The feasibility of shockwave lithotripsy for treating solitary, lower calyceal stones over 1 cm in size

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Abstract

Introduction: Recently, few studies were reported about the treatment of large, solitary, renal calculi between shockwave lithotripsy (SWL) and percutaneous nephrolithotomy (PNL). We assess the feasibility of SWL for managing solitary, lower calyceal stones over 1 cm by comparing the results of lower pole calculi treatment between patients that underwent SWL or PNL.

Methods: We retrospectively reviewed clinical data for patients who had undergone PNL or SWL due to lower calyceal stones over 1 cm. Group 1 consisted of patients who underwent SWL to treat lower pole renal calculi from 2010 to 2011. Group 2 included patients who underwent PNL to manage lower pole renal calculi from 2008 to 2009. We compared patient age, gender, stone size, comorbidities, postoperative complications, additional interventions and anatomical parameters between the two groups.

Results: A total of 55 patients were enrolled in this study. The mean ages (±SD) of groups 1 (n = 33) and 2 (n = 22) were 55.1 (±13.0) and 50.0 (±10.6) years (p = 0.133) and mean stone sizes were 1.6 (±0.7) and 1.9 (±0.8) cm (p = 0.135), respectively. There were no significant differences in gender distribution, comorbidities or stone laterality between the two groups. No significant differences in various parameters were observed between patients with stones 1 to 2 cm and ones with stones 2 cm or larger.

Conclusions: Our results demonstrated that SWL is a safe, feasible treatment for solitary, lower calyceal stones over 1 cm.

Introduction

Extracorporeal shock wave lithotripsy (SWL) and percutaneous nephrolithotomy (PNL) have been performed since the early 1980s to surgically treat patients with renal stones. Recently, retrograde ureteroscopic stone removal using a laser device was introduced following the technical development of devices.[1] However, the management of larger renal calculi over 1 cm remains problematic and can be further complicated by the location of the stone, particularly ones in the lower pole calyx. Havel and colleagues demonstrated that PNL has better outcomes than SWL for solitary, lower pole calculus.[2] May and colleagues reported that PNL is better than SWL for treating lower pole calyceal stones over 2 cm.[3] Since then, Albala and colleagues reported the results of a comparison between SWL and PNL for treating lower pole calyceal stones.[4] They suggested poor stone-free clearance of SWL and introduced a technique for measuring various parameters related to lower calyx anatomy, such as lower pole infundibular length and width along with the lower pole infundibulopelvic angle. This group also suggested predictive values of these anatomical parameters for stone-free clearance. Chibber and colleagues emphasized the predominant effectiveness of PNL for managing lower pole calyceal stones 1 to 2 cm.[5]

Despite these findings, the use of PNL may be limited for the general population as this procedure involves invasive renal parenchymal puncture to access the renal calyceal stones, and should be performed under general anesthesia with the patient in a prone position. Therefore, SWL still plays an important treatment option for the management of lower calyceal stones because it does not require general anesthesia. The rapid development of technical devices also makes SWL an attractive treatment modality.[6,7] Some recent studies identified anatomical factors, such as skin-to-stone distance and stone density, using radiologic tools and suggested the importance of considerations about these factors prior to performing SWL.[8,9] The present study was designed to assess the feasibility of SWL for managing solitary, lower calyceal stones over 1 cm by comparing the results SWL and PNL for treating lower pole calculi based on anatomical parameters.

Methods

We retrospectively collected data for patients who underwent PNL or SWL to manage lower pole calyceal stones 1 cm or larger. We enrolled individuals who suffered from asymptomatic microscopic hematuria or pyuria in whom solitary lower pole calyceal stones were detected by computed tomography (CT). We excluded patients who were simultaneously diagnosed with another urinary stone at any site and patients for which CT scans were unavailable. All patients were divided into two groups. Group 1 included consecutive patients who underwent SWL conducted by a single physician (SJY) from 2010 to 2011. Group 2 included consecutive patients who underwent PNL performed by a single surgeon (HJ) to treat lower pole renal calculi under general anesthesia from 2008 to 2009. We subdivided Group 1 according to stone size with a 2-cm cut-off value to evaluate the effects of various parameters on stone-free clearance.

We compared patient age, gender, stone size, comorbidities, postoperative complications and any additional interventions required between the two groups. Furthermore, we calculated anatomical parameters using coronal views of the CT scans, such as stone density, skin-to-stone distance, lower pole infundibular length width and infundibulopelvic angle, using a previously described method.[4,9,10] We defined stone-free status as no evidence of calculi at urinary tract at the follow-up CT scans.

This study was approved by the Institutional Review Board of Gachon University Gil Hospital (Incheon, South Korea).

Technique of extracorporeal shockwave lithotripsy

Intravenous sedation was used for all patients. With the patient in a supine position, a MODULITH SLX-F2 lithotripter (Storz Medical, Switzerland) was used for SWL with fluoroscopy-guided focusing at the centre of the stone. Shock waves were delivered at a rate of 60 with a maximum of 2000 shocks per one session of treatment. We usually applied a "wide-focus, low-pressure" regimen for treating lower pole calculi in our study. The routine follow-up period per one round of SWL was 2 weeks after performing a urinalysis and radiologic imaging. Follow-up exams were stopped after confirming the complete removal of lower pole calyceal stones.

Technique of percutaneous nephrolithotomy

While under general anesthesia, the patient was placed in a lithotomy position. Using a rigid cystoscope, we inserted a 6-Fr open-ended ureteral stent into the affected ureter via a guide wire. After changing the patient's position into a prone position, we punctured the affected lower calyx using a fluoroscopy-guided "eye of the needle" technique.[11] For the next step, balloon dilation of access tract was performed until ballooning pressure reached 10 times that of atmospheric pressure. We inspected the lower calyx with a nephroscope via the access sheath and fragmented the lower calyceal stones with a lithoclast. After stone fragmentation and removal, we inserted a double-J stent into the affected ureter and placed gel-foam at the access tract using a tubeless technique. All patients were discharged after confirming that there was no evidence of bleeding.

Statistical analysis

A descriptive analysis of age, stone size and other parameters related to lower calyceal anatomy was performed. Analyses of various parameters between the two groups were performed using an independent Student t-test and chi-square test. In Group 2, anatomical data and the number of sessions of SWL for stone clearance were analyzed by using a nonparametric Mann-Whitney U-test. *P* values of <0.05 were considered statistically significant. All statistical analyses were performed using SPSS 12.0 (Chicago, IL).

Results

A total of 55 patients were enrolled in this study. The mean patient age (±SD) was 53.1 (±12.3) years. There were 23 males and 32 females. Mean stone size was 1.8 (±0.8) cm with 28 stones in the left side and 27 stones in the right side. The mean skin-to-stone distance was 85.9 (±16.5) mm and mean stone density was 770.3 (±312.7) Hounsfield units (HFU) (Table 1). All patients in both groups were stone-free after surgery. When comparing the parameters of Group 1 (n = 33) and Group 2 (n = 22), we found no differences in age, gender, comorbidities, stone laterality, stone size or almost any other anatomical parameter. However, the lower pole infundibular width of Group 1 was significantly longer than that of Group 2 ($p = 0.008$) (Table 2).

No SWL-related complications that required further intervention were observed in Group 1 during the treatment period. However, one case of hemothorax, one case of laryngeal edema and one case of postoperative renal bleeding were reported in Group 2. When we subdivided Group 1 according to stone size, patients with 1 to 2 cm stones required fewer shock waves during lithotripsy for stone-free clearance compared to individuals with stones over 2 cm. No other statistically significant differences for other parameters associated with stone size were observed (Table 3). All patients in Group 1 were stone-free after undergoing a mean of 3.8 (±2.5) SWL sessions. However, Group 1 patients with stones over 2 cm needed an average of 2.3 additional SWL sessions than the patients with stones 1 to 2 cm ($p = 0.039$).

Discussion

Lower pole calyceal stones have been difficult to properly manage because it is not easy to perform the retrograde approach anatomically and it has a large burden, such as general anesthesia and iatrogenic renal injury for parenchymal puncture if percutaneous approach. Some studies

Table 1. Demographic and clinical characteristics of the 55 patients in our study

Age (years)	53.1 ±12.3
Gender	
Male	23
Female	32
Comorbidities	
Hypertension	11
Diabetes	15
Tuberculosis	4
Other	12
Stone laterality	
Left	28
Right	27
Stone size (cm)	1.8 ± 0.8
Anatomical parameters	
Skin-to-stone distance (mm)	85.9 ± 16.5
Stone density (HFU)	770.3 ± 312.7
Lower pole infundibular length (mm)	25.9 ± 4.9
Lower pole infundibular width (mm)	11.0 ± 3.5
Lower pole infundibulopelvic angle (degrees)	56.0 ± 9.5

All values represent the mean ± standard deviation. HFU: Hounsfield units.

Table 2. Analysis of various parameters between Group 1 and 2

	Group 1 (SWL)	Group 2 (PNL)	*p* value*
Number (n)	33	22	
Age (years)	55.1 ± 13.0	50.0 ± 10.6	0.133
Gender			0.503
Male	15	8	
Female	18	14	
Comorbidities			
Hypertension	5	6	0.271
Diabetes	9	6	1
Tuberculosis	2	2	0.672
Other	8	4	0.594
Stone laterality			0.329
Left	15	12	
Right	28	9	
Stone size (cm)	1.6 ± 0.7	1.9 ± 0.8	0.135
Anatomical parameters			
Skin-to-stone distance (mm)	85.6 ± 16.1	86.2 ± 17.3	0.896
Stone density (HFU)	756.7 ± 291.3	790.6 ± 348.6	0.69
Lower pole infundibular length (mm)	25.1 ± 4.0	27.2 ± 5.9	0.125
Lower pole infundibular width (mm)	9.9 ± 2.7	12.7 ± 4.0	0.008
Lower pole infundibulopelvic angle (degrees)	57.4 ± 9.4	54.0 ± 9.7	0.198

All values represent the mean ± standard deviation. *Student's t-test and chi-square test were used for data analysis. HFU: Hounsfield units.

have also reported low stone-free clearance rates for lower pole calculi.[2,12] Albala and colleagues suggested selective treatment for lower pole calculi, while considering renal anatomy and various anatomical parameters, such as lower pole infundibular length and width and the lower pole infundibulopelvic angle.[4]

To treat lower pole calyceal stones less than 1 cm, some studies demonstrated that SWL is equally effective as PNL.[2] Furthermore, Pearle and colleauges reported that the outcomes of SWL are comparable to those of ureteroscopic stone removal for treating lower pole calculi 1 cm or less considering more patient acceptance and short recovery periods.[1,13] However, excellent surgical outcomes have been reported for PNL in treating lower pole calyceal stones 1 cm or larger. The use of PNL has also become more popular with the development of newer devices, such as laser instruments and mini-lap.[5,14] SWL is the preferred option for patients who are not suitable for general anesthesia. SWL devices have also undergone remarkable changes with the advancement in medical technologies; newly designed SWL equipment results in desirable stone-free clearance and better performance compared to older devices.[6,15]

Few studies comparing PNL to SWL for treating cases of lower pole calculi with stone sizes 1 cm or more against upper or mid pole calculi have been performed.[12] Similarly, we conducted an up-to-date analysis to compare SWL and PNL outcomes. In our study, SWL was conducted using a MODULITH SLX-F2, electromagnetic cylindrical shock wave lithotripter with a dual focus zone. Verze and colleagues reported that SWL is favourable to manage single, distal ureteral stones less than 1 cm compared to ureteroscopic stone removal.[16] De Sio and colleagues reported that MODULITH SLX-F2 is safe and effective for treating solitary stones.[15] However, few studies have reported on the management of lower pole calyceal stones over 1 cm with SWL. Our study thus compared SWL to PNL for treating patients with lower pole stones.

In our study, CT was used to measure anatomical parameters. Although Albala and colleagues[4] published anatomical data collected with intravenous urography, more recent studies have shown that CT scans are excellent for measuring renal anatomic parameters related to lower pole calyceal stones.[9,17] Using CT, it was possible for us to estimate stone density within regions of interest. Perks and colleagues[9] suggested that stone densities below 900 HFU and skin-to-stone distances less than 9 cm are significant factors for predicting successful treatment with SWL. El-Assmy and colleagues[17] also emphasized the suitability of three-dimensional CT for viewing stone formation in the lower pole calyx. Weld and colleagues[18] demonstrated that stone characteristics, such as stone density and size as determined by CT, are important predictors of stone-free clearance with SWL. CT scanning may not only measure stone density within a region of

Table 3. Analysis of data according to stone size in Group 1

	Stone size		p value*
	1-2 cm	>2 cm	
Number (n)	26	7	
Age (years)	54.0 ± 12.0	59.1 ± 16.7	0.375
Stone size (cm)	1.3 ± 0.22	2.9 ± 0.45	
Anatomical parameters			
Skin-to-stone distance (mm)	86.8 ± 13.6	81.2 ± 24.3	0.62
Stone density (HFU)	775.5 ± 291.4	687.2 ± 302.3	0.352
Lower pole infundibular length (mm)	25.4 ± 3.8	24.1 ± 5.0	0.62
Lower pole infundibular width (mm)	9.9 ± 2.9	10.0 ± 1.5	0.813
Lower pole infundibulopelvic angle (degrees)	56.4 ± 9.2	61.2 ± 9.7	0.249
No. of SWL needed for stone clearance.	3.3 ± 2.2	5.6 ± 2.8	0.039

All values represent the mean ± standard deviation. *Mann-Whitney U-test and Fisher's exact test were used for data analysis. HFU: Hounsfield units.

interest, but may also accurately calculate other anatomical parameters. We found that it was possible to measure lower pole infundibular width more accurately using cross-sectional and coronal images.

Our study was designed with the consecutive data of patients who suffered from solitary, lower pole calculi over 1 cm from 2008 to 2011. For the first 2 years, all consecutive lower pole calculi over 1 cm were treated using only PNL, at the surgeon's discretion, by a single surgeon (HJ). On the other hand, for the last 2 years, all consecutive patients who came to our centre for the management of lower pole calculi were treated using only SWL. For these reasons, we have minimized any selection bias.

In our study, there was no significant difference in stone size or the presence of comorbidities between Groups 1 and 2. Nevertheless, Group 2 had larger stones, greater stone density and longer lower pole infundibular lengths. Despite these tendencies, no significant anatomical differences were observed between the two groups possibly because stone management was determined not by anatomical factors related to radiologic imaging, but by the patient's general condition and other factors, such as risks associated with general anesthesia and the patient's understanding of the management technique. Indeed, Group 1 included patients who suffered from moderate-to-severe cardio-pulmonary disease. Therefore, SWL may help in managing lower pole calculi compared to PNL with respect to risks and complications related to general anesthesia.

The sub-analysis of Group 1 showed that an average of 2.3 additional sessions were needed to reach a stone-free status for patients with stones 2 cm or more. However, the other parameters measured in the study were not statistically different between the subgroups. These results differ somewhat from those of other studies. Elkoushy and colleagues reported on the surgical outcomes with the same SWL device used in our study. They suggested that the factors affecting stone-free rates are stone sizes less than 1 cm, right-sided laterality, patient age (younger) and the absence of ureteral stenting.[19] In our study, these factors were not clinically significant when comparing SWL to PNL outcomes. These different results may be due to the fact that the Elkoushy and colleagues study involved an analysis of cases related to SWL only, while our study compared SWL to PNL. Due to a small sample size, it was not possible to properly analyze the SWL group in this study.

On the other hand, there was no difference between the two groups in terms of cost-effectiveness. Our results demonstrated that 1 session of PNL is compatible with 3 to 5 sessions of SWL to reach stone-free status. As the cost of SWL is almost covered with the national system of medical insurance in our country, SWL was more cost-effective than PNL. However, medical insurance systems vary from country to country and as such cost-effectiveness was excluded in our study.

Future investigations with larger sample sizes are needed for analyzing various factors associated with SWL.

Conclusions

We determined that SWL is a safe, feasible treatment for solitary, lower calyceal stones over 1 cm. Our findings strongly suggest the use of SWL to treat patients with comorbidities and anatomical weakness rather than PNL, regardless of the risk of general anesthesia.

Competing interests: None declared.

This paper has been peer-reviewed.

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