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Does Previous Open Stone Surgery Affect the Outcome of Shock Wave Lithotripsy Treatment in Children?

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Keywords

Renal stones · Shock wave lithotripsy · Children · Open stone surgery

Abstract

Introduction: The aim of the study was to evaluate the efficiency of shock wave lithotripsy (SWL) in children who previously underwent ipsilateral open renal stone surgery (ORSS). ***Methods:*** A total of 315 renal units (RUs) with renal stones underwent SWL treatment in our department over a period of 18 years. A total of 274 RUs (87%) with no history of ORSS were categorized as group 1 and 41 RUs (13%) with a history of ORSS were categorized as group 2. The characteristics of the patients and renal stones, as well as the treatment modalities, were reviewed retrospectively, and the results were compared in terms of the rates of stone-free patients and complications. ***Results:*** The stone-free rates were statistically lower in patients with an existing history of ORSS (p = 0.002), especially for stones located at the lower calyx (p = 0.006). However, there were no differences between groups in the rate of complications (p = 0.75). History of ipsilateral ORSS, age, and stone burden were independent risk factors that predicted a stone-free status in the regression analysis ($p = 0.016$, $p = 0.045$, and $p = 0.001$, respectively). ***Conclusion:*** The overall stone-free rate after SWL was found to be significantly lower in children with a history of ORSS than in those without, and this finding was significantly prominent for lower calyx stones. In spite of the possible difficulties in achieving surgical access due to anatomical changes in retrograde intrarenal surgery or mini-/micro-percutaneous nephrolithotomy, we believe that these techniques might be good alternatives for SWL in future cases.

Introduction

Pediatric urolithiasis has a wide epidemiologic variation, with a prevalence of 1–17%. Its incidence is increasing all over the world on an age-dependent basis [1–5]. The etiology of this condition is multifactorial [6]. Its increased prevalence and recurrent nature cause patients to go through repeated interventions [5].

Pediatric guidelines recommend various minimally invasive treatment modalities for urolithiasis based on patient characteristics. Shock wave lithotripsy (SWL) is the only noninvasive method and is the first-line treat-

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ment modality for renal stones smaller than 2 cm. However, minimally invasive surgical methods changed the established views on SWL because its success rate depends on several factors: stone characteristics, lithotripter type, renal anatomy, and renal function [6, 7].

Although SWL has been optimized to improve disintegration efficacy, increase success, and reduce complication rates, many studies have reported that cases that are at risk of demonstrating a low success rate with SWL should be treated with minimally invasive endourological techniques, such as percutaneous nephrolithotripsy (PCNL; mini/micro), ureterorenoscopy, and retrograde intrarenal surgery (RIRS) [7]. Today, open stone surgery is only conducted in special conditions, such as large stones, orthopedic deformities, and obstructed systems, which also require surgical intervention [6, 8]. However, in our daily practice, we often encounter children who have previously undergone open stone surgery and routinely evaluate them for recurrent urolithiasis.

Most stones in children can be managed by SWL and endoscopic techniques. It is wise to define the patients who will benefit the most from the treatment, since more sophisticated patient selection and nomograms are needed. Several authors have compared the effectiveness of PCNL in children with previous ipsilateral renal surgery with those who have no previous surgery [8, 9]. However, to our knowledge, no study has previously made this comparison for SWL treatment in children. Recently, in our previous study, open renal stone surgery (ORSS) was implicated as a factor that adversely affects the outcome of SWL treatment in adults [10]. Hence, in this study, we aimed to evaluate whether a previous history of ORSS affected SWL success in a pediatric population.

Methods

After institutional ethical approval was obtained (number: 1395-37694), the records of 356 children who had been treated with SWL for urolithiasis in our institution over a period of 18 years (between 1997 and 2015) were retrospectively reviewed. Patients with abnormal renal anatomy (i.e., horseshoe kidney, pelvic kidney, and rotation anomaly), nonopaque stones, history of minimally invasive surgical intervention, and/or a history of renal stone surgery in the previous year were excluded from the study. The remainder of 315 renal units (RUs) of 301 patients with complete data for evaluation were included in the study.

The RUs were separated into 2 groups: RUs that had not received prior ORSS on the side the SWL was administered on were assigned to group 1 (n = 274) and those who had received ORSS (nephrolithotomy or pyelolithotomy) on the same side as SWL were assigned to group 2 (n = 41). To eliminate the statistical bias in our study, children were separated into 3 groups based on stone burden (<1.0, 1.0–2.0, and >2 cm^2). The stone location was categorized as pelvis, upper calyx, mid-calyx, and lower calyx. Information about patient characteristics, demographics, data on prior stone treatments, stone parameters (localization and size), treatment characteristics (additional procedures, average energy level, and average number of shock waves), outcomes (stone free or failure), and complications (formation of steinstrasse [SS], subcapsular hematoma, fever, and urinary tract infection) were obtained from the relevant databanks with written consent from our center.

All the children underwent urinalysis and urine culture, serum biochemistry, and coagulation tests before SWL. Children who were affected with urinary tract infection were treated with appropriate antibiotics according to their urine culture results. Kidney-bladder radiographs (KUB), intravenous pyelography (IVP), and ultrasonography (USG) were used to evaluate the stones. The size of the stone was calculated in centimeters by multiplying its length and its longest width according to the KUB. In cases with multiple stones, the sum of all stone sizes was calculated.

The children's procedures were performed under intravenous sedation (midazolam 0.1 mg/kg and alfentanil 2–3 μg/kg). The Siemens Lithostar lithotripter device (Siemens Medizinische Technik, Erlangen, Germany) was used, and all sessions were planned and performed in supine position under fluoroscopic control by the same urologist (N.T.) on an outpatient basis. The lung and gonadal fields were protected in all children. Auxiliary procedures, such as double J-stents and percutaneous nephrostomy tubes, which were used in a small portion of children, were also noted.

The energy and number of shock waves were specified for each patient. The treatment was mostly initiated at a level of 13 kV, which was increased in increments of 0.3 kV by monitoring the patients' hemodynamics and level of stone fragmentation. The procedure was over when complete fragmentation of the stones was determined under fluoroscopy. According to our standard clinic SWL protocol, an additional session was performed 2 weeks after the initial session, when insufficient or residual fragmentation was detected under fluoroscopic, USG, or computerized tomography (CT) control according to the stone characteristics after the maximum number of shocks was completed. The patients were evaluated with USG, KUB, and/or IVP according to their stone characteristics and previous radiological evaluation 12 weeks after their last procedure. Detection of no stone in radiological evaluations was accepted as stone-free. The presence of clinically insignificant residual stones (any evidence of persistent stone fragments irrespective of size) was regarded as failure of the procedure.

Statistical analyses were carried out by SPSS, version 13.0 software (IBM Corp., Armonk, NY, USA). The χ^2, Fisher exact, and Mann-Whitney U tests and regression analysis (enter method) were used for statistical evaluation. Statistical significance was defined as $p < 0.05$.

Results

A total of 315 RUs of 301 patients were included in the study. These patients were classified into 2 groups: group 1 (n = 274) and group 2 (n = 41), based on their history of ORSS.

Table 1. Stone characteristics, stone location, and stone burden of RUs according to groups

	Group 1	Group 2	*p* value
Side, *n* (%)			
Left kidney	117 (43)	17 (42)	0.88
Right kidney	157 (57)	24 (59)	
Stone location, *n* (%)			
Pelvis	210 (77)	7 (17)	<0.001
Upper calyx	20 (7)	1 (2)	
Middle calyx	8 (3)	2 (5)	
Lower calyx	36 (13)	31 (76)	
Stone burden, median (range), cm^2	1 (0.20–3)	0.93 (0.20–3)	0.92
<1.0	167 (61)	24 (59)	0.19
1.1–2.0	84 (31)	10 (24)	
>2	23 (8)	7 (17)	

RUs, renal units.

Table 2. Treatment characteristics, results, distribution of complications, and treatment of steinstrasse according to groups

	Group 1	Group 2	*p* value
No. of shock waves, median (range)	1,600 (180–3,500)	1,830 (700–3,500)	0.08
Generator energy, median (range), kV	17.2 (14.8–18.4)	17.2 (15.5–17.6)	0.26
Auxiliary procedures, *n* (%)			
JJ stent	18 (7)	4 (9)	0.06
Percutaneous tube	4 (1)	0 (0)	
Results, *n* (%)			
Single session			
Stone free	143 (83)	15 (65)	0.044
Failure	29 (17)	8 (35)	
Multiple sessions			
Stone free	71 (70)	8 (44)	0.038
Failure	31 (30)	10 (56)	
Overall			
Stone free	214 (78)	23 (56)	0.002
Failure	60 (22)	18 (44)	
Complications, *n* (%)			
SS	22 (8)	2 (5)	0.75
Ureteral location of SS, *n* (%)			
Upper	3 (1)	2 (5)	NA
Lower	19 (7)	0 (0)	
Treatment of SS, *n* (%)			
SWL	18 (7)	2 (5)	NA
Medical	4 (1)	0	

SS, steinstrasse; SWL, shock wave lithotripsy.

The gender distribution of the 301 patients (315 RUs) was 171 females (G1: 85%, G2: 15%) and 130 males (G1: 92%, G2: 8%). Gender distributions of the groups were similar ($p = 0.18$). The median age was 8 (range: 1–17) years. The patients in group 1 were younger (median: 7 years, range: 1–17 years) than those in group 2 (median: 10 years, range: 1–17 years) ($p = 0.023$). Nine patients have solitary kidney (G1: 3, G2: 5%).

After SWL, the overall stone-free rate was 76%. The formation of SS was the only complication that was en-

Table 3. Number and rates of stone-free patients for groups according to stone localization

	Pelvis		Upper calyx		Middle calyx		Lower calyx	
	group 1, *n* (%)	group 2, *n* (%)	group 1, *n* (%)	group 2, *n* (%)	group 1, *n* (%)	group 2, *n* (%)	group 1, *n* (%)	group 2, *n* (%)
Patient, *n*	210 (96)	7 (4)	20 (95)	1 (5)	8 (80)	2 (20)	36 (54)	31 (46)
Stone-free patients, *n*	162 (77)	7 (100)	16 (80)	1 (100)	6 (75)	1 (50)	30 (83)	14 (45)
p value	0.211		1.000		1.000		0.006	

Table 4. Logistic regression analysis for stone-free status

	p value	95% CI for exp (β)		
		exp (B)	lower	upper
Age	0.045	1.061	1.009	1.001
Stone burden (≥2 cm) (ref)	0.001			
0–1 cm	0.001	0.216	0.93	502
1–1.8 cm	0.027	0.368	0.152	0.890
History of renal stone surgery	0.016	2.431	1.178	5.017

CI, confidence interval.

countered. The overall SS formation rate was 7%. The median stone burden was 1.8 cm^2 for group 1 and 1.3 cm^2 for group 2 patients with SS. Based on univariate analysis, overall the stone-free rates were associated with stone burden, history of ipsilateral ORSS, and age ($p < 0.001$, $p = 0.002$, and $p = 0.002$, respectively).

In the group analysis, the median stone burdens were calculated as 1 cm^2 for group 1 and 0.93 cm^2 for group 2 ($p = 0.92$). No statistical difference based on the classified stone burden (<1, 1.1–2.0, and >2 cm^2) was found in either of the groups ($p = 0.19$). On the contrary, a statistically significant difference was observed between the 2 groups in terms of stone localization ($p < 0.001$). The rate of lower calyx localization of stone was higher in group 2. The stone size, characteristics, and localizations for each group are shown in Table 1.

Both groups' treatment characteristics were similar. However, the stone-free status in group 1 was significantly higher than that of group 2 (78 and 56%, respectively; $p = 0.002$). Complications were observed at a higher rate in group 1 than in group 2, but the difference did not reach a statistically significant level (8 and 5%, respectively; $p = 0.75$) (Table 2). Since the stone location in the 2 groups was statistically significantly different, the stone-free rate was analyzed based on the stone's location. While a significant difference in terms of the stone-free rate was observed for lower calyx stones in the 2 groups (G1: 83 and G2: 45%, $p = 0.006$), no significant difference was observed in other locations (Table 3).

In addition, we found that a history of ipsilateral ORSS, age, and stone burden were independent risk factors for a stone-free status in the logistic regression analysis (p = 0.016, 0.045, and 0.001, respectively) (Table 4). When age, stone burden, and history of ORSS were taken as independent factors, this analysis showed that having a history of ORSS increased the SWL failure rate by 2.43 times.

Discussion

Urolithiasis is an important clinical challenge with a rising incidence rate globally. Obtaining a stone-free status while preserving the renal function of the developing kidney is the main goal of the treatment [11, 12]. Complete clearance is important as it reduces the regrowth of the stone and the requirement of additional intervention in children [6, 13]. SWL is the only noninvasive method of stone removal and is the first-line treatment modality for pediatric urolithiasis. However, it is wise to define the patients who will benefit the most from the treatment, since more sophisticated patient selection and nomograms are needed.

Previous studies about the effects of previous open surgery mostly focused on the PCNL procedure [14, 15]. This study focused on assessing whether a previous history of ipsilateral ORSS affects the SWL outcome. We were able to conclude that the stone-free rate of SWL was lower among the patients who had undergone prior open nephrolithotomy in the ipsilateral kidney than in patients without a prior history of ORSS. When age and stone burden were taken into consideration as independent factors, the logistic regression analysis showed that a history of ORSS increased the SWL failure rate by a factor of 2.43. This negative effect was particularly prominent in the lower calyx. Previous ipsilateral urological interventions have been regarded as risk factors for SWL failure in present nomograms [13]. The current study concluded that prior ipsilateral ORSS also had an unfavorable impact on SWL outcomes in the pediatric population. To the best of our knowledge, this is the first study that reports the unfavorable effects of prior ipsilateral ORSS on the outcomes of SWL in a pediatric population. This series is similar to previous pediatric series that focused on the risk factors associated with SWL success in terms of gender, median age, and similarity, which allowed a comparison of the findings [13, 16, 17].

SWL is the first line of treatment in the majority of pediatric urolithiasis cases and is known to achieve a stone-free rate of 75–98% in children. However, its success rate is dependent on multiple factors [10, 17]. Stone burden and localization are the most discussed factors that impact the stone-free rates. Although some studies report a high stone-free rate with a high stone burden, general findings in the literature show that as the stone size increases, the stone-free rate decreases [13, 18]. In the current study, the overall stone-free rate was significantly lower in patients with a stone burden higher than 2 cm^2, and stone burden was an independent risk factor for the patients' overall stone-free status in the logistic regression analysis. Although not as strong as the previous history of ORSS, the other independent risk factor associated with the overall stone-free rate was age. Moreover, our children without a previous history of ORSS were found to be younger than the group who had undergone previous ORSS. As far as we know from the literature, the stone-free rate was higher in younger patients, suggesting that younger children have greater compliance in their urinary tract and require a shorter distance to pass the stones in the urine [19, 20]. Therefore, both having no previous history of ORSS and being younger provide higher stone-free rates.

Previous ipsilateral stone treatment had a negative impact on the stone-free status [13, 21]. This observation was consistent with other large SWL series. Nelson et al. [16] reported that the stone-free rate was lower (12%) in patients who underwent ipsilateral urological surgery for obstructive urological conditions. Badawy et al. [17] reported a higher retreatment rate (84%) in patients who had a history of ipsilateral surgery for ureteropelvic or ureterovesical obstructions. Onal et al. [21] investigated the impact of prior ipsilateral kidney treatments on the success of SWL treatment and found that these treatments had a negative effect on the success of SWL in children. In addition, our group published a study reporting that prior ORSS had a negative impact on the stone-free status in an adult series [10]. In the present study, the stone-free rate in patients with a history of ORSS was lower than that in the patients with no ORSS history (78 vs. 56%). Additionally, ORSS was associated with a lower stone-free rate, especially in the lower calyx (83 vs. 45%). We postulate that the blockages in propulsive peristalsis may be the result of scarring from prior surgical approaches, thus decreasing the ureteral contractions that help push the stone fragments out via urine after the SWL sessions [21]. Anatomical changes in the retroperitoneum are another possible explanation [10, 20, 22].

In most pediatric urolithiasis cases, SWL is still the first-line treatment option. However, in recent studies, RIRS/PCNL and microperc have been accepted as secondary treatment options for calyx stones that are <10 mm or in patients with complex anatomy [6, 23, 24]. PCNL has also been presented as an option for children who have previously undergone open nephrolithotomy; however, in these cases, the PCNL success rates may be lower and the risk of complication is high [25]. According to the literature, minimally invasive surgical techniques provide similar stone-free rates with lower complications and retreatment rates than SWL in the pediatric population [26, 27]. In the present study, the history of ipsilateral ORSS was one of the factors that affected the SWL outcome. Due to this, we recommend minimally invasive surgical procedures, such as RIRS and mini-/micro-PCNL, which are valuable options for pediatric patients who have undergone prior renal surgery and have lower calyx stones.

SWL is not only preferred to achieve acceptable stone-free rates but also for low rates of complications in a pediatric population. SS occurs at the rate of 4–7% within this demographic after the treatment [6]. In this study, the SS rate was also similar between groups and was not complicated by other renal pathologies. Ipsilateral ORSS was not regarded as a predisposing factor for SS in our statistical analyses.

The present study has several limitations. First, our study involved prolonged and retrospective data collection with a lack of knowledge on stone composition, which is considered crucial for SWL treatment. However, the stone composition is often unknown at the time of determining treatment in daily practice. Second, our study group includes only those who presented with radio-opaque stones, which can be listed as a limitation. In our clinical practice, we avoid using CT before or after

SWL to minimize radiation exposure in children. It can be thought that avoiding CT may have affected the classification of stone burden. However, the use of same radiological imaging modalities for evaluation (KUB and/or IVP and USG) before and after SWL alleviates this limitation in our study. Additionally, the advantage was that all the treatments were performed by 1 urologist with 25 years of experience in SWL (N.T.) who chose the energy and number of shock waves for each case and evaluated the results. Thus, we believe that we reduced the bias in our study to some degree. Despite the limitations, we believe that this study is valuable and our results provide useful insight for clinicians who offer counseling to the parents of children with renal calculi during the decision-making process regarding the course of treatment.

Conclusion

The overall stone-free rates after SWL treatment were found to be significantly lower in children with a history of ORSS than in patients without a significant history, and this finding was prominent for lower calyx stones, without having an impact on the complication rate. In spite of the possible difficulties in achieving surgical access due to anatomical changes in retrograde intrarenal surgery or mini-/micro-PCNL, we believe that these techniques might be good alternatives for SWL in future pediatric cases. However, comparative studies that evaluate the priority of SWL or RIRS for patients with nephrolithiasis who underwent prior ORSS are needed to verify our results.

Statement of Ethics

The study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Istanbul University-Cerrahpaşa Cerrahpaşa Faculty of Medicine (number:1395-37694).

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

Conception and design of the study: Bülent Önal. Acquisition of data: Berin Selçuk, Ahmet Fethi Türegün, Mehmet Hamza Güntekin, and Nejat Tansu. Drafting the manuscript: Elif Altınay Kırlı and Bülent Önal. Revision of the manuscript: Ahmet Erözenci. Final approval of the manuscript before the submission: Bülent Önal.

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