

Original Research Article

Analysis of extracorporeal shock-wave lithotripsy in renal calcular disease among children: a tertiary care experience

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ABSTRACT

Background: The aim of this study is to review 10 years of extracorporeal shock wave lithotripsy (ESWL) experience in paediatric urolithiasis patients.

Methods: Data from a cohort of paediatric urolithiasis patients who underwent shock wave lithotripsy between 2012 and 2019 at department of urology, Indraprastha Apollo, New Delhi were used in a single-centre, retrospective comparative study. During a seven-year period, 250 paediatric patients (Male/female: 134/116, mean age: 10.22 years, range: 1-18) had 284 shock wave sessions in our hospital, with 208 having primary and 42 having recurrent urolithiasis. A total of 328 stones were discovered, with 192 (58.5%) in boys and 136 (41.5%) in girls. For ample stone fragmentation, one session of 200 to 3000 shockwave impulses was required, though some patients required more than 8000 impulses over 4 sessions. However, in most patients, low-energy shockwaves with a frequency of 1-2 were used to fragment the stones.

Results: Younger age was associated with quicker stone clearance in our study, which was likely due to shorter urinary tracts and a smaller "barrier" between the device and the stone. Furthermore, children who had renal colic prior to lithotripsy had a considerably lower chance of removing stones within two days than those who did not. This can be explained by the colic's underlying mechanism, which evolves against the backdrop of ureteric wall spasm. Mild macrohematuria and "steinstrasse" were identified in almost all patients during the first post-lithotripsy days, as predicted during the post-op course. There were no major obstructive, infectious, or other severe complications.

Conclusions: Extracorporeal shock wave lithotripsy proved to be a safe and highly effective minimally invasive treatment of children with kidney stone disease.

Keywords: Paediatric, Urology, Stones, ESWL, Urolithiasis, Shock wave, Lithotripsy

INTRODUCTION

Urolithiasis is a relatively uncommon condition in the paediatric population. It has wide geographical variation, with documented occurrence ranging from 1 to 3% of all urinary stones, and it is increasing in both developing and developed countries.^{1,2} Stone formation is more common

in dry, sunnier climates.³ Experts expect an escalation in kidney stone disease and stone-related healthcare expenses as a result of global warming.⁴ The advent of ESWL in 1980 revolutionised the treatment of urolithiasis in both adult and paediatric patients.⁵ More than 3,000 lithotripters have been installed worldwide since then, and this system is used to treat over a million

patients each year. Newman et al published the first series of effective ESWL sessions in children in 1986, with additional series published in the late 1980s and early 1990s.⁶⁻⁸ The procedure has a reputation for being a tried and tested therapy for patients with stones. ESWL is now considered the first line therapy or one of the first options of management of upper urinary stones in paediatric patients.⁹⁻¹¹

In terms of age, it has been documented that the stone-free average in children handled with ESWL is higher than in adults.¹² This can be demonstrated by the limited energy lost in shock wave propagation through a child's small body, as well as the simpler discharge of even big stone fragments due to the ureter's greater elasticity and suppleness in children.¹³ ESWL is often favoured in children because it is less invasive, since endoscopic penetration is difficult due to the narrower diameter of the tubes that make up the urinary tract.¹⁴ However, general anaesthesia is required as an additional burden on the child, particularly if several ESWL sessions are required.¹⁵ Stone disintegration with lithotripsy is preferred over open surgical removal of stones in well-equipped urological clinics.^{16,17} To prevent a high rate of complications and side effects in SWL, such as injury to internal organs (pancreas, intestines, lungs), as well as subcapsular and perineal hematomas, lithotripsy should be performed in specialist centres with specific expertise in the care of children with urolithiasis.¹⁸

Aims and objectives

We studied patients presenting to Indraprastha Apollo hospital New Delhi, who were eighteen years or younger with renal calculi disease (including ureteric calculus). We compared demographic and clinical characteristics of those who had stone clearance within two days after ESWL versus those who had clearance more than two days after intervention in all children aged up to 18 years old who underwent ESWL in hospital from 2012 to 2019.

METHODS

Data from a cohort of paediatric urolithiasis patients who underwent ESWL between 2012 to 2019 were used in this retrospective observational study. Ultrasound was used to visualise and locate the stones during the ESWL session. This required the paediatric patient to be exposed to the least amount of radiation possible. For X-ray positive stones, X-ray monitoring was used only before and after the ESWL session. CT scan was used for stone density measurement whenever applicable. Lithotripter was turned off and the amount of shock waves registered if complete disintegration happened during the session. Younger children (up to 13 years old) were given propofol for in-session sedation, while older children were given fentanyl for analgesia. Ultrasound verified that the stones had been cleared. Two weeks, 1 month, and three months after the ESWL sessions, follow-up examinations were conducted.

Inclusion criteria

Children (0-18 years old) with urolithiasis who underwent ESWL in our hospital from 2012 to 2019 were included in the study.

Exclusion criteria

Coagulopathies, a concurrent infection of the urinary tract, obstruction below the stone, and other factors were all considered contraindications for ESWL were excluded from the study

Analysis

Patient cards were used to retrieve study-related results. STATA 11 mathematical programme was used for the statistical analysis. For all categorical variables, the Chi-square (χ^2) test was used to test for differences between groups (those with stone clearance within 2 days and those without clearance within 2 days of ESWL session), and the Student's t test was used to test for differences between groups for continuous variables (Fisher exact test was used in some situations due to low number of observations).

The stone clearance after ESWL was observed using the Kaplan Meier survival curve. The log rank test was used to determine the difference between curves for different classes. For both studies, the statistical significance level was set at $p=0.05$, and the 95% confidence interval (95% CI) was determined.

RESULTS

Between 2012 to 2019, a total of 250 children and teenagers (134 boys and 116 girls) in our hospital experienced ESWL (Figure 1). The average age of the participants was 10.2 years (range: 1-18). In most patients, low-energy shockwaves with a frequency of 1-2 Hz were used to break the stones. For ample stone fragmentation, one session of 200 to 3000 shockwave impulses was required, though some patients required more than 8,000 impulses over four sessions. The degree of stone fragmentation and successful stone clearing in children were found to be influenced by stone density. After fewer than 2000 shockwaves with low generator capacity, the stones with lower density (less than 700 HU) almost totally disintegrated. The medium density stones (700-1000 HU) necessitated the use of maximum permissible number of impulses. The high-density stones (over 1200 HU) necessitated multiple sessions with the maximum permitted energy of impulses, and often even multiple ESWL sessions.

There were 328 stones found in total, with 192 (58.5%) in boys and 136 (41.5%) in girls. Recurrent urolithiasis was diagnosed in 42 (16.8%) cases and primary urolithiasis in 208 (83.2%) cases. The following are the total number of stones: One stone was found in 204 (81.6%) of the

instances, two stones in 16 (6.4%), three stones in 28 (11.2%), and four stones in 2 patients (0.8%). The majority of the patients (n=158, 63.2%) had stones that were less than 10 mm long; 80 patients (32.0%) had stones that were between 11 and 15 mm long, and 12 patients (4.8%) had large stones that were 16-19 mm long. 136 patients (n=136, 54.4%) had renal stones (including two cases of staghorn calculi), while ureteric stones were found in 134 (53.6%) patients, with 92 (68.7%) in the distal ureter and 42 (31.3%) in the proximal ureter. Table 1 depicts the analysis of renal calcular disease and Table 2 depicts the analysis of ureteral calcular disease.

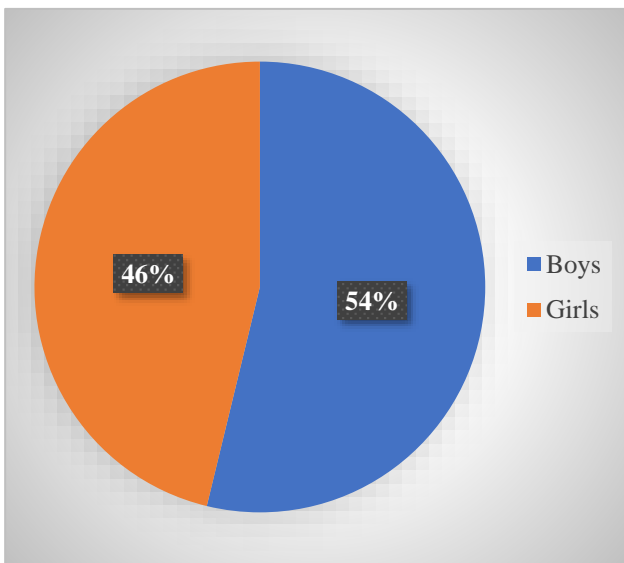


Figure 1: Gender distribution of stone disease.

Renal colic was encountered by 98 (n=98, or 39.2%) of the patients. In terms of sickness length, the patients were divided into three groups: those who had been sick for less than 8 weeks 92 (37.4%) cases, those who had been sick for 8-12 weeks 40 (16.3%), and those who had been sick for more than 12 weeks 114 (46.3%). As a result, the majority of patients were referred for ESWL more than 2 months after their urolithiasis diagnosis. The length of infection, on the other hand, has no impact on the clearance time (Table 3).

The cohort received 284 ESWL sessions, with 226 patients receiving one session, 18 patients receiving two sessions, 2 patients receiving three sessions, and 4 patients receiving four sessions. The involvement of large and/or high-density stones in the kidney (14 cases) or

ureter (14 cases) necessitated several sessions (12 cases).

The timing of stone clearance differed among patients. With the aid of a Kaplan-Meier curve, the possibility of getting stone clearance after ESWL at various time points was calculated. The chances of getting rid of the stone in the first two days were about 42%. As a result, "2 days after ESWL" was used as the arbitrary cut-off threshold for contrast in unadjusted analyses in order to have equivalent categories. Furthermore, there was a statistically important gap in clearance curves between patients who did not have renal colic and those who did (p=0.01). Similarly, there was a gap (p=0.01) between those who received ESWL under sedation and those who received it under analgesia.

Only "age," "in situ stone" (no manipulations with stone found in ureter), "renal colic," "anaesthesia type," and "dilatation" had a statistically important effect on clearance within 2 days among all independent variables. The average age of patients who had stone removal within two days of ESWL was 7.6 years, compared to 13.9 years in the second category. The mean age gap between the two classes was 6.35 years (95% CI 4.51-8.18, p=0.001), meaning that in the paediatric community, being younger raises the odds of stone removal within 2 days (faster clearance) after ESWL. As compared to those who had renal colic, those who did not have renal colic had 2.69 times (95% CI 1.28-5.62, p=0.01) better chances of getting clearance within 2 days. Another aspect related to the dependent variable was "in situ stone": people who did not have in situ stone had 2.12 times (95% CI 1.02-4.38, p=0.04) higher chances of clearance within 2 days than those who did. Anaesthesia method was also linked to faster clearing. The chances of stone removal within 2 days were 8.73 times (95% CI 3.72-20.45, p=0.01) higher among paediatric patients who underwent ESWL under sedation than those who required analgesia for ESWL (Table 3). Since sedation was used on younger adolescents, this observation may be influenced by their age.

Urinary tract dilatation (after previous sessions) was recorded in 82 (32.8%) patients, stein Strasse (after previous sessions) in 42 (16.8%), and hydronephrosis (dilation of the renal pelvis and/or calyces due to obstruction) in 8 (3.2%) patients. Only dilatation had an association with clearance speed: patients with dilatation had about double the chances of stone clearance within 2 days (0.44, 95% CI 0.19-1.00, p=0.05) than those without it (Table 3).

Table 1: Renal calcular disease analysis.

Patient characteristics		Total, n (%)	Stone clearance, n (%)		Odds ratio	P value
			≤48 hours	≥48 hours		
Gender	M	134 (54)	82 (56)	52 (50)	1.57 (0.72-3.44)	0.22
	F	116 (46)	64 (44)	52 (50)		
Renal stone	N	114 (45.6)	64 (44.4)	48 (46.1)	1.07 (0.52-2.19)	0.85
	Y	136 (54.4)	80 (55.6)	56 (53.8)		

Continued.

Patient characteristics		Total, n (%)	Stone clearance, n (%)		Odds ratio	P value
			≤48 hours	≥48 hours		
Affected side	Right	62 (47.7)	38 (48.7)	24 (46.1)	1.11 (0.41-3)	0.84
	Left	68 (52.3)	40 (51.3)	28 (53.8)		
Recurrent urolithiasis	N	208 (83.2)	122 (83.6)	86 (82.7)	1.3 (0.43-1.74)	0.6
	Y	42 (16.8)	24 (16.44)	18 (17.3)		
Stone count	1	204 (81.6)	122 (84.7)	80 (76.9)	1.66 (0.67-4.17)	0.27
	>1	46 (18.4)	22 (15.3)	24 (23.1)		
Staghorn stone	N	132 (97.1)	78 (97.5)	54 (96.4)	NA	NA
	Y	4 (2.94)	2 (2.5)	2 (3.57)		
Renal pelvis stone	N	52 (38.2)	28 (35)	24 (42.8)	1.39 (0.46-4.19)	0.43
	Y	84 (61.7)	52 (65)	32 (57.1)		
Renal calyx stone	N	72 (52.9)	50 (62.5)	22 (39.3)	2.58 (0.95-6.95)	0.06
	Y	64 (47.1)	30 (37.5)	34 (60.7)		

Table 2: Ureteric calculi disease analysis.

Patient characteristics		Total, n (%)	Stone clearance, n (%)		Odds ratio	P value
			≤48 hours	≥48 hours		
Ureter stone	N	116 (46.4)	66 (45.8)	50 (48.1)	1.09 (0.5-2.38)	0.8
	Y	134 (53.6)	78 (54.2)	54 (51.9)		
Affected side	Right	76 (57.6)	42 (55.3)	32 (59.3)	1.17 (0.43-3.2)	0.75
	Left	56 (42.4)	34 (44.7)	22 (40.7)		
Ureter site	Proximal	42 (31.3)	18 (23.1)	24 (44.4)	2.66 (0.92-7.72)	0.07
	Distal	92 (68.66)	60 (76.9)	30 (55.5)		

Table 3: Clinical presentation and efficacy of ESWL.

Patient characteristics		Total, n (%)	Stone clearance, n (%)		Odds ratio	P value
			≤48 hours	≥48 hours		
Renal colic	N	152 (60.8)	98 (68.1)	46 (44.2)	2.69 (1.28-5.62)	0.01
	Y	98 (39.2)	46 (31.9)	58 (55.7)		
Illness duration (Weeks)	<8	92 (37.4)	46 (31.9)	46 (46)	2.33 (0.76-7.13)	0.14
	8-12	40 (16.3)	28 (19.4)	12 (12)		
	≥12	114 (46.3)	70 (48.6)	42 (42)		
In situ stone	N	124 (49.6)	82 (56.9)	40 (38.5)	2.12 (1.02-4.38)	0.04
	Y	126 (50.4)	62 (43.1)	64 (61.5)		
Accompanying pathology	None	122 (48.8)	82 (56.9)	40 (38.5)	---	---
	Dilatation	82 (32.8)	38 (26.4)	42 (40.38)	0.44 (0.19-1.00)	0.05
	Obstruction	38 (15.2)	22 (15.3)	16 (15.38)	0.67 (0.23-1.92)	0.46
	Hydro-nephrosis	8 (3.2)	2 (1.39)	6 (5.77)	0.16 (0.02-1.66)	0.13
Fragmentation level (mm)	Bad (>5)	2 (0.81)	0 (0)	0 (0)	1.61 (0.76-3.42)	0.21
	Some (3-5)	162 (65.32)	100 (70.4)	62 (59.6)		
	Full (<3)	84 (33.87)	42 (29.58)	42 (40.4)		
Anaesthesia type	Analgesia	96 (38.4)	22 (16.2)	74 (64.9)	8.73 (3.7-20.45)	<0.01
	Sedation	154 (61.6)	114 (85.8)	40 (35.1)		

DISCUSSION

Urolithiasis was seen in babies as young as one year old, meaning that urinary stones could develop even before birth.¹⁹ Stone clearance was quicker with younger age, which was most likely due to shorter urinary tracts and a smaller "barrier" between the instrument and the stone.

Other factors affecting the pace of stone removal in the children with urolithiasis were also identified. The four

children who had renal colic before lithotripsy had a lower risk of getting rid of stones within two days than those who did not. The fundamental mechanism of colic, which evolves around the phenomena of ureteric wall spasm, may explain this.²⁰ Surprisingly, the occurrence of calculous obstruction prior to procedure (without dilatation of the urinary tract) had no effect on clearance time, while dilatation of the urinary tract did. Thus, ESWL seemed to effectively shatter the obstructing stone into tiny pieces without injuring the urinary tract wall,

and the intact urinary tract cleared those fragments quickly, while the dilated tract with its damaged walls was unable to do so. These results could aid in the prediction of stone clearance pace in children.

The clearance rate was 90.4 percent after a single ESWL session. With only 2 cases of clearance failure among 250 children, the system given an excellent overall (after multiple sessions where required) clearance rate (99.2%). This figure competes with data from the international literature on paediatric ESWL with a success rate of 79.8% published in 32 papers.²¹ Although several studies were available for its high success in the adult population.^{22,23}

In terms of protection, no significant adverse effects were identified in our study after ESWL, despite the fact that many complications are documented, such as colonic perforation, hepatic artery rupture, hepatic hematoma, spleen rupture, pneumothorax, acute necrotizing pancreatitis, abdominal aorta rupture, and so on, and surgeons should be conscious of these.²⁴

ESWL is more effective at a younger age, before the onset of organic changes in the urinary tract, and these patients have quicker stone removal. A multidisciplinary team approach including urologists, paediatricians, and paediatric nephrologists is important not just for effective treatment of paediatric urolithiasis but also for avoiding recurrences and complications.

Concerns about the impact of SWs on the developing kidney have been raised.²⁵ The deleterious effect can be reduced by reducing the energy in kilovolts and the number of SWs.²⁶ ESWL has been found to be stable, with no long-term bio-effects on the function or morphology of the developing kidney.²⁷⁻²⁹ However, after ESWL, a reduction in renal plasma flow has been well demonstrated, and animal studies examining chronic renal injury indicate that a therapeutic dose of ESWL may have long-term functional effects, and that the young or immature kidney is particularly vulnerable to such complications.³⁰

CONCLUSION

Extracorporeal shock wave lithotripsy has been shown to be a safe and successful minimally invasive therapy for kids with kidney stones.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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