

## Ultrasound Guided Extracorporeal Shock Wave Lithotripsy for Renal Calculi in Children

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**Abstract: Objective:** To evaluate the efficacy of Ultrasound guided extracorporeal shock wave lithotripsy (ESWL) for treatment of renal stones in children. **Patients and Methods:** This is a prospective interventional uncontrolled study conducted on a group of children who underwent ESWL under ultrasound guidance at Bab El-Sha'ariya university hospital. Fifty children with renal stone were included in the study after obtaining the local ethical committee approval. All parents of these children signed an informed consent. Our inclusion criteria were children aged from 1 to 18 years with both radiolucent and radio opaque renal stones up to 2cm. We excluded children with distal obstruction, stones > 2 cm, active UTI, children with uncorrected Coagulopathy, elevated serum creatinine and skeletal deformity or special/abnormal anatomy of the upper tract. All procedures were performed with the children in supine position and under general anesthesia using Dornier Lithotripter S II machine. **Results:** In all 50 patients the overall fragmentation rate was 94%. Stone free rate for pelvic, lower calyceal, middle calyceal and upper calyceal stone was 47.4%, 75%, 57.1% and 100% respectively. The most frequent complications were hematuria 4% and UTI 4%. The size and multiplicity of stones affected stone clearance after ESWL ( $p=0.025$  and  $p<0.001$ ), other factors as age, sex and stone site were not statistically significant, P values were above 0.05. **Conclusion:** Ultrasound guided ESWL is safe and curative for renal calculi in the majority of children (94%). Moreover, the results of the present study may recommend Ultrasound guided ESWL as the primary treatment of choice for renal stones in children up to 2 cm with minimal morbidity as well as in Solitary stones and radiolucent stones had better clearance rate.

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**Keywords:** Ultrasound; Guide; Extracorporeal; Shock; Wave; Lithotripsy; Renal Calculi; Children

### 1. Introduction

Urinary tract lithiasis (UTL) in children occurs only in 1.0% to 3.0% of total cases, with a slightly higher prevalence in males [1-3].

Compared with invasive treatments, ESWL offers many advantages including shorter hospitalization, more rapid recovery, lower complication rate, less renal injury and easier retreatment [4]. With its low morbidity and acceptable success rate, ESWL has become the preferred treatment for stone disease by patients and urologists [5].

Ultrasound is ideal for imaging of renal calculi for extracorporeal shock wave lithotripsy. Ultrasound can localize radiolucent stones and monitor fragmentation in real time. The use of ultrasound specifically reduces the radiation exposure to the patient and the operator, which is particularly desirable in children. Furthermore, ultrasound-guided lithotripsy can reveal any incidental finding in the affected kidney that may require further evaluation [6]. The ESWL works best with stones between 4 mm – 2 cm in diameter that are still located in the kidney [7]. Therefore, in the present study, we evaluated the efficacy of ultrasound guided ESWL for the treatment of renal stones in children.

### 2. Patients and methods

This is a prospective interventional uncontrolled study conducted on 50 children with renal stone who underwent ultrasound guided ESWL at Bab El-Sha'ariya Al-Azhar University hospital after a local ethical committee approval. All parents of those children assigned an informed consent. Their ages ranged from 1 to 18 years with both radiolucent and radio opaque renal stones up to 2cm. We excluded children with distal obstruction, stones > 2 cm, active UTI, children with coagulopathy, elevated serum creatinine and skeletal deformity or special/abnormal anatomy of the upper tract (i.e., horseshoe kidney, PUJ obstruction, bifid or double system, etc.). The studied children were evaluated preoperatively with full medical history taken from their parents including age, gender, complete physical examination, laboratory tests (CBC, RBG, Kidney function tests, and coagulation profile, Urine analysis), KUB, pelvi-abdominal ultrasound and non-contrast CT (NCCT) or IVU to provide a picture of the stone site and urinary passage that can affect stone clearance rate.

All procedures were performed with the children in supine position and under general anesthesia. The ultrasound probe was placed in the flank region and an ultrasound scan of the renal area was performed.

When the stone was localized on the screen, its dimensional co-ordinates were calculated. Real time ultrasound examination was performed at all time during the procedure to check the position of the stone and to define stone fragmentation. All patients underwent lithotripsy using the same machine with a gradual incremental energy increased from 10 to 20 kV. All selected patients were subjected to 60 shock waves per minute and average total number of shock waves from 1200 to 2500 wave in each session. The maximum numbers of sessions per patient were determined by operator according to response and fragmentation.

The patients were kept for 3 hours under observation until fully conscious and urine was relatively clear of hematuria. On discharge from the hospital all patients were instructed to maintain an adequate fluid intake. An analgesic was prescribed on discharge to be taken at home. Parents were also instructed to check for expected hematuria and passage of stone fragments, and to report if their children had fever or colic. Patients were reviewed two weeks after each session to assess fragmentation and the presence of renal obstruction by; Plain radiography (KUB) and abdominal ultrasound (U/S).

Repeat treatment was carried out if inadequate fragmentation of the stone was observed. If there was no breakage of the stone after three sessions, the case was considered an ESWL failure. Patients were finally evaluated 3 months after last lithotripsy session by KUB and US or spiral computerized tomography (CT) in faint opaque stones.

The collected data were revised, organized, tabulated and statistically analyzed using statistical package for social sciences (SPSS) version 23.0 for windows. Data were presented as mean  $\pm$  standard deviation (SD), frequency, and percentage. Categorical variables were compared using the chi-square ( $\chi^2$ ) and Fisher's exact tests (if assumed) with Phi and Cramer's V analysis to detect the degree of association between the variables. Continuous variables were compared using Student t test (two-tailed) and one – way ANOVA test with Tukey post hoc to detect the difference between subgroups for normally distributed data. Mann-Whitney U and Kruskal – Wallis tests for nonparametric data. Correlation and regression analysis was used to detect the linear relation between the continuous variables. The level of significance was accepted if the P value  $<$  0.05.

### 3. Results

From December 2015 to July 2016 a total 50 children met the inclusion criteria of our study and underwent elective ultrasound guided ESWL for renal calculi in Bab El-Sha'ariya, Al-Azhar university hospital. The mean and (SD) age at presentation was

5.42  $\pm$  3.87 years. There were 25 males (50%) and 25 females (50%) (Table 1). Energy used for each session ranged between 32 and 70 j with a mean  $\pm$  SD equals 82.41  $\pm$  44.44. Number of shocks ranged between 1200 and 2500 shocks per session according to the age of child with constant rate of 60 shocks per minute. Signs of stone fragmentation in the form of cavitation bubbles and collapse at stone surface were noticed in 47 cases (94%). All the procedures were assisted by ultrasound focusing of the stone. The stone free status was achieved in 26 cases (52%). Significant residual fragments were found in 21cases (42%) and ESWL failed to fragment the stones in 3 cases (6%) who underwent PCNL later on.

In this study 7 cases (14%) developed complications as hematuria occurred in two cases (4%), UTI in 2 cases (4%), all were self-limited, single case developed pyelonephritis and required hospital admission, the remaining two cases developed steinstrasse one of them received one session of ESWL on leading stone fragment to pass the fragments while the other one passed the fragments spontaneously on medical expulsive therapy.

Stone clearance among studied population was affected by multiple factors: Stone clearance was significantly affected by stone size: (Chi=9.3; df: 3; p= 0.025) (Table 2). Stone clearance was also significantly affected by number of stones (p  $<$  0.001) (Table 3). On the other hand, stone clearance was not significantly affected by density of stone: (p= 0.290). Also no relation found between stone clearance and patient age, gender or stone location.

**Table (1): The demographic and clinical data of the 05 studied children.**

Radiological Characteristics	Stone Number	Percentage
<b>Stone size(cm)</b>		
$\leq$ 1 cm	17	34%
$>$ 1 cm	33	66%
<b>Stone Location</b>		
Upper Calyceal	1	2%
Middle Calyceal	7	14%
Lower Calyceal	4	8%
Pelvic	38	76%
<b>Radiodensity</b>		
Radiolucent	13	26 %
Radiopaque	37	74 %
<b>Multiplicity</b>		
Single	46	92%
Multiple	4	8%

**Table (2): Stone clearance in relation to stone size**

Stone clearance				Stone size
Free		Insignificant residual		
%	No. of cases	%	No. of cases	
100.0%	4	0.0%	0	0.5-0.8
64.3%	9	35.7%	5	0.9-1.1
56.2%	9	43.8%	7	1.2-1.4
25.0%	4	75.0%	12	1.5-2

(Chi=9.3; df: 3; p-value: 0.025).

**Table (3): Stone clearance and multiplicity of stones**

No. of renal stones				stone clearance
Single		Multiple		
%	No. of cases	%	No. of cases	
2.2%	1	50.0%	2	Failed
97.8%	45	50.0%	2	Successful

p-value < 0.001

**Table (4) Stone clearance and density of stones**

Density of stone				Stone clearance
Radio opaque		Radiolucent		
%	No. of cases	%	No. of cases	
8.1%	3	0.0%	0	Failed
91.9%	34	100.0%	13	Successful

**4. Discussion**

ESWL is the first line of treatment for the majority of renal stones [8, 9]. Clear localization of the stone during ESWL is one of the determinants of success of the procedure. Stone localization can be done by fluoroscopy or ultrasound. In children there is much concern about the use of fluoroscopic guidance during ESWL due to the hazard of radiation exposure. ESWL with ultrasound-guided lithotripters was easy and efficient for radiolucent as well as radio opaque renal stones smaller than 20 mm, owing to the better direct localization of the stones [10]. Other factors

known to alter the outcomes of ESWL are: stone size, location, chemistry, number as well as patient anatomy. Stones larger than 15 mm and calcium oxalate monohydrate stones usually require several ESWL procedures for clearance. Uric acid, calcium oxalate dihydrate as well as struvite stones are much easier to be disintegrated. ESWL has poor results for stones located in the lower calyx (“stone free” rate of 41-70%) [11].

In our study we assessed ultrasound localization during ESWL in 50 children with renal stones. The mean stone size was 12.7 mm which was nearly

similar to that reported by Badawy and associates [12], but lower than that previously reported [13, 14] (mean stone size 17 mm) and slightly higher than that reported by Fayez and colleagues [15] (mean stone size 10.3mm).

In the present study, 66% of stones (33) were more than 10 mm, 34% of stones (17)  $\leq$  10 mm which agreed with that reported by Aksoy and coworkers [13]. In their study there were 114 renal stones, 68.4% of stones (78) were more than 10 mm, 26.3% of stones (30) were more than 20 mm and only 5.2% of stones (6) were less than 10 mm.

As regards to the distribution of stones within the collecting system, in our study as well as in others [12-15], the most common stone location was the renal pelvis. Renal pelvic stones were found in 76 % (38) of our cases, while in the remaining cases the stones were located in the middle calyces in 14%(7), the lower calyces in 8%(4) and upper calyces in 2%(1) of renal units.

In Aksoy et al. [13] study, there were 114 renal stones, 33.3%(38) pelvic stones, 11.4%(13) upper calyceal stones, 10.5%(12) middle calyceal stones, 29.8%(34) lower calyceal stones and 14.9%(17) stones in multiple sites. In study done by Slavkovic et al.[14] there were 185 renal stones, 38.4% (71) pelvic stones, 7.02% (13) upper calyceal stones, 15.7% (29) middle calyceal stones and 38.9% (72) lower calyceal stones. In the study of Badawy et al. [12] 298 (66%) patients had pelvic stones, 26 (5.7%) had upper calyceal, 57 (12.6%) had mid calyceal, and 69 (15.3%) had lower calyceal stones.

In the study done by Fayez and colleagues [15] there were 86 renal stones, 43.02% (37) were lower calyceal stones and 32.6% (28) were pelvic stones. Their study included 15.1 % (13) upper calyceal stones and 9.3 % ( 8) middle calyceal stones. The explanation for that is the fact that stones more commonly affect the dependant parts of the renal units, i.e. the bottom of the kidney as a result of urinary stasis and it is well known that renal pelvis is the most dependant part of the collecting system together with lower calyx, that is why the upper and middle calyces are the least common sites for stone formation in most studies. Another explanation for that phenomenon is that stones located in the renal pelvis may cause early symptoms and hence early diagnosis, so, may be detected frequently.

On the other hand, Da Cunha Lima and associates [16] from Brazil studied 147 renal stones, and the least common stone location was the renal pelvis. They had 10.9% (16) pelvic stones, 21.9 % (31) upper calyceal stones, 41.5% (61) middle calyceal stones and 26.5%(39) lower calyceal stones.

General anesthesia was used for adequate ESWL for the patients who would not cooperate. In the study

of Akin and Yucel [17] all patients less than 7 years of age in their series needed general anesthesia, and nine patients older than 7 years (29.0%) needed general anesthesia. In our study, all patients were treated with ESWL using Dornier machine in the supine position, and all procedures were performed under general anesthesia owing to poor cooperation. No significant anesthetic complications occurred.

The power of the shock wave should be started from the lowest level (14 kV) and may be escalated to the maximum level (20 kV) until fragmentation is observed. The number of shock waves should be limited to either the fragmentation observed or a maximum of 1,000 waves per session for children younger than 5 years and to fragmentation or a maximum of 2,500 waves per session for older children. Pulse frequency was 60 pulses per minute [17]. The mean number of shockwaves in the present study was 1750 (range 1000-2500) which is in agreement with the results of other researchers in the literature. Aksoy et al. [13] in their study reported that the mean number of shock waves was 1946. Similarly, in Slavkovic et al. [14] study the mean number of shock waves was 1950. Also, Fayez et al. [15] in their study mentioned that the mean number of shock waves was 2615.

In the study of Rostami et al. [18] JJ stents were placed in 11 infants (22%) with stones larger than 13 mm. In our study we did not insert JJ stent in any of our cases as stone size did not exceed 20 mm in largest diameter.

In the work of Rostami et al. [18] ESWL was successful in 39 (78%) patients after one session and in 9 (18%) after two sessions, and in 2 (4%) after three sessions. In our study, the overall fragmentation rate was 94% which is comparable to the results of previous studies. In the study done by Elsobky and associates [5] it was 94% and 92% in group treated by Dornier MFL5000 and Toshiba Echolith respectively. This is near to the fragmentation rate reported by [15] which was 93% and higher than that reported by others [3, 13, 14] which was 87.5%, 74.8% and 88.2% respectively.

The stone free rate in our study was lower than stone free rate reported by Fayez et al. [15] (i.e. 81%) in their study that included 84 renal stones. This increase in stone free rate in their study could be explained by the low stone burden (mean stone size 10.3mm) while in our study the mean stone size was 12.7mm.

In the study done by Elsobky and associates [5] renal stones were detected in 137 children, stone free rate was 86% and 14% were not cleared from stones. In study done by Aksoy et al. [13], it is included 114 renal stone, stone free rate was 86.8%. On the other hand Slavkovic et al. [14] studied 185 renal calculi,

stone free rate was 49.2% which is markedly lower than our stone free rate (52%), This difference in clearance rate may be explained by the variation in stone size as the mean stone size in our study was 12.7, while in their study the mean stone size was 16.8mm.

In the current study the stone free rate for pelvic, lower calyceal, middle calyceal and upper calyceal stone was 47.4%, 75%, 57.1% and 100% respectively. These findings are lower than the results of Aksoy et al. [13] who reported that stone free rate for pelvic, lower calyceal and middle calyceal stones was 89.8%, 88% and 91% respectively. In the study done by Elsobky and associates [5] stone free rate for pelvic and lower calyceal stone was 89% and 87% respectively, Also, Fayez et al. [15] reported, stone free rate for pelvic, lower calyceal and middle calyceal stone was 89%, 76% and 75% respectively.

Demirkesen and coworkers [19] however, found no statistically significant difference in the stone-free rate after ESWL for stones in the calyces and renal pelvis in pediatric patients.

Although ESWL is a non-invasive procedure, however, it is not without complications. In our study 7 cases (14%) developed complications which was similar to that reported by Fayez et al. [15]13%. In the present study hematuria occurred in two cases (4%), UTI in 2 cases (4%), all were self-limited, single case developed pyelonephritis and required hospital admission, the remaining two cases developed steinstrasse one of them received one session of ESWL on leading stone fragment to pass the fragments while the other one passed the fragments spontaneously on medical expulsive therapy.

In Fayez et al. [15] study, the rate of complications was 13% in the form of self limited renal colic and UTI. In the work of Elsobky and associates [5] there was only one case that developed steinstrasse and managed by ureteroscopy. Aksoy et al. [13] reported complications in 19 (14.7%) cases, 10 (7.75%) patients developed UTI, 7 (5.4%) cases developed steinstrasse (two of them managed by ureteroscopy, one (0.8%) patient developed small subcapsular hematoma and one (0.8%) developed skin bruising at the shockwave entry site. Srougi et al. [3] presented early complications in 47 (23.7%) cases, all of them mild and transient: 42 (21.2%) patients had pain and 5 had fever (2.5%), but the urine culture was negative in all of them. Nonsteroidal analgesics were enough to control the symptoms. In the study done by Slavkovic et al. [14] Steinstrasse was encountered in 22 (17.4%) patients, in situ ESWL was applied in 6(27.3%) of these patients, 7(31.8%) were managed with percutaneous nephrostomy, 3(13.6%) treated with ureteroscopy, while 6(27.3%) were treated conservatively.

## Conclusion

ESWL is safe and curative for renal calculi in the majority of children (94%). ESWL is recommended as the primary treatment of choice for renal stones in children up to 2 cm with minimal morbidity. Solitary stones and radiolucent stones had better clearance rate.

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