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UROLOGY – ORIGINAL PAPER

Extracorporeal shock wave lithotripsy as first line treatment for urinary tract stones in children: outcome of 500 cases

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Abstract
Purpose The continued evolution of stone treatment modalities, such as endourologic procedures, open surgery and shock wave lithotripsy, makes the assessment of continuous outcomes are essential. Pediatric urolithiasis are an important health problem allover the world, especially in Middle East region. We evaluate the safety, efficacy and factors affecting success rate and clearance of stones in children treated with shock wave lithotripsy.
Patient and methods Between 2005 and 2010, a total of 500 children with stones in the upper urinary tract at different locations were treated by Extracorporeal shock wave lithotripsy (ESWL) in our department, Sohag University, Egypt. We have used the Siemn's Lithostar Modularis machine, Germany. A total of 371 boys and 129 girls with the average age of 8.63 ± 5 years, and a range from 9 months to 17 years were included in this study. Diagnosis of their urinary calculi was established either by the use of abdominal ultrasound, plain X-ray, intravenous urography, or CT scan. The stones were located in the kidney in 450 (90%) patients; 298 (66%) pelvic, 26 (5.7%) upper calices, 57 (12.6%) mid calices, and lower calices in 69 (15.3%) patients. The average of their stone sizes was 12.5 ± 7.2 mm. The other 50 children their stone were located in the proximal ureteral stones in 35 patients (70%); middle third in 5 (10%) patients and in the distal ureter in 10 (20%) patients. The average ureteral stone size was 7.5 ± 3.2 mm. All children were treated under general anesthesia with adequate lung and testes shielding using air foam. We treated the distal ureteral stones of young children in the supine position through greater sciatic foramen and lesser sciatic foramen as the path of shockwave instead of prone position, which is not a comfortable or natural position and could adversely affect cardiopulmonary function especially under general anesthesia. Localization was mainly done by ultrasound, and X-ray was only used to localize ureteral calculi. For follow-up, we have used abdominal ultrasound, plain X-ray, and CT scan if needed to confirm stone disintegration and clearance.
Results The overall success rate for renal and ureteral calculi was 83.4 and 58.46%, respectively. The re-treatment rate was 4% in renal group and 28% for the ureteral group. No serious complications were recorded in our patients. Minor complications occurred in 15% of our patients; renal colic was

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reported in 10% of our treated patients, and repeated vomiting was reported in 5% that respond to antiemetics. In the renal group; children with history of pervious urologic surgical procedures had low success rate of stone clearance after ESWL. In the ureteral group stone burden, stone location, had a significant impact on stone clearance outcome.

Conclusion This study showed that SWL in pediatric age group for both renal and ureteral stone is cost effective, safe with an acceptable re-treatment rate; however children with large stone burden or previous urologic surgery have low success rate.

Keywords Children · SWL · Ureteroscopy · Urolithiasis · Ureter · Kidney

Introduction

Extracorporeal shock wave lithotripsy (ESWL) as a non-invasive technique becomes the most acceptable method of treatment for management of urinary tract calculi. However, its pediatric use has lagged behind the widespread use in adults. Probably because of concerns over the potential adverse effects of SWL on developing organ systems in children [1]. In the recent years, pediatric urolithiasis has become a major health problem due to the high morbidity and high recurrence rate. Many reports showed its safety and effectiveness for stones in urinary tract of children and were considered as a minimally invasive method [2].

Although endourologic procedures are an option for management of urinary calculi; urethral instrumentation in children may be dangerous especially in small boys as well as the safety of ureterosopy in pediatric age is not fully established.

This study provides a retrospective analysis to determine the efficacy of ESWL for treatment of renal and ureteral calculi in pediatric age group.

Patients and methods

During the last 5 years, more than 5,000 patients underwent ESWL at our institution, Sohag University Hospital, Sohag, Egypt. Between January 2005 and December 2010, 520 children with stones in the urinary tract were treated by ESWL using the Siemens Lithostar lithotripter; this group represents about 10% of all patients with urinary calculi treated with ESWL. 20 children were lost during their follow-up and were excluded from the study. Their age ranged from 9 months to 17 years with an average age of 8.63 ± 5.00 years. Of those patients, 371 (74.20%) were boys and 129 (25.80) were girls. 450 (90%) had renal stones and 50 (10%) had ureteral stones. Diagnosis was established by either the use of abdominal ultrasound, plain X-ray, intravenous urography (IVU), or CT scan.

The stones were located in the kidney in 450 patients: renal pelvic stones in 298 (66.2%) patients; upper calices in 26 (5.7%) patients, mid calices in 57(12.6%); and in the lower calices in 69 (15.3%).

Prior to treatment, all patients were routinely evaluated by history, physical examination, urine culture and analysis, blood tests for renal function, coagulation profile. For stone localization and assessment of site and size, abdominal ultrasound, plain X-ray, intravenous urography (IVU) out, or CT scan was carried.

Exclusion criteria for ESWL were febrile urinary tract infection, uncorrectable coagulation disorders, multiple or bilateral ureteric calculi, solitary kidney, renal insufficiency, and obstruction distal to the stone.

Children with good cooperation treated with analgesia for sedation; however, the majority of our patients were treated under general anesthesia, usually those below the age of 12 years.

The children were secured to the gantry with tapes, leaving the skin over the treated kidney uncovered. The mean number of shocks delivered was 3,000, and the generator voltage ranged from 16 to 19 kV and pulse frequency rang was 60–80 shocks per min. The procedure ended when a satisfactory fragmentation was seen on fluoroscopy or 3,000 shock waves had been delivered.

We reviewed our patients at 1 week after the ESWL session by plain X-ray film and or abdominal ultrasound. In a few cases, postoperative CT and/or IVU were performed. We repeated the treatment if the fragmentation was inadequate. CT or IVU was accepted as the final outcome when there is a controversy between the results of ultrasound and the IVU. ESWL was considered successful if no stone or residual fragments on plain X-ray film. Stones that show poor fragmentation after two sessions of ESWL or residual fragments failed to pass was considered a

failure. All our patients were evaluated 3 months after last ESWL session. The efficacy of SWL at 3-month follow-up was evaluated by efficacy quotient (EQ) [3]. The complications encountered in our study; only six patients (1.2%) have developed Steinstrasse and were managed by ureterscopy. The other complications encountered were minor: four children (0.8%) developed febrile urinary tract infection and responded readily to antibiotic treatment, renal colic, which reported in 30 patients (6%), was managed by anti-inflammatory and antispasmodics.

Statistical analysis was done with the SPSS (statistical program for social sciences) program. The groups were compared using, Kruskal–Wallis analysis test for numerical variables, because the data were not normally distributed. Chi-square test was used for categorical ones. A P value of < 0.05 was accepted as statistically significant.

Results

Five hundred children were included in this study. Their age ranged from 9 months to 17 years with an average age of 8.63 ± 5 years. 371 (74.20%) were boys and 129 (25.80) were girls. Of our patients 450 (90%) had renal stones and 50 (10%) had ureteral stones. Stones were located on the right side in 292 (58.40%) and on the left in 208 (41.6%).

The number, size, and stone burden for both real and ureteral group were shown in (Table 1). Four hundreds forty-seven children (89.4%) received only one session and 53 in (10.6%) received more than one session. The mean number of shocks delivered per session was 2,360 ± 225. Dissociation anesthesia was used in younger children below 12 years. No anesthetic complications were reported in our patients, and all patients were discharged on the same day of the procedures. Overall stone-free rate at 3 months was 90.40% for renal stones, and overall success rate for ureteral stone was 76.6%. A second-session treatment was encountered in 18 patients 4.2% for renal and in three patients (28%) for ureteral stones. Overall EQ was 83.4% stone-free rate at 3 months in the renal group and 58.46% for ureteral group. The success rate and EQ according to the location of the stones were shown in Table 2 and Fig. 1. The ESWL outcome and EQ according to the size of the stones were illustrated in (Table 3) and (Fig. 2).

Among the 500 patients, 12 patients required intervention, Steinstrasse developed in 6 patients and were managed by ureterscopy. Three patients required double J stent prior to treatment due to large stone burden for ESWL and PCN was inserted in three patients due obstruction associated with infection.

Discussion

The treatment of urolithiasis in children has gained more attention from pediatric urologists, possibly due

Table 1 The number, size, and stone burden in different locations

	Number	Stone size			Stone burden		
		Mean	SD	Range	Mean	SD	Range
Renal stone							
Renal pelvic	298	11.45	5.16	3–36	140.30	81.79	20–450
Upper calices	26	7.54	3.06	4–15	103.19	61.47	20–240
Mid calices	57	6.68	2.57	4–14	113.19	64.58	20–250
Lower calices	69	7.18	2.14	4–12	121.92	68.09	20–250
Total	450	10.0	4.88	3–36	131.95	77.52	20–450
P value		0.0001			0.025		
Ureteral stone							
Proximal	34	8.20	3.25	4–16	86.38	37.32	20–180
Mid	5	8.0	2.24	5–11	82.80	34.16	55–135
Distal	11	8.9	2.63	6–14	74.45	29.06	36–140
Total	50	8.34	3.0	3–13	83.4	35.07	20–180
P value		0.64			0.68		

Table 2 Efficacy of SWL in stones classified by location of stone

	Number	STR at 3 months No. (%)	Re-treatment No. (%)	Auxiliary procedures No. (%)	EQ (%)
Renal stone					
Renal pelvic	298	271 (90.94)	9 (3.02)	8 (2.68)	86.04
Upper calices	26	23 (88.46)	0 (0)	0 (0)	88.46
Mid calices	57	53 (92.98)	2 (3.51)	0 (0)	89.83
Lower calices	69	60 (86.96)	8 (11.59)	2 (2.90)	75.95
Total	450	407 (90.44)	19 (4.22)	10 (2.22)	83.40
P value		0.66	0.009	0.51	
Ureteral stone					
Proximal	34	26 (76.47)	10 (29.41)	0 (0)	59.09
Mid	5	4 (80.00)	1 (20)	0 (0)	66.67
Distal	11	8 (72.73)	3 (27.27)	1 (9.09)	53.34
Total	50	38 (76.00)	14 (28.0)	1 (2.00)	58.46
P value		0.11	0.91	0.16	

$$\mathrm{EQ} = \frac{\text{Stone free percentage}}{100\% + \text{re-treatment rate percentage} + \text{auxiliary procedures percentage}} \times 100\%$$

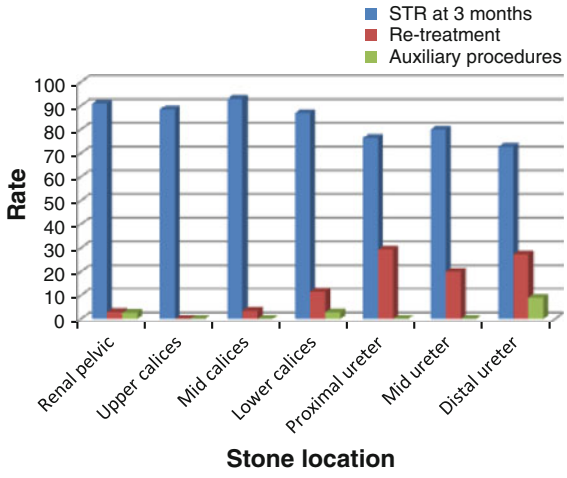

Fig. 1 Stone-free rate and re-treatment rate based on stone location

to the increasing incidence of kidney and ureteral stones [4].

In our series in the last 5 years, 5,000 patients presented to our ESWL unit with urinary calculi of these 500 children 10% were children. This series is one of the largest pediatric SWL series reported and to the best of our knowledge it is the largest reported pediatric series using the Siemens' Lithostar Modularis machine.

In the present series, the overall SFR for renal and ureteral calculi was 90.4 and 76%, respectively. Multiple studies document the efficacy of SWL in children with an overall stone-free rate of 79.9% at 3 months follow-up [5, 6, 7]. In other studies, the overall stone-free rate was 95.8% in renal stones and 94.8% in ureteral stones [8, 9, 10, 11].

The efficacy of ESWL for treatment of urinary stones in children is higher than adults as the pediatric ureter is shorter and more elastic, which contribute to the easy passage of stones and less fragments impaction. Also, children are more mobile than adults, and mobility is known to help stone passage. Another factor is that stones in the urinary tract of children are usually soft because they have not had time to impact firmly [12, 13].

In our study, the overall success rate for renal stones was 86% for stone located in the renal pelvis, 92.9% for middle caliceal, 88.5% for upper caliceal and 86% for lower caliceal, with overall success rate of 87.8%. The success rate in our study was similar to that reported by other EWL series in the rage of 75% to 98% stone-free rates in children [14]. However, as we noted, there are number of factors that make comparisons among SWL series difficult. A significant finding in this pediatric series is the low stone-free rate in children with lower caliceal stone, where the success rate decreased from 92.9% for mid caliceal to

Table 3 Efficacy of SWL in stones classified by size of stone

	Number	STR at 3 months No. (%)	Re-treatment No. (%)	Auxiliary procedures No. (%)	EQ (%)
Renal stone					
≤10	259	243 (93.82)	11 (4.25)	5 (1.93)	88.36
>10	191	164 (85.86)	8 (4.19)	5 (2.62)	80.39
Total	450	407 (90.44)	19 (4.22)	10 (2.22)	83.40
P value		0.005	0.98	0.63	
Ureteral stone					
≤10	43	31 (91.18)	2 (5.88)	1 (2.92)	83.81
>10	16	7 (43.75)	12 (75.00)	0 (0)	25.00
Total	50	38 (76.00)	14 (28.00)	1 (2.00)	58.46
P value		<0.0001	<0.0001	0.48	

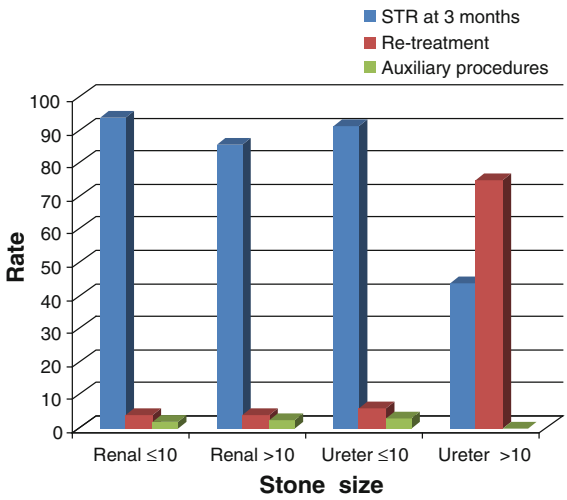

Fig. 2 Stone-free rate and re-treatment rate based on stone size

86% in the lower caliceal group. In renal stone group, re-treatment rate of lower pole stones was higher than that of stones in other locations, causing a lower EQ, which was mainly resulted from the retention of fragments due to the dependent position of lower pole. Penn et al. [15] reported that the stone-free rate of lower pole stones was much lower than that of renal pelvic stones.

Interestingly, from a total of 19 children who needed re-treatment, 16 patients (84%) had history of either PUJO or UVJ surgery. These findings also reported by Boston group in 114 children series [16].

The success rate for lower ureteric stones was 53.3%, for the middle ureteral stones was 66.7%, and for the upper ureteric stones was 59%. In ureteral stone group, there was no significant difference in stone-free rate between various locations. However, mid ureteral group were only 5 patients (10%).

The size of the stone was an important factor affecting the efficacy of SWL [7]. As expected, patients with stone burden >10 mm had lower EQ than smaller stones <10 mm due to a significant higher re-treatment rate (*P* value 0.05); however, in the ureteral group, the stone size >10 mm had a statistically significant relationship to success, the EQ from 83.3% for stone size <10 mm to 25% for stone size >10 mm (*P* value, 0.0001 is highly significant). Similar result were reported by several series that have shown improved outcomes in stones smaller than 10 mm compared to larger stones[17, 18]. The low success rate seen in children with ureteral stone >10 mm even with multiple treatments should reconsider whether SWL should be the first line treatment in such patients. The use of flexible endoscopy that is small enough for children combined with laser lithotripsy for stone should push for endoscopic management in such cases; however, the safety of pediatric ureteroscopy is not fully established. The dilation of the ureteral meatus with ureteroscopy in children may result in vesicoureteral reflux. In addition to the risk, urethral injury and stricture in males and ureteral damage in both sexes may develop postoperative. Although the use of small-sized ureteroscope with laser lithotripsy has a success rate of 90% [19].

The concern about damage to reproductive organs in pediatric age subjected to SWL for ureteral calculi has been disproved by most animal experiments that showed no long lasting permanent damaging effect on

the female reproductive system, particularly the ovaries [20]. Another concern may be raised about renal scarring in children who treated with ESWL for their renal stones. This concern was studied by Fayed et al. [21] on a study of 100 children with renal stones; they stated that none of the patients in their study exhibited any degree of renal scarring on DMSA scan or any decrease in split kidney function as evidenced by GFR measurement in ml per min using DTPA after shock wave lithotripsy.

Conclusions

Pediatric ESWL using a portable, late-generation lithotripter ESWL using the Siemens Lithostar Modularis lithotripter is well tolerated, and its effectiveness is consistent with historical reports of that of post-HM3 machines. SWL for both renal stones and ureteral stones in pediatric group has comparable result regarding the safety. However, the success rate in the renal group was higher than that of ureteral group. Children with a history of urological surgery and ureteral stone >10 mm have a low stone-free rate after and ESWL. Such children may be better served by alternative stone management techniques. Only, total stone diameter independently predicted success for ureteral stone.

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