Medium-Term Stone Recurrence after zero-fragment transperitoneal Laparoscopic Pyelolithotomy Compared with Percutaneous Nephrolithotomy for Large Single Renal Pelvis Stones

Hamid Pakmanesh[1], Sohrab Mohammad-Salehi[1], Mahboubeh Mirzaei[1]*, Morteza Hashemian[2] , Nazanin Eslami[1]Rayka Sharifian[1]

Purpose: To compare medium-term stone recurrence between laparoscopic pyelolithotomy (LP) and percutaneous nephrolithotomy (PCNL).

Material and methods: 98 patients who underwent PCNL or LP (2015-2019) for large single renal pelvis or staghorn stones (≥ 2 cm) were selected. The stone-free rate was evaluated using a computed tomography scan at one month and then, ultrasonography at six months intervals during the first year and annually thereafter for up to three years. Time-to-stone recurrence was compared using the Kaplan-Meier estimate. Hazard ratio was estimated by Cox regression.

Results: The one month stone-free rate was 93.88% in the LP group vs. 79% in the PCNL group (P = .03). The mean overall time-to-stone recurrence was 31 (CI:24-34) months in the LP vs. 28 (CI: 23-32) in the PCNL groups (P = .02). Cox regression analysis showed that PCNL increased the risk of stone recurrence with a hazard ratio of 2.3 (CI: 1.1 – 5.3) compared to the laparoscopy. (p = .03)
In subgroup analysis, time-to-stone recurrence in those without previous history of intervention was estimated at 31 (CI: 27 to 35) months in the LP vs. 25 (CI:16 to 34) in PCNL groups (= 0.04). Subanalysis with a BMI cutoff of 25 kg/m2 showed an overall time-to-stone recurrence of 34 (CI:30 to 37) months in the LP group and 28 (CI:22 to 33) months in the PCNL group (= 0.04) in those with BMI higher than 25 kg/m^2.

Conclusion: Medium-term time to stone recurrence was in favor of LP compared with PCNL for large single renal pelvis or staghorn stones.

Keywords: Kidney stone; Laparoscopy pyelolithotomy; percutaneous nephrolithotomy; PCNL; stone recurrence

INTRODUCTION

Renal stones are one of the most common disorders of the urogenital system.(1) Large renal pelvis stones have been treated by percutaneous nephrolithotomy (PCNL) for over two decades. EAU guideline recommended PCNL as the first-choice treatment for large renal stones of more than 2 cm in 2018.(2) The development of the laparoscopic (LP) technique facilitates PCNL application in renal stone treatment. A 2012 meta-analysis review article compared the effectiveness of PCNL and LP. Analysis of the included articles revealed that both PCNL and LP were favorable for renal pelvis stones; however, the bleeding and stone-free rates favored the LP.(3) Although many randomized trials have compared PCNL and LP for large renal pelvis calculi, there have been few comparative studies for the recurrence rate of renal stones with medium-term follow-up.(3,4) Since PCNL disintegrates the stone, theoretically, these tiny remaining particles may become a nidus for future stone recurrence in the urinary system. In the present study, we compared PCNL and LP in patients with a large renal pelvis stone of more than 2 cm and evaluated the recurrence rate status of the renal stone for three years.

MATERIAL AND METHODS

From July 2015 to January 2019, ninety-eight patients underwent PCNL or LP for a single large renal pelvis stone (≥2 cm). Only single renal pelvis stones or staghorn stones that could be removed through pyelolithotomy were included and patients with calyceal stones not connected to the main pelvis stones were excluded. (**Figure** 1) We excluded patients with a previous history of complicated nonrenal major intraperitoneal surgery, malignancy, and coagulopathies. However, participants with a single kidney or simple renal anomaly like a horseshoe kidney remained in our study. The patients were informed about the advantages and limitations of the surgical methods and the project was approved by the KUMS Human Ethics Committee (Ethic Approval Code: IR.KMU.REC.1396.1272(.
All patients were evaluated for positive urine culture one week before the operation, and treatment was done only for positive cultures. Moreover, intravenous urography (IVUs), spiral Computed Tomography (CT), and a pre-operative plain x-ray of the Kidney-Ureter-Bladder (KUB) were done for more information. The demographic parameters included gender, age, weight, height, body mass index (BMI), and types of previous intervention for stone including open stone surgery, PCNL, Schock Wave Lithotripsy (SWL), and Trans Ureteral

[1]Clinical Research Development Unit, Shahid Bahonar Hospital, Department of Urology, Kerman University of Medical Sciences, Kerman, Iran.
[2]Department of Anesthesia, Faculty of Medicine, Kerman University of Medical Sciences, Kerman, Iran.
*Correspondence: Urology Department, Shahid Bahonar Hospital, Qarani Street, Kerman, Iran.
E mail: mirzaeimahboubeh@yahoo.com.
Received February 2023 & Accepted December 2023

Table 1. Characteristics of the Patients and Stone

Patient and Stone Characteristics	LP (n=49)	PCNL (n=49)	*P* value
Patients	47 ±15	46 ±15	0.96
Age (years)			
Gender			0.53
Male	33 (67%)	29 (59%)	
Female	16 (32%)	20 (40%)	
BMI (Kg/m^2)	22 (17-30)	28 (14-45)	0.001
Stone			*
Laterality			1.00
Right	29 (59%)	30 (61%)	
Left	20 (41%)	19 (39%)	
Stone size (mm)	25 ± 7	28 ±7	0.06
Past stone treatment (same side)			0.001
Percutaneous Nephrolithotomy (PCNL)	3 (6%)	12 (24%)	
Shock Wave Lithotripsy (SWL)	7 (14%)	15 (31%)	
Trans ureteral Lithotripsy (TUL)	6 (12%	2 (4%)	
Open stone surgery (1)	2 (4%)	9 (18%)	

Data are presented as mean ± SD or count (percent).
* Significant (less than 0.05)

Lithotripsy (TUL), and stone characteristics consisting of maximal diameter, size, and laterality were recorded carefully. All participants received prophylactic antibiotics 30 minutes before the operation.

The laparoscopic procedure was done via the transperitoneal route in the flank position and under general anesthesia. A urinary catheter was inserted after anesthesia. The umbilical or pararectal 10-mm trocar was inserted under direct vision with the open access technique and CO2 was blown to maintain the pneumoperitoneum at 10-12 mmHg. Two 5-mm trocars were inserted in the subcostal area near the iliac crest at the midclavicular line. The renal pelvis and proximal ureter were exposed after incision of the withe line of Toldt and reflection of the colon medially. An appropriate pyelolithotomy was done, and the stone was extracted with forceps. The stone was inserted in an Endo-bag and pulled out from the trocar incision. The pelvis was repaired using an interrupted 4-0 vicryl suture after inserting a JJ stent antegradely. The Perinephric area was drained by a corrugated drain.

PCNL was performed in the prone position after placing a urethral catheter in the lithotomy position. Ultrasonography was used as a guide for access. After placement of the guidewire the tract was dilated using an Amplaths sheath and nephoscopy was performed by a standard 24F nephoscope through the working channel. Stones were disintegrated with a ballistic lithotripter and the particles were extracted by grasping forceps.[5] Finally, fluoroscopy was performed to ensure complete stone clearance and a nephrostomy catheter was placed. JJ stent was not placed routinely in this group.

the operation time in the PCNL group was recorded from the beginning of the kidney access to the end of the PCNL procedure excluding the time spent for catheter placement in the lithotomy position at the beginning of the procedure and time spent for patient repositioning to prone. In the laparoscopic group, the operation time was from the beginning of the anesthesia to the end of the procedure. Perioperative data consisting of the mean operation time, hospital stay, hemoglobin change, and creatinine were recorded in each group. We used the Clavien complication classification for grading perioperative complications. Stone-free status was evaluated by KUB the day after surgery and a noncontract CT scan was at the one-month follow-up. Any particle bigger than 4mm was considered significant, and complementary treatment was prescribed if required. Patients were followed up using ultrasound every 6 months in the first postoperative year and then annually thereafter. Statistical analysis was performed with SPSS version 24. A T-test for the numerical variables and a Chi-Square test for the categorical variables were appropriately used. The Kaplan-Meier estimate of survival was used for the analysis of time to stone recurrence. Cox regression was used to compare the hazard ratio between the two study groups. A *P*-value less than .05 was considered statistically significant.

This study was performed and approved by the Medical Ethical Committee of the Kerman University of Medical Sciences, ethical approval code IR.KMU.REC.1396.1272.

RESULTS

Ninety-eight subjects participated in our study and were enrolled in this study including LP (n = 49) and PCNL (n = 49) groups. Although there were no statistical differences in demographic characteristics (age and gender), the Body mass index was nonhomogeneous between the two groups. Stone characteristics of laterality

Table 2. Perioperative and Postoperative Data

Perioperative and Postoperative Data	LP (n=49)	PCNL (n=49)	*P* value
Perioperative finding			
Mean operation time (1)	136±31	72±24	0.001*
Mean hospital stay (day)	3±1	2±1	0.001*
Mean change in hemoglobin (g/dl)	1±1	2±1	0.002*
Mean change in creatinine (mg/dl)	0.07±0.2	0.03±0.1	0.36
Postoperative management			
Stone free rate (1 month)	46(93.88%)	39(79.59)	0.035*

Data are presented as mean ± SD or count (percent).

Table 3. Clavien Classification of Perioperative Complications

Clavien Classification	Lap (n=49)	PCNL (n=49)	*P*-value
No complication	34 (69.4%)	27 (55.1%)	0.14
Grade1			
Fever	7 (14.3%)	16 (32.7%)	0.03
Gross Hematuria	0 (0%)	2 (4.1%)	0.15
Grade 2			
Transfusion	3 (6.1%)	8 (18.4%)	0.06
UTI	2 (4.1%)	0 (0%)	0.15
Grade 3a			
Urine leakage	1 (2%)	1 (2%)	1
Omental herniation	1 (2%)	0 (0%)	0.31
Grade 3b			
Perirenal urine collection	1 (2%)	0 (0%)	0.31
Placement of DJS	0 (0%)	1 (2%)	0.31
Grade 4			
Ischemic heart disease	2 (4.1%)	0 (0%)	0.15
Pneumothorax	0 (0%)	1 (2%)	0.31
Intestinal injury	0 (0%)	0 (0%)	0.31
Grade 5			
Death	0 (0%)	0 (0%)	NA

Data are presented as count (percent).
NA: Not applicable

and mean stone size revealed no significant differences. Two subjects in the LP group and nine patients in the PCNL group had a previous history of open renal stone surgery (**Table 1**). The mean operation time of LP was significantly more than PCNL (P = .001). (The mean hospital stay was 3.33 days in LP subjects and 2 days in the PCNL group (P = .001). However, there was no meaningful difference in creatinine changes between the two groups, and the hemoglobin drop was more significant in the PCNL group (P = .002) (**Table 2**). Table 3 shows perioperative complications based on the Clavien classification. We gave routine painkillers to all participants, and post-operative pain was not evaluated. The overall complication rate in the PCNL group was higher than in the LP group but not statistically significant (P = .14) (**Table** 3).

Stone-free rate and time to stone recurrence

The postoperative 1-month CT scan showed that 93% of subjects in the LP group and 79% in the PCNL group had no stones more than 4 mm in the pyelocaliceal system (P = .035) (**Table 2**). In the laparoscopy group, 4 patients recurred at 6 months, 1 more patient at 12 months 3 more patients at 24 months, and no new patients at 36 months. In the PCNL group, 9 patients at six months, 5 more patients at 12 months 8 more patients at 24 months, and 1 more at 36 months had stone in the sonography. From all recurrences 9 patients including 3 in the laparoscopy and one in the PCNL group were bigger than one cm and underwent SWL. More, one patient in the laparoscopy and three patients in the PCNL group had stones bigger than 20 mm and were treated with PCNL. Other small recurrences received medical therapy.

The mean overall time to stone recurrence was estimated using Kaplan-Meier estimate of the survival to be 31 (CI:24-34) months in the LP vs. 28 (CI: 23-32) in the PCNL groups (P = .02). After three years, more than 70% in the Laparoscopy group were stone-free, whereas, the stone-free rate in the PCNL group was less than 50% at the end of the study. Cox regression analysis showed that PCNL increased the risk of stone recurrence with a hazard ratio of 2.3 (CI: 1.1 – 5.3) compared to the laparoscopy. (p = .03) (**Figure 2**)

Subanalysis; Previous stone intervention

We split the data into two groups. The first group included 42 patients who did not experience any previous intervention for stones. From these, 31 patients were in the laparoscopy group and 11 patients in the PCNL group and the overall time to stone recurrence was estimated 31 (CI: 27 to 35) months vs. 25 (CI:16 to 34) respectively in favor of laparoscopy (P = .04). The second group included 55 patients who formerly underwent at least one intervention for stone treatment. From them, 17 patients were in the laparoscopy group and 38 were in the PCNL group. Overall time to stone recurrence was estimated 29 (CI:24 to 34) and 28 (CI:23 to 33) months respectively (P = .2).

Subanalysis; BMI

Again, data was split into two groups. The first group included 50 patients with a BMI of less than 25 kg/m2. From these, 35 patients were in the laparoscopy group and 15 patients in the PCNL group and the overall time to stone recurrence was estimated 30 (CI: 26 to 35) months vs 28 (CI:21 to 35) respectively (P = .19). The second group included 47 patients with a BMI higher than 25 kg/m^2. Of them, 13 patients were in the laparoscopy group and 34 were in the PCNL group. Overall time to stone recurrence was estimated 34 (CI:30 to 37) and 28 (CI:22 to 33) months respectively in favor of laparoscopy (P = .04).

DISCUSSION

Numerous cases of laparoscopic stone surgery have been reported following the initial one 25 years ago.[6] Urologists generally prefer PCNL due to fewer invasions and better cosmetic results[7,8]; however, LP is an appropriate alternative for PCNL and even the treatment of choice in selected cases[9]. Only a few studies have compared PCNL vs. LP for the treatment of a single renal pelvis stone larger than 2cm, but the correlation between operation technique and rate of stone recurrence is still unknown.[10,11] In the present study, we compared LP and PCNL for the treatment of a solitary renal pelvis stone, and stone-free status was evaluated over a medium-term follow-up.

Most studies revealed a stone-free rate of more than 80 percent with PCNL or LP, and a few even reported a

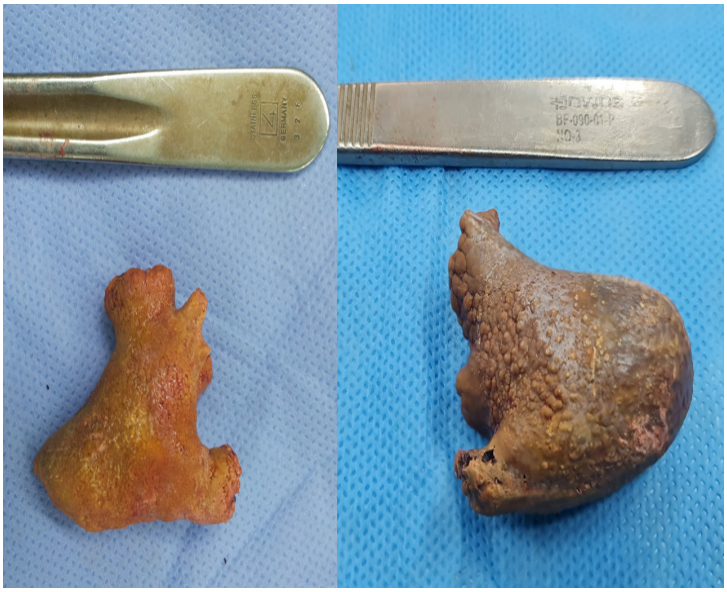

Figure 1. Staghorn stone removed laparoscopically

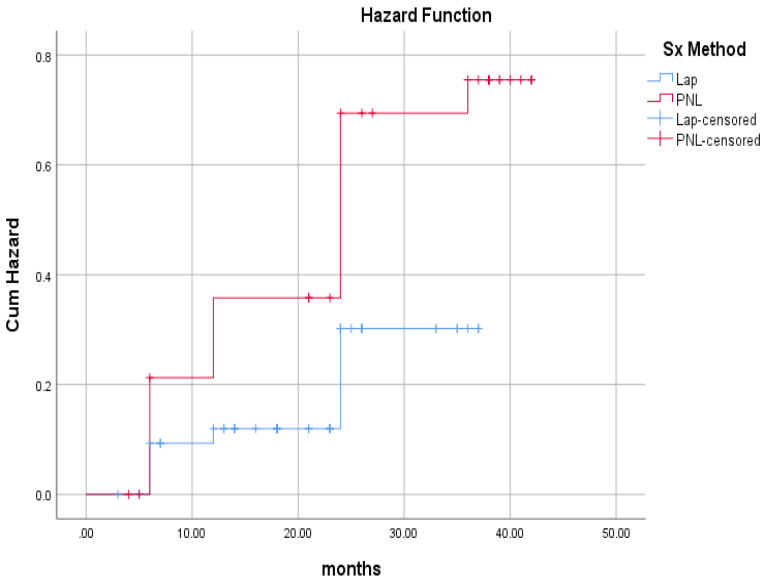

Figure 2. Hazard Function Plot depicting the risk of stone recurrence in the Laparoscopy and PCNL groups during 3 years of follow-up

100% stone-free rate.[7,12,13,14] There was a significantly higher stone-free rate in the LP group compared with the PCNL group in this study; however, this reference was not significant in some other studies.[10,11] Sharifi and colleagues reported a 100% stone-free rate for renal pelvis stones larger than 3 cm in the LP group, which was significantly more than the PCNL group.[15] A scattering of stone fragments in the pyelocaliceal system may decrease the stone-free rate in the PCNL group, while intact removal of pelvis stone increases its success rate in the LP group.[4] Because of intact stone removal, the risk of stone recurrence in this study was lower in the LP group than in the PCNL group. Stone fragments were scattered in the pyelocaliceal system after PCNL, so the time for new stone formation was shorter in the PCNL group. More, a subanalysis of our data showed that the stone-free duration was in favor of the laparoscopy group only in those who had a negative previous history of any stone intervention including open surgery, PCNL, SWL, or TUL. Although the size of subanalysis groups is not big, someone may speculate that the advantage of zero fragment laparoscopy in decreasing stone recurrence is more pronounced in those who did not have former stone disintegration in the urinary tract. Xia et al, compared 105 patients who underwent PCNL and LP and stated that the mean stone recurrence was found to be similar between the groups at a 47-month follow-up.[16]

Although the demographic characteristics were homogenous in the current study, BMI was higher in the LP group than in the PCNL group. Urologists prefer a patient with a lower BMI for LP because of less abdominal and intra-peritoneal fat tissue, and a biased selection may have happened. The mean operation time was significantly shorter in the PCNL vs. LP group, similar to studies by Meria et al[10] and Al-Hunayan et al[11]. The prolonged learning curve, removal of the stone with an endo bag, and suturing of multiple incisions in LP make its operation time longer. However, our LP operation time was acceptable and, in some cases, even lower than other studies.[10,11,17,18] It should be kept in mind that one limitation of our study was that the operation time in PCNL group was recorded from the beginning of the kidney access to the end of PCNL procedure excluding the time spent for catheter placement in lithotomy position at the beginning of the procedure and time spent for patient repositioning to prone, whereas, in the laparoscopy group, the operation time was recorded from the beginning of the anesthesia. The duration of the operation may be affected by the manner of surgery and surgeon experience, surgical tools, and patient factors. Moreover, in our study, laparoscopy was performed trans-peritoneally; however, in recent reports of retroperitoneal laparoscopic pyelolithotomy, the duration of the hospital stay and operation time are reported to be shorter in the retroperitoneal laparoscopic pyelolithotomy group compared with PCNL.[9,20] Li et al compared retro-peritoneal laparoscopic pyelolithotomy with PCNL and conversely reported a shorter operation time in the LP group.[4] We found that the mean hospital stay of the PCNL group was significantly shorter than the LP group. Although our experiences with PCNL were more than laparoscopic pyelolithotomy, the total hospital stay was shorter than similar studies by Lee et al., Meria et al., Hunayan et al., and Li et al. for PCNL and LP groups.[4,9-11]

Renal injury is more common in PCNL due to a direct insertion through the parenchyma to the pelvis; therefore, bleeding and other complications are more common in PCNL vs. LP. Bleeding is the most common complication of PCNL. In our study, a drop in hemoglobin and subsequent blood transfusion were significantly more in the PCNL group. Conversely, there were no significant differences between PCNL and LP in the study by Al-Hunayan.[11] Like many studies, we did not have any conversion to open[9], however, its incidence is reported as 12.5 to 20% in some studies.[7,19]

Fever and blood transfusion were significantly higher in the PCNL group, but other complications were not significantly different between the two groups. However, the use of open irrigation systems and 0.9% Sodium Chloride Irrigation USP may induce post-operation fe-

ver in PCNL participants.

Our study had some limitations. First, our study was small, with only 98 patients. Second, some demographic characteristics like BMI were non-homogeneous. Third, we overlooked the effect of stone composition, stone history, UTI, and metabolic disorders on stone recurrence. We attest that other important factors related to the stone formation are not addressed in this study. Indeed, we tried to evaluate the possibility of a difference in the stone recurrence in two groups based on the hypothesis that if the stone is removed without disintegration, there might be fewer particles in the collecting system which could be translated to a lower risk of stone recurrence. In this study, we tried to compare the effect of two different methods of stone removal i.e., with or without fragmentation on the recurrence irrespective of the stone composition or other metabolic factors. This could be a basis for future large-scale studies considering all aspects of stone formation as well as the surgical method.

CONCLUSIONS

PCNL is the gold standard for large renal pelvis stones; however, laparoscopy is a great alternative with lower complications, a superior stone-free rate, and a longer time to stone recurrence. Therefore, LP treatment for renal pelvis calculi of more than 2 cm is a good choice in a hospital with an expert laparoscopic surgeon.

FUNDING

Kerman University of Medical Sciences; Grant number :96000049

CONFLICT OF INTEREST

The authors have no conflicts of interest.

REFERENCES

1. Sofia, N.H., Manickavasakam, K., M. Walter, T. .. Glob. J. Res. Anal, 2277-8160, 2016.
2. Wang, X., Li, S., Liu, T., Guo, Y., Yang, Z. Laparoscopic pyelolithotomy compared to percutaneous nephrolithotomy as surgical management for large renal pelvic calculi: a meta-analysis. J urol, 190: 888, 2013.
3. Zheng, J., Yan, J., Zhou, Z. et al. Concomitant treatment of ureteropelvic junction obstruction and renal calculi with robotic laparoscopic surgery and rigid nephroscopy. Urology, 83: 237, 2014.
4. Li, S., Liu, T. Z., Wang, X. H. et al.: Randomized controlled trial comparing retroperitoneal laparoscopic pyelolithotomy versus percutaneous nephrolithotomy for the treatment of large renal pelvic calculi: a pilot study. J Endourol, 28: 946, 2014
5. Nouralizadeh, A., Pakmanesh, H., Basiri, A. et al.: Solo sonographically guided PCNL under spinal anesthesia: defining predictors of success. Scientifica, 2016, 2016
6. Salvadó, J. A., Guzmán, S., Trucco, C. A., Parra, C. A. Laparoscopic pyelolithotomy: optimizing surgical technique. J endourol, 23: 575, 2009.
7. Goel, A., Hemal, A. Evaluation of role of retroperitoneoscopic pyelolithotomy and its comparison with percutaneous nephrolithotripsy. Int. Urol. Nephrol., 35: 73, 2003.
8. Yunjin, B., Yin, T., Deng, L., Wang, X., Yang, Y., Wang, J., Han, P. Management of large renal stones: laparoscopic pyelolithotomy versus percutaneous nephrolithotomy.BMC Urology, 17: 75, 2017.
9. Lee, J. W., Cho, S. Y., Jeong, C. W. et al. Comparison of surgical outcomes between laparoscopic pyelolithotomy and percutaneous nephrolithotomy in patients with multiple renal stones in various parts of the pelvocalyceal system. J Laparoendosc Adv Surg Tech, 24: 634, 2014.
10. Meria, P., Milcent, S., Desgrandchamps, F. et al. Management of pelvic stones larger than 20 mm: laparoscopic transperitoneal pyelolithotomy or percutaneous nephrolithotomy? Urol. Int., 75: 322, 2005.
11. Al-Hunayan A, Khalil M, Hassabo M, Hanafi A, Abdul-Halim H. Management of solitary renal pelvic stone: laparoscopic retroperitoneal pyelolithotomy versus percutaneous nephrolithotomy. J endourol. 2011;25:975-8.
12. Gaur, D., Agarwal, D., Purohit, K., Darshane, A. Retroperitoneal laparoscopic pyelolithotomy. J urol, 151: 927, 1994.
13. Micali, S., Moore, R., Averch, T., Adams, J., Kavoussi, L. The role of laparoscopy in the treatment of renal and ureteral calculi. J urol, 157: 463, 1997.
14. Basiri, A., Tabibi, A., Nouralizadeh, A., Arab, D., Rezaeetalab, G., Hosseini Sharifi, S., Soltani, M. Comparison of Safety and Efficacy of Laparoscopic Pyelolithotomy versus Percutaneous Nephrolithotomy in Patients with Renal Pelvic Stones: A Randomized Clinical Trial. Endourology and Stone Disease,Urol J, 11: 06, 2014.
15. Aminsharifi, A., Hosseini, M.M., Khakbaz, A. Laparoscopic pyelolithotomy versus percutaneous nephrolithotomy for a solitary renal pelvis stone larger than 3 cm: a prospective cohort study. Urolithiasis, 41: 493, 2013.
16. Xiao, Y., Li, Q., Huang, C. et al. Perioperative and long-term results of retroperitoneal laparoscopic pyelolithotomy versus percutaneous nephrolithotomy for staghorn calculi: a single-center randomized controlled trial. World J Urol, 37: 1441, 2019
17. Hemal, A., Goel, A., Kumar, M., Gupta, N. Evaluation of laparoscopic retroperitoneal surgery in urinary stone disease. J endourol, 15: 701, 2001.
18. Kramer, B. A., Hammond, L., Schwartz, B. F. Laparoscopic pyelolithotomy: indications and technique. J endourol, 21: 860, 2007.
19. Sinha, R., Sharma, N. Retroperitoneal laparoscopic management of urolithiasis. J Laparoendosc Adv Surg Tech, 7: 95, 1997.
20. Mao, T., Wei, N., Yu, J., Lu, Y. Efficacy and safety of laparoscopic pyelolithotomy versus percutaneous nephrolithotomy for treatment of large renal stones: a meta-analysis. J Int Med Res, 49: 300060520983136, 2021.