

The Efficacy and Reliability of Extracorporeal Shockwave Lithotripsy (ESWL) nin Pediatric Urolithiasis: Our Clinical Experiences

Ramazan Altıntaş, Cemal Taşdemir, Fatih Oğuz, Ali Beytur, Serhan Çimen, Ali Güneş

İnönü University, School of Medicine, Department of Urology, Malatya, Turkey

Abstract

Objectives: As in adult patients, "Extracorporeal Shockwave Lithotripsy" treatment is a frequently used treatment in pediatrics. In this study, we retrospectively evaluated the results and the complications of ESWL treatment in children for renal and ureteral stones.

Material and Methods: In this study, we included the data of 282 pediatric patients that underwent ESWL using Stonelith PCK V-5 Lithotripter device for the treatment of renal and ureteral stones between January 1998 and February 2013. ESWL procedure is conducted in the supine position and with sessions of 20-45 mins. Each ESWL session exercised at least 2000 up to 3500 shock waves with 13 kV increasing up to 17 kV according to the severity of the case.

Results: The mean age of 105 girls and 177 boys was 10.41 (range: 1-17). The mean stone burden was 1.3 cm² (range: 0.5-5 cm²) (1.58 cm² for kidney stones and 1.02 cm² for ureteral stones) and a total of 392 ESWL sessions were performed. Fentanyl and/or ketamine sedo-analgesia were required in 204 patients. The complete stone free rate was 82.2 %. Hematuria, in 87 patients, and skin brushing, in 62, were the only minor complications. Ureterorenoscopy in 14 patients and percutaneous nephrolithotomy in 19 patients were performed as additional intervention for the treatment of the residual stones.

Conclusion: ESWL is a commonly used treatment method with low morbidity, applicability with minimal need for anesthesia, and high stone-free rate in the treatment of pediatric urolithiasis.

Key Words: Pediatric; Stone; ESWL.

Çocukluk Çağı Üriner Sistem Taş Hastalığında "Extracorporeal Shockwave Lithotripsy" (ESWL)'nin Etkinliği ve Güvenilirliği: Klinik Deneyimlerimiz

Özet

Amaç: Beden dışı şok dalgaları ile taş kırma (ESWL) tedavisi, erişkin hastalarda olduğu gibi çocuk yaş grubunda da son yıllarda sıkça uygulanan bir tedavi yöntemidir. Bu çalışmada kliniğimizde böbrek ve üreter taşları nedeniyle ESWL uygulanan çocuklarda tedavi sonuçlarını ve komplikasyonları retrospektif olarak değerlendirdik.

Gereç ve Yöntemler: Bu çalışmada Ocak 1998 ve Şubat 2013 arasında böbrek ve üreter taşlarının tedavisi için Stonelith PCK V-5 Lithotripter cihazı kullanılarak ESWL uygulanan 282 pediatik hastanın verileri değerlendirmeye alındı. ESWL işlemi supin pozisyonunda ve 20-45 dakikalık seanslar şeklinde yapıldı. Her ESWL seansında en az 2000 en fazla 3500 şok dalgası, 13 kV'dan başlayıp gereken hastalarda en fazla 17 kV olacak şekilde artırılarak uygulandı.

Bulgular: Yüzbeş kız ve 177 erkek hastanın ortalama yaşı 10,41 (1-17) yıl idi. Ortalama taş yükü 1,3 cm² (0,5-5 cm²) (böbrek taşları için 1,58 cm², üreter taşları için 1,02 cm²) olup toplam 392 seans ESWL uygulandı. İki yüz dört hastada fentanil ve/veya ketamin ile sedoanaljezi gerekti. Tam taşsızlık oranı % 82,2 olarak bulundu. Seksen yedi hastada hematüri, 62 hastada da deri ekimozları minor komplikasyon olarak görüldü. Kalan taşların tedavisi için ek girişim olarak 14 hastaya üreterorenoskopi ve 19 hastaya da perkütan nefrolitotomi uygulandı.

Sonuç: ESWL çocuk yaş grubundaki üriner sistem taş hastalığı tedavisinde düşük morbidite, minimal anestezi ile ayaktan günübirlik uygulanabilirliği ve yüksek taşsızlık oranı ile sıkça kullanılan bir tedavi yöntemidir.

Anahtar Kelimeler: Pediatrik; Taş; ESWL.

INTRODUCTION

Urinary tract stones detected in childhood constitute 1-5% of all urinary tract stone cases in developed countries, wherein this ratio reaches 30% in developing countries (1,2). In an epidemiological study conducted in Turkey, it has been found that this disease is endemic and that it is reported to be present in 17% of children under the age of 14 (3). Urinary tract stone disease identified in childhood is one of the most important reasons of end-stage renal disease, which often shows different epidemiological characteristics, and of renal transplantation and dialysis. Although there are many

alternative treatment methods in this age group, the use of minimally invasive methods has increased in the last 10 years and ESWL occupies an important place among these methods (4).

During the selection of treatment methods, the idea of ensuring stone clearance with the least morbidity and mortality rates is the most important issue to be taken into consideration (5,6). Through technological advances, invasive procedures such as open stone surgery are being replaced by the increasing use of minimally invasive methods like Extracorporeal Shock Wave Lithotripsy (ESWL), ureterorenoscopy (URS), and percutaneous nephrolithotomy (PNL).

Chaussy et al.'s application of ESWL in 1980 to break kidney stones in adult patients initiated the use of this method (7). It was Newman et al. who reported the successful application of the method on children in 1986 (8). From this date onwards, the method has become a preferred method in the treatment of pediatric stone diseases due to its accepted success rate, high reliability, and applicability with minimal morbidity rate (9,10,11).

Compared with adult patients, it is known to have higher rates of success in pediatric cases. This is explained by the high proportion of body water in pediatric patients, higher texture and elasticity, early diagnosis, and the fragility and size of stones in this age group (9). The fact that the risk of stone recurrence is higher in pediatric patients than in adults has made ESWL the first treatment option that comes to mind in this age group (12,13,14).

In our study, we evaluated the efficacy, safety, and possible complications of the ESWL applied to the patients admitted to our clinic because of urinary stone disease.

MATERIAL AND METHODS

Our study got the approval of the "Inonu University, Malatya Clinical Research Ethics Board" on 15.05.2013 with the protocol number 2013/44. We have retrospectively examined the records of ESWL application for renal and ureteral calculi on paediatric patients between January 1998 and February 2013. Throughout our study we applied ESWL to a total of 231 renal and 51 ureteral stones. With ages ranging from 1 to 17, 177 male and 105 female patients were included in the study. Patients with missing clinical information were excluded from the study. Patients with opaque urinary stones on plain radiographs were treated with Stonelith-V5 (PCK, Turkey) ESWL device.

Before the ESWL application and with the help of imaging methods such as urinary tract ultrasonography and intravenous pyelography (IVP), we checked with the appropriateness of the method along with the size of the stone in all patients using the following preliminary tests and methods: urinalysis and urine culture, serum urea, creatinine and electrolytes level test, complete blood count, and measurements for prothrombin and partial thromboplastin levels. Stone size was calculated by measuring the two longest axes and multiplying them by each other. In case of need, we also used computed tomography and/or renal scintigraphy. Patients with infection in their urinary cultures were treated with antibiotics in accordance with the culture antibiogram test results. Patients were treated with ESWL only after negative urine culture was obtained. We did not implement this method in patients with urinary obstruction in the distal of the stone, UP and UV stenosis, or less than 50% renal reserve and in cases with clinically uncontrollable urinary tract infection, coagulopathy, and non-opaque stones.

ESWL procedure is conducted in the supine position and with sessions of 20-45 mins. In patients under the

age of fifteen and to increase the treatment compliance and success of the process, an anaesthesiologist applied sedoanalgesia with fentanyl and/or ketamine. Each ESWL session exercised at least 2000 up to 3500 shock waves with 13 kV increasing up to 17 kV according to the severity of the case. The ESWL sessions were carried out in 10-14-day intervals and were limited to 4 sessions for kidney stones and to 3 for ureteral stones. The stones were checked by abdominal X-ray radiographs after each session and the ESWL sessions was repeated in cases necessary. At the end of the repeated sessions, unbroken stones and clinically significant residual fragments (≥ 4 mm) were considered as failures.

In the statistical analysis of the data obtained we used arithmetic mean values.

RESULTS

Of all the 282 patients with a mean age of 10.41 years, 231 (81.91%) had kidney stones while in 51 patients (18.09%) the stones were in the ureter. As seen in Table 1, kidney stones were located in the renal pelvis in 70 patients (30.30%), in the upper calyx in 41 (17.74%), in the middle calyx in 71 (30.73%), and in the lower calyx in 44 (19.04%) patients. In 5 patients (2.19%) kidney stones were identified in multiple locations. As shown in Table 2, ureteral stones were found in the upper ureter in 28 of our patients (54.90%), in the mid-ureter in 8 (15.68%), and in the lower ureter in 15 patients (29.42%).

Throughout the study, we applied ESWL to the stones in the right kidney in 117 patients while the method was administered to the stones in the left kidney in 114 patients. 28 of the patients were treated for right ureter stones, and 23 for left ureter stones. Of the 282 patients evaluated in the study, 177 (62.76%) were males and 105 (37.24%) were females. 62 of the children (21.98%) were 1-5 years old. 72 patients (25.53%) were between the ages of 6-10 while 78 (27.65%) were at the age of 11 to 15. The remaining 70 (24.84%) were 16 years or over. The increase in the application of ESWL in the past 10 years compared to previous years can be noted in Figure 1. The average stone burden for all patients was 1.3 cm² (0.5 to 5 cm²); this ratio was 1.58 cm² for the kidney stones while it was 1.02 cm² for ureteral stones. A total of 392 sessions of ESWL was performed on 282 patients (mean value 1.39). Of all the ESWL patients, 96 had already had ESWL sessions on the same side while 11 of these patients had also undergone surgical operations. 204 patients (72.34%) under the age of fifteen were administered sedo-analgesia with fentanyl and/or ketamine by an anaesthesiologist during the ESWL session; the rest 78 patients (27.66%) over the age of fifteen were given intramuscular analgesics.

The ESWL application enabled total stone clearance in 57 (81.4%) patients with renal pelvis stones, 35 (85.3%) patients with upper pole stones, 54 (76%) patients with middle pole stones, and in 38 (86.3%) patients with lower pole stones; in the end, a total of 184 (79.6%) patients had complete stone clearance. The success rate of ureteral calculi removal in the upper ureter was

96.4%; the rate was 100% and 86.6% for the middle and lower ureteral stones, respectively. The overall success rate for ureteral stones was 94.1%. The overall success rate of ESWL treatment was 82.26% (232 of 282 of patients). We needed to implement PNL in 5 of the 13 renal pelvis cases, 7 of the 17 middle calyx stone cases, 2 of the 6 lower calyx stone patients, and all 5 of the multiply localised stone patients. In addition, for 14 patients with further ureteral stones, who failed to pass

the stones (kidney stones in 11, and ureteral stones in 3; and in 3 of these patients, we observed stone path formations) 14 days after the ESWL treatment, we felt the need to apply URS. No double-j catheter placement was administered in any patient prior to the ESWL session while the catheter was placed in all patients following the URS. Untreated patients were called for evaluation for further sessions though they did not turn up.

Table 1. The number of kidney stones, their sizes, localisations, and success rates of the treatment.

	Renal pelvis	Upper calyx	Middle calyx	Lower calyx	Multiple calyces	Total
Number of patients n (%)	70 (30,30)	41 (17,74)	71 (30,73)	44 (19,04)	5 (2,19)	231 (100)
Mean Age	9,31	10,97	10,43	11,03	11,60	10,33
Gender distribution n (%)						
Female	23 (28,39)	11 (13,58)	31 (38,27)	16 (19,76)	0 (0)	81 (100)
Male	47 (31,33)	30 (20)	40 (26,66)	28 (18,66)	5 (3,35)	150 (100)
Average stone burden (cm ²)	1,03	1,06	1,02	1	3,8	1,58
Average number of sessions	1,40	1,46	1,39	1,29	3,2	1,74
Success Rate n (%)	57 (81,4)	35 (85,3)	54 (76)	38 (86,3)	0 (0)	184 (79,6)
Additional intervention	3 URS 5 PNL	3 URS	4 URS 7 PNL	1 URS 2 PNL	5 PNL	11 URS 19 PNL

Table 2. The number of ureteral stones, their sizes, localisations, and success rates of the treatment.

	Upper ureter	Middle ureter	Lower ureter	Total
Number of patients n (%)	28 (54,90)	8 (15,68)	15 (29,42)	51 (100)
Mean Age	11,35	10,62	9,86	10,8
Gender distribution n (%)				
Females	12 (50)	3 (12,5)	9 (37,50)	24 (100)
Males	16 (59,25)	5 (18,51)	6 (22,24)	27 (100)
Average stone burden (cm ²)	1,27	0,81	0,99	1,02
Average number of sessions	1,17	1,25	1,26	1,22
Success rates n (%)	27 (96,4)	8 (100)	13 (86,6)	48 (94,1)
Additional intervention	3 URS		2 URS	3 URS

Table 3. ESWL series applied to children.

Author	Number of patients	Stone-free Success Rate
Newman (8)	15	%93
Tan (19)	85	%85
Aksoy (9)	129	%89
Müslümanoğlu (22)	344	%79,9
Demirkesen (10)	126	%71,5

After the ESWL treatment 4 patients (1.41%) developed febrile urinary tract infection that required hospitalisation. Other patients were discharged the same day after a 2-4 hour follow-up. Three patients (1.06%) had fever that did not exceed twenty-four hours. The minor complications we came across were as follows: 87 patients (30.85%) had hematuria, 62 (21.98%) had skin ecchymosis but were healed spontaneously, and 59 (20.92%) showed colic pain that required the use of analgesics.

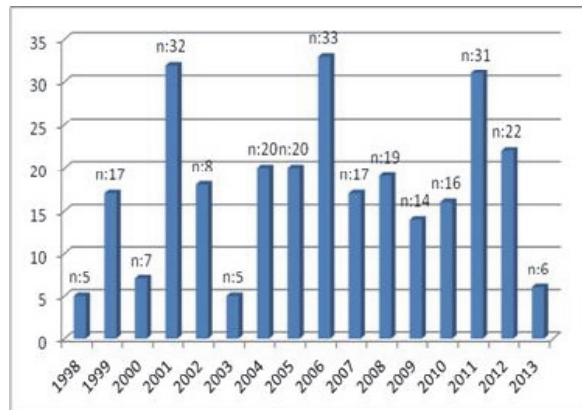


Figure 1. The distribution of pediatric patients with ureteral stones treated with ESWL in our clinic in years.

DISCUSSION

Nowadays, there are many lithotripter devices used in the treatment of urinary tract stones. This abundance has brought the fragmentation of opaque as well as non-opaque stones (15). All of these devices are made of an energy supply to create shock waves, a coupling mechanism to transmit this energy into the body, and a fluoroscopic and/or ultrasonic focusing system to focus the waves on stones (16). The working principle of this device is based on the idea of transmitting the energy produced by a source, aiming it on the stone, and breaking the stone into pieces with the shock waves so as to make it small enough to pass spontaneously. In our study, we made use of Stonelith-V5 (PCK, Turkey) electro-hydraulic lithotripter device that only had

fluoroscopic focusing system to fragment opaque stones only.

Despite the growing experience and many published studies, treatment guidelines for ESWL in children is not yet fully established (17,18,19,20). The necessity of ureteral stent before ESWL is still debated. Some authors state that, despite the small diameter of the ureter in children, the transition of ureteral stone particles is easier in children than in adults due to the flexible structure of the ureter in children, and that the placement of an ureteral stent would make the flow of urine more difficult (18, 20). They also argue that the implementation of the ureteral stent increases morbidity (as an additional surgical intervention under anaesthesia), causes discomfort, frequent urination, and, thus they do not recommend the routine use of the stent in ESWL treatment in children (18,21). On the other hand, in cases where a higher stone burden is at hand or in the presence of a solitary kidney, the use of stents is recommended because, in such cases, it is difficult to focus due to the anatomical abnormalities or the presence of radiolucent stones (3,12,19,22). Throughout the ESWL procedure, we did not need to use any stents though we did use ureteral stenting during the URS process to eliminate the urinary obstruction caused by the stones that did not pass after the treatment.

Using ESWL in the treatment of renal and ureteral calculi in children is successfully applied and the success rate of the method in the literature is between 68% and 97.6%. Some of the ESWL series implemented in children in the literature are provided in Table 3 (3,7,12,13,22). The overall rate of stone-free cases in our series was, consistent with the literature, 82.2%. The localisation of stones in the ureteral and calyx is among the factors affecting the success of the ESWL. In their study, Demirkesen et al. have found the success rates to be 62% for the lower calyx, 65.3% for the middle/upper calyx, and 80% for the renal pelvic stones (10). Yoon et al., in their ESWL series for 142 stones in the calyx in 117 patients, has reported the following success rates: 88.5% (46/52) in the upper calyx, 90.9% (10/11) in the middle calyx, and 74.7% (59/79) in the lower calyx (23). Regardless of the size, Gunes et al.'s study reveals the success rates as follows: 52.9% in the lower calyx, 71.4% in the middle calyx, and 76.1% in the upper calyx, and 84.8% for the pelvic stones (24). In our series, the ESWL treatment gave the following results: a success rate of 57 (81.4%) in the renal pelvis stones, 35 (85.3%) in the upper pole, 54 (76%) in the middle pole, and 38 (86%) in the lower pole stones (Table 1-2). Another factor affecting the success of ESWL is the size of stones (10,21). In our series, too, the failure rate has increased in the cases with stones bigger than 2 cm² and/or multiply localised stones.

In Salvatore et al.'s study of ESWL treatment, at the follow-up after 3 months, the success rate was 84% for the upper ureter, 80.4% for the mid-ureter, and 83.3% for the lower ureter, respectively (25). In a series of 189 patients, Gnasnapragasam et al.'s success rates according to the localisation were 90%, 89%, and 86%

for the upper, middle, and lower ureter, respectively (26). In our study, the same rates were reported to be 96.4%, 100%, and 86.6% for the upper, middle, and lower ureter, respectively. In other studies performed in Turkey, the success rates of URS treatment of lower ureteral stones vary between 75.7% and 98% (27). Similar success rates of URS and ESWL, a less invasive method in paediatric patients, adds to ESWL's popularity among doctors. Myers et al. have reported only one major complication, septicaemia, in their study of 446 patients with ESWL method (28). Moreno et al. reported hematuria in all the children in their study along with renal colic and fever ($\geq 38^{\circ}\text{C}$) with an incidence rate of 21.4% (29). In our study, 30.85% of our patients had hematuria while 1.41% of our patients had febrile urinary tract infection requiring hospitalization and parenteral treatment. We also observed renal colic in 20.92% of the patients. There are no reports in the literature with life-threatening acute kidney injury or mortality associated with the ESWL application. The stone path development incidence rate in the ureter after the ESWL application, on the other hand, is reported as 6-20% (30,31). The stone path development rate in our study was 1.06%.

In paediatric ESWL series, a variety of techniques have been used ranging from intravenous sedation to general anaesthesia (32). Although it is stated that general anaesthesia should be preferred in the ESWL procedure in children under 10 years with neurological diseases or mobilisation issues, some other studies argue that intravenous and/or neuroleptic anaesthesia is also sufficient in such cases (17). We adapted sedo-analgesia as the anaesthesia method during the ESWL administration in 204 (72.34%) patients at the age of 15 or below; for the rest, we applied intramuscular analgesia.

The ≥ 4 mm residual stone fragments in adult patients after the ESWL are usually regarded as clinically insignificant residual fragments (CIRFU) but this definition does not always apply to paediatric patients. Because the risk of stone recurrence in children is bigger than it is in adults and these residual particles carry more risk for the formation of new stones for children. After a two-year follow-up, Afshar et al.'s series shows that the incidence of residual fragments in children has grown by 34.5% which in turn signifies that CIRFU may lead to clinically significant morbidity (33). Keeping this point in mind, especially children with metabolic or anatomical disorders should be closely monitored and given medical treatment. Patients with stones are evaluated periodically with DUSG and USG throughout our study to check for new stone formation. In addition, we would also like to emphasise that we only considered stone-free patients as successful cases and regarded the CIRF cases as failures.

Due to its low morbidity rate, high incidence rate for stone-free results, its applicability and practicality with minimal anaesthesia, and low complication rate compared with other surgical procedures, ESWL is a safe method to treat urinary tract stone diseases for pediatric

age group. It should be kept in mind that the most important factor determining the safety and efficacy of the treatment is to apply the treatment within the appropriate indications.

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Correspondence/İletişim

Ramazan ALTINTAŞ
İnönü University, School of Medicine, Department of
Urology, MALATYA, TURKEY
E-mail: ramazan.altintas@inonu.edu.tr

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