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Prognostic factors of success of extracorporeal shock wave lithotripsy (ESWL) in the treatment of renal stones

Abdulla Al-Ansari, Khalid As-Sadiq, Sami Al-Said, Nagy Younis, Osama A. Jaleel & Ahmed A. Shokeir
Urology Department, Hamad Medical Corporation, Doha, Qatar

Abstract. *Objectives*: To evaluate the factors that affect the success rate of extracorporeal shock wave lithotripsy (ESWL) for treatment of renal stones. *Patients and methods*: Between January 2000 and December 2003, 427 patients with single or multiple renal stones (<30 mm, largest diameter) underwent ESWL monotherapy using Storz SL 20 lithotriptor. The results of treatment were evaluated after 3 months of follow-up. Treatment success was defined as complete clearance of the stones or presence of clinically insignificant residual fragments <4 mm. The success rate was correlated with the characteristics of the patients, conditions of the urinary tract and stone features. *Results*: At 3-month follow-up, the overall success rate was 333/427 (78%). Repeat treatment was needed in 226 patients (53.1%). Post-ESWL auxiliary procedures were required in 36 patients (8.4%). Post-ESWL complications were recorded in 16 patients (3.7%). Of the 10 prognostic factors studied, 5 had a significant impact on the success rate, namely: renal morphology, congenital anomalies, stone size, stone site and number of treated stones. Other factors including age, sex, nationality, stone nature (*de novo* or recurrent) and ureteric stenting had no significant impact on the success rate. *Conclusions*: The success rate of ESWL for the treatment of renal stones could be predicted by stone size, location and number, radiological renal features and congenital renal anomalies.

Key words: Kidney, Shock wave lithotripsy, Stone

Introduction

The development of endourological and extracorporeal lithotripsy techniques led to an increasing number of options for the management of renal calculi. Each of the methods available needs to be evaluated in terms of its stone clearance rate, potential morbidity and cost-effectiveness. Extracorporeal shock wave lithotripsy (ESWL) is an effective, well-established method for treatment of renal calculi. The efficacy of ESWL for treatment of kidney stones depends on several factors including the size, location and coposition of the stones [1, 2].

The aim of this report is to study the factors that affect the success rate of ESWL for treatment of renal stones. Notably, all patients were treated at Hamad Medical Corporation.

Patients and methods

Patients

From January 2000 to December 2003, 432 patients were subjected to ESWL monotherapy for renal stones at Hamad Medical Corporation. Residual stones after percutaneous nephrolithotomy (PCNL) or open surgery were excluded. Follow-up data for 427 of them were available at 3 months. The series included 380 males (89%) and 47 Females (11%). Their mean age was 39.3 ± 11.3 years (ranging from 1 to 97 years). Of the patients, there were 75 Qatari (17.6%) and 352 non-qatari (82.4%). There were no limitations as regards to body size or weight.

All patients except 24 (5.6%) were treated as outpatients. Those treated as inpatients were

admitted as an emergency due to anuria or persistent severe renal colic were subjected to pre--ESWL management by other methods. All patients were subjected to pre-treatment urinalysis, culture and sensitivity test, coagulation profile, serum creatinine, blood picture, urinary tract plain X-ray (KUB), ultrasonography (US) and intravenous pyelography (IVP) if the renal function permits. Non-contrast computed tomography (NCCT) was not routinely performed and done in cases of radiolucent stones when IVP was not informative.

Exclusion criteria were the presence of ureteric strictures, coagulopathies and non-functioning kidney. Among the entire group of treated patients, 13 (3%) had congenital anomalies including: 4 horseshoe kidney, 4 ectopic iliac or pelvic kidney and 5 duplex.

Stones

The features of the treated stones, i.e., size, location in the kidney, nature (*de-novo* or recurrent) and number, are shown in Table 1. Moreover, the radiological features of the upper urinary tract and presence or absence of congenital renal anomalies are also depicted in Table 1. All the treated stones were < 30 mm in largest diameter.

Technique

All patients were treated with the same lithotriptor (Storz SL 20). This lithotriptor uses electromagnetic waves for shock wave generation, water cushion for coupling, membrane for shock wave focusing and fluoroscopy for stone localization.

Ureteric double-J stents were placed in 93 patients (21.8%) before ESWL. Indications for ureteral stenting were solitary kidney, calculus anuria and large stone burden (> 20 mm, largest diameter). Percutaneous nephrostomy (PCN) was required in 2 patients of anuria and in 2 patients with obstructed infected kidneys.

Adequate sedoanalgesia was given to the patients in the form of fentanyl (1.5 μg/kg). In 5 children, general anesthesia was needed. ESWL therapy is usually started at a low voltage of 5 kV until the patient becomes accustomed to the shocks, and the voltage is then gradually increased to a maximum of 9 kV. The average number of shocks per session was 2500–3000. All the patients were treated in the supine position with the exception of some patients with congenital renal anomalies and those with vertebral deformities, who were treated in the prone position.

Follow-up

Patients were reviewed 1 week after the first ESWL session using a KUB film and renal US to assess fragmentation and the presence of renal

Table 1. Patient characteristics and stone features in correlation with success rate

Variable	No. of pts	%	Success rate		p-value
			No.	%	
Age (years)					
≤ 40	226	55.9	165	73	NS
> 40	201	47.1	159	79	
Sex					
Males	380	89	288	75.8	NS
Female	47	11	34	72.3	
Nationality					
Qatari	75	17.6	58	77.3	NS
Non-qatari	352	82.4	275	78.1	
Renal morphology					
Perfect	319	74.7	265	83	< 0.05
Obstructed	108	25.3	82	76	
Congenital anomalies					
No	414	97	327	79	< 0.03
Yes	13	3	7	54	
Stone size (mm)					
≤ 10	249	58.3	224	90	< 0.05
> 10	178	41.7	125	70	
Stone site					
Renal pelvis	71	16.6	62	87.3	< 0.05
Upper calyx	52	12.2	46	88.5	
Middle calyx	56	13.1	41	73.2	
Lower calyx	174	40.8	121	69.5	
Multiple site	74	17.3	55	74.3	
Stone nature					
De-novo	328	76.8	243	74.1	NS
Recurrent	99	23.2	75	75.8	
Stone number					
Single	341	79.9	267	78.3	< 0.01
Multiple	86	20.1	54	62.8	
Ureteric stenting					
No	334	78.3	260	77.8	NS
Yes	93	21.8	70	75.3	

NS, non-significant, chi square test.

obstruction. Repeat treatment was carried out if there was inadequate fragmentation of the stone. If there was no response after three sessions, the case was considered ESWL failure. Follow-up using KUB film and renal US was continued every 2 weeks until there was complete stone clearance. All the follow-up data were analyzed after the 3-month visit. Treatment success was defined as complete stone clearance or presence of clinically insignificant residual fragments (CIRFs) (<4 mm, peripheral, not causing renal colic, with no infection or gross hematuria). Failure was defined as no gross response to ESWL or presence of significant residual fragments after the third session.

Statistical analysis

The success rate was correlated with the characteristics of the patients, urinary tract, and stones using the chi square test. A p value <0.05 was considered significant.

Results

At 3-month follow-up an overall success rate of 78% (333/427) was obtained using ESWL monotherapy. The stone clearance rate is summarized in Table 2. Repeated treatment was needed in 226 patients (53%). Among the re-treatment group, 128 patients (30%) needed more than two sessions to ensure complete disintegration. The mean number of sessions per stone was 2.2 ± 1.43. The mean number of shocks per stone in total was 3400 ± 625, the mean voltage was 5.95 ± 1.22 kV. Post-ESWL auxiliary procedures were needed in a total of 36 patients (8.4%) and enlisted in Table 3. Post-ESWL complications were encountered in 16 patients (3.7%) and enlisted in Table 4.

Table 2. Stone clearance rate

	No. of pts	%
Success	333	78
Stone-free	262	61.4
CIRFs	71	16.6
Failure	94	22
No response	42	9.8
SRFs	52	12.2

CIRFs, clinically insignificant residual fragments; SRFs, significant residual fragments.

Table 3. Post-ESWL auxillary procedures

Procedure	No. of pts	%
Double-J stent	21	4.9
PCN	4	0.9
Ureteroscopy	11	2.6
Total	36	8.4

The success rate was correlated with characteristics of the patients, condition of the urinary tract and stone features. Moreover, the effect of ureteric stenting was studied. Factors which significantly affected the success rate included the following:

1. Stone size (largest diameter): The success rate for stones ≤ 10 mm was 90%, while it was 70% for stone >10 mm ($p < 0.05$).
2. Stone site: the success rate decreased from 87.3% to 88.5% for stones in the renal pelvis and upper calyx, respectively, to 69.5% for lower calyceal stones ($p < 0.05$).
3. Stone number: the success rate for single stones was 78.3% and 62.8% for multiple ones ($p < 0.01$).
4. Radiological renal features: the success rate for patients with normal renal units was 83% and it was 76% for obstructed units ($p < 0.05$).
5. Congenital anomalies: the success rate decreased from 79% for stones located in kidneys without congenital anomalies to 54% in those with congenital anomalies ($p < 0.03$).

Other factors including age, sex, nationality, stone nature and ureteric stenting had no significant impact on the success rate (Table 1).

Table 4. Post-ESWL complications

Complication	No. of pts	%
Hematoma	2	0.5
Massive hematuria	3	0.7
Steinstrasse	9	2.1
Septicemia	1	0.2
Anuria	1	0.2
Total	16	3.7

Discussion

In this study, as in others [1–4], stone size was a significant predictor of ESWL outcome. Lalak et al. [3] evaluated the outcome of ESWL of 500 renal calculi using Dornier compact Delta lithotriptor. The overall stone-free rate for stones <10 mm in size was 76% at 3 months. For 10–20 mm stones, the rate was 66%, while the rate for stones >20 mm in size was 47%. The authors do not recommend ESWL as primary therapy for stones >20 mm in size [3]. In another study [4], 246 cases of lower pole renal calculi <20 mm in size were treated with the Doli 50 lithotriptor. The overall stone-free rate was 78%, 73%, 43% and 30% for stones <5, 6–10, 11–15 and 16–20 mm in size, respectively. The authors concluded that stone size rather than lower pole calyceal anatomy is predictive of treatment outcome [4]. In a third recent study [2], Abdel-Khalek et al. defined the prognostic factors that affect the success rate after ESWL in 2954 patients with renal stones. They demonstrated that stone size had a significant impact on the success as the stone-free was 89.7% for stones <15 mm and 78% for stones >15 mm ($p < 0.001$) [2].

In the present study, the stone free rate was significantly higher for pelvic and upper calyceal stones compared to lower calyceal ones. This finding was supported by similar previous studies [2, 5–7]. For upper and middle calyceal stones, stone-free rate ranges from 70% to 90%, whereas that for lower calyceal stones ranges between 50% and 70% [2, 5–7].

In our study, stone number was a significant predictor of success. Ackermann et al. [8] studied prognostic factors affecting treatment outcome after ESWL. They found that body mass index and stone number were the only significant predictors. The authors concluded that the number of stones seemed to be more important than the stone burden in patients with a small to medium stone burden [8].

We found that obstructed kidneys had a significantly lower stone-free rate compared with normal kidneys. This finding is in agreement with similar studies [2, 9]. This may be due to weak peristalsis that leads to poor clearance of the fragments. In a recent study of 680 patients with lower pole calculi, Poulakis et al. [9] reported that the pattern of dynamic urinary transport represented the most influential predictor of stone clearance.

Lingeman et al. [10] reported that the type of lithotriptor impacts on the treatment outcome, as the original HM3 machine is more effective than the newer lithotriptors. Logarakis et al. [11] compared operator-specific success rates of ESWL performed by 12 urologists at one center (the study included 5769 renal and ureteral stones treated with Dornier MFL 5000). They found clinically and statistically significant intra-institutional differences in success rate; the best results being obtained by the urologists who treated the greatest number of patients, used the highest number of shocks and had the longest fluoroscopy time [11]. In a recent experimental study, Pateson et al. [12] reported that slowing the shock wave rate during ESWL significantly improves stone fragmentation.

Joseph et al. [13] evaluated the CT attenuation value of renal calculi as a predictor of successful fragmentation using ESWL in 30 patients. The success rate for stones with an attenuation value >1000 HF units was significantly lower than that for stones with a value of <1000 HF units. The mean attenuation value and the number of shocks required for calculus fragmentation correlated significantly [13].

Conclusions

The overall success rate of Storz SL 20 lithotriptor for treatment of renal stones at Hamad Medical Corporation was 78%. Post-ESWL auxiliary procedures were required in 8.4%. The re-treatment rate was 53% and the overall complication rate was 3.7%. Factors that significantly affected the success rate included: renal morphology, congenital anomalies, stone size, stone location and number of treated stones.

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Address for correspondence: Ahmed A. Shokeir, Professor of Urology, Urology and Nephrology Center, Mansoura University, Mansoura, Egypt
Fax: +20-50-2263717
E-mail: ahmedshokeir@hotmail.com, unc@mum.mans.edu.eg