Transperitoneal Laparoscopic Pyelolithotomy versus Percutaneous Nephrolithotomy for Treating the Patients with Staghorn Kidney Stones: A Randomized Clinical Trial

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Purpose: To compare the performance and outcomes of laparoscopic pyelolithotomy (LPL) versus percutaneous nephrolithotomy (PCNL) in the management of staghorn kidney stones.

Materials and Methods: This study was a parallel-group randomized clinical trial study carried out on 68 patients with staghorn stones (one single piece or maximally two-piece stones with large extra renal part) over 18 years referred to Labbafinejhad Hospital. Patients were randomly divided on a ratio of 1:1 into two groups of LPL and PCNL using random allocation software. The primary outcome was the stone free rate, which was evaluated with KUB, and ultrasonography. Secondary outcomes were duration of surgery, bleeding, fever, post-operative pain, length of hospital stay, and postoperative complications.

Results: The mean±SD age of patients in PCNL and LPL groups were 48.50 ± 13.33 years and 52.17 ± 15.74 years, respectively (P = .303). LPL was associated with a higher duration of surgery (196.55 ± 26.58 minutes versus 110.88 ± 34.82; P = .001). Hemoglobin drop in the PCNL group was higher than the LPL group (2.67 ± 2.61 g/dL versus -0.7912 ± 1.06 g/dL; P=.001). Stone free status was observed in 29 (85.3%) patients in the LPL group, which was significantly higher than the PCNL group (22 patients, 64.7%; P =.050).

Conclusion: The results of this study indicate that LPL offers a higher stone free rate with less bleeding in patients with single particle or limited particles staghorn stones with extrarenal pelvis but is associated with a higher duration of operation. The application of LPL in patients with multiple stones carries a lower achievement and is not encouraged.

Keywords: calculi; laparoscopy; percutaneous nephrolithotomy; pyelolithotomy; staghorn stone

INTRODUCTION

It is estimated that about 2% to 5% of people in the community have urinary tract stones and Iran is one of the countries located on the kidney stone belt with a prevalence of 2-3%. [1,2] Staghorn stones consist of 4% of all urinary stones in developed countries. Regarding severe morbidities associated with this type of stones (10-year mortality of 28% and 36% renal impairment), the treatment should be commenced as soon as possible.[3,4] Staghorn stones were reported to be struvite in 49–68% of the cases which has close relation with urease-producing organisms.[5] However, according to more recent studies, staghorn stones composed of calcium phosphate (55%), calcium oxalate (14%), uric acid (21%), and cysteine are increasing in number, which reveals the association between staghorn stones and metabolic disorders.[6]

There are several treatment modalities for the management of staghorn stones. Percutaneous nephrolithotomy (PCNL) offers stone free rates of 98% for partial staghorn stones and 71% for complete staghorn stones and a complication rate of 4% and has supplanted open surgery for treatment of staghorn stones.[7-10] Laparoscopic pyelolithotomy (LPL) is also a suitable option for kidneys with extrarenal pelvis and a single pelvic stone.[11,12] Some studies have reported convincing results of LPL for the management of multiple renal stones[13], and stones in kidneys with intrarenal pelvis.[14]

However, evidence on the use of LPL for the management of staghorn stones is poor and mostly in the format of limited case series. Therefore, this study was designed to investigate the performance of PCNL and LPL in the treatment of partial and complete staghorn stones in a randomized clinical trial.

MATERIALS AND METHODS

Study Population

This study was a parallel-group randomized clinical trial with 1:1 allocation ratio carried out on 68 patients

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Received May 2021 & Accepted December 2021

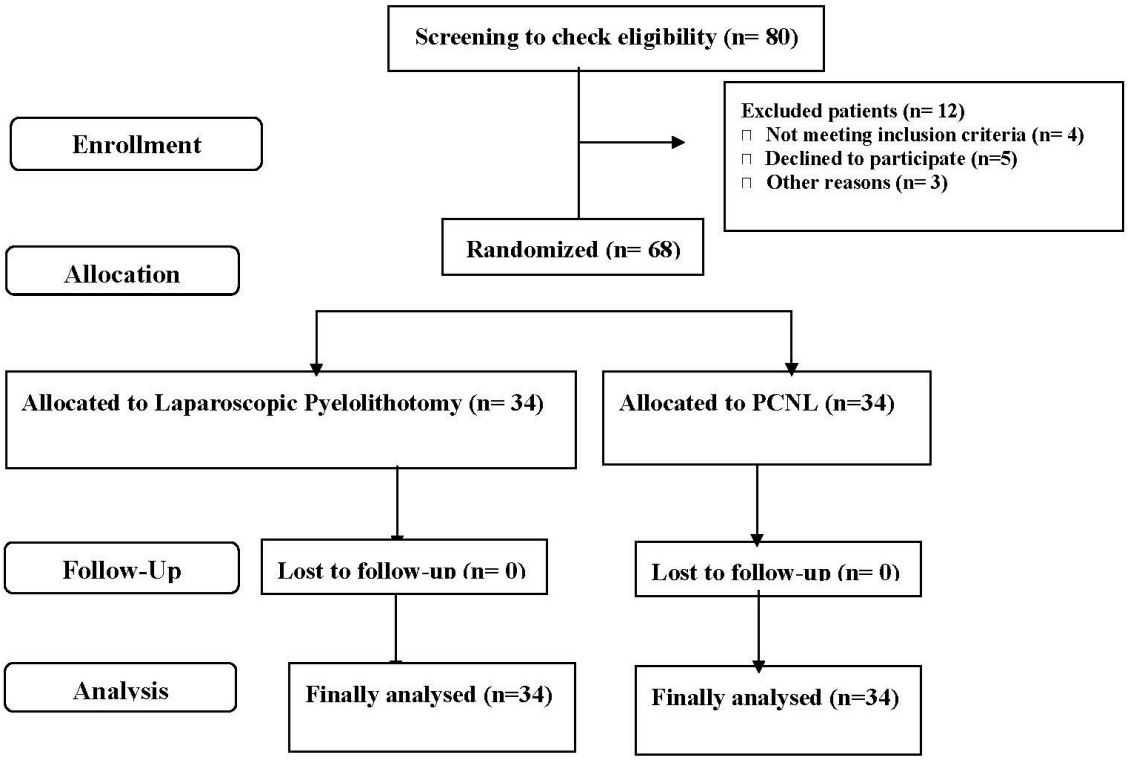

Figure 1. CONSORT flow chart showing the flow of patients through the trial.

with staghorn stones with extrarenal pelvis over 18 years who were referred to Labbafinejad hospital for treatment modalities. Sample size was determined using a presumed stone free rate of 91% for LPL and 64% for PCNL based on the outcomes reported by Lee and colleagues. Considering a type I error rate of 0.05 and type II error rate of 0.2, the needed sample size for each group was determined to be 34 patients. Random allocation software was used to divide the patients into two groups of laparoscopic pyelolithotomy and PCNL (**Figure 1**). Patients were randomized by permuted block randomization in block sizes of four to either of the treatment modalities by pregenerated allocation sequence of the software that was kept in concealed envelopes.

Inclusion and exclusion criteria

Inclusion criteria were: American Society of Anesthesia Class I or II, willingness to participate, complete staghorn stone in imaging, age between 18-65 years, absence of coagulopathy, preoperative hemoglobin equal to or above 10 mg/dL, and absence of urinary tract infection. Exclusion criteria were: a need for urgent surgery, sepsis, active bleeding, patient decision to leave the study before the operation, patients with solitary kidneys, anatomical abnormalities of the urinary tract, and history of previous surgery on the same kidney (open surgery or PCNL). Patients underwent general anesthesia based on the diagnosis of the anesthesiologist after an initial examination. One hour before surgery, 1 gram intravenous cefazolin was administered to all patients.

In the preoperative room, patients were assessed regarding the criteria for inclusion after discussing with them and receiving their acceptance to enroll in the study. Patients were then investigated for exclusion criteria and relevant information was recorded. Then patients were allocated to either of the interventions by the opening of the concealed envelopes containing the allocation treatment as explained above. The surgeons were blind to the allocation of every next patient and after fulfillment of eligibility criteria, the envelopes were opened.

PNCL procedure

PCNL was done in the standard prone position under fluoroscopic guidance as described previously[7]. Patients were placed in lithotomy position and a 5F ureteral catheter was inserted by cystoscopy or ureteroscopy. Then, the patient was turned into the prone position with careful padding of the pressure points. Access was made under fluoroscopy guidance and a 24F Wolf nephroscope was used for nephroscopy. Stones were disintegrated with a pneumatic lithoclast (EMS, Switzerland) and fragments were removed by grasper. A second access was established if deemed necessary for better stone clearance. A double pigtail catheter and a nephrostomy tube were inserted at the termination of the operation for all PCNL patients.

Laparoscopic pyelolithotomy

LPL was done in lateral decubitus position using one camera port and three 5mm working trocars in triangular orientation. After medialising colon, the ureter was identified and was pursued to release renal pelvis from surrounding tissues. A horizontal incision was made by cautery on renal pelvis. After releasing the attachments of stone to pelvis and calices, the stone was grasped with forceps and extracted. As the pyelocalyceal system was dilated in most cases, the laparoscopy camera was

introduced inside the pyelocalyceal system, and residual stones were searched and extracted. A double pigtail catheter was inserted and pelvis incision was repaired in a separate or running manner using 4-0 vicryl sutures. Stones were extracted by endobag through the lower 5 mm trocar site under laparoscopic vision.

Stone free rate was evaluated by the 1st postoperative day KUB. Remnants larger than 4 mm were considered clinically significant residual fragments.

Haemorrhage was defined as postoperative hemoglobin drop more than 2.5gr/dL. Postoperative pain severity was evaluated by visual analogue pain score.

The primary outcome of interest was the stone free rate. Secondary outcomes were duration of surgery (recorded from anesthesia induction up to end of the surgery), bleeding, fever, post-operative pain (quantifying by frequency of narcotic administration in the first postoperative day), length of hospital stay, postoperative hemoglobin drop, prolonged urinary leakage (lasting more than 4 days), and other complications.

The ethics of this study was approved by the ethics committee of the Urology and Nephrology Research Center of the Shahid Beheshti University of Medical Sciences on 20th July 2019 with the following code: IR.SBMU.UNRC.REC.1399.003. Patients were explained about the study objectives in their own language and their informed consent was obtained. This study is registered in the Iranian Registry of Clinical Trials (IRCT) with the following code: IRCT20180625040232N5 (https://en.irct.ir/trial/48258).

Statistical Analysis

Data were entered into SPSS and the statistician who analyzed data was not aware of the patient's group allocation. Frequency and percentage were used to describe the qualitative variables. The mean and standard deviation for the quantitative variables was reported. Student t-test or Mann-Whitney test were used to compare quantitative variables between the two groups, and Chi-square was used to compare qualitative variables.

RESULTS

As indicated previously the study aimed to enroll 68 participants in the two study groups. Enrollment began from April the 3rd 2020 and ended on December the 3rd 2020. Eighty participants with staghorn stones who were candidates for stone operation were screened to enroll the required number of patients. Twelve patients were excluded after primary screening due to the following causes: 5 patients did not accept the probability of open surgery in the laparoscopy group, 4 patients had previous history of surgery in the same side (2 percutaneous nephrolithotomy, 1 open surgery, and 1 laparoscopic pyeloplasty), and surgery was postponed in 3 patients because of failure in preoperative preparation. The comparison of demographic and operative parame-

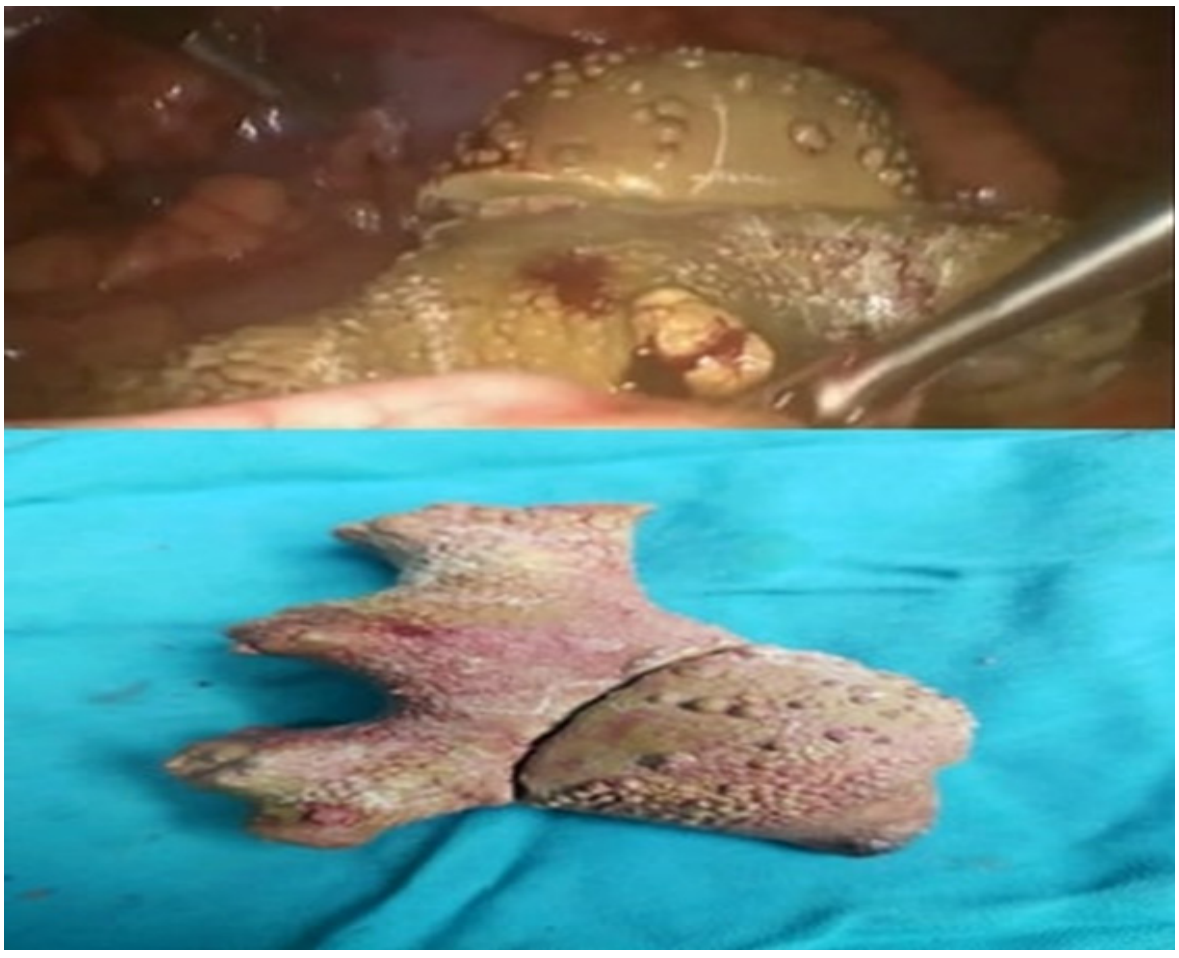

Figure 2. Laparoscopic stag-horn stone extraction.

Table 1. Comparison of the demographic and perioperative variables between the two study groups.

Variable	Groups		*P*-value
	PCNL	LPL	
Age, years; mean±SD 4	8.5 ± 13.3	52.2 ± 15.7	.03
Preoperative hemoglobin, mg/dL; mean±SD	13.7 ± 2.0	13.4 ± 1.7	.65
Preoperative creatinine, mg/dL; mean(IQR)	1.36 (1.15-1.47)	1.64 (1.30-1.80)	.018
Weight, kg; mean±SD	80.6 (67.7-90.0)	74.9 (66.7-82.5)	0.11
Surgery duration, minutes; mean (IQR)	110 (90-131)	197 (183-210)	< .001
1st postop day hemoglobin, mg/dL; mean±SD	11.0 ± 1.8	12.7 ± 1.9	< .001
1st postop day creatinine, mg/dL; mean±SD	1.33 (1.09-1.47)	1.47 (1.10-1.80)	.16
Hospitalization days; mean±SD	2.3 ± 1.1	2.4 ± 0.9	.62
Postoperative fever; N(%)	9 (27)	8 (23)	.78
Postoperative pain			
Severe/Moderate/Mild	24 (70.6) / 10 (29.4) / 0	14 (41.2) / 20 (58.8) / 0	.015
Stone free status; N(%)	22 (65)	29 (85)	.05
Transfusion; N(%)	6 (18)	1 (3)	.046
Hemorrhage; N(%)	15 (44)	5 (15)	.008
Prolonged urinary leakage; N(%)	1 (2.94)	8 (23.52)	.012
Gender; N(%) Female	21 (61.8)	18 (52.9)	.462
Male	13 (38.2)	16 (47.1)	

Clavien-Dindo grade of complications; N(%)	**PCNL group**			**LPL group**		
	Grade 1	**Grade 2**	**Grade 3a**	**Grade 1**	**Grade 2**	**Grade 3a**
Fever	9 (26.5)	-	-	8 (23.5)	-	-
Prolonged extravasation	1(2.9)	-	-	8 (23.5)	-	-
Transfusion -	6 (17.6)	-	-	1(2.9)	-	
TUL for residual ureteral stones	-	-	2 (5.9)	-	-	-
Salvage PCNL for residual upper ureteral stone	-	-	-	-	-	1 (2.9)
Total	10	6 (17.6)	2 (5.9)	16 (47)	1(2.9)	1(2.9)

ters in the two studied groups has been provided in Table 1. There was no statistically significant difference in the age of patients, their weight, preoperative hemoglobin and creatinine between the studied groups. The mean ± SD age of patients in PCNL and LPL groups was 48.50 ± 13.33 and 52.17 ± 15.74 years, respectively (P = .303). The comparison of demographic and perioperative data of patients in the two study groups has been presented in **Table 1**.

The staghorn stone in the LPL group was a single staghorn stone and in a few patients, the stone consisted of two pieces including a main stone bulk and a separate stone apart from the main bulk. We did not include patients with staghorn stones consisting of more than one separate stone in calices. Stone free status was observed in 29 (85.3%) patients in the LPL group, which was significantly higher than the PCNL group (22 patients, 64.7%; P =.050).

In the PCNL group, 11 patients (32.35%) needed more than one access to achieve stone free status, 4 (36.36%) of these accesses were supracostal. Eight (23.52%) patients in the pyelolithotomy group had urinary leakage that lasted more than 4 days after surgery. Seven (87.5%) of these patients were managed conservatively by maintaining Foley catheter and keeping the abdominal drain for a longer time, however, a patient required salvage PCNL because of an obstructive stone in the ureteropelvic junction. In the PCNL group, 1 (2.94%) patient developed prolonged urinary leakage for more than 4 days that was managed conservatively, 2 (5.88%) patients needed salvage TUL after ureteral stent extraction.

The drop in the 1st postoperative day hemoglobin relative to preoperative hemoglobin for the PCNL group was 2.67 ± 2.61 g/dL compared to 0.79 ± 1.06 g/dL for the LPL group (P = .001). The mean (IQR) of drop in postoperative creatinine relative to preoperative creatinine for the PCNL group was .03 (-.1/.15) mg/dL versus 0.17 (0/.23) mg/dL for the LPL group (P = .014). Residual stone equal to or more than 5 mm according to postoperative KUB was noticed in 12 patients in the PCNL group, and 5 patients in the LPL group. In Figure 2, a sample of stag-horn stone can be seen.

DISCUSSION

The results of this study indicate a higher stone free rate as the primary outcome of study in patients with complete staghorn stones who underwent LPL. LPL was also associated with less bleeding and need for transfusion but at the cost of a longer operating time and a higher frequency of urinary leakage.

Despite being the first option for the treatment of large renal stones, PCNL is still associated with complications like massive bleeding and infectious complications including fever and sepsis, and infrequent but serious complications like colon injury.[15] Severe bleeding necessitating transfusion has been reported in 16% of PCNL operations for staghorn stones and angioembolization has been resorted to control bleeding in 2% of these cases in one report.[16] Besides, postoperative fever was observed in 27% and septic shock in 1.8% of PCNLs for staghorn stones in another report.[17] Parenchymal laceration and vascular injury in the access tract and torque during nephroscopy are the causes of bleeding in PCNL. The absorption of irrigation fluid bacteria through veins and lymphatics especially in high pressure situations is the main cause of infectious complications and sepsis.[18] LPL is not associated with parenchymal injury or with irrigation and absorption of irrigation fluid. Furthermore, the stone is not broken into small parts as with PCNL so that bacteria embedded within stone are released during the operation and hence will theoretically be associated with less infectious complications. This theory has been substantiated in a meta-analysis comparing LPL with PCNL.[19]

The comparison of PCNL with LPL in case of non-staghorn stones has been investigated in a few reports. Most such comparative studies performed LPL for pa-

tients with a single pelvic stone or with limited number of stones.[20,21] These studies mainly reported a higher stone free rate in LPL with less bleeding at a cost of higher operation duration and/or hospitalization. The application of LPL for patients with multiple renal stones is more challenging. Lee and colleagues reported a higher SFR with less bleeding and postoperative pain but longer operation duration for LPL compared with PCNL for multiple renal stones.[13]

We have previously presented the experience of our center with LPL for patients with staghorn stones, patients with intrarenal pelvis, and patients with prior extensive abdominal operations.[14,22,23] Up to our best knowledge, only one recent randomized clinical trial has compared PCNL with retoroperitoneal LPL in the case of staghorn stones. In this study, 54 patients in the PCNL group were compared with 51 patients in the LPL group. The results revealed that LPL was associated with higher SFR, less hemoglobin drop, less postoperative fever, less need for ancillary procedures, and better kidney function one year after surgery. However, the surgery duration and its cost were higher in the LPL group.[24] Laparoscopic operation for pyelolithotomy can be performed through a transperitoneal or a retroperitoneal approach. The aforementioned randomized clinical trial included performance of LPL through a retroperitoneal route. The comparison of transperitoneal and retroperitoneal routes for pyelolithotomy has only been presented in a small study on 20 patients who underwent robotic pyelolithototmy.[25] The authors reported a higher operation duration and bleeding in case of retroperitoneal operation for robotic pyelolithotomy compared with a transperitoneal route with similar SFRs. In the transperitoneal route, the kidney pelvis is incised on its anterior surface so that when the pelvis is incised, the pelvis area and calices are in front of the surgeon and incision line so that insertion of rigid nephroscope, or laparoscopic camera, or even semi-rigid ureteroscope through the working trocars will allow inspection of the kidney calices for removal of residual fragments as we have commented on earlier[14] In comparison, in the retroperitoneal route, the incision is made on the posterior surface of kidney and the trocars look to the kidney from its posterior side. Therefore, inspection of kidney calices is more difficult considering the angle of entry to kidney pelvis from the posterior surface of body and will usually be possible with use of flexible instruments.[24] Perhaps the longer duration of operation and higher amount of bleeding in retroperitoneal pyelolithotomy as reported by D'Agostino and colleagues can be explained by the above elaborations. Up to our best knowledge, no prior study has compared transperitoneal LPL with PCNL in case of staghorn stones. The results of the current study also confirm a higher SFR with less bleeding and need for transfusion at the expense of a higher likelihood for urinary leakage and a considerably longer operation duration as the operation duration in the LPL group was on average 80% longer than the PCNL group.

It is also noteworthy to consider that LPL in the current study was implemented for staghorn stones in kidneys with extrarenal pelvis with a maximum of one separate stone from the main bulk. It is highly likely that the application of LPL for staghorn stones with intrarenal pelvis or in case of multiple separate stone particles will result in a different success or complication profile.

At last, it should be noted that this study suffers from the following limitations. This study reports short term follow up for the investigated operations, long term outcomes regarding stone recurrence or the long term effect of this operation in kidney function were not evaluated in this study. This study is a single center study, multicenter studies can provide more convincing results.

CONCLUSIONS

The results of the current study disclose that transperitoneal laparoscopic pyelolithotomy compared with PCNL offers a higher stone free rate, with less bleeding and need for transfusion at the expense of a higher likelihood of urinary leakage and longer operation duration.

CONFLICTS OF INTEREST

The authors report no conflicts of interest.

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