



Extracorporeal shock wave lithotripsy for the treatment of urinary lithiasis in children

Litotricia extracorpórea para el tratamiento de la litiasis urinaria en el niño

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Abstract

Introduction: Extracorporeal shock wave lithotripsy (ESWL) is an option for the treatment of urinary lithiasis.

Objective: To describe the outcomes of ESWL for the treatment of urinary lithiasis in children.

Methods: A descriptive and retrospective study of 51 patients with urinary lithiasis that underwent ESWL from 2014 to 2019.

Results: Males and 15–18-year-old patients prevailed; 27.4% had prior surgery; 10-20 mm lithiasis of renal location and density between 400-799 HU were the most common; a double J stent was the most utilized urinary derivation prior to lithotripsy treatment; 7.8% required retreatment; 13.7% additional interventions; the stone-free rate was 74.5% at one month and 92.2% at three months. The size of the lithiasis was associated with the success of the treatment ($p < 0.023$). The most frequent complication was steinstrasse; endourologic procedures were the most utilized, grade III b (Clavien-Dindo) prevailed and were associated to older patients ($p = 0.04$), renal lithiasis localization ($p = 0.017$), larger size ($p = 0.08$), and density ($p = 0.036$).

Conclusions: ESWL is effective and safe for treating urinary lithiasis in children. Its success was significantly associated to smaller stone size and its complications to patients of older age, larger stone size, density and renal localization of the lithiasis.

Key words:

Lithiasis; Child; Pediatrics; Lithotripsy

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Resumen

Introducción: La litotricia extracorpórea (LEOC) es una opción para el tratamiento de la litiasis urinaria.

Objetivo: Describir los resultados de la LEOC para el tratamiento de la litiasis urinaria en el niño.

Metodología: Estudio descriptivo y retrospectivo en 51 pacientes con litiasis urinaria que recibieron LEOC, entre 2014-2019.

Resultados: Predominó el sexo masculino y los pacientes entre 15-18 años; el 27.4% tenían cirugía previa; predominaron las litiasis entre 10-20 mm; de localización renal y con densidades entre 400-799 UH; el cateterismo con doble J fue la derivación urinaria más empleada previa al tratamiento con litotricia; el 7.8% requirió retratamiento; el 13.7% intervenciones adicionales; el 74.5% resultó libre de litiasis al mes y el 92.2% a los 3 meses. El tamaño de la litiasis se asoció con el éxito del tratamiento ($p<0.023$). La complicación más frecuente fue la calle litíásica; los procedimientos endourológicos fueron los más utilizados para su tratamiento, predominaron las complicaciones de gravedad IIIb (Clavien-Dindo) y se asociaron a mayor edad del paciente ($p=0.04$), localización renal de la litiasis ($p=0.017$), su mayor tamaño ($p=0.08$) y densidad ($p=0.036$).

Conclusiones: La LEOC para el tratamiento de la litiasis urinaria en el niño es eficaz y segura. Su éxito se asoció, significativamente, al menor tamaño de la litiasis; y las complicaciones al incremento de la edad de los pacientes, el mayor tamaño y la densidad de la litiasis, así como su localización renal.

Palabras clave:

Litiasis, Niño, Pediatría,
Litotricia

Introduction

Urinary lithiasis is considered a disease with a high prevalence worldwide; its incidence differs from one geographic region to another, representing 4-8% of the causes of terminal chronic renal disease, especially, when it has not been properly treated. In the past years, the incidence has increased, especially in developing countries. Urinary lithiasis has also increased in children, and, although there is no definite explanation, an increase in the in-

cidence of metabolic origin, and a decrease of infectious origin has been identified.^(1,2)

Urinary lithiasis in children affects the complete age range. There are reports in newborns, but its highest incidence is between 7-8-year-old children. Recurrence in the pediatric patient is estimated between 24-50%, especially in patients suffering from a metabolic disorder. Eighty percent of urinary lithiasis in a child is passed spontaneously or with me-

dical treatment, the rest of the patients require some type of intervention.⁽³⁾

With the introduction and development of new technologies, the treatment of urinary lithiasis in children has changed in the past 30 years. Extracorporeal shock wave lithotripsy (ESWL), endourologic procedures, such as percutaneous nephrolithotomy (PNL), ureteroscopy (URS), retrograde intrarenal surgery (RIRS), and laparoscopic surgery are among the therapeutic options.

ESWL plays the most important role in the treatment of urinary lithiasis in children. It is considered a safe technique, and complications and the need for additional surgical retreatments are infrequent, and not linked to loss of renal function or the formation of renal scars.⁽⁴⁾

Currently, it is considered the treatment of choice or first line treatment for pediatric patients with uncomplicated lithiasis ≤ 20 mm, of the upper urinary tract, with successful percentages as a monotherapy, fluctuating between 68-92%, which is higher than in adult patients.⁽⁵⁻⁷⁾

In 1986, with the acquisition of the first HM3 Donier lithotripter and the training on its operation, ESWL was introduced in Cuba for the treatment of renoureteral lithiasis in adults, and months later, in pediatric patients.

The aim of this research is to describe the outcomes of ESWL for the treatment of urinary lithiasis in pediatric patients.

Methods

A descriptive, longitudinal and retrospective study of a series of 51 pediatric patients. The patients were diagnosed with urinary lithiasis and treated with ESWL in the Department of

Urology at the Centro Havana Pediatric Hospital (CHPH), between January 2014 and December 2019.

The patients were assessed with preoperative blood tests, urine culture, abdominal ultrasound (US), abdominal X-ray and no contrast CT scan. Patients with obstructive and impacted (for six weeks or more) lithiasis underwent dynamic renal Gammagram with MAG-3, to assess renal unit function.

Patients with recurrent urinary infection and/or asymptomatic bacteriuria received antibiotic treatment based on the sensitivity of the isolated germ in the urine culture, until the culture was negative. All patients received prophylactic antibiotic treatment with Cefazolin.

Patients with obstructive lithiasis ≥ 6 weeks, or with nephritic colic refractory to medical treatment (febrile or not), underwent urinary derivation with a double J stent, prior to ESWL. Percutaneous nephrostomy was performed on patients with obstruction and infection.

ESWL was performed under sedation or intravenous anesthesia, according to age and cooperation of the patient, in a supine decubitus position.

The Karl Storz MODULITH SLX-F2 extracorporeal lithotripsy equipment, with a calculus focalization system by fluoroscopy was used. The procedure began with energy from 2-3 Joules, increasing, progressively, without exceeding 6 Joules. No more than 2000 waves per session were applied for renal stones, and no more than 3000 waves for ureteral stones. The frequency utilized was 60 waves/minute.

The patients were assessed by abdominal US and abdominal X-ray, the day after ESWL. Patients with evidence of proper fragmentation, passing of fragments, who were asymptomatic and with no complications, were

discharged during the first 24 hours. Patients with symptoms or clinical signs, and/or radiological findings of complications, were kept in hospital and consequently underwent endourologic procedures and/or medical treatment. After discharge, the patients were assessed at one week, one month and three months, with US, urine culture and abdominal no contrast CT scan. Residual fragments were considered when ≥ 4 mm at three months, and the need for retreatment was evaluated.

The studied variables were: age, sex, prior surgery for lithiasis, size of lithiasis, location, density (HU), side, length of hospital stay, urinary derivation prior to ESWL, a stone-free rate at one month and at 3 months (considered as successful ESWL), the need for retreatment, additional interventions, complications, treatment of complications, and severity according to the Clavien-Dindo classification.

A database was created in Microsoft Excel, and the SPSS program, version 23.0, was used to process the data. Absolute frequencies and percentages were utilized for qualitative variables,

and mean, standard deviation and rate were calculated for quantitative variables. A univariate analysis was made to find the association of the lithiasis-free condition at three months and complications with other variables by Ji square (X²), Fisher's exact test, and Student's t test, with a significance level of $p \leq 0.05$.

Results

Male patients prevailed (58.8%), and ages between 15-18 years (56.9%). The mean age was 14.1 years. Twenty-seven point four percent of the patients had a past history of other surgeries to treat urinary lithiasis. ESWL and open surgery prevailed.

The mean size of the stone was 15.45 mm, lithiasis between 10-20 mm prevailed (86.3%). Renal location was the most frequent (62.7 %). Nine point eight percent were bilateral. The mean density was 681.98 HU, and lithiasis with densities between 400-799 HU (52.9 %) prevailed. Table 1.

Table 1. Characteristics of the series

Variables	Outcomes	
	Mean	SD
Age (years)	14.1	± 3.48
Size (mm)	15.45	± 6.4
Density (HU)	681.98	± 306.7
	No	%
Males	30	58.9
Comorbidities	34	66.7
Prior surgery for lithiasis	14	
ESWL	8	
Open surgery	8	15.7
Renal location	32	62.7
Right/Left side	22/24	43.1/47.1
Bilateral	5	9.8

The mean length of hospital stay was 3.33 days (± 2.196). Twenty-nine point four percent of the patients required urinary derivation prior to ESWL, and ureteral catheterization with a double J stent was the most frequently performed (21.6%). A patient with nephritic colic refractory to medical treatment and dilatation of the excretory system had stones wedged into the bifurcation of a ureter in Y. Consequently, the placement of a double J stent was technically impossible, thus a simple catheter was placed the day before ESWL and removed the day after the procedure. Seven point eight percent of the patients required retreatment. Additional interventions were performed in 13.7% of the patients, ureteroscopy being the most frequent (9.8%). A mentally retarded patient had a lithiasic fragment impacted in the

prostatic urethra and required cystoscopy for its removal.

One month after ESWL, the stone-free rate was 74.5%, reaching 92.2% after three months.

There were complications in 12 patients (23.5%). One patient presented two complications (renal hematoma and urinary infection). Steinstrasse (SS) was the most frequent complication (17.6%). Thirteen point seven percent of the patients were treated by endourologic procedures. Six required endourologic procedures (46.2%), out of the nine patients that presented SS. Grade III-b complications prevailed (13.7%). Nine point eight percent only required antibiotics and/or treatment with alpha-blockers (grade II). There was no grade IV or V complications. Table 2.

Table 2. Perioperative outcomes of ESWL in Pediatric Patients

Variables	Outcomes	
	Mean	SD
Length of hospital stay (days)	3.33	± 2.196
	No	%
Prior urinary derivation	15	29.4
• Double J stent	11	21.6
• PCN	3	5.9
• Simple stent	1	2.0
Retreatment	4	7.8
Additional interventions	7	13.7
• URS	5	9.8
Stone free rate (one month)	38	74.5
Stone free rate (3 months) (success)	47	92.2
Complications	12	23.5
• steinstrasse	9	17.6
Treatment of complications		
• Medical	5	9.8
• Endourologic	7	13.7
Grade of Severity (Clavien Dindo)		
• Minor (Grade I/II)	5	9.8
• Major (Grade III b)	7	13.7

Complications were similar for both sexes ($p=0.351$). The mean age for patients with complications (15.92 years) was significantly higher ($p=0.004$). No relation between prior surgery for lithiasis and the presence of complications ($p=0.087$) was observed. Most patients (58.3%) with complications had no urinary derivation at the time of ESWL ($p=0.237$).

A smaller size of the stone was significantly associated to a higher stone-free rate (success) ($p=0.023$). Other variables did not show a significant statistical relation with the success of ESWL in children ($p \geq 0.005$). Table 3.

Table 3. Association between the success of ESWL and other variables

Variables	Stone-free (n=47)		Residual Lithiasis (n=4)		P
	No.	%	No.	%	
Sex					
Male	29	61.7	1	25.0	0.184
Female	18	38.3	3	75.0	
	Mean	SD	Mean	SD	
Age	14.32	3.539	12.50	2.380	0.320
Comorbidities					
No	16	34.0	1	25.0	0.593
Yes	31	66.0	3	75.0	
Prior surgery for lithiasis					
No	34	72.3	3	75.0	0.700
Yes	13	2.7	1	25.0	
Prior Urinary Derivation					
No	32	68.1	4	100.0	0.236
Yes	15	31.9	0	0.0	
Size	Mean	SD	Mean	SD	
	14.90	4.799	22.0	13.952	0.023
Density	Mean	SD	Mean	SD	
	677.08	308.905	739.50	310.673	0.700
Location					
Renal	28	54.9	4	7.9	0.017
Ureter	19	40.4	0	0	

The complications of ESWL were significantly higher for larger size and greater density of stone ($p=0.008$ and $p=0.036$, respectively). Ureteral location of the stone was also significantly related to a higher percentage of complications ($p=0.017$), whereas other variables did not show that association ($p \geq 0.05$) (Table 4).

Table 4. Association between complications of ESWL and other variables

Variables	No complications (n=39)		Complications (n=12)		p	
	No.	%	No.	%		
Sex						
Male	24	61.5	6	50.0	0.351	
Female	15	38.5	6	50.0		
		Mean	SD	Mean	SD	
Age	13.64	3.745	15.92	1.505	0.004	
Comorbidities	No.	%	No.	%		
No	14	35.9	3	25.0	0.371	
Yes	25	64.1	9	75.0		
Prior surgery for lithiasis	No.	%	No.	%		
No	26	66.7	11	91.7	0.087	
Yes	13	33.3	1	8.3		
Prior urinary derivation	No.	%	No.	%		
No	29	74.4	7	58.3	0.237	
Yes	10	25.6	5	41.7		
Size	Mean	SD	Mean	SD		
	13.70	4.087	21.17	7.882	0.008	
Density	Mean	SD	Mean	SD		
	632.38	302.497	843.167	271.104		
Location	No.	%	No.	%		
Renal	26	51	6	11.8	0.017	
Ureter	13	33.3	6	50.0		

Discussion

The results of this investigation correspond with those of other authors who report in their series a mean stone size that fluctuates between 10-18 mm.^(8,9)

The mean size of the lithiasis treated in this study was approximately 15 mm and the lithiasis-free results were satisfactory and comparable to those reported by other authors who inform excellent fragmentation and discharge

of the fragments in 93.8% of the patients for similar size lithiasis.⁽¹⁰⁾

Several factors influence the outcome of ESWL, especially those related with the characteristics of the lithiasis, such as size, location, composition and density. In our institution we consider that ESWL is the technique of choice for stones smaller than 2 cm. Other authors prefer percutaneous renal surgery for renal and

high ureteral stones of more than 2 cm, because they are more successful, and complications are less frequent, thus, ESWL is selected only for smaller stones.⁽¹¹⁻¹⁴⁾

Renal localization of the lithiasis was the most frequent in this series, as other papers report, while in other series those of distal or proximal ureteral localization.⁽¹⁵⁻¹⁸⁾

We order ESWL in the child when the lithiasis is located in the inferior pole and is <1 cm just as reported by McAdams & Shukla,⁽¹⁹⁾ while avoiding ESWL for stones in the middle and distal ureter because of difficulties locating them in the sacroiliac joint and to avoid possible injury to the developing organs of the reproductive system. Regarding side, reports are variable, in this series there was a prevalence of the right urinary tract.^(14,18)

Yazici *et al.*⁽¹⁸⁾ reported 745 HU (± 303) as the mean density of the stones. Nevertheless, Alsagheer *et al.*⁽¹⁴⁾ reported a mean density of 602 (± 204). Similar results were obtained in this study.

ESWL is the least invasive method for the treatment of urinary lithiasis in children, usually accompanied by a short hospital stay, and in some centers, it is even performed as an ambulatory procedure with short operative time. Several authors have reported a mean hospital stay of 2.3 days and 2-6 days rate. Similar results were found in the present study, but we do not apply ambulatory ESWL in children because being a national reference center we receive patients from afar and thus prefer admitting them for at least 24 hours.^(11,20,21)

In the current study we observed a greater use of previous urinary derivation compared to reports from other authors. The patients had had nephritic colic refractory to medical treatment or obstructive lithiasis that could not

have immediate ESWL treatment. The need for urinary derivation prior to ESWL is still controversial. Those who defended utilizing ureteral catheters or percutaneous nephrostomy previously, relate this to low frequency of complications, but have not demonstrated that it improves the lithiasis-free index. Indications for performing prior urinary derivation are patients with a single kidney, large lithiasic masses, obstructive stones and anatomic alterations of the urinary tract. The most utilized derivation is the double J stent. The utilization of percutaneous nephrostomy is reported in patients with obstruction of the urinary tract associated to infection.^(1,4,7)

Retreatment in pediatric patients is controversial due to the need for anesthesia to perform the procedure; moreover, the effect of the shock waves on the renal tissue is still not clear. However, a retreatment frequency between 22% and 49% is reported, whereas others report lower retreatment frequencies.^(8,12,15,17)

The need for ESWL retreatment in this series was less than that reported by other authors. ESWL, compared with other surgical techniques such as PNL and RIRS, report a higher frequency of retreatment, greater need for auxiliary procedures and a lower index of lithiasis-free condition. Retreatment can be necessary in cases of residual fragments >4mm. A maximum of three sessions are recommended. When the proper fragmentation of the stone is not achieved, other types of treatments should be considered, such as PNL.⁽²⁰⁻²²⁾

URS was the most frequent treatment utilized for complications in this series. Other additional interventions are performed after ESWL to treat complications or residual fragments; these procedures include PCN, PNL, RIRS, and ureteral catheterization, even open surgery. Al-

though the child's ureter is capable of passing the fragments after ESWL, thus an expectant conduct in these ages is suitable, even, in patients that develop *steinstrasse*. Additional interventions can reach up to 15.3%.^(8,18,23)

The rates of stone free after ESWL in children are considered higher than in adults and vary between 68-92%, as a result of presenting smaller and less consistent stones; they have less body volume which facilitates the transmission of the shock waves with a minimum loss of energy, greater peristalsis and distension of the ureter which facilitates passing the fragments.^(5-7,13)

In the current investigation the percentage of stone free patients was high just as other authors reported. However, there are authors that report lower success indexes after the first session of ESWL.^(11,14,15,24)

Several factors affect the success of ESWL; they include anatomic aspects of the collecting system, the age of the patient, and characteristics of the lithiasis, such as: composition, radiopacity, size, and location in the collecting system.⁽¹⁶⁾

The present study only confirmed the association of the success of ESWL with the size of the stone. Meanwhile, other authors have demonstrated that lithiasis of lower density or equal to 600 HU and ≤ 12 mm in size are independent predictors of successful ESWL in children.^(7,25)

Alsagheer *et al.*⁽¹⁴⁾ found in a multivariate analysis that only the age of the patient was an independent factor predictor of success. Garrido *et al.*⁽²⁶⁾ demonstrated the significant relation between lithiasis-free rate and size, volume, and density of the lithiasis, besides the skin-stone distance and the body mass index. In a Cochrane revision, Srisubat *et al.*⁽²¹⁾ observed

an ESWL success rate between 32%-65% that was directly proportional to the size of the stone and its location. Shouman *et al.*⁽¹⁰⁾ found that the frequency of stone free condition decreases and residual fragments that require treatment increases. In the multivariate analysis, age (≤ 16 months) and a single stone lithiasis resulted predictive factors for the success of ESWL.⁽¹⁵⁾

There are several studies that show a significant relation between the size of the lithiasis (< 1 cm) and the success of ESWL.^(7,11,24,27)

The frequency of complications in the present investigation is slightly higher than that reported by other authors. However, grade IIIb complications prevailed in this study, because *steinstrasse* was the most frequent complication, resolved with endourologic techniques that require general anesthesia in pediatric patients.

Complications of ESWL in a child have a low frequency, which can be between 7-18%. The most frequent ones are minor (Grade I and II Clavien Dindo), such as: hematuria, nephritic colic, temporary fever, and urinary infection, which resolve with conservative treatment; SS and subcapsular renal hematoma can also appear. Other authors found lower frequencies of complications (5%).^(17,23,28)

When proper focalization is not achieved applying shock waves, uncommon complications can appear, such as: colon perforation, rupture of the hepatic artery, hepatic hematoma, pneumothorax, rupture of the spleen, necrotizing acute pancreatitis and rupture of the abdominal aorta. These complications are usually acute without long-term effects. To avoid them, the urologist should be vigilant for their appearance, and should be careful with the focalization of the stone during the procedure.⁽²²⁾

Regarding the severity of the complications, the authors that use the Clavien Dindo classification found that grade I and II were the most frequent.⁽⁹⁾

In this series, complications were associated to larger size and density of the lithiasis, as well as renal localization. Factors such as size, composition, and location of the stone, as well as anatomic issues of the urinary tract, and type of lithotripter utilized, are related with the presence of ESWL complications in children.^(24,26,27)

Conclusions

ESWL is efficient and safe in pediatric patients. Its success was significantly associated to smaller stone size of the lithiasis, and complications associated to older patients, larger stone size, density, and renal location of the lithiasis.

CRedit Taxonomy

Yalaisy Rodríguez Gómez, MD: conceptualization, data organization, formal analysis, investigation, methodology, writing

Tania González León, MD: conceptualization, data organization, supervision, formal analysis, edition

María Victoria Labrada, MD: data organization, formal analysis, methodology

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Conflict of interest

The authors declare no conflicts of interest.

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