Extracorporeal Shockwave Lithotripsy for Ureteral Stones

Twelve years of Experience with 2836 Patients at a Single Center

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Purpose: To retrospectively analyze the efficacy of extracorporeal shockwave lithotripsy (SWL) for managing ureteral stones in patients who were treated during a 12-year period at a single center in Turkey.

Materials and Methods: The study involved 3300 patients who had single ureteral stone and underwent SWL between January 1999 and March 2011. Medical records from 2836 (85%) patients were available for evaluation. Only patients with radiopaque stones of 5- to 15-mm diameter were included. All procedures were carried out by an experienced urologist (ACK). Patients with proximal ureteral calculi were treated in supine position. Those with mid or distal ureteral stones were treated in modified prone position. Persistence of radiologic image of the stone after three SWL sessions or no spontaneous passage of stone fragments after one month of follow-up was defined as treatment failure. Treatment success was defined as radiologically confirmed fragmentation and spontaneous passage of the stone.

Results: The success rates for the subgroups with stones located in the proximal, mid, and distal ureter were 85.1%, 83.9%, and 88.4%, respectively (P = .257). The success rates for individuals with smaller stones (≤ 10 mm) in the proximal, mid, and distal ureter were 90%, 85.8%, and 90.4%, respectively (P = .07). The corresponding rates for individuals with larger stones (> 10 mm) were 75.3%, 81.3%, and 81.6%, respectively (P = .09).

Conclusion: Our retrospective evaluation of this large patient series reveals that SWL is effective for treating stones in the proximal, mid, and distal ureter.

Keywords: urinary calculi, extracorporeal shockwave lithotripsy, ureterolithiasis

INTRODUCTION

The prevalence of urolithiasis is estimated to range from 4% to 15% worldwide, and 20% of all urinary system stones are in the ureters.[1] The various treatment options for ureteral stones include extracorporeal shockwave lithotripsy (SWL), ureteroscopy (URS), laparoscopy, and open surgical ureterolithotomy. Laparoscopy and open ureterolithotomy are rarely used to remove these stones, but may be considered in rare cases where SWL, URS, and antegrade URS fail or are unlikely to be successful.[2]

Non-invasiveness, low morbidity, and high efficacy of SWL have made it an important treatment modality for urinary tract calculi since its introduction by Chaussy and colleagues in 1980.[3] In this study, we retrospectively analyzed the efficacy of SWL for managing ureteral stones in patients who were treated during a 12-year period at a single center in Turkey.

MATERIALS AND METHODS

The study involved 3300 patients who had single ureteral stone and underwent SWL between January 1999 and March 2011 at the Bursa ACK Urotas Shock Wave Lithotripsy Center. However, only 2836 (85%) patients were fully analyzed and the remaining 464 patients were lost to follow-up or there were missing data. Only patients with radiopaque stones of 5- to 15-mm diameter were included. The exclusion criteria were congenital abnormality causing urinary obstruction, pregnancy, obesity (body mass index > 30), non-functioning kidney, advanced hydronephrosis, elevated serum level of creatinine (> 2 mg/dL), coagulation disorder, and serious underlying infection.

The data collected from each subject's medical records included age, gender, stone location, stone size, number of SWL sessions, and number of shock waves applied. We calculated rates of SWL success (stone-free status after SWL alone) and failure (persistence of the stone with no fragmentation after three SWL sessions or no spontaneous passage of the fragmented stones after one month of follow-up) for the patients overall and for various subgroups.

During workup, stone size and stone location were evaluated primarily by plain kidneys, ureters, and bladder (KUB) radiography and ultrasonography of the urinary tract. Unenhanced helical (spiral) computed tomography (CT) scan was not used routinely to detect the presence of minute stone fragments, due to concerns about the amount of radiation dose needed for performing the test without changing the management of the patient.[4] It was used only if the clinical findings and radiologic diagnosis with KUB and/or ultrasonography needed to be explained or confirmed.

Stones located between the ureteropelvic junction and the iliac crest were defined as proximal ureteral stones; those overlying the iliac bone were defined as mid-ureteral stones; those located between the iliac bone and the ureterovesical junction were categorized as distal ureteral stones. Stone size was measured as the maximum length and width in millimeters as viewed on plain radiography. Only patients with stones larger than 5 mm long or wide were included in the study because 71% to 98% of uroliths < 5 mm were resolved by spontaneous passage.[5]

In all cases, SWL was the first-line treatment. Prior to the initial SWL session, each patient underwent a physical exam and laboratory investigation with complete blood count, blood biochemistry, urinalysis, urine culture where indicated, and coagulation profile. Patients with positive urine culture were treated with appropriate antibiotics before they underwent SWL.

Before the first SWL procedure, each individual received a 3-day course of simethicone 80 mg four times a day to prevent intestinal gas shadowing from interfering with fluoroscopic guidance. Diclofenac 75 mg was given orally or intramuscularly for analgesia. Patients who experienced pain during SWL despite diclofenac were given pethidine (meperidine).

A Multimed 9200® Lithotriptor Spark Gap unit (Elmed Medical Systems, Turkey) was used and lithotripsy was performed under fluoroscopic guidance as an outpatient procedure. The SWL unit has a movable treatment table and a fixed shock wave generator.

Patients with proximal ureteral calculi were treated in supine position and those with mid- or distal ureteral stones were treated in modified prone position, as defined previously.[6] An experienced urologist (ACK) performed all procedures. Each SWL treatment typically started at a low power of 12 kV and then increased incrementally to 20 kV. A maximum of 4500 shockwaves were delivered in each session.[7] The

session was terminated if satisfactory fragmentation was observed before the maximum number of shock waves was reached.

All patients were re-evaluated with plain radiography 24 to 48 hours after each session to assess stone fragmentation. Ultrasonography was also done to evaluate the kidney if necessary. One week later, plain radiography was repeated and patients with residual stone or fragments underwent another SWL session. If no stone or fragments were visualized on the films, ultrasonograpy was done to confirm, and the patient was considered to be stone-free. This cycle was repeated for 3 sessions maximum. Treatment failure was defined as persistence of the stone without fragmentation after 3 SWL sessions or retained fragmented stones after one month of follow-up. Treatment success was defined as radiologically confirmed fragmentation and spontaneous passage of the stone. Patients in whom SWL failed were treated with surgery.

The SPSS software (the Statistical Package for the Social Sciences, Version 15.0, SPSS Inc, Chicago, Illinois, USA) was used for statistical analysis. Outcomes were stratified by stone location (proximal, mid, and distal ureter) and stone size (≤ 10 mm and > 10 mm). Student's *t* test, ANOVA, additionally post-hoc tests where needed, and Pearson's Chi-Square test were used to compare findings in various groups and subgroups. *P* values < .05 were considered significant.

RESULTS

Of a total of 2836 patients, 726 (25.6%) were women and 2110 (74.4%) were men. The mean age was 40.6 ± 12.5 years (range, 15 to 74 years). The mean maximum stone length and width were 9.7 ± 2.7 mm (range, 5 to 15 mm) and 6.4 ± 2.0 mm (range, 2 to 14 mm), respectively. Eight hundred and seventy-one (30.7%) stones were located in the proximal ureter, 312 (11%) were in the mid-ureter, and 1653 (58.3%) were in the distal ureter. There were more stones in the left ureter than in the right ureter (1530 versus 1306, respectively; *P* = .121). The mean number of sessions was 1.75 ± 0.7 and the mean number of shock waves applied was 3358.4 ± 2069.6 (range, 110 to 13500).

Overall, 2466 (87%) patients had their stone fragmented and became stone-free after a maximum of three SWL treatments. In the remaining 370 (13%) subjects, SWL failed to fragment stone or spontaneous passage of the fragmented stones was not observed after one month of follow-up. Table shows results for the SWL success and failure groups with patients categorized according to demographic characteristics and stone parameters. Maximum stone dimension, mean number of sessions, and the mean number of shock waves administered were all smaller or lower in the stone-free group than in the failure group (*P* < .001 for all).

A few patients encountered minor complications, such as self-limiting hematuria, dysuria, and pain that responded to oral analgesics.

The success rates for the subgroups with stones located in the proximal, mid, and distal ureter were 85.1%, 83.9%, and 88.4%, respectively (*P* = .257). The success rate for patients with a stone in the left ureter was significantly higher than that for the patients with a stone in the right ureter (88.1% versus 85.5%, respectively; *P* = .039). There was no statistical difference between the SWL success rates for men and women (87.3% versus 85.9%, respectively; *P* = .371).

Analysis was also done with stones categorized by size (≤ 10 mm or > 10 mm). The rates of SWL success for individuals with smaller stones (≤ 10 mm) in the proximal, mid, and distal ureter were 90%, 85.8%, and 90.4%, respectively (*P* = .07). The corresponding rates for individuals with larger stones (> 10 mm) were 75.3%, 81.3%, and 81.6%, respectively (*P* = .09).

Among the subgroup with smaller stones (≤ 10 mm), patients with mid-ureteral stones had a lower SWL success rate than those with proximal and distal ureteral stones, but it was not statistically significant (85.8% versus 90% and 90.4%, respectively; *P* > .05). Among the subgroup with larger stones (> 10 mm), individuals with proximal ureteral stones had a lower SWL success rate than those with mid-ureter and distal stones, but it was statistically insignificant (75.3% versus 81.3% and 81.6, respectively; *P* > .05).

DISCUSSION

Since the initial attempt at extracorporeal lithotripsy by Chaussy and colleagues 30 years ago, SWL has become the first-line therapy for most forms of urolithiasis.[8] However, the optimal approach for managing ureteral stones remains

Results for the successful and failed shockwave lithotripsy groups with the 2836 total patients categorized according to demographic characteristics and various stone parameters.

		Successful (stone-free)	Failed (Surgery)	*P*
Gender	Male	1842 (74.7%)	268 (72.4%)	.371
	Female	624 (25.3%)	102 (27.6%)	
Mean age, y		40.4 ± 12.5	42.66 ± 12.13	.003
Stone location	Proximal ureter	742 (85.1%)	129 (14.8%)	.257
	Mid-ureter	262 (83.9%)	50 (16%)	
	Distal ureter	1462 (88.4%)	191 (11.5%)	
Side affected	Right	1117 (85.5%)	189 (14.4%)	.039
	Left	1349 (88.1%)	181 (11.8%)	
Stone size and location in ureter	Proximal stones ≤ 10 mm	526 (90%)	58 (10%)	< .001
	Proximal stones > 10 mm	216 (75.3%)	71 (24.7%)	
	Mid-ureter stones ≤ 10 mm	158 (85.8%)	26 (14.2%)	
	Mid-ureter stones > 10 mm	104 (81.3%)	24 (18.7%)	
	Distal stones ≤ 10 mm	1160 (90.4%)	123 (9.6%)	
	Distal stones > 10 mm	302 (81.6%)	68 (18.4%)	
Mean maximum stone dimension (range), mm		9.5 ± 2.66 (5 to 15)	10.86 ± 2.56 (5 to 15)	< .001
Mean no. of shockwaves (range)		3084.06 ± 1866.46 (110 to 13400)	5186.92 ± 2404.22 (800 to 13700)	< .001

controversial. Guideline published by the European Association of Urology (EAU) states that both SWL and ureteroscopic surgery are acceptable first-line treatments for patients with ureteral stones, whereas laparoscopy and open surgical ureterolithotomy are rarely used in these cases. Such techniques may be considered where SWL, conventional URS, and antegrade URS fail.[2]

According to the guideline mentioned above, there is no significant difference between the success rates (stone-free rates) for SWL and URS in patients with proximal and mid-ureteral stones.[2] However, when stone size is taken into account, patients with larger (> 10 mm) proximal ureteral stones or any size of distal ureteral stone (≤ 10 mm or > 10 mm) are significantly more likely to become stone-free with URS than with SWL.[2] In contrast, a number of studies have also shown that SWL is effective for removing stones from the distal ureter, and several have documented success rates above 90% for this patients group.[9,10] Furthermore, SWL offers several advantages over URS, including shorter operation time, fewer complications, and faster convalescence.[9]

Stone-free rates for ureteral stones with SWL treatment reported in the EAU guidelines are 74%, 73%, and 82% for proximal, mid, and distal ureteral stones, respectively.[2] Our success rates are higher than those reported in the EAU Guideline. However, the SWL success rates that Hara and associates documented for proximal, mid, and distal ureteral stones (97.4%, 95%, and 98%, respectively) were better than ours. Hara and coworkers treated their 314 patients in rotated supine or prone position, which is similar to the position we used for treating mid and distal ureteral stones.[10] The modified prone position that we described previously for patients with stones in the mid or distal ureteral was an important factor in our success.[6] Furthermore, an experienced urologist (ACK) performed all of our SWL procedures and we believe that this had significant impact on our success as well.

A common problem during SWL, particularly in patients with ureteral stones, is poor visualization of the uroliths on imaging due to intestinal gas. When such gas is present, it is virtually impossible to administer effective shock wave treatment. Our patients received a 3-day course of simethicone 80 mg four times a day before the procedure to ensure clear imaging of the stones and thus, optimal fluoroscopic guidance

for shock wave administration.

The other main problem during SWL is that many patients discontinue treatment because of pain. To address this, we administered diclofenac 75 mg orally or intramuscularly and gave pethidine as well if patients felt pain despite the diclofenac analgesia. Previous reports have indicated that analgesia improves the efficacy of SWL.[11-13]

We found that age was negatively correlated with stone-free rate. The younger patients in our study were more compliant than older ones with respect to increasing hydration and movement, and this might have contributed to the lower rates of SWL success in older patients.

Not surprisingly, our analysis revealed that patients with larger stones, higher numbers of SWL sessions, and larger numbers of shock waves applied were less likely to become stone-free. We also found that the subgroups for stones ≤ 10 mm with proximal or distal ureter stones had higher rates of SWL success than the group with mid-ureteral stones. Although we used the proven successful SWL treatment position known as the modified prone position for patients with mid and distal ureteral stones, blockage of shock wave effect by the pelvic bones led to lower success of SWL for those with mid-ureteral stones.

Our results showed that SWL treatment was more successful for large (> 10 mm) distal and mid-ureteral stones than proximal ureteral stones. Our results were in line with the EAU guideline.[2]

CONCLUSION

Our retrospective evaluation of this large patient series reveals that SWL is effective for treating stones in the proximal, mid, and distal ureter. We believe that experience of the urologist who performs SWL, use of the modified prone position, effective analgesia during SWL, and administration of simethicone before each session are all important factors in the success of this therapy. Although advances continue to be made in endourologic surgery, SWL remains an appropriate treatment option for stones of 5- to 15-mm diameter in any location along the ureter, and yields good success.

CONFLICT OF INTEREST

None declared.

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