KJU
Korean Journal of Urology

www.kjurology.org
http://dx.doi.org/10.4111/kju.2013.54.12.865

Pediatric Urology

Efficacy of Extracorporeal Shock Wave Lithotripsy in Pediatric and Adolescent Urolithiasis

Joon Yeop Jee, Soo Dong Kim, Won Yeol Cho

Department of Urology, Dong-A University College of Medicine, Busan, Korea

Purpose: To retrospectively evaluate the efficacy of extracorporeal shock wave lithotripsy (ESWL) by age and current condition as a first-line treatment for pediatric and adolescent urolithiasis.

Materials and Methods: The computerized records of 55 children were retrospectively reviewed from March 1991 to July 2007. The children were below 18 years of age and had undergone ESWL monotherapy for urolithiasis. There were 36 boys (65.5%) and 19 girls (34.5%), with a mean age of 8.5 years (range, 0.5–18 years). There were 24 patients aged 7 years or less and 31 patients aged more than 7 years.

Results: The mean size of the stones was 9.48 mm (range, 4–22 mm). The overall success rate of ESWL was 90.9% (50 children). The mean number of ESWL sessions was 2.02 (range, 1–10). The mean number of ESWL sessions for the patient group aged 7 years or less was 1.16 (range, 1–2) and that for the patient group aged more than 7 years was 2.97 (range, 1–10; p=0.037). There was also a statistically significant difference in the mean number of ESWL sessions between the younger and older patients who needed general anesthesia (1.16 vs. 2.2 sessions, respectively; 0.042).

Conclusions: In the patient group aged 7 years or less, the number of ESWL sessions and the complication rate were comparable with those for endoscopic management. Thus, ESWL is an effective first-line treatment modality for patients aged less than 7 years.

Keywords: *Extracorporeal shockwave lithotripsy; Pediatric urolithiasis*

Article History:
received 10 June, 2013
accepted 23 September, 2013

Corresponding Author:
Won Yeol Cho
Department of Urology, Dong-A University Hospital, Dong-A University College of Medicine, 26 Daesingongwon-ro, Seo-gu, Busan 602-715, Korea
TEL: +82-51-240-2816
FAX: +82-51-253-0591
E-mail: urogate@dau.ac.kr

INTRODUCTION

Pediatric and adolescent urolithiasis has drawn increasing attention of late owing to its increasing morbidity and high recurrence rate. Extracorporeal shock wave lithotripsy (ESWL) was introduced by Chaussy et al. [1] in the 1980s, and the first report of successful ESWL in children was published in 1986 [2]. Thereafter, several reports showed the safety as well as the stone-free rates of ESWL, which were comparable with those of adults [3-5]. Recently, the long-term safety of ESWL in children was also proven [6].

In ESWL, shock waves are generated by a source (lithotripter) outside the patient's body and are then propagated into the body and focused on a renal stone, with the goal of fracturing the stone to allow the passage of the stone fragments via the urinary tract. This procedure has become more widely available throughout the world and has come to be considered a first-line treatment for the minimally invasive management of pediatric and adolescent urolithiasis [5,7].

Although ESWL is widely accepted throughout the world as a first-line treatment modality, and although various studies have been conducted on it, its role in the management of pediatric and adolescent patients has not been fully established. Furthermore, the endourological procedures available (e.g., ureteroscopy, percutaneous nephrolithotomy) have been used owing to their high single-use probability in pediatric and adolescent urolithiasis. Thus, the efficacy of ESWL by age and current condition as a first-line treatment modality for pediatric and adolescent ur-

olithiasis was retrospectively evaluated in this study.

MATERIALS AND METHODS

The computerized patient records at the authors' institute were retrospectively reviewed from March 1991 to July 2007. A total of 55 patients who were below 18 years of age and who underwent ESWL monotherapy for urolithiasis were included in the study. There were 36 boys (65.5%) and 19 girls (34.5%) with a mean age of 8.5 years (range, 0.5–18 years).

Prior to treatment, all patients were routinely evaluated (i.e., determining the medical history, physical examination, serum renal function test, serum coagulation test, and urine analysis and culture). The patients with coagulation disorders, sepsis, and nonfunctioning kidneys were excluded from the study. For stone localization and site and size assessment, plain X-ray, intravenous urography, renal ultrasonography, and/or computed tomography scan were carried out preoperatively.

The stones were found to be localized in the lower, middle, and upper ureter and in the renal pelvis (staghorn stone) and renal calyx. ESWL was performed with a Medispec Extracorporeal Shockwave Lithotripter E-3000 (Medispec, Yehud, Israel). The therapeutic power was started from 15 kV and increased in steps up to 20 kV. The mean number of shocks was 700–1,000 per session, and the pulse frequency was 60 shocks per minute.

General anesthesia was required for all patients aged 7 years or less and for nine patients above 7 years of age (29.0%). The other patients did not need anesthesia; instead, fentanyl 2–2.5 μg/kg was administered to them for pain control. The ESWL sessions were performed with the patient in the supine position for the renal and upper ureteral stones and with the patient in the prone or supine position for the middle and lower ureteral stones. Fluoroscopy and ultrasound were used for stone localization during the session. The patients were examined 2 weeks after each session via kidney-ureter-bladder and renal ultrasonography to assess stone fragmentation and the presence of renal obstructions. If additional sessions were needed, one such session was held on a weekly basis.

ESWL success was defined as stone-free status or the presence of clinically insignificant residual fragments. Stone-free status indicated no evidence of residual stones in the imaging studies. The clinically insignificant residual fragments were asymptomatic, noninfectious, and nonobstructive fragments smaller than 3 mm at 3 months of follow-up. ESWL failure was defined as the continued presence of the rest of the stones and fragmentation after 3 months of follow-up or the nonreduction of the stone size after three sessions of ESWL [8,9].

RESULTS

Of the patients studied, 28 (50.9%) were found to have

TABLE 1. Characteristics of patients and treatment

Characteristic	≤7 y	>7 y	p-value
Age (y), mean (range)	2.69 (0.5–6.58)	13.0 (7.16–18)	
No.	24	31	0.71
Sex			
Boys	16	20	0.71
Girls	8	11	0.66
Stone side			
Right	12	16	0.45
Left	10	12	0.52
Bilateral	2	3	0.63
Stone size (mm), mean (range)	10.20 (4–20)	8.94 (4–22)	0.37
Stone site			
Renal	13	17	0.51
Pelvis (Staghorn)	1	1	0.39
Calyx	12	16	0.53
Ureter	11	14	0.57
Upper	6	8	0.53
Mid	1	1	0.32
Low	4	5	0.37
Anesthesia			
General	24	9	
Sedation	0	22	
Session of ESWL, mean	1.16	2.97	0.037[a]
		General anesthesia: 2.2	0.042[a]

ESWL, extracorporeal shock wave lithotripsy.
[a]:p-value of <0.05 was considered statistically significant.

right-kidney stones, 22 (40%) had left-kidney stones, and 5 (9.1%) had bilateral stones. There were 30 patients (54.5%) with renal stones (including two staghorn stones) and 25 (45.5%) with ureteral stones (upper, 14 patients; mid, 2 patients; lower, 9 patients). The mean size of the stones was 9.48 mm (range, 4–22 mm). The mean number of ESWL sessions was 2.02 (range, 1–10).

In the patient group aged 7 years or less, the mean number of ESWL sessions was 1.16 (range, 1–2), and in the patient group older than 7 years, it was 2.97 (range, 1–10). There was a statistically significant difference between the two groups (p=0.037). There was no statistically significant difference between the two groups, however, in urinary tract infection, stone size and location, or congenital renal abnormality. General anesthesia was required in all the patients aged 7 years or less and in nine patients older than 7 years (29.0%) owing to poor cooperation. The other patients did not need anesthesia. The mean number of ESWL sessions of the nine patients older than 7 years who received general anesthesia was 2.2. This result also showed a statistically significant difference from the younger patient group (p=0.042) (Table 1).

The overall success rate of ESWL was 90.9%. There was no statistically significant difference between the patient group aged 7 years or less and the patient group aged more than 7 years (91.7% vs. 90.3%). Complications developed after ESWL in three patients (5.5%), and two patients required intervention owing to steinstrasse. In the patient group older than 7 years, one patient had acute pyelonephritis. Two patients required intervention owing to steinstrasse, one in the younger group and one in the older group (Table 2).

DISCUSSION

After the initial report that a large series of ESWL in children had shown complications, safety and stone-free rates comparable to those in adults were reported in 1986 [2], and the safety and efficacy of ESWL have been shown in children [10,11]. Even though ESWL is widely accepted as a first-line treatment modality throughout the world, its role in the management of pediatric and adolescent patients has not been fully established.

The recent refinement of the endoscopic management of urinary stone disease almost enabled it to replace open surgery in children. Both ESWL and ureteroscopy had satisfactory curative effects in the treatment of pediatric ureteral stones [2,5,12]. Several authors have reported high success rates with ureteroscopy (80–100%) [13-15] or percutaneous management of urinary stones (79–88%) in children, with minimal morbidity [16,17]. Notwithstanding these reported good surgical outcomes, various surgically related concerns have to be considered. The dilation of the ureteral meatus with ureteroscopy in children may result in vesicoureteral reflux. In addition to this risk, urethral injury and stricture in males and ureteral damage in both sexes may develop postoperatively. Ureteroscopes less than 6.9 Fr in diameter have been used of late for the treatment of ureteral stones in children, without dilation of the ureteral meatus, but the technical requirement for ureteroscopy in children is much higher than in adults [12,18]. Thus, endourological management is generally reserved as an ancillary procedure for failed ESWL owing to its comparable success rate and higher safety profile.

In children, there is no consensus regarding which residual fragment sizes are considered clinically insignificant. Consequently, there is no clear definition of "stone-free status" [19,20]. ESWL success was defined in this study as a radiographically stone-free status with no infection at 3 months of follow-up.

In this study, the overall success rate was 90.9%, and the younger ($\leq$7 years) and older ($>$7 years) age groups showed similar results (91.7% and 90.3%, respectively). This result is comparable to the success rates reported by other ESWL series, with stone-free rates in children in the range of 75% to 98% [21-23].

Complications occurred in 3 patients (5.5%). One patient required hospitalization because of fever and flank pain. The patient was treated with intravenous hydration, antiemetics, analgesics, and antibiotics until pain-free and able to tolerate oral intake. Steinstrasse developed in two patients (3.6%), one in the younger age group (4.2%) and

TABLE 2. Overall success rate and complications

Variable	≤7 y	>7 y	Total	p-value
No.	24	31	55	0.66
Success rate	22 (91.7)	28 (90.3)	50/55 (90.9)	0.49
Failure rate	2 (8.3)	3 (9.7)	5/55 (9.1)	0.52
General complaint				
Hematuria	9 (37.5)	11 (35.5)	20 (36.3)	0.56
Flank pain	3 (12.5)	10 (32.3)	13 (23.6)	0.25
Fever	1 (4.2)	1 (3.2)	2 (3.6)	0.21
Complication				0.54
Acute pyelonephritis	0 (0)	1 (3.2)	1 (1.8)	
Steinstrasse stones	1 (4.2)	1 (3.2)	2 (3.6)	

Values are presented as number (%).

one in the older age group (3.2%). In the patient in the younger age group, the fragments passed spontaneously after decompression of the obstructed renal units by percutaneous nephrostomy. The other patient was treated with ureteroscopy and extraction of the leading stones. Other studies reported an incidence of steinstrasse of 6% to 20% after ESWL [24,25]. The data obtained in the present study are similar to those obtained in other studies. The general complaints were pain in the treated side (23.6%), hematuria (36.3%), and fever (3.6%). All the general complaints were well controlled by oral hydration and nonsteroidal anti-inflammatory drugs, without other complications.

Aydogdu et al. [26] compared adult and pediatric ureters in transporting fragments following ESWL and found better stone clearance by pediatric ureters. This outcome is probably due to the fact that shock waves are transmitted with little loss of energy through the small body volume in contrast with the long course that the wave has to travel in the adult body [27]. In fact, the pediatric ureter was more elastic and more distensible, which permitted easier passage of stone fragments and prevented ureteral impaction [28]. All patients in the present study appeared to tolerate the passage of stone fragments quite well. Interestingly, the mean number of ESWL sessions for the patient group aged 7 years or less was 1.16 (range, 1–2), whereas that for the patient group aged more than 7 years was 2.97 (range, 1–10). There was thus a statistically significant difference between the two groups (p=0.037). This result showed that the passing of stone fragments was easier in the younger patients, and that 7 years of age could be the cutoff at which the first-line treatment modality for pediatric and adolescent urolithiasis can be selected (Fig. 1).

Ever since ESWL was adopted for pediatric patients, several concerns have emerged. One is the concern about the damage to the reproductive organs in a pediatric patient subjected to ESWL for ureteral calculi. This has been disproven by most animal experiments that showed no long-lasting permanent damage on the female reproductive system [29]. Another concern is about renal scarring in children treated with ESWL for their renal stones. This concern was investigated by Fayad et al. [30] in a study involving 100 children with renal stones; the researchers reported that none of the patients in their study exhibited any degree of renal scarring in the dimercaptosuccinic acid scan or any decrease in split kidney function as evidenced by the glomerular filtration rate measurement in mL per minute by using diethylentriamene pertaacetate after shock wave lithotripsy.

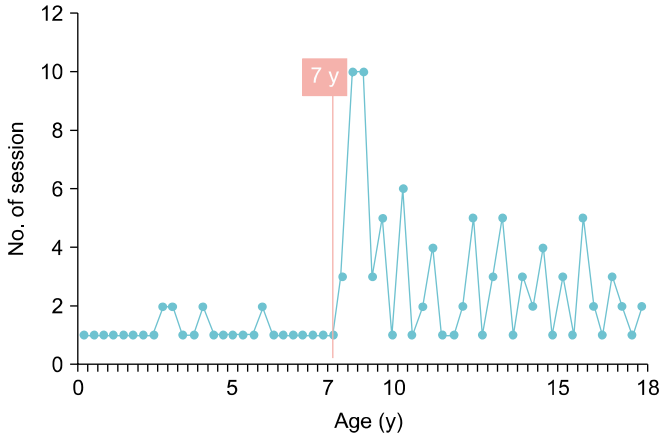

FIG. 1. The number of extracorporeal shock wave lithotripsy sessions according to age.

The last concern is the necessity of anesthesia. There is no agreement on the best anesthetic method to use during ESWL in pediatric patients, and numerous anesthetic methods have been used in children undergoing ESWL [27]. In the present study, general anesthesia was used for adequate ESWL for the patients who would not cooperate. All patients less than 7 years of age needed general anesthesia, and nine patients older than 7 years (29.0%) needed general anesthesia owing to poor cooperation. No significant anesthetic complications occurred.

Unfortunately, the present study had some limitations. First was the absence of chemical composition analysis. Depending on the patient's age, the chemical composition of the stone might be changed, which could affect the stone disintegration; however, such data were not integrated in this work. Carrying out chemical composition analysis will be very helpful for the treatment of pediatric urolithiasis. Second, the mechanical factor was not considered in the present study because the lithotripter was changed once during the study period. Last, the efficacy of ESWL was compared with that of endoscopic management indirectly on the basis of data obtained from the literature.

CONCLUSIONS

In the patient group aged 7 years or less, the number of ESWL sessions and the complication rate were comparable to those of endoscopic management. Thus, ESWL is an effective first-line treatment modality for patients aged less than 7 years.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

ACKNOWLEDGMENTS

This work was supported by the Dong-A University research fund.

REFERENCES

1. Chaussy C, Brendel W, Schmiedt E. Extracorporeally induced destruction of kidney stones by shock waves. Lancet 1980;2:1265-8.
2. Newman DM, Coury T, Lingeman JE, Mertz JH, Mosbaugh PG, Steele RE, et al. Extracorporeal shock wave lithotripsy experience in children. J Urol 1986;136(1 Pt 2):238-40.
3. 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.
4. Muslumanoglu AY, Tefekli A, Sarilar O, Binbay M, Altunrende F, Ozkuvanci U. Extracorporeal shock wave lithotripsy as first line treatment alternative for urinary tract stones in children: a large scale retrospective analysis. J Urol 2003;170(6 Pt 1):2405-8.
5. Aksoy Y, Ozbey I, Atmaca AF, Polat O. Extracorporeal shock wave lithotripsy in children: experience using a mpl-9000 lithotriptor. World J Urol 2004;22:115-9.
6. El-Nahas AR, Awad BA, El-Assmy AM, Abou El-Ghar ME, Eraky I, El-Kenawy MR, et al. Are there long-term effects of extracorporeal shockwave lithotripsy in paediatric patients? BJU Int 2013;111:666-71.
7. D'Addessi A, Bongiovanni L, Sasso F, Gulino G, Falabella R, Bassi P. Extracorporeal shockwave lithotripsy in pediatrics. J Endourol 2008;22:1-12.
8. 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.
9. Soygur T, Arikan N, Kilic O, Suer E. Extracorporeal shock wave lithotripsy in children: evaluation of the results considering the need for auxiliary procedures. J Pediatr Urol 2006;2:459-63.
10. Nazli O, Cal C, Ozyurt C, Gunaydin G, Cureklibatir I, Avcieri V, et al. Results of extracorporeal shock wave lithotripsy in the pediatric age group. Eur Urol 1998;33:333-6.
11. Turk TM, Jenkins AD. A comparison of ureteroscopy to in situ extracorporeal shock wave lithotripsy for the treatment of distal ureteral calculi. J Urol 1999;161:45-6.
12. al Busaidy SS, Prem AR, Medhat M. Paediatric ureteroscopy for ureteric calculi: a 4-year experience. Br J Urol 1997;80:797-801.
13. Yucel S, Akin Y, Kol A, Danisman A, Guntekin E. Experience on semirigid ureteroscopy and pneumatic lithotripsy in children at a single center. World J Urol 2011;29:719-23.
14. Dogan HS, Onal B, Satar N, Aygun C, Piskin M, Tanriverdi O, et al. Factors affecting complication rates of ureteroscopic lithotripsy in children: results of multi-institutional retrospective analysis by Pediatric Stone Disease Study Group of Turkish Pediatric Urology Society. J Urol 2011;186:1035-40.
15. Thomas JC. How effective is ureteroscopy in the treatment of pediatric stone disease? Urol Res 2010;38:333-5.
16. Kumar R, Anand A, Saxena V, Seth A, Dogra PN, Gupta NP. Safety and efficacy of PCNL for management of staghorn calculi in pediatric patients. J Pediatr Urol 2011;7:248-51.
17. Schuster TK, Smaldone MC, Averch TD, Ost MC. Percutaneous nephrolithotomy in children. J Endourol 2009;23:1699-705.
18. Lu J, Sun X, He L, Wang Y. Efficacy of extracorporeal shock wave lithotripsy for ureteral stones in children. Pediatr Surg Int 2009;25:1109-12.
19. Wu HY, Docimo SG. Surgical management of children with urolithiasis. Urol Clin North Am 2004;31:589-94.
20. Farhat WA, Kropp BP. Surgical treatment of pediatric urinary stones. AUA Update Series 2007;26:22-7.
21. Ehreth JT, Drach GW, Arnett ML, Barnett RB, Govan D, Lingeman J, et al. Extracorporeal shock wave lithotripsy: multicenter study of kidney and upper ureter versus middle and lower ureter treatments. J Urol 1994;152(5 Pt 1):1379-85.
22. Turunc T, Gonen M, Kuzgunbay B, Bilgilisoy UT, Dirim A, Tekin MI, et al. The effects of hydronephrosis and stone burden on success rates of shockwave lithotripsy in pediatric population. J Endourol 2010;24:1037-41.
23. Hammad FT, Kaya M, Kazim E. Pediatric extracorporeal shockwave lithotripsy: its efficiency at various locations in the upper tract. J Endourol 2009;23:229-35.
24. Fedullo LM, Pollack HM, Banner MP, Amendola MA, Van Arsdalen KN. The development of steinstrassen after ESWL: frequency, natural history, and radiologic management. AJR Am J Roentgenol 1988;151:1145-7.
25. Sayed MA, el-Taher AM, Aboul-Ella HA, Shaker SE. Steinstrasse after extracorporeal shockwave lithotripsy: aetiology, prevention and management. BJU Int 2001;88:675-8.
26. Aydogdu O, Burgu B, Gucuk A, Suer E, Soygur T. Effectiveness of doxazosin in treatment of distal ureteral stones in children. J Urol 2009;182:2880-4.
27. Vandeursen H, Devos P, Baert L. Electromagnetic extracorporeal shock wave lithotripsy in children. J Urol 1991;145:1229-31.
28. 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.
29. McCullough DL, Yeaman LD, Bo WJ, Assimos DG, Kroovand RL, Griffin AS, et al. Effects of shock waves on the rat ovary. J Urol 1989;141:666-9.
30. Fayad A, El-Sheikh MG, Abdelmohsen M, Abdelraouf H. Evaluation of renal function in children undergoing extracorporeal shock wave lithotripsy. J Urol 2010;184:1111-4.