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Laparoscopic Pyelolithotomy: Comparison of Surgical Outcomes in Relation to Stone Distribution Within the Kidney

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Abstract

Purpose: To evaluate surgical outcomes of laparoscopic pyelolithotomy (LP) in relation to stone distribution within the kidney.

Methods: Between August 2008 and February 2012, 77 patients underwent LP as first-line treatment for renal stone(s). Cases were classified into four groups, depending on stone location: Group I (located in only renal pelvis), Group II (located only in renal calyx), Group III (located in renal pelvis and in one calyx), and Group IV (located in renal pelvis and in multiple calyces). Patient and stone characteristics, surgical outcomes, and complications were evaluated.

Results: Sixty-seven (81.8%) cases were stone-free after LP for large renal stones. Stone-free rates in a single session significantly decreased with greater stone dispersion ($p < 0.001$). Mean hospital stay in group IV was significantly longer than in other groups ($p = 0.038$). However, there were no significant differences in mean operation times ($p = 0.214$), mean change in serum hemoglobin ($p = 0.709$), postoperative analgesics usages ($p = 0.153$), and number of analgesics used on an as-needed basis ($p = 0.079$). There were no complications of grade IIIb or of greater severity. One patient in group II received blood transfusion, and 1 in group III required percutaneous drainage due to perirenal urine collection.

Conclusions: LP is an effective and safe modality for managing renal stones diseases. Distribution of stone burden, and total stone burden, is an important predictor of surgical outcome of LP in renal stone diseases.

Introduction

To date, renal stone disease has been most commonly treated with extracorporeal shockwave lithotripsy (SWL) and minimally invasive procedures such as percutaneous nephrolithotomy (PNL) or ureterorenoscopy (URS).[1] However, surgical outcomes of these modalities widely vary depending on total stone burden, location of stone burden, stone composition, and anatomy of the collecting system.[2–6] In large or complex renal stones located in multiple calyces, it may be difficult to achieve complete stone clearance in a single session. Such cases may require multiple procedures or multiple access tracts during PNL, which increase the risk for significant complications such as renal parenchymal injury or massive hemorrhage.

Laparoscopic pyelolithotomy (LP) was first introduced over 20 years ago.[7] However, the role of laparoscopy in managing renal stones is currently quite limited due to greater technical difficulty, greater degree of invasiveness, longer operation time, prolonged convalescence, along with poor cosmetic results.[8] Recently, some previous studies published high success rates using LP for patients with solitary renal stones.[9–12] However, the effects of stone burden and location on the surgical outcomes of LP have yet to be reported.

We compared the surgical outcomes of LP with respect to stone distribution within the kidney.

Materials and Methods

Between August 2008 and February 2012, 77 patients underwent LP as first-line treatment for renal stone(s) at our institution. For all cases, the maximal length of a main stone was ≥15 mm. Cases were classified into four groups, depending on stone location: Group I (located in only renal pelvis), Group II (located only in renal calyx), Group III (located in renal pelvis and in one calyx), and Group IV

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(located in renal pelvis and in multiple calyces). Exclusion criteria were coagulopathy, congenital anomaly, and history of abdominal surgery except appendectomy. This study was approved by the institutional review board of the Seoul National University Boramae Hospital. Clinical data from eligible patients were retrospectively collected from medical records.

All patients underwent preoperative laboratory tests, including serum hemoglobin, creatinine, coagulation profile, urinalysis, and urine culture. Stone(s) were evaluated via plain X-ray of the kidney-ureter-bladder (KUB) region and nonenhanced computed tomography (CT), and, if needed, along with intravenous urograms (IVU) in some cases. Stone size was calculated using the sum of the maximal diameter of renal stone(s) (mm) that were radiologically evaluated.

The LP technique

All patients underwent LP via the transperitoneal route as previously described by Salvadó et al.[7] Patients were placed in modified lateral decubitus position under general anesthesia. The primary port of the camera (12-mm) was placed 2 cm below the umbilicus and lateral margin of the rectus muscle after formation of the pneumoperitoneum using a Veress needle. The working port (12-mm) was placed at the anterior axillary line of the umbilicus level and a 5-mm port was placed 7–8 cm cephalad to the camera port under direct vision. The line of Toldt was dissected and the peritoneum was detached from Gerota's fascia. The renal hilum was carefully explored, and the ureter and gonadal vein were identified. After the ureter was traced up, the renal pelvis was fully exposed. Pyelotomy was done in a vertical fashion using a No. 11 laparoscopic knife. Pelvic stone(s) was (were) then removed using grasping forceps. The entire pelvocalyceal system was explored using a flexible nephroscope through one of the instrument ports, and calyceal stone(s) was (were) removed using a stone basket. Removed stones were collected in a hand-made rubber basket and pulled under direct vision. A ureteral stent was inserted through the pyelotomy incision using a guide-wire. Pyelotomy closure was performed with interrupted sutures using 4/0 polyglycolic acid. A JP drain was placed in the perinephric area.

Clinical data for each group were evaluated, including patient (age, gender, and body mass index [BMI]) and stone (laterality, stone number, and volume) characteristics. To compare surgical outcomes, we analyzed operation time, estimated blood loss, change in serum hemoglobin, postoperative usage and number of analgesics used on an as-needed basis, and length of hospital stay.

We performed postoperative X-ray KUB to assess immediate stone-free states. All patients underwent nonenhanced CT or IVU to evaluate whether there were any residual stones or delayed excretion at 3 months postoperatively. The primary endpoint in our study was complete stone clearance in a single session. "Stone-free" states were defined as the absence of any visible fragments and no delayed excretion on nonenhanced CT or IVU at 3 months after surgery.

All statistical analyses were processed using the statistical software SPSS ver. 19.0 (SPSS, Inc., Chicago, IL). Continuous variables were analyzed with a Kruskal–Wallis test, and categorical variables were assessed with the chi-square test or Fisher's exact test. p values were estimated, and $p < 0.05$ was considered statistically significant. Clinical parameters were presented as mean ± standard deviation.

Results

Patient and stone characteristics are shown in Table 1. Mean ages were 55.2 ± 15.8 years, 56.4 ± 17.5 years, 55.6 ± 13.7 years, and 54.0 ± 13.5 years in Groups I, II, III, and IV, respectively ($p = 0.989$). Mean BMIs was 26.3 ± 3.1 kg/m^2, 27.0 ± 3.0 kg/m^2, 24.9 ± 3.7 kg/m^2, and 24.1 ± 3.9 kg/m^2 in each group, respectively ($p = 0.172$). Gender and laterality were similar in all groups. Mean stone numbers, which showed significant differences, were 1.1 ± 0.4, 2.0 ± 1.7, 3.1 ± 1.1, and 8.8 ± 8.3 in Groups I, II, III, and IV ($p < 0.001$). Stone sizes showed significant differences, with 20.7 ± 7.4 mm in Group I, 25.2 ± 13.0 mm in Group II, 41.1 ± 18.4 mm in Group III, and 86.2 ± 42.3 mm in Group IV, respectively ($p < 0.001$).

Surgical parameters are compared in Table 1. All 77 laparoscopic surgeries were performed without open conversion. With increasing complexity in location of renal stones, slight, though not statistically significant, increases in mean operation times were noted, with 128.3 ± 48.0 minutes in Group I, 145.8 ± 97.2 minutes in Group II, 156.4 ± 76.3 minutes in Group III, and 176.3 ± 66.4 minutes in Group IV ($p = 0.214$). Mean estimated blood loss was 38.0 ± 60.5 mL in Group I, 164.0 ± 258.9 mL in Group II, 26.1 ± 35.5 mL in Group III, and 30.6 ± 37.0 mL in Group IV, ($p = 0.020$). No statistically significant differences were noted with respect to mean change in serum hemoglobin (−0.82 ± 0.75 g/dL in Group I, −1.00 ± 1.48 g/dL in Group II, −0.92 ± 0.94 g/dL in Group III, and −1.09 ± 0.78 g/dL in Group IV, ($p = 0.709$)), postoperative usage of analgesics (40.0%, 60.0%, 39.3%, and 77.8%, respectively, $p = 0.153$) and number of analgesics used on an as-needed basis (0.7 ± 1.1, 1.4 ± 1.6, 1.2 ± 2.4, and 5.1 ± 9.8, respectively, $p = 0.079$). Group IV had significantly longer hospital stay than other groups, with 3.4 ± 1.9 days in Group I, 4.5 ± 1.5 days in Group II, 4.2 ± 2.0 days in Group III, and 6.6 ± 6.4 days in Group IV ($p = 0.038$). There were statistically significant differences in stone-free rates at 3 months postoperatively, depending on the location of the renal stones, 96.7% in Group I, 90.0% in Group II, 78.6% in Group III, and 33.3% in Group IV ($p < 0.001$). One patient in Group I, 1 in Group II, 6 in Group III, and 6 in Group IV had residual stones at 3 months after surgery on nonenhanced CT or IVU. Among them, 2 patients in Group III and 2 in Group IV needed SWL, and the remaining 10 patients had clinically insignificant (≤4 mm without symptoms) residual stones and were on surveillance.

Complications with respect to stone distribution within the kidney are shown in Table 2. None of the patients had complications of grade IIIb or higher according to the Clavien classification of surgical complications.[13] One patient in Group II received blood transfusion (grade II), and 1 in Group III had perirenal urine collection (grade IIIa), which needed percutaneous drainage.

Discussion

Since laparoscopic nephrectomy was first introduced by Clayman et al in 1991,[14] the laparoscopic approach has

Table 1. Demographics and Surgical Outcomes with Respect to Stone Distribution Within the Kidney

Location of involved stone(s)	*Renal pelvis (n=30)*	*Renal calyx (n=10)*	*Pelvis and one calyx (n=28)*	*Pelvis and multiple calices (n=9)*	*p-Value*
Patient characteristics					
Mean age (years)	55.2 ± 15.8 (31–81)	56.4 ± 17.5 (27–82)	55.6 ± 13.7 (24–74)	54.0 ± 13.5 (34–69)	0.989
Gender (M:F)	25:5	8:2	20:8	8:1	0.631
Mean BMI (kg/m^2)	26.3 ± 3.1 (20.8–35.2)	27.0 ± 3.0 (21.6–31.5)	24.9 ± 3.7 (17.1–30.9)	24.1 ± 3.9 (19.8–31.4)	0.172
Stone characteristics					
Laterality (right:left)	11:19	4:6	13:15	5:4	0.755
Mean stone number (*n*)	1.1 ± 0.4 (1–3)	2.0 ± 1.7 (1–6)	3.1 ± 1.1 (2–5)	8.8 ± 8.3 (3–25)	< 0.001
Stone size (mm)	20.7 ± 7.4 (15–47)	25.2 ± 13.0 (15–58)	41.1 ± 18.4 (20–86)	86.2 ± 42.3 (38–148)	< 0.001
Surgical outcomes					
Stone-free rate (%)	96.7 (29/30)	90.0 (9/10)	78.6 (22/28)	33.3 (3/9)	< 0.001
Mean operation time (min)	128.3 ± 48.0 (42–240)	145.8 ± 97.2 (55–314)	156.4 ± 76.3 (30–300)	176.3 ± 66.4 (85–290)	0.214
Mean estimated blood loss (mL)	38.0 ± 60.5 (0–300)	164.0 ± 258.9 (0–880)	26.1 ± 35.5 (0–100)	30.6 ± 37.0 (0–100)	0.020
Mean change in Hb level (g/dL)	−0.82 ± 0.75 (−2.80–0.60)	−1.00 ± 1.48 (−5.10–0.00)	−0.92 ± 0.94 (−3.80–0.00)	−1.09 ± 0.78 (−2.20–0.20)	0.709
Postoperative analgesic usage (%)	40.0 (12/30)	60.0 (6/10)	39.3 (11/28)	77.8 (7/9)	0.153
Mean used analgesics number (*n*)	0.7 ± 1.1 (0–3)	1.4 ± 1.6 (0–5)	1.2 ± 2.4 (0–10)	5.1 ± 9.8 (0–31)	0.079
Mean hospital stay (days)	3.4 ± 1.9 (1–11)	4.5 ± 1.5 (3–7)	4.2 ± 2.0 (2–8)	6.6 ± 6.37 (3–23)	0.038
Complementary treatment					
Surveillance	1	1	4	4	
SWL			2	2	

BMI = body mass index; SWL = extracorporeal shockwave lithotripsy.

Table 2. Classification of Complications with Respect to Stone Distribution Within the Kidney[13]

Location of involved stone(s)	*Renal pelvis (n = 30)*	*Renal calyx (n = 10)*	*Pelvis and one calyx (n = 28)*	*Pelvis and multiple calices (n = 9)*
Grade I	Pain requiring analgesics: 12 Fever requiring antipyretics: 1 Transient voiding difficulty: 2 Transient decrease of O_2 saturation: 1	Pain requiring analgesics: 6 Fever requiring antipyretics: 2 Nausea requiring antiemetics: 2 Transient voiding difficulty: 1 Hypokalemia requiring KCl replacement: 1 Transient PSVT not needing treatment: 1	Pain requiring analgesics: 11 Transient voiding difficulty: 1	Pain requiring analgesics: 7 Fever requiring antipyretics: 2 Nausea requiring antiemetics: 1 Wound problem: 1 Transient hypotension: 1 Pleural effusion not needing treatment: 1
Grade II	-	Hypertension requiring nicardipine: 1 Blood transfusion: 1	Hypertension requiring nicardipine: 1	UTI: 1
Grade IIIa	-	-	Perirenal urine collection requiring percutaneous drainage: 1	-
Grade IIIb - V	-	-	-	-

steadily gained popularity among urologists. Laparoscopic surgery has many merits, including the ability to minimize bleeding, lessen pain, reduce hospitalization time, and lower morbidity. Because LP, however, is more invasive and less cosmetic than PNL,[8] it has not been recognized as the standard in the field of urinary stones diseases. Recently, some studies have reported favorable results using LP, with stone-free rates of 88.9%–100% in managing solitary renal pelvic stones.[9–12] In our study, the stone-free rate in Group I (located only in the pelvis) was 96.7% (29/30), which is comparable to results reported by other centers. LP, therefore, should be considered a feasible modality in the management of renal pelvic stones.

Currently, the most common treatment modalities for renal stones are SWL, PNL, and URS.[15] Predictive factors associated with surgical outcomes of these modalities have been reported to be total stone burden and location of stone burden.[2–6] Stone-free rates for SWL ranged from 45% to 99%, depending on stone location, burden, and composition.[2–4] Stone-free rate for PNL in a single session consisting of 180 patients was 51%, and upper pole stones and greater size have been associated with lower rates of attaining stone-free states.[5] Turna et al demonstrated an overall stone-free rate of 78.6%, which decreased with increasing stone size and caliceal component.[6] To our knowledge, studies on surgical outcomes of LP in patients classified according to stone distribution within the kidney have not been reported in the literature. Therefore, we evaluated the effectiveness and safety of LP with respect to stone distribution within the kidney.

Compared with previous studies that used PNL for managing large, complex renal stone diseases, our results demonstrated excellent surgical results with respect to effectiveness and safety. In our study, 63 (81.8%) cases were stone-free after LP for large renal stones, and 14 patients had residual stones after a single session, 4 of whom required secondary procedures. Such rates were comparable to those in previous studies, which reported stone-free rates of 51% to 100% after PNL.[16] As for complication rates, a prospective study on PNL on 5,803 patients by the Clinical Research Office of the Endourological Society reported findings according to the modified Clavien classification system. Their reported complication rates were 11.1% (grade I), 5.3% (II), 2.3% (IIIa), 1.3% (IIIb), 0.3% (IVa), 0.2% (IVb), and 0.3% (V).[17] Additionally, a study (811 PNLs) by Tefekli et al reported complications of grade III or higher in 10.9% of patients.[18] On the other hand, most of the complications that arose after LP in our study were grade I or II, with no severe complications of grade IIIb or higher. Our results demonstrate excellent surgical results in terms of effectiveness and safety.

The number and location of stones have been recognized as important factors in determining surgical outcomes for SWL and PNL. In our study, greater diversity of renal stone location led to increases in number and volume of stone burden, and stone-free rates decreased. Hence, stone burden and location of stone burden seem to influence surgical outcomes for LP, as well. In contrast to other procedures, however, LP enabled us to remove most of the renal stones using a flexible nephroscope to explore the entire pelvocalyceal system. Therefore, while stone burden and location of stone burden were important predictive factors of complete stone clearance in a single session of LP, we believe that LP could overcome these factors by use of a flexible nephroscope.

Stone location did not seem to influence significant changes in hemoglobin levels. Chances of significant bleeding were less than with PNL because LP enabled us to remove renal stones without harming the renal parenchyma. The mean EBL in 1 patient from group II did rise due to massive bleeding (880 mL) and therefore required blood transfusion. In all other groups, mean EBL values were similar, regardless of stone location. Therefore, stone burden or complexity of stone distribution did not seem to significantly impact surgical parameters.

The best route of approach in LP has been debated. Many authors have asserted that the retroperitoneal route reduces resumption time for oral intake, hospital stay, and operation time, in addition to bowel complications.[10] Others, however, reported that there were no differences in technical difficulty or morbidities such as infection in both routes.[19,20] In our study, all procedures were performed via the transperitoneal route because this method enables the surgeon to operate with ample working space and better aspects of anatomical view, which enabled us to dissect the renal pelvis completely without bowel injury. In addition, urine leakage was reduced via more meticulous closing of the pyelotomy site, and postoperative ileus or peritonitis was minimized. Mean operation times in our study was longer than reported by previous studies using the retroperitoneal route or PNL, but longer operation time did not increase postoperative morbidities. No dietary problems also were observed on the day after the operation.

PNL currently represents the gold standard for managing large or complex renal stone diseases. Despite favorable results in our study, LP still has a greater degree of invasiveness and technical difficulty compared with PNL.[8] The indications for LP are restricted to large single renal stones, renal anomalies such as ureteropelvic junction obstruction or ectopic kidney, and poorly compliant patients.[1] The laparoscopic approach is not feasible in patients with prior abdominal or renal surgery, in particular. However, LP can be a useful modality for impacted pelvic or multiple calyceal stones with extrarenal or dilated pelvis. Further, LP can be considered a feasible procedure for managing complex renal stones, which are difficult to remove completely using other endoscopic modalities, such as SWL, retrograde intra-renal surgery, or PNL.

Limitations of our study include that it was nonrandomized, retrospective, and had relatively few cases. Despites the small number of cases, we believe that our results may provide much information on the roles of laparoscopic surgery and predictive factors of surgical outcome of LP for renal stone diseases.

Conclusions

According to our findings, LP indicates acceptable results comparable to those of PNL in managing renal stone diseases. With greater diversity in locations of stones, stone-free rates in a single session decreased. However, the number of cases of complications did not increase. Surgical parameters, including mean operation time, change in serum hemoglobin, postoperative usage, and number of used analgesics, did not significantly differ with increasing complexity in distribution of stones in cases with multiple renal stones. In addition, total stone burden also seems to influence stone-free rates for LP. In conclusion, total stone burden and location of stone burden are important predictors of surgical outcome of LP in renal stone diseases. We suggest that LP would be more helpful in the management of renal calculi than PNL in certain cases, especially in complex renal stones distributed in multiple calyces if surgeons were well-trained specialists in laparoscopic surgery.

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Disclosure Statement

No competing financial interests exist.

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Abbreviations Used

BMI = body mass index
CT = computed tomography
IVU = intravenous urograms
KUB = plane X-rays of the kidney-ureter-bladder
LP = laparoscopic pyelolithotomy
PNL = percutaneous nephrolithotomy
SWL = extracorporeal shockwave lithotripsy
URS = ureterorenoscopy