DOI: https://doi.org/10.53350/pjmhs20221611465

ORIGINAL ARTICLE

Factors Affecting the Outcome of Extracorporeal Shockwave Lithotripsy in Urinary Stone Treatment

NISAR AHMAD[1], SHAH JAHAN UR REHMAN[2], KHALID KHAN[3], MAJED SAEED[4], SAQLAIN AMJAD[5], AJMAL RASHEED[5], USSAMA IFTIKHAR[5]

[1]*Associate Professor Sahiwal Teaching Hospital/ Sahiwal Medical College, Sahiwal*
[2]*Associate Professor Urology, AIMC/Jinnah Hospital, Lahore*
[3]*Assistant Professor Urology, Sahiwal Teaching Hospital, Sahiwal*
[4]*M.B.B.S, FCPS (Urology) Medical Officer Urology Department, Sahiwal Teaching Hospital, Sahiwal*
[5]*Resident Urology department, Sahiwal Teaching Hospital, Sahiwal*
Corresponding author: Nisar Ahmad, Email: nisarahmad741@gmail.com

ABSTRACT

Background and aim: The recurrence of urinary stones occurs in two thirds of patients within a 20-year period, making urinary stones a common pathology. Among urology pathologies, kidney stones rank third behind urinary infections and conditions of the prostate. The present study intended to assess various factors affecting the extracorporeal shockwave lithotripsy (ESWL) outcome in urinary stone treatment.

Methods: This cross-sectional study was carried out on 136 urinary stone patients who underwent extracorporeal shockwave lithotripsy in the Department of Urology, Sahiwal Teaching Hospital, Sahiwal for the duration from September 2021 to August 2022. Computed tomography confirmed the presence of stones and measured the size (3-20 mm), distance from skin to stone, location, and density in Hounsfield units. Patient's characteristics such as estimated rate of glomerular filtration and BMI were measured. A successful ESWL requires at least a 3mm residual renal stone fragment in post-therapy, and at least a complete clearance of ureteric stones at the end of treatment. SPSS version 26 was used for descriptive statistic.

Results: Of the total 136 urinary stone patients, there were 108 (79.4%) male and 28 (20.6%) females. The incidence of stones present in proximal ureter, mid, and distal ureter was 72 (52.9%), 7 (5.1%), and 57 (41.9%) respectively. All the patients underwent ESWL 1.5 times (average), and the success rate in first, second, and third session was 67.8% (n=92), 83.8% (n=114), and 91.2% (n=124) respectively. The overall success rate of ESWL was 80.9%. A multivariate analysis revealed that HU [OR=0.89, 95% CI, 0.96-0.98, P=0.001) and stone size [OR=0.79, 95% CI, 0.62-0.98, P=0.051] were significantly affecting the first ESWL session success rate. Third session success rate was significantly affected by stone size [OR=0.76, 95% CI, 0.58-0.95, P=0.015]. Stent associated higher failure rate [OR=6.425, 95% CI, 2.132-18.235, p=0.001] and ESWL failure was three-times higher in females than in male.

Conclusion: The present study found that the overall success rate of ESWL in urinary stone treatment was 80.9%. ESWL success rates were affected by stone size and HU. Patients' pain and fragmentation levels should be considered when adjusting the intensity of ESWL.

Keywords: Urinary stone treatment, Outcomes, Extracorporeal shockwave lithotripsy

INTRODUCTION

Extracorporeal shock wave lithotripsy (ESWL) has been widely utilized to treat urinary stones due to its comparatively high effectiveness and non-invasive flora [1]. ESWL provides a good therapeutic outcome, especially for less than 1 cm ureteral stones [2]. The ESWL success rate mainly rely on different factors such as renal anatomy (urinary anomaly, hydronephrosis, stenosis, calyceal diverticulum), patient-associated factors (obesity, skin-to-stone distance, and renal function), and stones (size, location, components, and density) [3, 4]. Various approaches for increasing ESWL success rate have been investigated. Frequency of low shock wave reduces tissue injury and stone free rate was enhanced by shock wave frequency 60-90 shock wave per minute [5, 6]. Recent research suggests gradually raising the power, since this ramping strategy increases stone breakup and decreases renal damage during ESWL [7-9]. Furthermore, medical expulsive treatment (MET) is effective for pain relief and stone passage; however, the types of shock waves generated by other procedures are ineffective [10].

The recurrence of urinary stones occurs in two thirds of patients within a 20-year period, making urinary stones a common pathology. Among urology pathologies, kidney stones rank third behind urinary infections and conditions of the prostate. The rate of urinary stones has been found to be growing in developing and developed countries in recent few years [11]. Computed tomography is a radiological modality used for diagnosis of urinary tract lithiasis in ureters, bladder, and kidney [12]. Ureteric stones are symptomatic however, renal stones are asymptomatic and converted to symptomatic stones upon the migration to ureter or pelvic junction in turn leads to serious complications such as urinary tract infections, hematuria, renal failure, and flank pain [13]. There are several therapeutic methods available to prevent these problems, including Extracorporeal Shock Wave Lithotripsy (ESWL), Retrograde Intra-Renal Surgery (RIRC), ureteroscopy (URS), open surgery, and Percutaneous Nephrolithotomy (PNL) [14]. Although various studies investigated the outcomes of ESWL in treatment of urinary stones. But, a limited study has been carried out on ESWL final energy intensity. In clinical practice, a higher ultimate energy intensity may result in a better SFR. Although a higher ultimate energy intensity may result in improved performance, it can also induce discomfort and urinary tract damage. If the SFR did not alter depending on intensity, we could safely do ESWL without changing the energy intensity. As a result, we conducted this study to assess the treatment results of ureteral stones based on ESWL energy intensity.

METHODOLOGY

This cross-sectional study was carried out on 136 urinary stone patients who underwent extracorporeal shockwave lithotripsy in the Department of Urology, Sahiwal Teaching Hospital, Sahiwal for the duration from September 2021 to August 2022. Computed tomography confirmed the presence of stones and measured the size (3-20 mm), distance from skin to stone, location, and density in Hounsfield units. Patient's characteristics such as estimated rate of glomerular filtration and BMI were measured. A successful ESWL requires at least a 3mm residual renal stone fragment in post-therapy, and at least a complete clearance of ureteric stones at the end of treatment. A total of 3,000 shocks were administered at a rate of 70-80 per minute. During the surgery, no analgesia was administered. Fluoroscopy was used mostly for targeting. Uncontrolled coagulopathy patients and pregnant women, congenital anatomical abnormalities, BMI>35 kg/m2, anatomical obstruction of secondary stones, urinary tract ongoing infection, and previous renal surgery patients were excluded. Fluoroscopy was used for stone localization. Stones was reassessed for fragmentation after two or three weeks using ultrasonography.

ESWL second session was given to insignificant fragmentation (>4 mm) in patients. Patients were followed up on three months after their initial ESWL treatment to see if their stones had cleared. Patients were examined at the endpoint using X-ray KUB and ultrasonography. ESWL frequency, stone clearance, auxiliary procedure, stone fragmentation, and complications were recorded. Treatment was considered effective when ureteric stones were completely cleared and stone-free for renal stones. Therapy failure was referred to a cases where no fragmentation or remaining stone pieces more than 4 mm after ESWL three session and patient require different treatment modalities.

SPSS version 26 was used for descriptive statistics. Treatment outcomes were correlated with radiological and clinical factors from the gathered data. Logistics regression model was used for different factors affecting treatment outcomes which confirmed the ESWL failure or success. To investigate the relationship between the various parameters and treatment results, a univariate analysis was utilized. The factors that were significant in the univariate analysis (P<0.2) were then incorporated in a multivariate logistic regression analysis to find the independent predictors of treatment outcomes.

RESULTS

Of the total 136 urinary stone patients, there were 108 (79.4%) male and 28 (20.6%) females. The incidence of stones present in proximal ureter, mid, and distal ureter was 72 (52.9%), 7 (5.1%), and 57 (41.9%) respectively. All the patients underwent ESWL 1.5 times (average), and the success rate in first, second, and third session was 67.8% (n=92), 83.8% (n=114), and 91.2% (n=124) respectively. The overall success rate of ESWL was 80.9%. A multivariate analysis revealed that HU [OR=0.89, 95% CI, 0.96-0.98, P=0.001) and stone size [OR=0.79, 95% CI, 0.62-0.98, P=0.051] were significantly affecting the first ESWL session success rate. Third session success rate was significantly affected by stone size [OR=0.76, 95% CI, 0.58-0.95, P=0.015]. Stent associated higher failure rate [OR=6.425, 95% CI, 2.132-18.235, p=0.001] and ESWL failure was three-times higher in females than in male. Figure-1 illustrate the gender's distribution. The location of stones are depicted in Figure-2. Table-I represents the intensity parameters of shock wave setting. Different outcomes and per procedures are shown in Table-II. Logistic regression study for several parameters influencing success rate after ESWL session is shown in Table-III. Figure-3 depicts the SFR after each session.

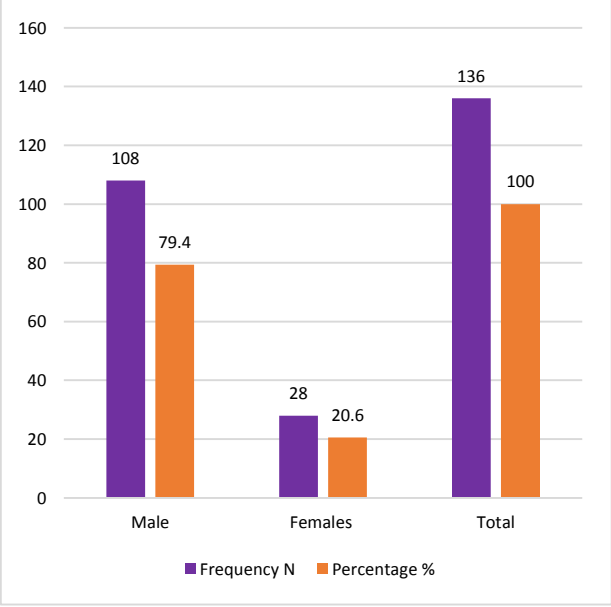

Figure-1: Gender's distribution (n=136)

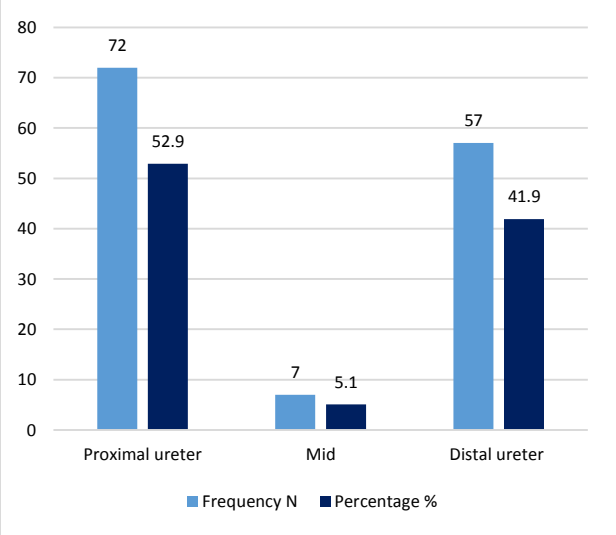

Figure-2: Location of stones

Table-1: Intensity parameters of shock wave

Intensity	a	b	c	1	2	3
Focal pressure (MPa)	6.4	10.2	15.8	20.9	30.8	54.6
E (12 mm)	2.3	3.6	6.9	10.8	19.7	28.9
ED (mJ/mm2)	0.02	0.06	0.09	0.13	0.27	0.45
RPF (shot/min)	180	180	180	120	120	120

*E Disintegrating energy, ED Energy flux density, RPF Max. Pulse repetition frequency

Table-2: Different outcomes and per procedures

Parameters	Value (N=136)
Age (yrs.)	48.62±6.85
Gender N (%) Male Females	 108 (79.4) 28 (20.6)
BMI (kg/m2)	24.2±3.8 (18.5–34.9)
Stone size (mm)	6.9±4.3 (2.5–36.5)
Density (HU)	667.9±258.6 (178–1,388)
Side N (%) Right Left	 66 (48.5) 70 (51.5)
Preoperative Cr	0.89±0.19 (0.61–1.8)
Preoperative e-GFR	88.6±48.4 (42.6–126.8)
Pain during ESWL N (%) No pain Moderate Sever	 69 (50.7) 62 (45.6) 5 (3.7)

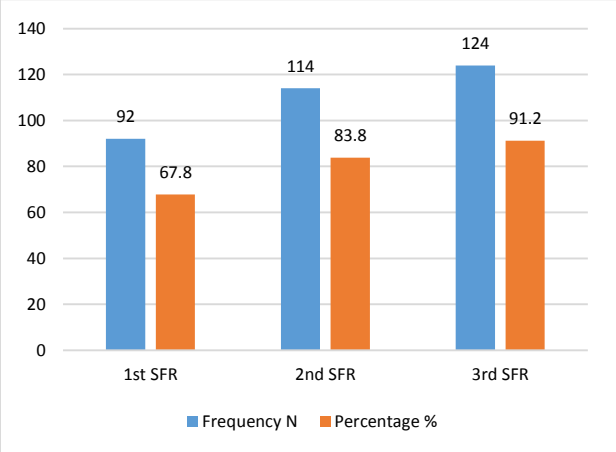

Figure-3: incidence of SFR after each session

Table-3: Logistic regression study for several parameters influencing success rate after ESWL session.

Parameters	Univariate (OR, 95% CI)	Multivariate (OR, 95% CI)
Age (yrs.)	0.96 (0.94-1.01)	-
Gender (females)	0.97 (0.46-2.03)	-
BMI (kg/m2)	0.98 (0.83-1.12)	-
Stone size (mm)	0.64 (0.53–0.87)	0.79 (0.62–0.98)
HU	0.93 (0.97-0.99)	0.89 (0.96-0.98)
Location of ureteral stones Proximal Mid Distal	- 0.83 (0.12–5.51) 1.22 (0.64–2.51)	- - -
Preoperative eGFR	0.96 (0.94–1.02)	-

DISCUSSION

The current investigation focused on the various factors affecting urinary stones treatment outcome using extracorporeal shockwave lithotripsy and found that the total success rate of ESWL in urinary stone therapy was 80.9%. Stone size and HU had an effect on ESWL success rates. When changing the strength of ESWL, patients' pain and fragmentation levels should be taken into account. Clinicians commonly assume that ESWL high intensity might result in elevated SFR; however, intensity had no effect on SFR in this investigation. In this investigation, a repeat operation boosted the SFR by almost 90%. Though ESWL is a safe operation, it seldom results in serious consequences like renal hematomas or organ damage. More crucial than intensity is the use of the energy ramping strategy. A randomized trial of 418 individuals employing a voltage ramping strategy vs a fixed power group found that the ramping approach generates fewer renal hematomas (5.6%) than fixed power (13%) [14-16].

The ESWL outcome was inversely related to stone size. Numerous investigations have found that stone size is a key determinant in SFR following ESWL [17-19]. ESWL failures relatively commonly for stones larger than 10 mm. The outcomes of treating stones less than 10 mm are superior to those of treating stones larger than 10 mm in all regions of the ureter [20].

Calculi density on CT scan an axially has also been investigated as fragmentation predictor and treatment success [21]. More shockwaves are required to shatter a stone as its density increases [22]. Similarly, in numerous clinical investigations, patients with stone densities greater than 750 HU required more than three ESWL treatments than those with stone densities less than 750 HU [23]. Furthermore, some studies have found that individuals are more susceptible to ESWL failure with stone density greater than 750-1,000 HU, and explore alternate treatment options [24]. In situations of high HU stones, several ESWL sessions were ineffective, and endoscopic removal was frequently undertaken. As a result, if a stone is larger than 10 mm and 1,000 HU, we should be prepared for ESWL failure.

Previous research has found that the size of the stone is a major predictor of ESWL treatment outcome. The bigger the stone, the greater the likelihood of ESWL failure. The authors recorded a success rate of 89.7% for stones 15 mm and 78% for stones >15 mm in a trial of 2954 individuals with renal stones (p 0.001) [25]. Another research of 427 individuals with renal stones found that ESWL was 90% successful for stones less than 10 mm and 70% successful for stones greater than 10 mm (p 0.050) [26].

In multivariate analysis, stent was revealed to be an independent predictor of ESWL failure. A greater failure rate of ESWL might be attributed to numerous factors, including difficulty in targeting, energy loss, and the influence of the stent on ureter peristalsis, resulting in lower fragment clearance. The presence of a stone larger than 15 mm in diameter was an indication for stenting in our research.

CONCLUSION

The present study found that the overall success rate of ESWL in urinary stone treatment was 80.9%. ESWL success rates were affected by stone size and HU. Patients' pain and fragmentation levels should be considered when adjusting the intensity of ESWL.

REFERENCES

1. Shinde S, Al Balushi Y, Hossny M, Jose S, Al Busaidy S. Factors affecting the outcome of extracorporeal shockwave lithotripsy in urinary stone treatment. Oman Medical Journal. 2018 May;33(3):209-17.
2. Jeong US, Lee S, Kang J, Han DH, Park KH, Baek M. Factors affecting the outcome of extracorporeal shock wave lithotripsy for unilateral urinary stones in children: a 17-year single-institute experience. Korean Journal of Urology. 2019 Jul 1;54(7):460-6.
3. Wagenius M, Oddason K, Utter M, Popiolek M, Forsvall A, Lundström KJ, Linder A. Factors influencing stone-free rate of Extracorporeal Shock Wave Lithotripsy (ESWL); a cohort study. Scandinavian journal of urology. 2022 Apr 8:1-7.
4. Yoon JH, Park S, Kim SC, Park S, Moon KH, Cheon SH, Kwon T. Outcomes of extracorporeal shock wave lithotripsy for ureteral stones according to ESWL intensity. Translational andrology and urology. 2021 Apr;10(4):1588.
5. Türk C, Petřík A, Sarica K, et al. EAU Guidelines on Interventional Treatment for Urolithiasis. Eur Urol 2016;69:475-82. 10.1016/j.eururo.2015.07.041
6. Al-Dessoukey AA, Abdallah M, Moussa AS, et al. Ultraslow full-power shock wave lithotripsy versus slow power-ramping shock wave lithotripsy in stones with high attenuation value: A randomized comparative study. Int J Urol 2020;27:165-70. 10.1111/iju.14158.
7. He Z, Deng T, Yin S, et al. Energy output modalities of shockwave lithotripsy in the treatment of urinary stones: escalating or fixed voltage? A systematic review and meta-analysis. World J Urol 2020;38:2443-53. 10.1007/s00345-019-03049-2.
8. Lee SM, Collin N, Wiseman H, et al. Optimisation of shock wave lithotripsy: a systematic review of technical aspects to improve outcomes. Transl Androl Urol 2019;8:S389-S397. 10.21037/tau.2019.06.07.
9. Rabah DM, Mabrouki MS, Farhat KH, et al. Comparison of escalating, constant, and reduction energy output in ESWL for renal stones: multi-arm prospective randomized study. Urolithiasis 2017;45:311-6. 10.1007/s00240-016-0912-7.
10. Skuginna V, Nguyen DP, Seiler R, et al. Does Stepwise Voltage Ramping Protect the Kidney from Injury During Extracorporeal Shockwave Lithotripsy? Results of a Prospective Randomized Trial. Eur Urol 2016;69:267-73. 10.1016/j.eururo.2015.06.017.
11. Hirsch B, Abt D, Gusewell S, et al. Outcome groups and a practical tool to predict success of shock wave lithotripsy in daily clinical routine. World J Urol. 2021;39(3):943–951.
12. Assimos D, Krambeck A, Miller NL, et al. Surgical management of stones: American urological association/endourological society guideline, PART IJ Urol. 2016;196(4):1153–1160.
13. Jendeberg J, Geijer H, Alshamari M, et al. Size matters: the width and location of a ureteral stone accurately predict the chance of spontaneous passage. Eur Radiol. 2017;27(11):4775–4785.
14. Yallappa S, Amer T, Jones P, et al. Natural history of conservatively managed ureteral stones: analysis of 6600 patients. J Endourol. 2018;32(5):371–379. doi: https://doi.org/10.1089/end.2017.0848.
15. Li W, Mao Y, Lu C, et al. Role of sexual intercourse after shockwave lithotripsy for distal ureteral stones: a randomized controlled trial. Urol J. 2020;17(2):134–138.
16. Wagenius M, Jakobsson J, Stranne J, et al. Complications in extracorporeal shockwave lithotripsy: a cohort study. Scand J Urol. 2017;51(5):407–413.
17. Goel H, Gahlawat S, Bera M, et al. Role of clinical and radiological parameters in predicting the outcome of shockwave lithotripsy for ureteric stones. Urol Ann. 2018;10(2):159–164.
18. Tokas T, Habicher M, Junker D, et al. Uncovering the real outcomes of active renal stone treatment by utilizing non-contrast computer tomography: a systematic review of the current literature. World J Urol. 2017;35(6):897–905.
19. Guler Y, Erbin A, Kafkasli A, Ozmerdiven G. Factors affecting success in the treatment of proximal ureteral stones larger than 1 cm with extracorporeal shockwave lithotripsy in adult patients. Urolithiasis. 2021 Feb;49(1):51-6.
20. López-Acón JD, Alba AB, Bahílo-Mateu P, Trassierra-Villa M, de Conca-Baenas MLA, de Ordaz-Jurado DG et al (2017) Analysis of the efficacy and safety of increasing the energy dose applied per session by increasing the number of shock waves in extracorporeal lithotripsy: a prospective and comparative study. J Endourol 31:1289–1294.
21. Drake T, Grivas N, Dabestani S, Knoll T, Lam T, Maclennan S et al (2017) What are the benefits and harms of ureteroscopy compared with shock-wave lithotripsy in the treatment of upper ureteral stones? A systematic review. Eur Urol 72:772–786.
22. Lawler AC, Ghiraldi EM, Tong C, Friedlander JI (2017) Extracorporeal shock wave therapy: current perspectives and future directions. Curr Urol Rep 18:25
23. Park HS, Gong MK, Yoon CY, du Moon G, Cheon J, Choi YD (2016) Computed tomography-based novel prediction model for the outcome of shockwave lithotripsy in proximal ureteral stones. J Endourol 30:810–816
24. Niwa N, Matsumoto K, Miyahara M, Omura M, Kobayashi H, Kikuchi E et al (2017) Simple and practical nomograms for predicting the stone- free rate after shock wave lithotripsy in patients with a solitary upper ureteral stone. World J Urol 35:1455–1461.
25. Xun Y, Li J, Geng Y, Liu Z, Yu X, Wang X et al (2018) Single extracorporeal shock-wave lithotripsy for proximal ureter stones: Can CT texture analysis technique help predict the therapeutic effect? Eur J Radiol 107:84–89
26. Kim CH, Shin DS, Kim TB, Jung H (2019) The efficacy of early extracorporeal shockwave lithotripsy for the treatment of ureteral stones. Urol J 16:331–336