World Journal of Urology (2024) 42:392
https://doi.org/10.1007/s00345-024-05073-3

ORIGINAL ARTICLE

Impact of previously failed extracorporeal shock wave lithotripsy on ureterorenoscopy outcomes in upper urinary tract stones: a prospective comparative study

Rabie M. Ibrahim[1] · Ahmed Gamal Mohamed[1] · Abdelrahman F. Abdelsattar[1] · Faysal Elzawy[1] · Ahmed Yousef[1] · Hany F. Badawy[1] · Mahmoud Abdallah[1] · Osama Sayed[1] · Akram Elmarakbi[1]

Received: 6 February 2024 / Accepted: 20 May 2024

Abstract

Objective We sought to prospectively evaluate the impact of previously failed SWL on subsequent URS outcomes in the treatment of upper urinary tract stones.

Materials and methods Between May 2021 and May 2023, one hundred thirty-six patients with proximal ureteral stones < 1.5 cm and renal stones < 2.5 cm who were candidates for URS were prospectively assigned to a non-SWL group, which included patients without a history of failed SWL before URS, and a post-SWL group, which included patients with a history of failed SWL before URS. The success rate was the primary outcome. The perioperative data of the two groups were compared.

Results The stone-free rate was 83.3% in the post-SWL group versus 81.3% in the non-SWL group, and 8.3% in the post-SWL group versus 9.4% in the non-SWL group had clinically insignificant residual fragments. There was no significant difference in the stone-free rate or success rate between the groups. No significant differences in intraoperative fluoroscopy time, operative time, intraoperative stone appearance, perioperative complications, or the presence of embedded fragments in the ureteral mucosa were detected between the two groups.

Conclusion Compared with patients who underwent primary URS, patients who underwent salvage URS for upper urinary tract stones had similar stone-free rates, success rates, operative times, fluoroscopy times, and complication rates without any significant differences.

Keywords Upper urinary tract stones · Renal stones · Ureteroscopy · Urolithiasis · Flexible URS

Abbreviations

BMI	Body mass index
HU	Hounsfield unit
KUB	Kidney–ureter–bladder
NCCT	Non-contrast computed tomography
SAV	Stone attenuation value
SFR	Stone-free rate
SSD	Skin-to-stone distance
SWL	Shock wave lithotripsy
US	Ultrasonography
M ± SD	Mean ± standard deviation

✉ Rabie M. Ibrahim
rabee75@yahoo.com

[1] Urology Department, Faculty of Medicine, Beni-Suef University, Beni-Suef, Egypt

Introduction

The management of urolithiasis varies in different centres worldwide. In developing countries, for renal stones less than 2 cm in size, there is a tendency first to use extracorporeal shock lithotripsy (SWL), which has become the modality of choice for selected cases in developed countries [1]. This discrepancy is because of the development of minimally invasive techniques in developed countries, such as mini-percutaneous nephrolithotomy (PNL) and ureterorenoscopy (URS), and common failures with SWL [2, 3]. The success of SWL varies significantly, with approximately 80% and 69% success rates reported for renal pelvis,

Published online: 10 July 2024

upper calyceal and lower pole stones, respectively [4, 5]. Thus, stones resistant to treatment by SWL usually require retreatment by URS or PNL. SWL may cause inflammatory and oxidative damage in renal and ureteric tissues, leading to oedema [6]. However, whether these changes caused by prior SWL influence subsequent URS outcomes is still unclear. Most of the studies that addressed this topic were retrospective studies with a high risk of bias for outcome assessment. In a trial adjusting for confounding factors, only two studies were performed that matched patients who underwent URS with a history of failed SWL and patients without a history of SWL [7]. In this study, we aimed to prospectively evaluate the impact of previously failed SWL on subsequent URS outcomes in the treatment of the upper urinary tract.

Patients and methods

Between May 2021 and May 2023, all patients who presented with proximal ureteral stones < 1.5 cm and renal stones < 2.5 cm were candidates for URS who attended the Beni-suef University Hospital outpatient clinic were prospectively, randomly selected and categorized into 2 groups: Group 1 included 64 patients without a history of previous failed SWL before URS, and Group 2 included 72 patients with a history of previous failed SWL (within one month after failed SWL session) before URS. Failed SWL either residual fragments > 4 mm after the third SWL session or patients requests early URS after the complete failure of stone fragmentation after the first or second SWL session. The research ethical committee of Beni-Suef University approved the study (FMBSUREC/09012022 /Abdelsattar), and all patients provided informed consent. Patients with congenital skeletal malformations, congenital urological anomalies, active urinary tract infections, distal ureteral stones, or pregnancy were excluded. Urine analysis, urine culture and sensitivity, serum creatinine, prothrombin time and concentration, kidney-ureter-bladder (KUB) radiography, abdominopelvic ultrasonography (US) and computerized tomography (CT) were performed preoperatively for all patients to assess the stone size, site, stone attenuation value, and post-SWL complications (subcapsular and perinephric hematomas).

In SWL an electrohydraulic EMD E-1000 lithotripter was used and intravenous analgesia (meperidine hydrochloride) was administered to all participants. The SWL was performed at a rate of 60 shock waves /minute. Power ramping was conducted from 8 to 20 kV during the first 1000 shock waves. Alpha-blockers and non-steroidal anti-inflammatories were used post-SWL to help stone passage and as analgesics on demand respectively. A prophylactic antibiotic was given at the time of anaesthesia induction. In the dorsal lithotomy position, a ureteral catheter (6 Fr) was passed over a guide wire through the ureteric orifice, a retrograde pyelogram and gradual ureteric dilatation up to 14 Fr were performed, and a safety guide wire was inserted under fluoroscopic guidance. According to the site and accessibility of the stone, a semirigid 6.5/8.5Fr or an 8.5Fr Flex-Xc Karl Storz ureteroscope (Tuttlingen, Germany) was used. We used an 11/13F ureteral access sheath during flexible ureteroscopy. Stone disintegration was performed using a 30 W LISA Sphinx holmium: YAG laser and an energy output of 0.8–1.8 J at 8–15 Hz was used. A JJ stent or ureteric catheter was inserted, and JJ stents were removed 2 weeks after the procedure. One week after the procedure, KUB X-ray and US were performed. CT was performed at the 3-month follow-up for all participants to determine the primary outcome, stone-free rate (SFR) and clinically insignificant residual fragments (CIRFs include patients with residual fragments ≤ 4 mm fragment), while patients with residual fragments > 4 mm were considered as treatment failure, the success rate included patients of the SFR and CIRFs.

The sample size was estimated using an online epitools program for "Prospective, cohort, and randomized clinical trials studies". The 95% confidence intervals were 95% (power: 95% and alpha: 0.05).

Analysis of the data was performed using a social science statistical package (SPSS 27). The quantitative variables are described as the mean, standard deviation or median and IQR according to the normality of the distribution. The qualitative variables are described as frequencies and percentages. Comparisons between normally distributed means were performed using the independent t test, and comparisons between non-normally distributed variables were performed using the Mann–Whitney U test. Comparisons between categorical data were performed using the Chi-square test. The P value was calculated as either non-significant if > or equal to 0.05 or significant if < 0.05.

Results

The mean ages were 43.9 ± 15.1 and 41.6 ± 12.1 years in the post-SWL group and in the non-SWL group, respectively. Forty patients in the post-SWL group were male (55.6%), while 34 patients in the non-SWL group were male (53.1%). The baseline characteristics of age, sex, BMI, patient comorbidities, and stones were similar and are summarized in Table 1 and Table 2 ($P > 0.05$). There were 20 (27.8%) and 16 (25.0%) patients with lower calyceal stones in the post-SWL group and non-SWL group, respectively ($P = 0.993$). The mean time interval between shockwave and URS was

Table 1 Demographic data and medical comorbidities in both groups

Variable	Post ESWL (no = 72)	No ESWL (no = 64)	*P*-value
Gender			
Females	40 (55.6%)	34 (53.1%)	0.841
Males	32 (44.4%)	30 (46.9%)	
Age (Mean ± SD), years	43.9 ± 15.1	41.6 ± 12.1	0.496
BMI (kg/m2) (Mean ± SD)	28.7 ± 4.793	29.38 ± 4.851	0.149
Comorbidities			
HTN	18 (25.0%)	18 (28.1%)	0.771
DM	24 (33.3%)	12 (18.8%)	0.174
Metabolic syndrome	10 (13.9%)	2 (3.1%)	0.118
Cardiac	6 (8.3%)	6 (9.4%)	0.880
Others			0.506
CKD	0 (0.0%)	2 (3.1%)	
Hyperthyroidism	2 (2.8%)	2 (3.1%)	
Rheumatoid arthritis	0 (0.0%)	2 (3.1%)	

SD: standard deviation, DM Diabetes Mellitus, HTN hypertension, BMI body mass index, SWL shock wave lithotripsy, CKD: chronic kidney disease. SAV stone attenuation value

Table 2 Distribution of stone characteristics in both groups

Stone characteristics	Post SWL (no = 72)	No SWL (no = 64)	*P*-value
side RT	32 (44.4%)	20 (31.3%)	0.264
LT	40 (55.6%)	44 (68.8%)	
Size (mm): Mean ± SD	11.8 ± 3.2	12.3 ± 2.9	0.589
Site			
Dispersed	8 (11.1%)	10 (15.6%)	0.993
Lower calyceal	20 (27.8%)	16 (25.0%)	
Middle calyceal	12 (16.7%)	12 (18.8%)	
Proximal ureter	10 (13.9%)	8 (12.5%)	
UPJ	6 (8.3%)	4 (6.3%)	
Upper calyceal	16 (22.2%)	14 (21.9%)	
SAV (HU) (median[IQR])	1028.5 (895,1280)	1011.5 (911.2,1242.5)	0.667 (MW)
Preoperative CT			
Subcapsular hematoma	4 (5.6%)	NA	NA
Number of SWL session			
One	12 (16.7%)		
Two	40 (55.6%)	NA	NA
Three	20 (27.8%)		
VAS on admission Median [IQR])	8 (3,50)	8 (3,48)	0.626 (MW)

mean ± standard deviation. NA not applicable, distance, N number, SWL shock wave lithotripsy, IQR: interquartile range, MW: Mann-Whitney U test, UPJ ureteropelvic junction, SAV Stone attenuation value, HU Hounsfield unit, VAS visual analogue score

20 days (range 15 to < 30 days). Intraoperative fluoroscopy time, operative time, intraoperative stone appearance, JJ stent insertion, impacted ureteral stones, oedema around the stone, and the presence of embedded fragments in the ureteral mucosa were similar between the two groups ($P > 0.05$) (Table 3). The residual stones in both groups were similar, and 83.3% of patients in the post-SWL group and 81.3% in the SWL group were completely stone-free, while the success rate was 91.6% in the post-SWL group and 90.6% in the non-SWL group. CIRFs, postoperative fever, ER consultation, hospital readmission and sepsis were also similar, and no significant differences were detected between the two groups (Table 4). The median postoperative hospital stay was one day in the two groups, with no significant differences (Table 4).

Table 3 Distribution of intra-operative procedure circumstances

Intra-operative	Post SWL (no = 72)	No SWL (no = 64)	*P*-value
Fluoroscopy time/min (Median[IQR])	2.01 (2,2.5)	2.1 (1.5,2.5)	0.475 (MW)
Operative time/min Median[IQR])	45 (42,56)	51 (41.3,58.8)	0.453 (MW)
Intraoperative stone appearance			
Comminuted	24 (33.3%)	NA	NA
Intact	48 (66.7%)		
Double J insertion	20 (27.7%)	19 (29.7%)	NA
Invisible field due to bleeding	0 (0%)	0 (0%)	NA
Fragments embedded in ureteral mucosa	6 (8.3%)	4 (6.3%)	0.743
Impacted stones	3 (4.16%)	1(1.56%)	0.122
oedema around the stone	5 (6.9%)	3 (4.6%)	0.352

IQR: interquartile range, MW: Mann-Whitney U test, NA not applicable, SWL shock wave lithotripsy, URS ureteroscopy

Table 4 Comparison between the studied groups regarding the post-operative outcomes

Postoperative	Post SWL (no = 72)	No SWL (no = 64)	*P*-value
Stone free rate	60 (83.3%)	52 (81.3%)	
CIRFs ≤ 4 mm fragment	6 (8.3%)	6 (9.4%)	0.869
Success rate	66 (91.6%)	58 (90.6%)	
failed> 4 mm fragment	6 (8.4%)	6 (9.4%)	
Complications according to the modified Clavien classification system			
G I Fever			
High grade >39.4 °C	4 (5.6%)	2 (3.1%)	
Low grade ≤ 39.4 °C	6 (8.3%)	4 (6.3%)	0.833
G IVb Sepsis	4 (5.6%)	2 (3.1%)	0.480
ER consultations	10 (13.9%)	6 (9.3%)	0.184
Readmision	4 (5.6%)	2 (3.1%)	0.480
Hospital stay / days Median[IQR])	1(1,1) 1.3 ± 0.7	1(1,1) 1 ± 0.1	0.062 (MW)

IQR: interquartile range, MW: Mann-Whitney U test, SWL shock wave lithotripsy, CIRFs: clinically insignificant residual fragments

Discussion

Flexible URS and lasers are the first treatment options for upper urinary tract stones according to the European Association of Urology guidelines [1, 2]. However, in developing countries, flexible ureteroscopy and laser lithotripsy are not commonly used due to their high costs, and these devices are not always available [1, 8]. Therefore, upper urinary tract stones may still have to be treated with SWL, which is a treatment alternative for stones < 2 cm [9]. As a part of these countries, we still treat our patients with upper urinary tract stones with SWL. Whether previously failed SWL affects subsequent URS is still unclear. A recent systematic review and meta-analysis concluded that salvage URS for renal stones has significantly lower success rates and significantly greater complication rates than primary URS as evidenced by retrospective studies [7]. Therefore, we designed this prospective comparative study to answer this question. According to Selmi and associates (2018), patients with previously failed SWL before URS had a lower stone-free rate ($P=0.03$) but an equal success rate to patients in the primary URS group [10]. In contrast, the success rate was up to 80% in the primary group versus 67% in the salvage group, as reported by Holland et al. [11]. In our study, Philippou et al., and Yu¨ru¨k et al., the stone-free rate and success rates were nearly similar, and there was no significant difference between the groups [12, 13]. One of the most common causes of SWL failure is lower pole stones, so including a greater number of lower pole stones in the arm of salvage URS usually affects the success rate of subsequent URS rather than the effect of the SWL itself [14, 15]. Therefore, in this study, we included an equal number of lower pole stones in the two groups ($p=0.993$).

In our study, the mean fluoroscopy time was not significantly different between the two groups; however, in Selmi and Associates 2018, the fluoroscopy time was significantly greater in patients who received SWL treatment before URS ($P=0.022$). They considered that difference was due to the presence of hard stones in patients with previous failed SWL [10]; they assumed this reason without any data recorded about stone density in their study. In our study, the stone density was recorded and was not significantly different between the two groups. The operative time was nearly similar, without any significant difference between the two groups in this study or in previous studies [7]. A meta-analysis was conducted by Li H and associates. In 2022, they reported a significant increase in Grade 2 complications according to the Calvien–Dindo classification system in the salvage URS group but no difference in Grade 1 or Grade 3 complications compared to those in the primary URS group. In this study, we did not observe any significant difference between the two groups in any complication grade or length of hospital stay. The strength of this study was being a prospective comparative study, limitations were the short follow-up period, the number of patients included, and the number of patients with upper ureteric stones, so we cannot perform a subgroup analysis.

Conclusion

This prospective study revealed that patients who underwent salvage URS for renal stones had similar stone-free rates, success rates, operative times, fluoroscopy times, and complication rates without any significant differences compared to those who underwent primary URS.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00345-024-05073-3.

Author contributions R M. Ibrahim, Manuscript writing, Protocol development, Data analysis. A A. Elmarakbi, Data analysis, Data management. A Abdelsattar, Data management. F Elzawy. Protocol development. A Yousef, Data analysis. H F Badwy, Manuscript writing. A G Mohamed, Data management. M Abdallah, Data analysis. O Sayed, Protocol development. Research involving human participant. Approval was obtained from the ethics committee of Beni-suef University. Informed consent was obtained from all participants.

Declarations

Research involving human participant Approval was obtained from the ethics committee of Beni-suef University. Informed consent was obtained from all participants.

Conflict of interest Authors declared no conflicts of interest or relevant financial or nonfinancial interests to disclose.

References

1. Agarwal A, Singhania P, Patil A, Shah K Is extracorporeal shock wave lithotripsy still the treatment of choice for renal and upper ureteric calculi: our experience with 274 cases and its comparison with retrograde intrarenal surgery literature. MGM J Med Sci 6(3):p 131–136, Jul–Sep 2019.
2. Quhal F, Seitz C (2021) Guideline of the guidelines: uro-lithiasis. Curr Opin Urol 31:125–129
3. Basulto-Martínez M, Klein I, Gutiérrez-Aceves J (2019) The role of extracorporeal shock wave lithotripsy in the future of stone management. Curr Opin Urol 29:96–102
4. Liourdi D, Adamou C, Kallidonis P (2021) Systematic review and Meta-analysis comparing Percutaneous Nephrolithotomy, Retrograde Intrarenal surgery and shock Wave lithotripsy for Lower Pole Renal stones Less Than 2 cm in Maximum Diameter. Reply J Urol 205:184
5. Nielsen TK, Jensen JB (2017) Efficacy of commercialised extracorporeal shock wave lithotripsy service: a review of 589 renal stones. BMC Urol 17:59
6. Clark DL, Connors BA, Evan AP, Handa RK, Gao S (2011) Effect of shock wave number on renal oxidative stress and inflammation. BJU Int 107:318–322
7. Li H, Hu XF, Deng L, Zhang L, Li H (2022) Does prior failed shock-wave lithotripsy impact outcomes of ureterorenoscopy? A systematic review and meta-analysis. Eur Rev Med Pharmacol Sci 26(7):2501–2510
8. Khairy-Salem H, El Ghoneimy M, El Atrebi M (2011) Semi-rigid Ureteroscopy in Management of Large Proximal Ureteral

Calculi: Is There Still a Role in Developing Countries? Urology 77: 1064–1068. Link: https://bit.ly/35U1Gnp
9. Türk C, Petřík A, Sarica K, Seitz C, Skolarikos A et al (2016) EAU Guidelines on Diagnosis and Conservative Management of Urolithiasis. Eur Urol 69: 468–474. Link: https://bit.ly/3qxbOuf
10. Selmi V, Sarı S, Çakıcı MÇ, Özdemir H, Kartal İG, Özok HU, İmamoğlu MA (2019) Does previous failed shockwave lithotripsy treatment have an influence on Retrograde Intrarenal surgery outcome? J Laparoendosc Adv Surg Tech 29:627–630
11. Holland R, Marcel D, Livne PM, Lask DM, Lifshitz DA (2006) Retrograde intrarenal surgery as second-line therapy yields a lower success rate. J Endourol 20:556–559
12. Philippou P, Payne D, Davenport K, Timoney AG, Keeley FX (2013) Does previous failed ESWL have a negative impact on the outcome of ureterorenoscopy? A matched pair analysis. Urol Res 41:531–538
13. Yürük E, Binbay M, Akman T, Özgör F, Berberoğlu Y, Müslümanoğlu AY (2014) Previous shock-wave lithotripsy treatment does not impact the outcomes of flexible ureterorenoscopy. Turk Urol Derg 40:211–215
14. Liourdi D, Adamou C, Kallidonis P (2021) Systematic review and Meta-analysis comparing Percutaneous Nephrolithotomy, Retrograde Intrarenal surgery and shock Wave lithotripsy for Lower Pole Renal stones Less Than 2 cm in Maximum Diameter. Reply J Urol 205:1845
15. Karim SS, Hanna L, Geraghty R, Somani BK (2020) Role of pelvicalyceal anatomy in the outcomes of retrograde intrarenal surgery (RIRS) for lower Pole stones: outcomes with a systematic review of literature. Urolithiasis 48:263–270