Unfavorable Anatomical Factors Influencing the Success of Retrograde Intrarenal Surgery for Lower Pole Renal Calculi

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Purpose: To determine the unfavorable factors, related to lower pole anatomical characteristics (LPACs), influencing the success of retrograde intrarenal surgery (RIRS) for lower pole renal calculi (LPC).

Materials and Methods: We reviewed the data of 36 patients who underwent RIRS for LPC between October 2012 and October 2013. The infundibulopelvic angle (IPA), infundibular length (IL) and infundibular width (IW) were measured on preoperative intravenous urographies. On follow-up stone-free status was defined as complete clearance at the first month kidney-ureter-bladder X-ray and computed tomography if necessary.

Results: The median stone size was 10 mm (range, 5-35). The stone-free rates according to LPACs at the first month follow-up were 100% (n = 17), 57.9% (n = 11), 90% (n = 18), 62.5% (n = 10), 90.5% (n = 19) and 60% (n = 9) for patients with IPA ≥ 70°, IPA < 70º, IL < 3 cm, IL ≥ 3 cm, IW ≥ 5 mm and IW < 5 mm, respectively. While IPA and IW were associated with success of RIRS for LPC in multivariate analysis (*P* = .003 and *P* = .046, respectively), only IW was found to be a significant factor after applying multivariate analysis (*P* = .05).

Conclusion: The results of our study demonstrated that only IW had a significant effect on the success rate of RIRS for LPC.

Keywords: kidney calculi; surgery; kidney calculi; therapy; nephrostomy; percutaneous; ureteroscopy; treatment outcome; kidney calculi.

INTRODUCTION

Treatment options for lower pole renal calculi (LPC) depending on the stone size are extracorporeal shock wave lithotripsy (SWL), percutaneous nephrolithotomy (PNL) and retrograde intrarenal surgery (RIRS).[1] SWL is a non-invasive procedure and can be performed as an outpatient setting under local anesthesia or sedation. SWL has been accepted as a standard treatment for renal stones measuring less than 2 cm. However, lower success rates have been reported for LPC.[2]

The first application of flexible ureteroscopy was reported by Marshal in 1964. A 9 French (F) fiberscope manufactured by American Cystoscope Makers (Pelham Manor, NY, USA) was passed into the ureter to visualize an impacted ureteral calculus. Downsizing of flexible ureterorenoscope from 9.8 F to 7.5 F and improvement in its deflection capacity while maintaining the same 3.6 F working channel has allowed urologists to reach renal calyces easily. This event has opened up a new era in the treatment of renal stones and RIRS became a treatment option for renal stones smaller than 20 mm, in cases with an unsuccessful SWL.[3] Furthermore, depending on operator skills, it has been found to be safe and effective procedure even in stones larger than 2 cm.[4]

Despite technological improvements in flexible ureteroscopy, insertion of the laser probe may cause loss of deflection ability of the flexible ureterorenoscope within lower pole calyces and result in difficulties in access. This may be more crucial in patients with unfavorable anatomy. Besides difficulties in access, calyceal unfavorable anatomy may also influence on the stone clearance rate by the effect of gravity after RIRS.

There are few studies assessing the effect of lower pole anatomical characteristics (LPACs) on the success rates of RIRS.[5-7] The impact of intrarenal anatomy on stone-free rates after RIRS is not completely clear yet. In our study, we tried to reveal the unfavorable anatomical factors influencing the success of RIRS for LPC.

MATERIALS AND METHODS

Study Population

A total of 36 patients with radio opaque or non-opaque lower pole renal stones, who underwent RIRS as a primary treatment for LPC between October 2012 and October 2013 were included in the study. The patients who had stones in other localizations than lower pole were excluded.

Before surgery, all patients were evaluated routinely with urinalysis, urine culture, coagulation tests, complete blood count, serum biochemistry and intravenous urography (IVU). Stone length was calculated on preoperative kidney-ureter-bladder (KUB) X-ray by two experienced urologists. In case of multiple stones, the stone size was calculated by adding the length of the longest axis of each

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Received September 2014 & Accepted February 2015

Table. Overall outcomes of retrograde intrarenal surgery.

Variables	Stone Free	Non Stone Free	Univariate	Multivariate		
	(n = 28)	(n = 8)	*P* Value	*P* Value	Odds Ratio	95% CI
Mean age (year)[1]	45.96 ± 9.83	46.63 ±13.17	.877	____	____	____
Median stone size (mm)[2]	10.00 (5-35)	12.00 (5-15)	.825	____	____	____
Median operation time (min)[2]	60 (12-210)	45 (14-90)	.668		____	____
Gender[3] n (%)						
Male	13 (62.3)	7 (36.8)	.053	____	____	____
Female	15 (93.8)	1 (6.2)				
IPA[3] n (%)						
≥ 70º (n = 17)	17 (100)	0 (0)	.003*	____	____	____
< 70º (n = 19)	11(57.9)	8 (42.1)				
IL[3] n (%)						
≥ 3 cm (n = 16)	10 (62.5)	6 (37.5)	.103	____	____	____
< 3 cm (n = 20)	18 (90)	2 (10)				
IW[3] n (%)						
≥ 5 mm (n = 21)	19 (90.5)	2 (9.5)	.046*	.050	8	1.001-63.963
< 5 mm (n = 20)	9 (60)	6 (40)				

Abbreviations: IPA, infundibulopelvic angle; IL, infundibular length; IW, infundibular width; CI, confidence interval.
* Statistically significant; 1 Homogeneous variables; 2 Non-homogeneous variables; 3 Nominal variables.

stone. The infundibulopelvic angle (IPA), infundibular length (IL) and infundibular width (IW) were measured by two experienced urologists on IVU. The IPA of lower calyx was measured as the inner angle formed at the intersection of the ureteropelvic and central axis of the lower pole infundibulum. The IL was measured from the most distal point at the bottom of infundibulum to a mid-point at the lower lip of the renal pelvis. The IW was measured at the narrowest point along the infundibular axis as defined by Elbahnasy and colleagues.[7] Lower pole IPA, IL and IW were measured and recorded for each patient as shown in the **Figure**. Stone- free and non-stone-free patients were analyzed according to their IPA < 70°, IPA ≥ 70º, IL ≥ 3 cm, IL < 3 cm, and IW < 5 mm and IW ≥ 5 mm. Perioperative variables including age, gender, stone size, duration of operation and residual stone were recorded.

Surgical Technique

All patients were operated under general anesthesia by one experienced surgeon. Patients were placed in a modified combined Trendelenburg (head down approximately 20°) lithotomy position.[8] Storz Flex-XTM 2 (Karl Storz, Tutlingen, Germany) flexible ureterorenoscope (7.5 F) was used in the operations. The instrument has continuous controlled dual deflection with increased downward and upward deflection up to 270 degrees in both directions. Before insertion of flexible ureteroscope a semi-rigid ureterorenoscope was inserted into the bladder under endoscopic vision. A guide wire (polytetrafluoroethylene [PTFE] coated, 0.0035 inch) was inserted into ureter through a working channel. The semi-rigid ureterorenoscope was placed into the ureter under the guidance of the guide wire. Once the ureterorenoscope had been in the ureter, the second guide wire (sensitive, 0.0035 inch) was inserted through the other working channel of the ureterorenoscope. Then, the rigid ureterorenoscope was withdrawn and the access sheath (9.5 F) was inserted over the PTFE coated guide wire under fluoroscopy. The flexible ureterorenoscope was inserted. The visual image was coordinated with a fluoroscopy image to enter appropriate calyces.[9] A 270 micron laser fiber was used for lithotripsy. The holmium laser was set at an energy level of 0.5-1.2 joule and a rate of 10-25 Hz. The stones were dusted with a holmium YAG laser, however, when it was not possible to dust a stone (in case of a hard stone) the stone was fragmented smaller than 3 mm diameter. A ureteral double J (DJ) ureteral stent (4.8 F) was placed at the end of the procedure. The DJ ureteral stents were withdrawn four weeks after the procedure when KUB X-ray shows complete clearance of stone fragmentation. The patients were advised to drink 2.5 L of water daily.

KUB X-ray was used to determine stone clearance at the first month follow-up for radio-opaque stones. The stone free statues of the non-opaque stone were evaluated with computed tomography scan (CT) scan. The success was defined as stone-free status which means complete clearance of the stone fragments.

Statistical Analysis

The normality was tested with Shapiro-Wilk test. Student's *t*-test was used for the homogeneous variables. Mann-Whitney *U* test was used for non-homogeneous variables. Logistic regression test was used for multivariate analysis. The statistical evaluation of nominal variables was made by Chi-square and Fischer exact tests. Statistical analysis was done with Statistical Package for the Social Science (SPSS Inc, Chicago, Illinois, USA) version 20.0. The level of significance used was set at $P < .05$.

RESULTS

The mean age of the patients was 46.11 ± 10.46 years. Among 36 patients 20 (55.6%) were male and 16 (44.4%)

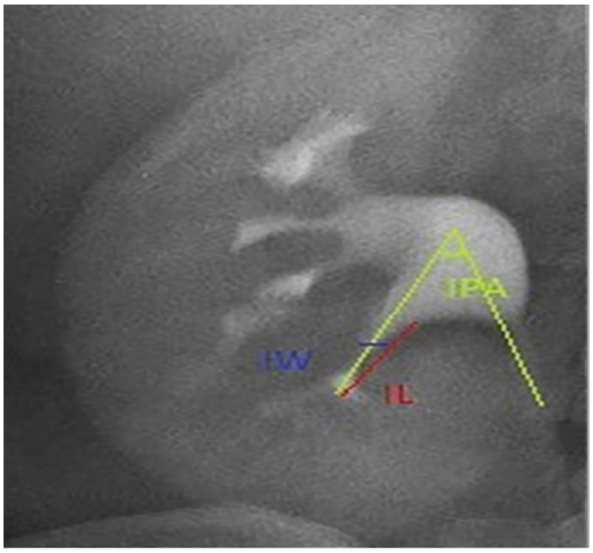

Figure. Measurements of the infundibulopelvic angle (IPA), the infundibular length (IL) and the infundibular width (IW).

were female. The median stone size was 10 mm (range, 5-35). The median duration of operation was 60 minutes (range, 12-210). Two patients underwent simultaneous ureterorenoscopy for ipsilateral ureteral calculi. We used the basket catheter to relocate the lower pole stone into renal pelvis in 4 cases because of difficulties in deflection. The success rate was 77.8% (n = 28) after a single session of RIRS. Comparison of age, stone size and length of operation between patients who were stone free and who were not, demonstrated statistically significant differences (P = .877, P = .808 and P = .668, respectively). Complications observed in this study were, urinary tract infection in 5 and urosepsis in 1 patient. All of these patients were treated with appropriate antibacterial therapy.

There was no significant difference in terms of stone free rate (SFR) between patients with > 3 cm and < 3 cm infundibular length (P = .103). For patients who had IPA < 70º and IPA ≥ 70º, SFR was 57.9% (n = 11) and 100% (n = 17), respectively. When patients with IW < 5 mm and W ≥ 5 mm were compared, SFR was 60% (n = 9) and 90.5% (n = 19), respectively. Both IPA and IW were associated with stone-free status (P = .003, P = .046, respectively). However, IW was the only independent factor after performing multivariate analysis (P = .050). All findings were summarized in the **Table**.

DISCUSSION

Unfavorable anatomical characteristics of the lower pole (such as IPA, IL and IW) have been reported to influence SFR in patients who underwent SWL for LPC. Thus, these parameters should also be taken into consideration before planning treatment.[10,11] There are a few reports assessing the effects of these aforementioned factors on success of RIRS for LPC.[6,7] In the present study, we evaluated unfavorable anatomical factors influencing the success of RIRS for LPC. Both IW and IPA were found to be important factors for SFR in after univariate analysis. However, only IW was found to be statistically significant after multivariate analysis.

There is no clear definition of SFR in literature. Resorlu and colleagues defined SFR as no residual fragments or residual fragments smaller than 4 mm on non-contrast CT scan at the second month follow-up. They reported 80.6% of SFR.[6] Ito and colleagues described it as no residual fragments on the postoperative first day and at the third month on plain KUB films. They reported a SFR of 50.8% for the postoperative first day. In their study, the stones were at different localizations in the kidney and the mean stone size was larger than ours (stone-free and non-stone-free were 16.92 ± 10.22 cm and 36.42 ± 18.51 cm, respectively).[12] Recent studies have reported 85% of SFRs for LPC.[12-16] In the present study, SFRs was 77.8% which was in accordance with other studies. Scopes with higher deflection and double deflection ability may have higher stone free rates and success.

Resorlu and colleagues reported that the age was not an influencing factor as well.[17] In our study we also found that patient's age was not a significant factor influencing the success in the treatment of LPC in our adult patients (P = .877).

The mean stone size was slightly higher for patients with residual stones, but it was not statistically significant (P = .808). Contrary to our results, Resorlu and colleagues reported the stone size as a significant factor on SFR.[6] However, in their study, stone-free status was accepted as either when there were no stone or stone fragments smaller than 4 mm on the first month follow up with non-contrast CT. Ito and colleagues using the same SFR definition with us, also found that stone size affects the SFRs after RIRS for LPC.[12] In these two studies their mean cumulative stone sizes were higher than ours. These could be the reasons why stone size did not reach to statistical significance in our study.

The duration of operation has been found to be longer in non-stone free patients than stone free patients.[12] Stone size seems to influence the stone free status and the operation time. In our study we didn't find any statistical difference in regards to the duration of the operation between stone free and non-stone free patients. This could also be attributed to the stone size since our cumulative stone size was smaller than the reported study.

Many studies have paid attention to the importance of unfavorable lower pole anatomy on the success of SWL in patients with LPC.[7,18] After these reports, it has been emphasized to be of importance for the success of SWL in patients with LPC.[1] However, there are a few reports evaluating unfavorable lower pole anatomy on the success of RIRS in patients with LPC.

In case of steep IPA, access to lower pole calyx may be difficult and it might make stone clearance complicated. In univariate analysis, we found that IPA was associated with stone- free status after RIRS for LPC (P = .003). However this was not significant in multivariate analysis. An IPA ≥ 70º was found to be significant in a study by Elbahnasy and colleagues.[7] Resorlu and colleagues reported the similar result in terms of IPA,[6] but their cut-off value for favorable IPA was ≥ 45º. In a recent study, an acute IPA (< 30°) also was found to have significant influence.[19] Geavlete and colleagues reported that the success rate was 87.5% (7/8 patients) in patients with infundibulopelvic angle wider than 90 degrees, 74.3% (26/35 patients) when this angle ranged between 30 and 90 degrees and 0% (0/4 patients) in patients with infundibulopelvic angle smaller than 30 degrees.[20]

The narrow infundibulum may cause hemorrhage hampering the vision when ureterorenoscope is advancing in the narrowest part of it. The bleeding may become the access failed. In spite of good stone fragmentation, injured calyceal wall may deteriorate passive stone clearance after RIRS. IW has been reported to be important for the patients who undergo SWL for LPC.[7] In our study, the results of the multivariate analysis showed that IW (IW ≥ 5 mm) was the most important favorable anatomical factor influencing stone clearance for the patients who underwent RIRS for LPC (P = .046). Contrast to our study, Resorlu and colleagues have reported that, IW not to be a predictive factor on SFRs.[6] The IL has shown to be able to affect the results in patients with LPC undergoing SWL.[7] We found IL to be statistically an insignificant factor for the stone-free status, similar to the report by Resorlu and colleagues.[6]

The limitation of the present study was that our study consisted of 36 patients which were relatively small to draw an absolute conclusion. Further large scale studies are needed to evaluate the effect of these factors in RIRS treatment of LPC.

CONCLUSION

The results of our study demonstrated that IW ≥ 5 mm had a significant effect on the success of RIRS for LPC. IL, IPA stone size, age and gender were not predictors of unsuccessful RIRS for LPC. RIRS can be safely and effectively used in the treatment of LPC in selected patients having favorable anatomical characteristics.

CONFLICT OF INTEREST

None Declared.

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