sessions was higher in the RIRS group ($P < 0.001$ and $P < 0.001$, respectively), while the procedural time and anesthesia time were higher in the SWL group ($P < 0.001$ and $P < 0.001$, respectively) [Table 2]. There were no significant differences in success rates (60% vs. 70%, SWL and RIRS, respectively), auxiliary treatment rates ($n = 12$; 16.4% vs. $n = 8$; 14%), complication rates (26% vs. 24.5%), and fluoroscopy time. In the SWL group, 12 patients with residual stones had RIRS performed and in 10 (83.3%) of them, SF status was achieved. In the RIRS group, 8 patients with residual stones had SWL performed and in 5 (62.5%) of them, SF was achieved.

On binary logistic regression analyses, patient age, stone size, SWL session number and shockwave number, stone localization, and stone number were found to be independent predictive factors of SWL success [Table 3]. The AUC values were 0.99, 0.94, 0.96, 0.98, 0.85, and 0.81 for age, stone size, SWL session number, shockwave number, stone localization and stone number, respectively [Figure 1].

Stone size and operation time were found to be independent predictive factors of RIRS success on binary logistic regression analyses [Table 4]. The AUC values were 0.91 and 0.95 for stone size and operation time, respectively [Figure 2].

Table 1: Demographic features and stone characteristics

Parameters	SWL (n=73)	RIRS (n=57)	P
Sex, n (%)			
Male	40 (55)	34 (60)	0.86
Female	33 (45)	23 (40)	
Age (years), mean±SD	6.6±4.2	7±4.4 (1-15)	0.63
BMI (kg/m ²), mean±SD	18.5±2.9	17.6±3.4	0.89
Stone volume (mm ³), mean±SD	308±85 (54-800)	336±96 (60-720)	0.46
Stone side, n (%)			
Right	38 (53)	27 (47)	0.59
Left	35 (47)	30 (53)	
Stone localization, n (%)			
Renal pelvis	32 (44)	28 (49)	0.99
Lower calyx	14 (19)	7 (12.2)	
Upper calyx	10 (14)	8 (14)	
Middle calyx	5 (7)	4 (7)	
Upper ureter	12 (16)	10 (18)	
Stone number, n (%)			
Single	63 (86.3)	35 (61.4)	0.007
Multipl	10 (13.7)	22 (38.6)	
2	7 (9.6)	14 (24.6)	
3	2 (2.7)	6 (10.5)	
4	1 (1.4)	2 (3.5)	
Total	87	89	
HU	685±135	746±224	0.65

SWL=Shock wave lithotripsy, RIRS=Retrograde intrarenal surgery, SD=Standard deviation, BMI=Body mass index, HU=Hounsfield unit

Table 2: Operative data and complications

Parameters	SWL (n=73)	RIRS (n=57)	P
Shockwave number, mean±SD	4447±3271	N/A	
Session and anesthesia number, mean/range	2.4±1.1 (1-5)	3.09±0.3 (3-4)	
1, n (%)	14 (19.2)	0	<0.001
2, n (%)	32 (43.8)	0	
3, n (%)	14 (19.2)	52 (91.2)	
4, n (%)	8 (11)	5 (8.7)	
5, n (%)	5 (6.8)	0	
Procedural time (min), mean±SD	74.2±54.2	43.5±12	<0.001
Anesthesia time (min), mean±SD	74.2±54.2	51.7±13.5	<0.001
Fluoroscopy time (s), mean±SD	37±27.2	33.5±9.8	0.34
Success rate, n (%)	44/73 (60)	40/57 (70)	0.33
Multiple stones	4/10 (40)	16/22 (72.7)	<0.001
Auxiliary treatment, n (%)			
RIRS	12 (16.4)	-	0.08
SWL	-	8 (14)	
Complications, n (%)	19 (26)	14 (24.5)	0.9
Clavien-Dindo classification			
Grade-1 (pain/hematuria)	4 (5.4)/3 (4.1)	6 (10.5)/4 (7)	
Grade-2 (uti)	7 (9.6)	4 (7.1)	
Grade-3b (steinstrasse)	5 (6.8)	0	

SWL=Shockwave lithotripsy, RIRS=Retrograde intrarenal surgery, SD=Standard deviation, uti=Urinary tract infection

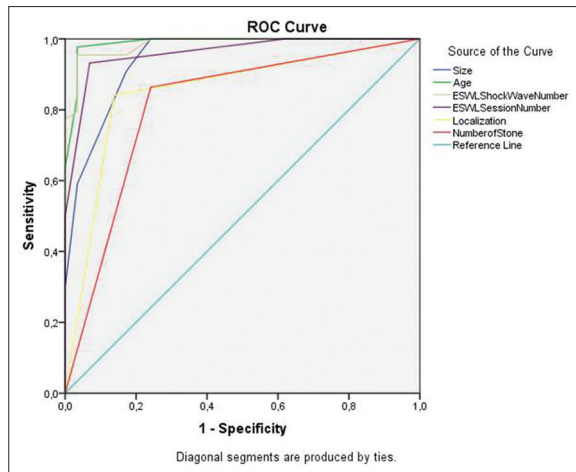


Figure 1: Area under the curve values in the receiver operating curve analysis chart of independent predictive factors influencing extracorporeal shockwave lithotripsy success

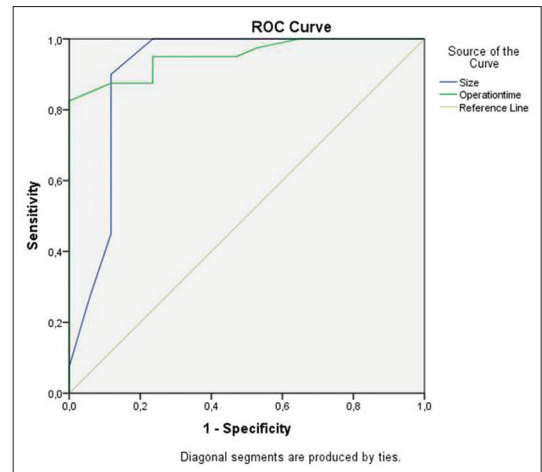


Figure 2: Area under the curve values in the receiver operating curve analysis chart of independent predictive factors influencing retrograde intrarenal surgery success

Table 3: Binary logistic regression analysis for shockwave lithotripsy success

Parameters	OR	95% CI		P
		Lower	Upper	
Age	1.43	1.18	1.789	<0.001
Stone size	1.57	1.24	1.98	<0.001
ESWL session number	28.89	3.24	257.42	0.003
Shockwave number	1.00	1.00	1.00	<0.001
Stone localization	1.53	1.05	2.22	0.024
Stone number	48.82	5.23	45.77	<0.001
BMI	0.96	0.79	1.16	0.680
Stone side	1.53	0.50	4.68	0.453

ESWL=Extracorporeal shockwave lithotripsy, OR=Odds ratio, CI=Confidence interval

Table 4: Binary logistic regression analysis for retrograde intrarenal surgery success

Parameters	OR	95% CI		P
		Lower	Upper	
Age	0.972	0.817	1.156	0.747
BMI	1.023	0.807	1.296	0.850
Stone size	1.314	1.059	1.631	0.013
Stone lateralization	0.489	0.105	2.276	0.362
Operation time	1.084	1.017	1.156	0.026
Stone localization	0.742	0.403	1.369	0.340
Stone number	0.796	0.305	2.080	0.641

OR=Odds ratio, CI=Confidence interval, BMI=Body mass index

DISCUSSION

Extracorporeal SWL has been used for more than 3 decades for pediatric upper urinary system stone disease with satisfactory success in the outpatient setting.^[7] It continues to be the most commonly chosen treatment method globally for ≤ 2 cm upper urinary tract stones.^[8-10] In the pediatric age group, there is less loss of energy of shock sound waves due to the small body volume.^[11] Probably due to lower energy loss and easier fragment passage, the SF rate after SWL is reported to be better in pediatric stone patients compared to adult patients.^[12] The only difference in performing SWL at

pediatric ages compared to adult patients is that all sessions of pediatric SWL are performed under IV anesthesia.^[13] Badawy *et al.* performed SWL on 500 children with mean stone size of 12.5 ± 7.2 mm and reported overall success rates of 83.4% and 58.5% for kidney and ureter stones, respectively.^[14] Ramakrishnan obtained 97% success in total with 88% SF after SWL in infants with kidney stone diameter 18.2 mm and ureter stone diameter of 9.4 mm.^[15]

RIRS is a comparable option to SWL for success in pediatric patients. Ekici *et al.* reported 68% success at the end of the first session and 100% success at the end of the second session for patients with stone size 10.18 ± 4.92 mm.^[16] Azili reported 85.1% SF rate after repeated sessions and claimed that RIRS can be used as a first line therapy to treat renal stones in children.^[17] Our study (SF: 70%) confirmed these results. The SWL failures were treated by RIRS, while the RIRS failures were managed by SWL. After these auxiliary treatments, the SF increased to 73.9% for the SWL group and 78.9% for the RIRS group. This experience suggests that both the treatment options play a complementary role for the successful management of pediatric calculi.

Stone size has been found to be the main factor to predict success of both the methods. We found a 16 mm cut off for RIRS success, and 11.5 mm cut-off for SWL success. Gamal *et al.* and Yuruk *et al.* obtained 100% success with RIRS for patients with mean stone diameter 12.2 ± 1.5 mm and 13.6 ± 2.4 mm, respectively.^[18,19] In a multi-institutional study, it was reported that stone diameter was the only independent predictive factor for single-session SWL success, while another multicenter study reported SWL success for upper urinary tract stones ≤ 10 mm was better than for stones > 1 cm.^[20,21] Habib *et al.* reported 80% failure for > 13.5 mm stones and 52.3% success for ≤ 13.5 mm stones.^[22] Landau reported higher success for stones below 11 mm.^[23]

Age was an independent predictive factor for SWL success in our study and we determined a cut off value of 7.5 years. Extracorporeal SWL was more successful for pediatric patients younger than this age. Jee *et al.* reported better SWL session numbers and complication rates for children <7-year-old compared to older children.^[20] SWL success for small children younger than 6 years and low birth weight infants was reported to reach 100%.^[21] Aksoy *et al.* reported higher SF rates for children from 0 to 5 years of age than for 11–14 years (93.3% vs 76.5%).^[24]

Stone location was another independent predictive factor for SWL success and lower pole and upper ureter predicted poorer outcomes. Important variables for clearance of stones from the lower calyx are infundibulum length (>3 cm), infundibular width (<5 cm), and infundibulopelvic angle (<45°).^[25] In our study, these analyses could not be performed, since not all patients had intravenous pyelography films. Extracorporeal SWL is reported to be less successful for impacted stones in the upper ureter probably due to the associated edema-polyposis burying the stone in the ureteric wall.^[26]

We found that success rates of SWL fell for patients with >1 stone. Jeong *et al.* reported that multiple stones required more SWL sessions to obtain SF status.^[27] Patients with multiple stones, for example, one in the ureter and the other in any calyx or the renal pelvis, cannot have SWL applied for all stones at the same time. Initially, the obstructing stone is targeted, and the other stone is targeted only when the first stone is completely fragmented. We think it is possible to manage most low density multiple stones within maximum three sessions of SWL, however, it appears logical to consider RIRS as the first choice for patients with multiple stones. In the study, we achieved higher success rates from RIRS for patients with multiple stones.

The majority of complications after SWL and RIRS are minor (Clavien–Dindo Grade 1–2) ranging from 5% to 23%.^[28] However, in the SWL group, five patients with stone size above 1 cm developed steinstrasse. Steinstrasse is a Clavien–Dindo grade 3b complication and needs a DJ stent insertion to ensure urinary drainage. In the literature, the probability of steinstrasse after SWL is reported to be high for large kidney stones.^[29]

Most studies comparing RIRS with SWL reported that the operation time for RIRS was longer. However, our results do not match the literature. Even when we included the time taken for pre-RIRS stent insertion and later stent removal, operation time, and anesthesia times were still longer in the SWL group. RIRS has been performed in our clinic for 10 years and we have extensive experience in the field of endourology. We think that this could explain the shortened operation time in the RIRS group. Stone hardness is another factor determining the number of SWL sessions.

This basic factor may have been responsible in extending SWL procedural time.

The major limitation of our study is that it is a retrospective analysis. Another potential limitation is that we did not have data related to stone composition, so we could not include this factor, which could affect the success of SWL. Another limitation is that the lower pole anatomy of patients was not evaluated by urographic imaging. Despite these limitations, we think that the present study including detailed statistical analysis will contribute to the literature and that it will guide clinical practice thanks to the predictive factors and cut off values determined.

CONCLUSIONS

RIRS was superior in terms of total procedure and anesthesia duration, while SWL was superior in terms of numbers of anesthesia sessions and active procedure sessions. Although RIRS was more successful for multiple stones, both methods have similar success, complication and auxiliary treatment rates for ≤2 cm upper urinary system stones. We propose that extracorporeal SWL should be chosen for pediatric patients with ≤2 cm upper urinary system stones as it is a less invasive method.

REFERENCES

1. Tasian GE, Kabarriti AE, Kalmus A, Furth SL. Kidney stone recurrence among children and adolescents. *J Urol* 2017;197:246-52.
2. Jobs K, Rakowska M, Paturej A. Urolithiasis in the pediatric population - current opinion on epidemiology, pathophysiology, diagnostic evaluation and treatment. *Dev Period Med* 2018;22:201-8.
3. Slavković A, Radovanović M, Sirić Z, Vlajković M, Stefanović V. Extracorporeal shock wave lithotripsy for cystine urolithiasis in children: Outcome and complications. *Int Urol Nephrol* 2002;34:457-61.
4. Khan M, Lal M, Kash DP, Hussain M, Rizvi S. Anatomical factors predicting lower calyceal stone clearance after extracorporeal shockwave lithotripsy. *African J Urol* 2016;22:96-100.
5. Park HK, Kim JH, Min GE, Choi WS, Li S, Chung KJ, *et al.* Change of trends in the treatment modality for pediatric nephrolithiasis: Retrospective analysis of a US-based insurance claims database. *J Endourol* 2019;33:614-8.
6. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: A new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004;240:205-13.
7. Köhrmann KU, Neisius D, Rassweiler J. Die Zukunft der ESWL [The future of ESWL]. *Urologe A*. 2008;47:569-77.
8. Asi T, Dogan HS, Altan M, Bozaci AC, Ceylan T, Asci A, *et al.* Shockwave lithotripsy for kidney stones as a first-line therapy in children younger than 2 years. *J Pediatr Urol* 2020;16:193.e1-00000.
9. Alsagheer G, Abdel-Kader MS, Hasan AM, Mahmoud O, Mohamed O, Fathi A, *et al.* Extracorporeal shock wave lithotripsy (ESWL) monotherapy in children: Predictors of successful outcome. *J Pediatr Urol* 2017;13:515.e1-5.
10. Salerno A, Nappo SG, Matarazzo E, De Dominicis M, Caione P. Treatment of pediatric renal stones in a Western country: A changing pattern. *J Pediatr Surg* 2013;48:835-9.
11. D'Addressi A, Bongiovanni L, Sasso F, Gulino G, Falabella R, Bassi P.

- Extracorporeal shockwave lithotripsy in pediatrics. *J Endourol* 2008;22:1-2.
12. Gofrit ON, Pode D, Meretyk S, Katz G, Shapiro A, Golijanin D, *et al*. Is the pediatric ureter as efficient as the adult ureter in transporting fragments following extracorporeal shock wave lithotripsy for renal calculi larger than 10 mm? *J Urol* 2001;166:1862-4.
 13. Akelma H, Kiliç ET, Salik F, Kaydu A. Comparison of ketamine with midazolam versus ketamine with fentanyl for pediatric extracorporeal shock wave lithotripsy procedure: A randomized controlled study. *Anesth Essays Res* 2018;12:464-9.
 14. Badawy AA, Saleem MD, Abolyosr A, Aldahshoury M, Elbadry MS, Abdalla MA, *et al*. Extracorporeal shock wave lithotripsy as first line treatment for urinary tract stones in children: Outcome of 500 cases. *Int Urol Nephrol* 2012;44:661-6.
 15. Ramakrishnan PA, Medhat M, Al-Bulushi YH, Nair P, Al-Kindy A. Extracorporeal shockwave lithotripsy in infants. *Can J Urol* 2007;14:3684-91.
 16. Ekici M, Ozgur BC, Senturk AB, Aydin C, Akdaglı Ekici A, Yaytokgil M, *et al*. Efficacy and Reliability of Retrograde Intrarenal Surgery in Treatment of Pediatric Kidney Stones. *Cureus* 2018;10:e3719.
 17. Azili MN, Ozcan F, Tiryaki T. Retrograde intrarenal surgery for the treatment of renal stones in children: Factors influencing stone clearance and complications. *J Pediatr Surg* 2014;49:1161-5.
 18. Gamal WM, Hussein MM, Rashed EN, Mohamed AD, Mmdouh A, Fawzy F. Pediatric retrograde intra-renal surgery for renal stones <2 cm in solitary kidney. *Indian J Urol* 2016;32:296-300.
 19. Yuruk E, Tuken M, Gonultas S, Colakerol A, Cakir OO, Binbay M, *et al*. Retrograde intrarenal surgery in the management of pediatric cystine stones. *J Pediatr Urol* 2017;13:487.e1-0000.
 20. Jee JY, Kim SD, Cho WY. Efficacy of extracorporeal shock wave lithotripsy in pediatric and adolescent urolithiasis. *Korean J Urol* 2013;54:865-9.
 21. Alsagheer G, Abdel-Kader MS, Hasan AM, Mahmoud O, Mohamed O, Fathi A, Abass M, *et al*. Extracorporeal shock wave lithotripsy (ESWL) monotherapy in children: Predictors of successful outcome. *J Pediatr Urol* 2017;13:515.
 22. Habib El, Morsi HA, Elsheemy MS, Aboulela W, Eissa MA. Effect of size and site on the outcome of extracorporeal shock wave lithotripsy of proximal urinary stones in children. *J Pediatr Urol* 2013;9:323-7.
 23. Landau EH, Shenfeld OZ, Pode D, Shapiro A, Meretyk S, Katz G, *et al*. Extracorporeal shock wave lithotripsy in prepubertal children: 22-year experience at a single institution with a single lithotripter. *J Urol* 2009;182:1835-9.
 24. Aksoy Y, Ozbey I, Atmaca AF, Polat O. Extracorporeal shock wave lithotripsy in children: Experience using a mpl-9000 lithotripter. *World J Urol* 2004;22:115-9.
 25. Özgür Tan M, Karaođlan U, Sen I, Deniz N, Bozkirli I. The impact of radiological anatomy in clearance of lower calyceal stones after shock wave lithotripsy in paediatric patients. *Eur Urol* 2003;43:188-93.
 26. Ghoneim IA, El-Ghoneimy MN, El-Naggar AE, Hammoud KM, El-Gammal MY, Morsi AA. Extracorporeal shock wave lithotripsy in impacted upper ureteral stones: A prospective randomized comparison between stented and non-stented techniques. *Urology* 2010;75:45-50.
 27. Jeong US, Lee S, Kang J, Han DH, Park KH, Baek M. Factors affecting the outcome of extracorporeal shock wave lithotripsy for unilateral urinary stones in children: A 17-year single-institute experience. *Korean J Urol* 2013;54:460-6.
 28. He Q, Xiao K, Chen Y, Liao B, Li H, Wang K. Which is the best treatment of pediatric upper urinary tract stones among extracorporeal shockwave lithotripsy, percutaneous nephrolithotomy and retrograde intrarenal surgery: A systematic review. *BMC Urol* 2019;19:98.
 29. Dobrowiecka K, Przekora J, Jobs K, Kowalczyk K, Plewka K, Paturej A, *et al*. Early complications of extracorporeal shockwave lithotripsy in the records of the Department of Paediatrics, Nephrology and Allergology of the Military Institute of Medicine - preliminary results. *Dev Period Med* 2018;22:260-4.

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