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ORIGINAL ARTICLE

Factors That Affecting Success and Re-admission in the Treatment of Proximal Ureteral Stones with Shock Wave Lithotripsy

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Abstract

Introduction: Extracorporeal shock wave lithotripsy (ESWL) is one of the methods applied in urinary system stone disease. ESWL has a very high success rate, and there are many factors that affect its success. In our study, we aimed to present our shock wave lithotripsy (SWL) results in proximal ureter stones, the reasons for re-admission to the hospital after SWL, and the final success achieved after additional interventions.

Methods: Between March 2017 and October 2019, 142 patients aged 18 years and over who underwent SWL for proximal ureteral stones were retrospectively evaluated. Age, sex, body mass index, stone laterality, stone size and volume (π×1/6×length×width×height), stone-skin distance, stone density, hydronephrosis degrees, number of SWL sessions, reasons for re-admission, and final success results were evaluated. The stone size determined on CT<4 mm was defined as successful SWL treatment. Other interventional procedures were performed to unsuccessful SWL patients, and final success rate was determined. Complications were classified according to Clavien-Dindo classification.

Results: Age, BMI, laterality of the stone, degree of renal ectasia, number of SWL sessions, and stone-skin distance did not contribute to SWL success ($p>0.05$). Factors affecting ESWL success include male gender, stone size, stone volume, and stone density; stone-skin distance and degree of renal ectasia were found to affect final success ($p<0.05$). Complications were more frequent in the unsuccessful group ($p<0.05$).

Discussion and Conclusion: Stone volume, size and density of stone in proximal ureter stones are among the factors affecting the SWL success. The final success rate can be increased after additional interventions performed in the necessary situations of SWL, which is a minimally invasive procedure.

Keywords: Shock wave lithotripsy; success rate; proximal ureteral stone.

Although the guidelines offer various treatment options for the treatment of ureteral stones; size, localization and patient-related characteristics create a quandary in terms of treatment options for each ureteral stone [1]. With technological advances in urological surgery in the last decade, urologists have turned from open surgery to minimally invasive methods in the treatment of ureteral stones. In the nineteenth century, dorsal lumbotomy, transperi-

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toneal and extraperitoneal ureterolithotomy had been used for the treatment of ureteral stones; in the second half of the 20th century a new era in the treatment of ureteral stones have begun with the emergence of lithotripsy. Today, lithotripsy has become a standard method for the treatment of ureteral stones with a high safety and comparable efficacy profile [2]. One of the methods of lithotripsy is extracorporeal shock wave lithotripsy (ESWL). Initial treatment for the renal stones <2 cm in the renal pelvis or upper/middle calyx is shock wave lithotripsy (SWL) or retrograde intrarenal surgery (RIRS); for proximal ureteral stones smaller than 1 cm is SWL, proximal ureteral stones between 10 and 20 mm SWL or RIRS, according to the European Association of Urology guidelines. Although there are many factors affecting the success of SWL, its success rate is 85% [3]. Besides the efficacy of SWL, it is often preferred as the first choice in the treatment of ureteral stone disease due to its less invasive than other techniques, ease of application, generally no hospitalization, low cost, reduction of radiation exposure by ultrasound, and low morbidity rates [4,5]. Re-admission rate after SWL varies between 5% and 15% in the literature [6].

In our study, we aimed to present our SWL results in proximal ureteral stones, the reasons for re-admission to hospital after SWL and the final success rate after additional interventions.

Materials and Methods

A total of 142 patients aged 18 years and over who underwent SWL for proximal ureteral stones in Fatih Sultan Mehmet Training and Research Hospital between March 2017 and October 2019 were retrospectively screened. Patients with regular follow-up were included in our study. Patients with abdominal aortic aneurysm, unregulated anticoagulant therapy, active urinary tract infection, pregnancy, and solitary kidneys were excluded from the study. Patients were evaluated with urine analysis, urine culture; routine hematological, biochemical blood parameters, and non-contrast enhanced computed abdominal tomography (CT) before the procedure. All patients underwent non-contrast CT as a control imaging at the 1st month after the procedure to determine residual stone status after SWL. The level of ureteral stones was based on the starting point of the sacroiliac joint, and ureteral stones above this point were accepted as proximal ureteral stones. Focusing was done with ellipsoid-focused C-arm scopy. Patients with difficulty in focusing to stones were evaluated additionally by ultrasonography. Verbal and written informed consent was obtained from all patients before the procedure. The procedure was performed by using the electromagnetic SWL (Siemens Variostar) device in supine position. All patients underwent bowel cleaning 1 day before the procedure. Routine analgesia was not performed before the procedure. After the procedure, nonsteroid anti-inflammatory agents were not started routinely, taking into consideration many adverse effects, especially gastrointestinal side effects. Pain management was determined according to the clinical status of patients. Routine antibiotic prophylaxis was not performed because all patients had sterile urine cultures. Age, gender, BMI, stone laterality, stone size and volume ($\pi \times 1/6 \times$length$\times$width$\times$height), stone-skin distance, stone density (Hounsfield Unit [HU]), grade of hydronephrosis, number of SWL sessions, reasons for re-admission and final success results were evaluated. Success was defined as no stones or stones smaller than 4mm in non-contrast CT at 1 month after procedure. Endourological methods (ureterorenoscopy [URS], double J [DJ] stent, RIRS etc.) were applied to patients who did not achieve success with SWL and final success rate was determined after additional interventions. Complications classified according to Clavie-Dindo classification [7].

Statistical Analysis

Number Cruncher Statistical System (NCSS 11, 2017 Statistical Software) and MedCalc Statistical Software version 18 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2018) program was used for evaluating the findings obtained in this study. Descriptive statistics were used to define the demographic and disease characteristics of the patients. Kolmogorov–Smirnov test was used to ensure normal distribution of variables. While calculating percentages and frequencies for categorical variables, mean+SD and median respectively for the variables that do not show normal distribution and Chi-square test/ Fisher's Exact Test were used to compare categorical variables. Parametric and nonparametric continuous variables were compared using the Two Sample t-test or the Mann Whitney U test, respectively. In all statistical tests, $p<0.05$ was considered statistically significant.

Results

A total of 94 (66.1%) patients included in the study were male and 48 (33.8%) were female. The mean age and mean BMI of the patients were 44.4+12.7 years and 25.97+3.66 kg/m^2, respectively. All patients admitted to the hospital complained of side pain. 72 (51.4%) of patients had right and 70 (48.6%) had left proximal ureteral stone (Table 1).

Table 1. Demographic features of patients

Age (year) (Mean±SD)	44.4±12.7
Gender (M/F) (%)	66.2/33.8
Laterality (Right/Left) (%)	51.4/48.6
BMI (kg/m^2) (Mean±SD)	25.97±3.66
Stone number (Mean±SD)	1.25±0.56
Number of sessions (Mean±SD)	2.4±0.8
Stone volume (π × 1/6 × length × width × height) (Mean±SD)	325.9±231
Stone size (mm) (Mean±SD)	10.3±2.5
Stone-skin distance (cm) (Mean±SD)	10.69±2.3
HU (Mean±SD)	971.5±294

HU: Hounsfield Unit; BMI: Body mass index.

Forty-three patients were diagnosed and treated with urinary tract stone disease in their medical history. Of these patients, 13 (30.2%) had a history of percutaneous nephrolithotomy, 18 (41.8%) had endoscopic ureteral stone surgery (URS or RIRS), 12 (27.9%) had a history of SWL, and 1 had a history of endoscopic cystolithotomy. There was no statistically significant correlation between SWL success and age, BMI, laterality of stone, renal ectasia degree, number of SWL sessions, and stone-skin distance (p>0.05). A statistically significant relationship was found between SWL success and male gender, stone size, stone volume and stone density (p=0.018, p=0.02, p=0.003, p<0.001, respectively). Stone-skin distance and degree of renal ectasia were found to be statistically significant among the factors affecting final success, while other factors did not contribute to final success (Table 2). Seventy-two (51%) patients obtained stone-free after SWL treatment. When we evaluated the complications after SWL, there were 11 (15.2%) patients (5 urinary tract infections, 2 hematuria, 4 renal colic) in whom SWL was successful, and 37 (52.8%) patients (14 urinary tract infection, 12 renal colic, 6 steinstrasse, 3 hematuria, 2 sepsis) who had unsuccessful SWL. A statistically significant relationship was observed between SWL success and complication rate (p<0.001). After successful SWL, 3 (4.1%) patients admitted with high fever and antibiotic therapy were applied. After unsuccessful SWL, 11 (15.7%) patients underwent URS, 9 (12.9%) patients underwent DJ stent application, 22 (31.4%) patients underwent RIRS and 2 (2.9%) patients underwent multiple endoscopic procedures. With additional endoscopic procedures, 113 (79.5%) patients had final stone free results. While there was no significant difference between the groups with and without final stone free status in terms of complications after SWL, additional surgical procedures were found to be significantly more in the nonstone free patients. (p=0.53, p<0.001, respectively) (Table 3).

Table 2. Comparison of demographic findings according to success

	Successful (SWL) n=72	Failed (SWL) n=70	p	Successful (Final) n=113	Failed (Final) n=29	p
Age (year)	43±12.36	45.93±13.01	0.17	44.58±12.68	43.90±13.21	0.79
Gender (n, %)						
Male	41 (56.9)	53 (75.7)	0.018	72 (63.7)	22 (75.9)	0.21
Female	31 (43.1)	17 (24.3)		41 (36.3)	7 (24.1)	
BMI (kg/m^2)	24.86 (19.57-33.56)	25.99 (19.79-33.02)	0.54	24.97 (19.57-33.56)	26.00 (20.59-32.48)	0.74
Laterality (n, %)						
Right	34 (47.2)	39 (55.7)	0.32	57 (50.4)	16 (55.2)	0.68
Left	38 (52.8)	31 (44.3)		56 (49.6)	13 (44.8)	
Grade of hydronephrosis (n, %)			0.12	22 (19.5)	17 (58.6)	<0.001
0	25(35.7)	14 (19.4)		55 (45.1)	6 (20.7)	
1	26 (37.1)	31(43.1)		37 (32.7)	4 (13.8)	
2	16 (22.9)	25 (34.7)		3 (2.7)	2 (6.9)	
3	3 (4.3)	2 (2.8)	0.37	1 (1-3)	1 (1-5)	0.94
Number of sessions, (median, min-max)	3 (1-4)	3 (1-3)	0.17	3 (1-4)	3 (1-3)	0.38
Stone volume (median, min-max)	213 (70-1419)	269.5 (126-1092)	0.003	245 (70-1419)	216 (126-936)	0.82
Stone size (mm)	10 (6-15)	10 (7-17)	0.02	10 (6-15)	10 (7-17)	0.78
Stone-skin distance (cm) (Mean±SD)	10.68±1.93	10.69±2.72	0.96	10.98±2.26	9.53±2.34	0.005
HU (median, min-max)	850 (436-1621)	1091 (405-1682)	0.000	961.20±292.68	1012±302.03	0.40

HU: Hounsfield unit; BMI: Body mass index.

Table 3. Comparison of complications of SWL and additional interventions according to success

	Successful (SWL) n= 72	Failed (SWL) n=70 n=113	p	Successful (Final) n=29	Failed (Final)	p
Complications of SWL (n, %)						
None	61 (84.7)	33 (47.1)	<0.001	81 (71.7)	13 (44.8)	0.53
UTI	3 (4,1)	14 (20)		11 (9.7)	8 (27.6)	
Sepsis	0 (0)	2 (2.9)		1 (0.9)	1 (3.4)	
Hematuria	3 (4,1)	3 (4.3)		3 (2.7)	2 (6.9)	
Colic pain	5 (6.9)	12 (17.1)		13 (11.5)	3 (10.3)	
Steinstrasse	0 (0)	6 (8.6)		4 (3.5)	2 (6.9)	
Additional interventions after SWL (n,%)						
None	69 (95.8)	4 (5.7)	<0.001	70 (61.9)	3 (10.3)	<0.001
URS	0 (0)	11 (15.7)		11 (9.7)	0 (0)	
DJ stent application	0 (0)	9 (12.9)		7 (6.2)	2 (6.9)	
RIRS	0 (0)	22 (31.4)		20 (17.7)	3 (10.3)	
Multiple intervention	0 (0)	2 (2.9)		2 (1.8)	0 (0)	
Following with antibiotherapy	3 (4,1)	22 (31.4)		3 (2.7)	21 (72.4)	

DJ Stent: Double J stent; SWL: shock wave lithotripsy RIRS: Retrograd intrarenal surgery; URS: Ureteroscopy; UTI: Urinary tract infection.

Discussion

Because SWL is easy to apply, does not require hospitalization, does not cause any loss of labor, and has lower costs compared to the operation; it is an alternative to surgical intervention in selected patients in the treatment of urinary system stone disease. Many factors such as the size of the stone, its location, and the presence of obstruction, the possibility of loss of renal function, the status of implantation determine the method of choice for the treatment of ureteral stones. Which method should be preferred in which group of patients is still a matter of debate. The success of SWL depends on the effectiveness of the device, the size, location, stone-skin distance, the type of stone and the anatomical features of the the patient and the kidney. In addition, special conditions such as the presence of obstruction, abnormal kidneys, and the condition of the opposite kidney affect SWL preference [8]. However, it is reported that the treatment of upper ureteral stones with SWL provides high success rates [9]. Izamin et al.,[10] found 81.8% success rate of SWL in the treatment of upper ureteral stones. In our study, the success rate of SWL was found to be 51%, but when the literature is examined, it is seen that kidney ureter bladder graphy (KUB) is frequently used for success evaluation. In our study, non-contrast CT was used in stone-free assessment. Due to the higher sensitivity and specificity of non-contrast CT in stone detection compared to KUB, we had relatively low SWL success rate compared to literature. The incidence of urinary system stone disease is higher in males than in females, with a higher proportion of males receiving treatment [11]. In our study, we found that the ratio of male to women was about twice as high as those who received SWL therapy, but SWL failure was found to be higher in male.

Many studies have shown that the increase in BMI is effective in the pathophysiology and treatment success of urinary tract stone disease [12]. In a study by Pareek et al.,[13] 72% of the patients had stone-free and 28% had residual stone after SWL. The mean BMI of the stone-free group was 26.9 kg/m^2, while the mean BMI of the residual stone was 30.8 kg/m^2 ($p<0.05$). In addition, El-Nahas et al.,[14] revealed the relationship between BMI and SWL success rate, as well as the relationship between skin-stone distance and SWL success rate. In our study, we found no relationship between BMI, stone-skin distance and SWL success rate for proximal ureteral stone. It is difficult to decide on the structure of the stone according to the density of the stone measured in imaging methods, since the stones are complex and usually a few stone structures can come together [15,16]. In a study conducted by Joseph et al.,[17] found that after SWL all patients who had stones with a density of <500 HU were stone free, however, 86% of those with a density of 500–1000 HU were found to be stone-free, while only 55% of those with a density of more than 1000 HU were found to be stone-free. In our study, we demonstrated the relationship between SWL success rate and stone density. Success rates were seen to decrease in patients with stones over 1000 HU ($p<0.001$). However, there was no correlation between the increase in stone density and final success rate. Evaluating the density of the stone before the procedure allows us to predict the success of SWL. Especially in stones with a density>1000 HU, if the stone size is large, the patient's stone-related symptoms are active and treatment delay is likely to lead to additional pathologies in the patient; endoscopic surgical procedures may be applied instead of SWL. Stone volume is also a factor that affects the stone-free rate after SWL [18]. In our study, it was found that SWL success rate decreased with increasing stone volume ($p<0.05$).

Although SWL is a minimally invasive treatment method, it has some complications. Petechiae and ecchymosis on the skin, microscopic or macroscopic hematuria, hypertension (8%), colic pain (13–36%), fever (5–36%), and necessity for hospitalization (3–8%) are common complications. Iliac vein thrombosis, cardiac arrhythmia, hearing loss, adjacent organ damage, ureteral obstruction, and renal scar development can be rarely seen [19-23]. In our study, the most common complications were renal colic and fever in accordance with the literature. In addition, the rate of complications in SWL successful group was found to be less than SWL failed group. It can be concluded from our study that we need to better determine the group of patients with a high probability of SWL success before the procedure to face fewer complications. In some studies, it is reported that approximately 12% of patients require additional treatment after SWL, and 17% of patients have undergo additional procedures after SWL [24,25]. In a report including 18,825 patients treated with SWL for ureteral stones in the United States, 84% of patients had stone-free, but the need for retreatment was found to be 11% [26]. In our study, 62.9% of patients who failed SWL underwent additional procedures and final success rate was shown to increase to 79.5%.

The strengths of this article are to determine some parameters to predict success in ESWL treatment. In our study, these parameters were found as stone volume, size and stone density.

Our study has some limitations. Firstly, our study was retrospective. Secondly, we had no stone analyses of patients. Finally, follow-up times of patients were not determined in our study.

Conclusion

The stone volume, size and density are among the factors affecting SWL success in proximal ureteral stones. The final success rate of SWL is increased after additional interventions in case of necessity. Because SWL failure and complication rates are related to each other, this patient group should be closely monitored after the procedure. The results obtained in our study should be supported by larger-scaled prospective studies.

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