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Factors Affecting the Number of Shock Wave Lithotripsy Session in Children with Renal Stones: Are age and Radiolucency the Predictors of Success?

ORIGINAL INVESTIGATION

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ABSTRACT

Objective: We aimed to investigate the effectiveness of shock wave Lithotripsy (SWL) and factors affecting seance number while treating children with renal stones.

Materials and Methods: A total of 50 children (53 renal units) who underwent SWL for renal stones between 2012 and 2014 were investigated retrospectively. The demographics of patients, the number, size, side, location, and radiolucency of stones in kidneys, placement of JJ stents, shock number, energy, seance number, stone-free rate, and complications were noted.

Results: Patients involved 25 girls and 25 boys with a median age of 4.0 years ranging from eight months to 16 years (21≤3y). Stones were located in the renal pelvis and calyxes in 20 and 33 patients, respectively. Of the renal stones, 33 were single and 20 were multiple. The mean stone size was 11.02±5.4 mm. Success rates were 45.3, 75.5, and 92.5% after seances 1, 2, and 3, respectively. Per seance, the mean SWL shock waves and energy were 1219±262 and 12.6±0.9 kV. A significant relationship was found between the need for a third seance and patient age (≤3 years and >3), radiolucent and radiopague, ≤10 mm and >10 mm or single and multiple stone ($p<0.05$). However, no significant relationship was found between success rate and age; sex; number, size, location, and side of stones; and radiolucent stones.

Conclusions: Age, radiolucency, stone size, and number of stones were significant predictors of SWL success in children. We observed that stone-free status is achieved more quickly, even within the first or second SWL seances by significantly decreasing the need for the third séance in group age ≤3 years, radiolucent, ≤10 mm or single renal stones.

Keywords: Renal stones, children, radiolucency, shock wave lithotripsy

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INTRODUCTION

Shock wave lithotripsy (SWL) was presented as a minimally invasive treatment for nephrolithiasis in the early 1980s (1). SWL has recently become a well-established, safe, and efficacious modality for the treatment of renal stones (2) and is now considered a first-line treatment for the minimally invasive management of pediatric stone disease of the upper urinary tract (3-6). When used as a primary treatment option for upper tract stones, the efficacy of SWL ranges between 68 and 94% (7, 8). Although it is known as a safe and effective treatment in children, repeated sessions can be needed. In the present study, we investigated the factors affecting the number of SWL sessions in children with renal stones and predictors of success.

MATERIALS and METHODS

The records of all pediatric patients with renal stones treated for SWL between February 2012 and November 2014 were retrospectively investigated in a single center. Age, sex, physical examination, and culture results, preoperative routine blood, urinary, and coagulation tests, familial stone, and medical histories, size, side, and location of stones in kidneys, number, and opacity of stones, placement of JJ stent, shock number, and energy, number of SWL sessions, stone-free rate, and complications were recorded. All patients were exposed to preoperative evaluation with kidney-ureter-bladder (KUB) radiography, urinary ultrasound (USG), and, when needed, non-contrast computerized tomography (NCCT).

Stone size was calculated by accumulating the longest stone length on urinary USG. All SWL procedures were performed with the electro-hydraulic lithotripter (Elmed Complit, Ankara, Turkey) under general anesthesia except for two children over 14 years of age. The stones were localized by fluoroscopy and/or USG during lithotripsy. In the study, we initially assessed all stones with USG, but sometimes we had to target radio-opaque stones with fluoroscopy. Informed consent was obtained from the parents of all children. All children were out-patiently treated on the supine position by a single surgeon (C.K.).

The procedure was started at a low energy and number of shocks (10 kV and 500 shocks) and then increased in steps up to 15 kV and 2000 shocks according to the child's age and fragmentation of stone. The shock waves were given at the rate of 60-70 shocks/min. All patients were evaluated by KUB radiography, USG, and, when needed, NCCT every two weeks after SWL sessions. Those with fragments bigger than 4 mm were scheduled for another session. The interval between sessions was two weeks. All patients were re-evaluated at the third month, and stone-free status or clinically insignificant residual fragments (CIRFs) were defined as success. Consistent with the literature, if residual stones were asymptomatic (non-infectious and non-obstructive), smaller than 4 mm, and associated with sterile urine after the procedure, they were defined as CIRFs (9,10). The maximum number of sessions allowed for our patients was three. Non steroidal anti inflamatuar drugs were used to relieve pain in all patients after SWL sessions.

The efficacy quotient (EQ) was used to assess the effectiveness of SWL. The value of the EQ was calculated with the following formula: stone-free%/(100% + re-treatment rate% + auxiliary procedures of post SWL%) (11). Univariate analysis and multivariate analysis (stepwise logistic regression analysis with backward elimination using the likelihood ratio) were used to identify predictive factors acting independently and to predict the probability of stone-free status and CIRFs after SWL sessions. To compare data, the chi-square test was performed. A $p<0.05$ was considered statistically significant. Statistical analyzes were performed using Statistical Package for the Social Sciences version 15.0 (SPSS Inc.; Chicago, IL, USA).

The study was approved by the local research ethics committee.

RESULTS

The data related to the demographic and SWL characteristics of patients are presented in Table 1. All patients were composed of 53 renal units (RUs). Of RUs, 24 (45.28%) required one, 16 (30.18%) required two, and 13 (24.5%) required ≥3 SWL sessions. After sessions 1, 2, and 3, cumulative rates of success were 45.3, 75.5, and 92.5%, respectively.

Ureteral JJ stents had been placed into 28 patients (56%) before SWL procedure to maintain the ureteral passage in case of obstruction with fragmented stones in those with either multiple and/or >10 mm renal stones and into six RUs of three cases with bilateral renal stones, as well as six RUs of cases with both renal and ureteral stones. For four unsuccessful cases, percutaneous nephrolithotomy was planned.

In the present study, the composition of stones could be analyzed and classified in only 22% of cases. These consisted of calcium oxalate monohydrate and dihydrate, hypoxantine, uric acid, and struvite stones. In the present study, the composition of stones could be analyzed and classified in only 22% of cases. These consisted of calcium oxalate monohydrate and dihydrate, hypoxantine, uric acid, and struvite stones.

Familial stone history was present in 18 (34%) patients. Whether our patients were cystinuric or not, 26 (52%) were medically treated with Shohl's solution (sodium citrate, n=17) or urocit (potassium citrate, n=9) due to prophylactic treatment, especially in patients with radiolucent stones. NCCT was performed to evaluate 16 patients (32%) required. NCCT of the abdomen and pelvis was done in some symptomatic patients as a result of negative USG findings and in conditions where hydronephrosis was suspected due to radiolucent ureteral calculi.

As postoperative complications, urinary tract infection was seen in two patients, hyperthermia in one, vomiting in one, and mild

Table 1. Demographic and SWL data of patients

Sex			
Boys n	25 (50)		
Girls n	25 (50)		
Age			
Mean	5.13±3.9 y		
Range	8 month to 16 years		
≤3 n	21 (42)		
≤10 n	44 (88)		
Stone size (mm)			
Mean	11.2±5.4		
Range	5-36		
≤10 n	25 (47)		
>10 n	28 (53)		
Stone location			
Renal pelvis n	17 (32)		
Calix n	30 (57)		
		Upper n	6 (11)
		Middle n	11 (21)
		Lower n	13 (25)
Together n	6 (11)		
Stone number			
Single n	33 (62)		
Multiple n	20 (38)		
Stone opacity			
Radio-opaque n	22 (42)		
Radiolucent n	31 (58)		
Stone side			
Right n	22 (44)		
Left n	25 (50)		
Bilateral n	3 (6)		
Shock waves per session			
Mean	1219±262		
Range	500-2000		
Shock Wave Lithotripsy power (kV)			
Mean	12.6±0.9		
Range	10-15		

Data in parentheses are presented as percentages. SWL: shock wave lithotripsy

Table 2. Need for sessions and success rate according to patient age and opacity, size, and number of stones

Number of sessions	Age		p
	≤3 y	>3 y	
1	13/23 (57)	11/30 (37)	0.150
2	9 /23 (39)	7/30 (23)	0.214
≥3	1/23 (4)	12/30 (40)	0.003
EQ	0.69	0.49	0.004
	Opacity		
	Radio-opaque	Radiolucent	
1	8/22 (36)	16/31 (52)	0.272
2	5 /22 (23)	11/31 (35)	0.319
≥3	9/22 (41)	4/31 (13)	0.020
EQ	0.48	0.64	0.023
	Stone size		
	≤10 mm	>10 mm	
1	15/25 (60)	9/28 (32)	0.042
2	7/25 (28)	9/28 (32)	0.074
≥3	3/25 (12)	10/28 (36)	0.045
EQ	0.66	0.49	0.015
	Stone number		
	Single	Multiple	
1	17/33 (52)	7/20 (35)	0.242
2	11/33 (33)	5/20 (25)	0.522
≥3	5/33 (15)	8/20 (40)	0.042
EQ	0.61	0.51	0.154

EQ: efficacy quotient
Data in parentheses are presented as percentages

Table 3. Factors affecting success rate

Factors	Success	Failure	p
Age			
≤3y	23 (100)	0 (0)	0.069
>3y	26 (87)	4 (13)	
Stone number			
Single	31 (94)	2 (6)	0.599
Multiple	18 (90)	2 (10)	
Stone size (mm)			
≤10	24 (96)	1 (4)	0.356
>10	25 (89)	3 (11)	
Stone opacity			
Radio-opaque	19 (86)	3 (14)	0.157
Radiolucent	30 (97)	1 (3)	
Stone location			
Renal pelvis	19 (95)	1 (5)	0.585
Calix	30 (91)	3 (9)	
Stone side			
Right	23 (92)	2 (8)	0.906
Left	26 (93)	2 (7)	
Sex			
Boys	25 (92)	2 (8)	0.969
Girls	24 (92)	2 (8)	
Family history			
Yes	17 (95)	1 (5)	0.694
No	32 (91)	3 (9)	
Medical treatment			
Yes	24 (92)	2 (8)	0.969
No	25 (92)	2 (8)	
JJ stent			
Yes	28	3	0.486
No	22	1	

Data in parentheses are presented as percentages

hematuria in 9 (24.5%). We classified the complications according to the Clavien-Dindo classification, and according to the classifications, our complications were grade 1 (12). No ecchymosis, ureteral obstruction, or sepsis was encountered.

According to univariate analysis, a significant association was found between the need for a third session and age (≤3 vs. >3) (p=0.003), between the need for a third session and stone radio-opacity (opaque vs. lucent) (p=0.02), between the need for second and third sessions and stone size (≤10 mm vs. >10 mm) (p=0.042 and p=0.045, respectively), and between the need for a third session and stone number (single vs. multiple) (p=0.042). Based on EQ results, age, radiolucency, and stone size were found to be statistically significant predictive factors (p=0.004, p=0.023, and p=0.015, respectively) (Table 2). However, no significant relationship was found between stone clearance and a patient's age and sex, the number, side, size, opacity, and location of stones in kidneys, use of JJ stents, family stone history, or administered medical treatment (Table 3). Statistically significant parameters on univariate analysis were evaluated by multivariate logistic regression analysis. We found that stone size was the only statistically significant predictive factor affecting success after SWL sessions (odds ratio 0.874, 95% CI 0.870-0.978, p=0.019), while stone number (odds ratio 0.39, 95% CI 0.149-1.016, p=0.054) and age (odds ratio 0.870, 95% CI 0.748-1.03, p=0.111) were insignificant in the final model.

DISCUSSION

Advances in the technology of medical instruments have provided a variety of safe and effective endourological procedures such as SWL, percutaneous nephrolithotomy, and ureteroscopy in the treatment of pediatric urolithiasis (13). Although SWL is a non-invasive out-patient procedure, the children in need of the procedure undergo multiple treatment sessions, resulting in additional patient anesthesia and stress for both patients and families. In addition, the need for multiple treatment sessions is concerning because the effects of shock waves on renal tissue could be hazardous (14). Stone-free rates after a single SWL session remain as low as 42.1% and 46% have shown in different series, and in harmony with our results, 45.3% (15, 16). the literature shows that stone-free rates of pediatric renal stones after multiple sessions of SWL remain 54-100% (16). SWL has been performed as the first-line treatment of pediatric stones in our center, and, consistent with the literature, a success rate of 92.5% was found in our study also.

Few studies have indicated various factors affecting the success rate of SWL in pediatric renal stones (15, 17-21); however, there are a few studies investigating the factors affecting the number of SWL sessions in children (8). Therefore, we investigated the factors affecting SWL and its session number and compared the significance rate of such factors. Pediatric patients have an increased clearance rate of stones compared with adult patients, possibly due to lesser length and greater distensibility of the pediatric ureter (22). Mandal et al. (23) found that the results of SWL for inferior caliceal calculi ≤20 mm remain poorer in adults compared with children, so children can achieve high stone-free rates, requiring fewer numbers of SWL sessions than adults to be stone-free, and have a lower need for repeated treatment and auxiliary procedures. In a study performed by Aksoy et al. (24), it was found that, after SWL, children aged between 0-5 years had the greatest stone-free rate and that children between 11-14 years had the poorest outcomes. Consistent with their findings, a significant association was found between the need for third sessions and age (≤3 vs. >3). Jee et al. (25) stated that a statistically significant difference was present in the mean number of SWL sessions between children aged ≤7 and >7 years. All these studies demonstrated that children <6 years had higher stone-free rates. In our study, we observed that children ≤3 years had higher stone clearance rates (100%) than children >3 years (86.6%) and that a significant relationship was found between the need for a third session and age (≤3 vs. >3 years). In the literature, there are also few studies mentioning SWL as a safe and effective treatment modality in toddlers and infants (6, 26). Similarly, we demonstrated that SWL is effective and safe in toddlers.

El-Assmy et al. (15) found that stone length ≤12 mm was a significantly independent predictor of SWL success in children. In addition, in a study by McAdams et al. (27), it was reported that patients with a mean total stone diameter of 11.1±13.4 were treated more successfully than those with a total stone diameter of 21.3±21.4. Consistent with their findings, a significant association was found between the need for second or third sessions and stone size (≤10 mm vs. >10 mm) in our study. We found that stone size was the only statistically significant predictive factor affecting success after SWL sessions. When stone size is >10 mm, success rate decreases by as much as 72%. If the size of pediatric renal stones is ≤10 mm, patients become stone-free status more quickly even after the first SWL session.

Jeong et al. (21) emphasized that the development of multiple pediatric stones in kidneys is a significant factor decreasing the success rate of SWL treatment. In our study, a significant relationship was found between the need for a third session and stone number (single vs. multiple).

While no study is presently investigating stone opacity as a predictor in pediatric population, there are fewer studies in the literature about Hounsfield units (HU) predicting the success of SWL in children (15); however, HU can be evaluated in conjunction with NCCT. Because only 16 (30%) patients needed preoperative evaluation with NCCT in our study, radiolucency was used as a predictor. Our results showed that children with radiolucent stones become stone-free status more quickly and easily. Twenty-two RUs (41.4%) had radio-opaque stones, and 31 RUs (58.4%) had radiolucent stones. After the second SWL session, success rates in radio-opaque and radiolucent stones were 54.5 and 87.1%, respectively. A significant relationship was detected between the need for the third session and radiopacity ($p<0.05$).

Consistent with previous studies (15, 21, 28), we found no significant association between sex, stone location in kidneys, stone side, and stone-free status and the number of SWL sessions. It is a general consensus in adult endourology that lower pole stones tend to be more refractory to SWL compared with stones in other locations. In pediatric series, however, stone location is not a significant predictor of success (3, 28), as is consistent with our findings.

While mean energy level and number of shock waves per session used in the previous studies were 15.5 kV, 950±785 (29) and 12-20 kV, maximum 3000 (30), mean energy level and number of shock waves administered to our patients were detected as 12.6 kV and 1219 per session. Consistent with the literature, SWL success rate was 92.5% in our study.

As postoperative complications, urinary tract infection was seen in two patients, hyperthermia in one, vomiting in one, and mild hematuria in nine (24.5%). No ecchymosis, ureteral obstruction, or sepsis was encountered. A low complication rate was achieved by consistently using very low energy shock wave therapy with an electro-hydraulic shock wave generator for all stones.

Study Limitations

Our study also included some limitations. The weakness of this study was the small number of patients. Our data include very few stone compositions that could be a significant predictor of stone-free status.

CONCLUSION

We consider that stone-free status can be achieved more quickly even within the first or second SWL sessions by significantly decreasing the need for the third session depending of factors such as patient age and the radiolucency, size, and number of the stones while treating renal stones through SWL in children.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Medical School of Necmettin Erbakan University Faculty of Medicine.

Informed Consent: Written informed consent was obtained from the parents of the patients in this study.

Peer-review: Conceived and designed the experiments or case: CK. Performed the experiments or case: CK., MS., ÇK. Analyzed the data: CK., MS., ÇK., AO. Wrote the paper: CK., ÇK. All authors have read and approved the final manuscript.

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