Predictors of Success for Stone Fragmentation and Stone-Free Rate After Extracorporeal Shockwave Lithotripsy in the Treatment of Upper Urinary Tract Stones

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Purpose: To evaluate factors affecting the success rate of stone fragmentation and stone-free rate after extracorporeal shockwave lithotripsy (SWL) in treatment of upper urinary tract stones.

Materials and Methods: A total of 121 patients with upper urinary tract calculi underwent SWL treatment.

Results: Success rate of stone fragmentation after SWL was 73.6% (89/121). In 89 patients who had success of breaking stones, 71 patients were followed up for the assessment of stone-free status, of whom 51 (71.8%) patients were stone-free at 3-month follow-up. Among four prognostic factors, including body mass index (BMI), stone size, stone position, and hydronephrosis, BMI and stone position had a significant impact on the success rate of stone fragmentation ($P = .04$ and U1: $P = .0108$, respectively). Among five prognostic factors of BMI, stone size, stone position, hydronephrosis, and times of SWL treatments, stone size was the only factor with significant impact on the stone-free rate (middle: $P = .0229$).

Conclusion: Our study suggests that stone fragmentation and stone-free rate after SWL treatment for upper urinary tract stones can be predicted.

Keywords: extracorporeal shockwave lithotripsy, risk factors, urolithiasis, kidney calculi, treatment outcome

INTRODUCTION

Renal and ureteral stones are common urological disorders. Extracorporeal shockwave lithotripsy (SWL) is an effective, well-established method for treatment of upper urinary tract stones. Several factors have been reported to influence the stone-free rate after SWL treatment for renal[1,2] and ureteral stones,[3,4] including patient's demographic characteristics, such as age and gender, and stone features, such as stone site and size.

However, there are few reports on prognostic factors, which predict stone fragmentation after SWL for upper urinary tract stone treatment. In this study, five prognostic factors, including body mass index (BMI), stone size, stone position, hydronephrosis, and times of SWL treatments, were selected for assessment.

MATERIALS AND METHODS

A total of 121 patients, 84 men and 37 women, with upper urinary tract stones were treated with SWL. Their mean age and BMI were 52.9 ± 14.2 years and 23.3 ± 3.3 (kg/m^2), respectively.

Stones were located on the right side in 66 patients and on the left in 55. The mean stone size was 15.0 ± 7.5 mm. The number of patients whose stones were localized in the renal pelvis and calices (R2) was 48, at the ureteropelvic junction (R3) was 11, and in the upper ureter (U1) was 62. The number of patients with and without hydronephrosis was 76 and 45, respectively.

The SWL treatment was accomplished using the Lithostar (Siemens LITHOSTAR Multiline) apparatus for all the patients. The mean energy level was 5.8 ± 0.3 (R2), 6.5 ± 0.6 (R3), and 6.5 ± 0.3 (U1) kV. The mean number of shocks per stone was 3235 ± 229 (R2), 2750 ± 478 (R3), and 3346 ± 217 (U1).

To determine the stone fragments, the kidneys, ureters, and bladder (KUB) X-ray or ultrasonography was performed at 2 weeks, 4 weeks, and 3 months after the first SWL session. In the case of inadequate fragmentation, repeated SWL treatment was performed. If there was no fragmentation after three sessions, the case was defined as SWL failure. The success of stone fragmentation after SWL was assessed by KUB and/or ultrasonography, and stone-free rate was considered when complete stone clearance was observed.

Multivariate logistic analysis was performed for this study, and the difference was considered statistically significant when the *P* value was less than .05.

RESULTS

Of 121 patients, 89 (73.6%) had successful stone fragmentation. The success of stone fragmentation for each factor is shown in Table 1. Among the four prognostic factors, BMI and stone position had significant impact on the SWL success rate (*P* = .04 and U1: *P* = .0108, respectively).

In 89 patients who had successful stone fragmentation, 71

Table 1. Factors affecting stone fragmentation.

Variable	Success, n (%)	*P*	Odds ratio
Body mass index, kg/m^2			
≥ 25	18/30 (60%)		
< 25	71/91 (78%)	.04	2.745
Stone size, mm			
Small (0 to 15)	59/80 (73.8%)		
Medium (16 to 25)	22/31 (71.0%)	.3556	0.611
Large (> 25)	8/10 (80.0%)	.5225	0.553
Stone position			
R2	42/48 (87.5%)		
R3	9/11 (81.8%)	.5054	0.517
U1	38/62 (61.3%)	.0108	0.167
Hydronephrosis			
Yes	52/76 (68.4%)		
No	37/45 (82.2%)	.8731	1.109

R2 indicates renal pelvis and calices; R3, ureteropelvic junction; and U1, upper ureter.

patients were followed up for determining the stone-free rate. Fifty-one (71.8%) patients were stone-free at 3-month follow-up. In the group which underwent more than 2 SWL sessions (4 patients), 2 (2/32, 6.3%) had hydronephrosis and 2 (2/19; 10.5%) were without hydronephrosis. The impact of each five factor on stone-free rate is presented in Table 2. Of them, only stone size had a significant impact on the stone-free rate (middle: $P = .0229$).

DISCUSSION

Extracorporeal shockwave lithotripsy has been established as the preferred method for treating upper urinary tract stones due to the minimally invasive character and low morbidity since 1980s. The overall stone-free rates have been reported to be 80% to 90%.[1-4]

An ideal method for stone therapy should provide high effectiveness with minimum complication rate, but SWL treatment has own failure and complications.[5] For example, immediate stone-free rate can not be achieved after SWL, and some patients may need repeated treatment due to stone recurrence.[6] Therefore, determining the patients who will benefit from SWL has outmost importance. Kanao and colleagues constructed pre-operative nomograms for predicting stone-free rates after single SWL treatment, and demonstrated that stone size, location, and number were significant factors affecting SWL successfully.[7] In this study, we evaluated separately five factors affecting the success of stone fragmentation and stone-free rate.

Body mass index was one of the statistically significant independent predictors of stone-free rate after SWL. A successful outcome was also significantly related to BMI (odds ratio, 1.34; 95% confidence interval, 1.09 to 1.65; $P < .01$).[8] In this study, BMI was one of the significant factors of the success for breaking stones, but not for stone-free status.

It has been generally accepted that stone size affects the clinical outcome of SWL treatment. Stone size has been reported as a significant predictor of SWL success for renal stones.[1,2] Abdel-Khalek and associates determined the prognostic factors that affect the success rate after SWL treatment in 2954 patients with renal stones and demonstrated that stone size had a significant impact on the success as the stone-free rate was 89.7% for stones < 15 mm and 78% for stones > 15 mm ($P < .001$).[1] In 427 patients with renal stones, the success rate for stones < 10 mm was 90%, while it was 70% for stone ≥ 10 mm ($P < .05$).[2]

Stone size was also a significant predictor of SWL outcome for ureteral stones. Stone size >10 mm (odds ratio, 3.46; 95% confidence interval, 2.16 to 5.53) was one of the

Table 2. Factors affecting stone-free rate.

Variable	Success, n (%)	*P*	Odds ratio
Body mass index, kg/m²			
≥ 25	10/15 (66.7%)		
< 25	41/56 (73.2%)	.5297	1.549
Stone size, mm			
Small (0 to 15)	39/49 (79.6%)		
Medium (16 to 25)	7/16 (43.8%)	.0229	0.205
Large (> 25)	5/6 (83.3%)	.5923	1.881
Stone position			
R2	20/32 (62.5%)		
R3	6/9 (66.7%)	.8269	0.517
U1	25/30 (83.3%)	.4326	0.167
Hydronephrosis			
Yes	32/42 (76.2%)		
No	19/29 (65.5%)	.5496	1.611
SWL treatment times			
1	47/61 (77%)		
> 2	4/10 (40%)	.06745	0.705

R2 indicates renal pelvis and calices; R3, ureteropelvic junction; U1, upper ureter; and SWL, extracorporeal shockwave lithotripsy.

strongest independent predictors of failure for SWL treatment in 688 patients with ureteral stones.[3] In 831 patients with ureteral calculi, stone size contributed significantly to the clinical outcome of SWL treatment [success: 1.00 cm (0.90 to 1.10) and failure: 1.30 cm (1.10 to 1.60); $P < .001$]. [4] In this study, interestingly, stone size was not a significant factor of the success for stone fragmentation; however, it significantly affected the stone-free rate. Our results indicated that after successful stone fragmentation, only stone size significantly affects stone-free rate.

In the present study, the stone-free rate was significantly higher for pelvic and upper calyceal stones compared to lower calyceal ones.[1,9-11] For ureteral stones, the relatively easier locations of the proximal and distal stones were generally considered to be the reason for the superior success rates, but the multivariate analyses indicated that ureteral stone site was not a significant factor in determining the clinical outcome.[4,12] In this study, three stone positions (R2, R3, and U1) were evaluated to assess the success for stone fragmentation and stone-free rate. Stone location significantly affected stone fragmentation, but not stone-free rate, confirming the previous reports.

Previous research has indicated that hydronephrosis has a significant influence on the success rate of SWL for treating distal ureteral calculi; however, its influence on the overall stone-free rate is not significant.[13] In this study, the factor of hydronephrosis was not a significant factor of the success for both stone fragmentation and stone-free status after SWL treatment.

CONCLUSION

In conclusion, this is the first report analyzing factors of the success for stone fragmentation and stone-free rate, separately. Our analysis indicated that different factors affect stone fragmentation and stone-free rate.

CONFLICT OF INTEREST

None declared.

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Effects of Surgical Position on Patients' Arterial Blood Gases During Percutaneous Nephrolithotomy

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Purpose: To compare arterial blood gas analysis of patients who underwent percutaneous nephrolithotomy (PCNL) in flank position under ultrasonography guidance with PCNL in prone and supine positions under fluoroscopic guidance.

Materials and Methods: In a clinical trial, a total of 90 patients with no upper urinary tract abnormalities were candidate for the PCNL. They were assigned into three groups using pseudorandomization method (30 patients in each group). Patients in group 1 underwent ultrasonography-guided PCNL in flank position. Patients in groups 2 and 3 underwent fluoroscopic-guided PCNL in prone and supine positions, respectively. Arterial blood gas was taken just before and 20 minutes after repositioning.

Results : The patients' mean age was 40.8 ± 6.9, 39.4 ± 10.6, and 37.2 ± 11.1 years in flank, prone, and supine positions, respectively ($P = .69$). The mean body mass index was 27.8 ± 3.4, 26.7 ± 4.7, and 28.1 ± 5.1 kg/m^2 in flank, prone, and supine positions, respectively ($P = .21$). Arterial oxygen pressure (PaO_2) increased significantly in flank (111.7 ± 43.8 to 132.8 ± 58.1 mmHg; $P = .01$) and prone (118.6 ± 50.2 to 134.6 ± 58.5 mmHg; $P < .001$) positions and decreased nonsignificantly in supine group (121.7 ± 64.5 to 119.7 ± 60.9 mmHg; $P = .23$). With surgical positioning, there were no significant changes demonstrated in $PaCO_2$ and serum concentration of HCO_3 in the flank, prone, and supine groups.

Conclusion: We could suggest that flank and prone positions could improve patients' oxygenation during PCNL procedure.

Keywords: percutaneous nephrolithotomy, blood gas analysis, prone position