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ORIGINAL PAPER

Retroperitoneoscopic nephrectomy for non-functioning kidneys related to renal stone disease

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Abstract Laparoscopic nephrectomy has become the gold standard procedure for nonfunctioning or symptomatic benign kidneys due to renal calculi, obstructive, refluxive, and inflammatory nephropathies or renovascular hypertension. We aimed to investigate the effect of renal calculi as a reason of non-functioning on the progress and complication rates of the retroperitoneoscopic nephrectomy (RPN).During a 2-year period, 108 patients with benign renal conditions underwent RPN by single surgeon. Among these patients, total of 27 (Group 1) with a non-functioning kidney due to renal calculi were retrospectively compared with 27 patients (Group 2) with other benign renal conditions. The two groups were matched for age, body mass index, and previous renal surgery. We analyzed operative and post-operative findings and complications. The mean age and the BMI of the groups were similar. The operation time was significantly longer in Group 1 than Group 2 ($p = 0.0001$). There was no significant difference between the groups with respect to mean hemoglobin drop postoperatively ($p = 0.9$) and hospitalization time ($p = 0.06$). The perioperative and postoperative complication rates were higher in Group 1 but not statistically different from Group 2 ($p = 0.19$, $p = 0.29$, respectively). RPN for nonfunctioning calculous kidneys is more challenging procedure and is associated with prolonged operation time related to difficult dissection of dense adhesions. It can be safely performed by experienced hands with similar perioperative and postoperative complication rates as well as for other benign conditions of the kidney.

Keywords Retroperitoneoscopy · Non-functioning kidney · Renal stone disease · Efficacy · Complication

Abbreviations

LN	Laparoscopic nephrectomy
RPN	Retroperitoneoscopic nephrectomy
PN	Pyelonephritis
PCNL	Percutaneous nephrolithotomy
SWL	Shockwave lithotripsy
BMI	Body mass index
PCKD	Policystic kidney disease
UPJ	Ureteropelvic junction
US	Ultrasonography
IVP	Intravenous pyelography
CT	Computed tomography
DMSA	Dimercaptosuccinic acid
UTI	Urinary tract infection

Introduction

Since the initial report of laparoscopic nephrectomy (LN) in 1991 by Clayman and associates [1], it has been regarded as the gold standard procedure for the management of non-functioning kidneys due to reflux, stone disease, and ureteropelvic junction (UPJ) obstruction [2]. The major indications for nephrectomy are UPJ obstruction, calculous

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disease, genitourinary tuberculosis, renal dysplasia, anomalous kidney, and renovascular hypertension [3].

Although LN requires advanced surgical experience and technical skills, the complication rates are closely related to the patient's underlying disease rather than the surgeon's experience [4]. LN in patients with renal stone disease is often complicated by perirenal adhesions formed secondary to previous episodes of pyelonephritis, pyonephrosis or previous open renal surgery, which makes dissection extremely difficult [5]. Recent published papers mention the feasibility of LN for pyelonephritic kidneys and non-functioning kidneys with a history of a previous renal surgery with similar results compared with virgin or other benign LN [6, 7]. To our knowledge, there is no study evaluating the effect of renal calculi or other reasons on the progress, complication, and success rates of LN.

In this study, we aimed to explore whether a non-functioning kidney caused by renal calculi has a negative effect on the progress and complication rates of retroperitoneoscopic nephrectomy by comparing perioperative and postoperative findings and complication rates of the procedure for a non-functioning calculous kidney versus other benign conditions with the aim of giving an insight to operating teams.

Materials and methods

During a 2-year period, 108 patients with benign renal conditions have undergone RPN by single surgeon (AT) at our institution. Age, body mass index (BMI), underlying condition, previous renal surgery, and other parameters were documented for all patients in our data base (Excel, Microsoft).

Preoperative-complete blood count, serum creatinine, platelet count, bleeding and coagulation profile, and urine culture were obtained from all patients. Radiological evaluation of patients included ultrasonography (US), intravenous urography (IVU), and computed tomography (CT). Renal functions were evaluated by dimercaptosuccinic acid (DMSA) renal scintigraphy.

Operative technique

The patient was placed in the lateral flank position with the table flexed to extend the uppermost flank. A standardized retroperitoneoscopic nephrectomy was performed in all cases as described previously [8]. A 15- to 18-mm incision was made in the "muscle-free" (Petit) triangle between the 12th rib and the iliac crest, bounded by the lateral edges of the external oblique and latissimus dorsum muscles (Fig. 1). A canal down to the retroperitoneal space was then created by blunt dissection. The canal was dilated with the index finger, which dissected the plane between the lumbodorsal aponeurosis and Gerota fascia pushing the peritoneum medially, thus creating a retroperitoneal cavity. The retroperitoneal space was created with the aid of inflation of a balloon distention system.

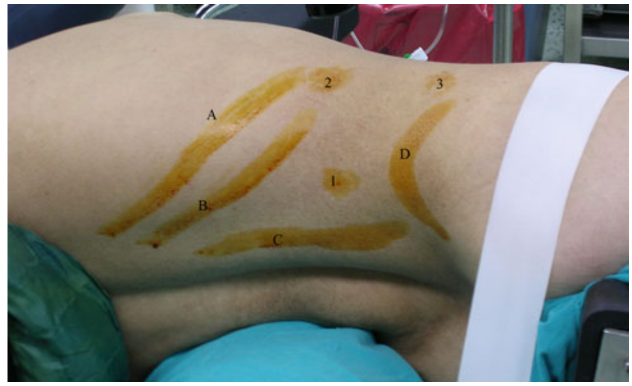

Fig. 1 The position of the trocars (1, 2 and 3) in the Petit triangle between the 11th (*a*) and 12th rib (*b*) and the iliac crest (*d*), bounded by the lateral edges of the external oblique (*c*) and latissimus dorsum muscles are shown on the patient in lateral flank position

The optic trocar (12 mm) was inserted through the primary access and the trocar was connected to the CO_2 insufflator to establish a pneumoretroperitoneum (12 mmHg, 3.5 l/min in adults). Two other trocars (10 and 5 mm) were then placed under endovision or digital guidance (Fig. 2).

A generous horizontal incision of the Gerota fascia was performed to expose the psoas muscle. The psoas muscle was exposed up to the diaphragm by blunt and sharp dissection. Thus, all other anatomic landmarks, such as the lumbar ureter, gonadal vein, and the lower pole of the kidney, undulating pulsations of inferior vena cava, and sharp well-defined pulsations of fat-covered renal artery

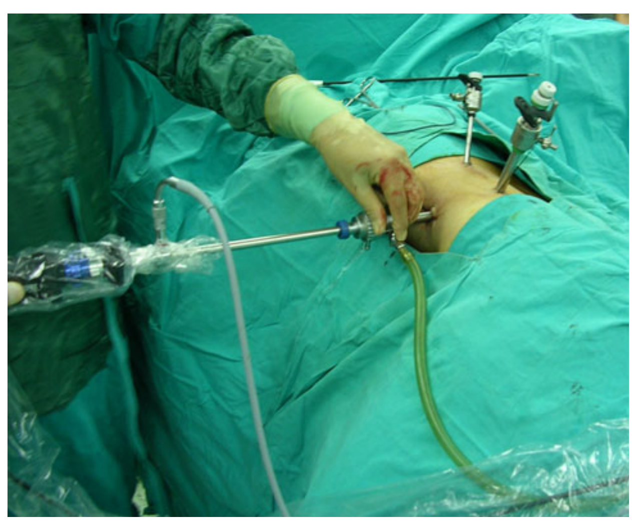

Fig. 2 The positions of the trocars are shown

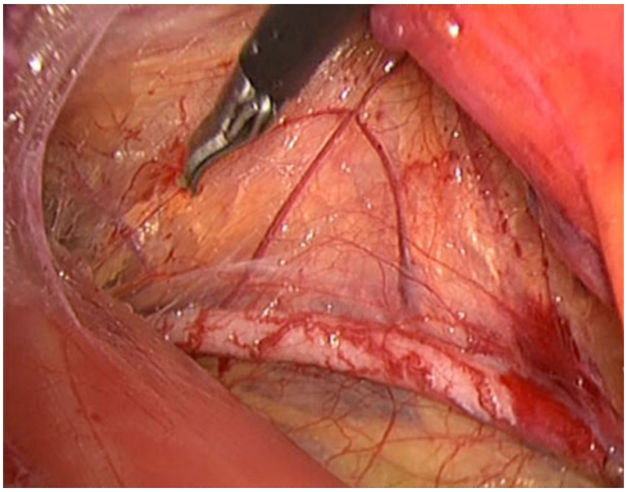

Fig. 3 The psoas muscle laying the retroperitoneal space and lumbar ureter are shown as two anatomical landmarks

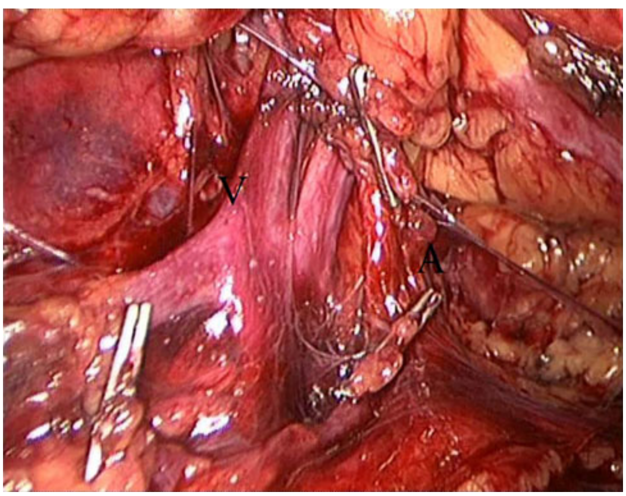

Fig. 4 The renal artery and vein were exposed after gentle and meticulous dissection of the dense adhesions

were identified (Fig. 3). The renal hilum was accessed easily by gentle preparation towards the pulsation, followed by dissection of the renal artery, and followed by isolation of the renal vein using right-angle forceps (Fig. 4). Two Hem-O-Lok® clips were applied proximally and one was applied distally. After the dissection of the upper pole and medial aspect and clipping, and incision of the ureter, the specimen was placed in a surgical bag. The specimen was removed intact by the extended first trocar incision.

Open conversion was performed as a final solution if the dissection could not be managed despite a slow and careful intervention by an experienced master or in the presence of laparoscopically uncontrolled complication. Conventional open nephrectomy was performed by standard flank approach.

Matched pair definition and statistical analyses

Twenty-seven patients who had a non-functioning kidney due to renal stone disease were treated with RPN at our institution. In the same period, RPN was performed in 81 patients with benign renal conditions (except stone disease). From this cohort, we selected 27 patients to serve as the control Group in this study. The 27 patients were retrospectively matched at a 1:1 ratio to index calculous RPN–non–calculous RPN cases with respect to age, gender, BMI, preoperative creatinine level, and previous renal surgery (Table 1). Furthermore, the conditions complicating the RPN such as xanthogranulomatous PN, tuberculosis PN, giant hydronephrosis, and polycystic kidney disease (PCKD) were excluded from the study**.** The indications for RPN in Group 2 are listed in Table 2.

Preoperative, perioperative, and postoperative data from Group 1 were retrospectively analyzed and compared with data from Group 2 (Table 3). The intraoperative complications/incidents were analyzed using Satava classification [9], and postoperative complications according to the modified Clavien classification [10].

Data were processed using SPSS-16 for Windows (SPSS, Inc., Chicago, IL, USA). Continuous variables were compared with Student's *t* test and Mann–Whitney *U* tests as appropriate. Proportions of categorical variables were analyzed for statistical significance using chi- square test or Fisher's exact test. In all analyses, two-sided hypothesis testing was carried out, and probability values less than 0.05 were deemed significant.

Results

The mean age, BMI, and preoperative creatinine values of the groups were similar ($p = 0.93$, 0.7 and 0.24, respectively) (Table 1). The operation time was found to be shorter in Group 2 than Group 1 (123.55 ± 38.13 vs. 98.88 ± 40.3, $p = 0.0001$). However, there was no significant difference between the groups with respect to mean hemoglobin drop postoperatively and mean hospitalization time ($p = 0.82$ and $p = 0.06$, respectively) (Table 3). According to Satava classification, hyperkapnia was observed as grade-I complication in one patient in Group 1 due to prolonged operation time. Major complications which required conversion to an open procedure occurred in three (11.1%) patients. Open conversion was required because of renal artery injury in one patient in Group 1 and inability to dissect pedicle in one patient in each groups ($p = 1$). Among the intraoperative complications, the grade II complications that repaired laparoscopically with no need for open conversion were the most seen ones. Peritoneal tear ($n = 2$), renal vein ($n = 1$), and ovarian

Table 1 Matched pair parameters and statistical analyses of the groups

	Group 1 (with renal stone)	Group 2 (with no renal stone)	p
No.of patients	27	27	
Mean age (years)	41.14 ± 15.13 (19–74)	41.48 ± 14.62 (12–74)	0.93[a]
Mean BMI (kg/m^2)	26.45 ± 2.92 (21.96–33.94)	26.84 ± 4.37 (17.95–38.06)	0.70[a]
Sex (m/f)	15/12	11/16	0.28[b]
Preoperative creatinine (mg/dl)	1.15 ± 0.61 (0.33–3.04)	0.94 ± 0.3 (0.56–1.7)	0.24[c]

[a] Student's t test
[b] Chi-square test
[c] Mann–Whitney U test

Table 2 Indications for RPN in Group 2

Indications	N
UPJ obstruction	10
Renovascular hypertension	13
Renal dysplasia	4

vein ($n = 1$) injury were observed in Group 1. Peritoneal tear was observed in only one case as a grade-II complication in Group 2. Intraoperative complications were higher in Group 1, but this finding was not statistically significant (7 vs. 2 patients, $p = 0.14$). The intraoperative complications observed are listed in Table 4.

According to the postoperative complication classification system suggested by Clavien et al. [10], grade-I complication was observed in one (3.7%) in both groups, while grade-II was detected in six (22.2%) cases (drop in hematocrit level requiring blood transfusion ($n = 2$), temporary ileus ($n = 2$), fever ($n = 2$)) in Group 1 and in 2 (7.4%) cases (drop in hematocrit level requiring blood transfusion ($n = 1$) and fever ($n = 1$) in Group 2, respectively ($p = 0.25$) Fortunately, grade III and IV complications did not occur in the present study. Although the postoperative complication rate was found to be higher in Group 1, there was no statistically difference between groups ($p = 0.29$) (Table 5).

Discussion

Despite the introduction of new techniques and devices including percutaneous nephrolithotomy (PCNL), shock-wave lithotripsy (SWL) and ureteroscopy in the treatment of urinary stone disease, it is unfortunately still one of the major causes of non-functioning kidneys and chronic renal failure. It is reported that the overall prevalence of urolithiasis in patients with end-stage renal disease on maintenance hemodialysis is 3.6–7.3% [11–13]. In a large series of RPN, calculous disease represents the second most common cause of non-functioning kidneys [3].

With the advances in minimal invasive techniques and surgical skills, LN has been regarded as a feasible method even for pyelonephritic, hydronephrotic, and inflammatory kidneys with the advantages of shorter hospitalization and convalescence periods, reduced morbidity, less analgesic requirement, and good cosmetic results compared with open surgery [6, 14]. Although this procedure is classified as simple, it may be very challenging in some of the situations mentioned above. Success and complication rates and other parameters related with this procedure may be affected with patient- and surgeon-related factors such as BMI, age, underlying condition, presence of giant hydronephrosis, previous renal surgery and other comorbidities, as well as the experience of the surgeon.

The studies focusing on patients' age have found that laparoscopic renal surgery in patients 65 or 70 year old is well tolerated and is associated with a significantly increased hospitalization period [15, 16]. Another patient-related factor, BMI, may affect the operation parameters. Obesity can make surgery more difficult, prolonging operative time and leading to more intraoperative complications [17, 18]. Most of these complications were related to hemorrhage and blood transfusion. On the other hand, some studies have not demonstrated any additional association between obesity and increased intraoperative and postoperative complication rates [19, 20]. In another study, patient-related factors such as age, BMI, ASA classification, percentage of renal function, baseline creatinine, and baseline hematocrit were found to play no role in increased complications [21].

Although the history of abdominal surgery has been regarded as a relative contraindication because of intraabdominal scars and adhesions, Mita et al. [22, 23] presented the feasibility of retroperitoneoscopic surgery with no

Table 3 Peroperative findings and comparative analyses of the groups

	Group 1	Group 2	p
Operation time (min)	123.55 ± 38.13 (75–210)	98.88 ± 40.3 (66–270)	0.0001[a]
Hemoglobin drop (gr/dl)	1.52 ± 1.46 (0.1–5.4)	1.57 ± 1.42 (0.1–4.79)	0.82[a]
Open conversion (n)	2	1	1[b]
Time of hospitalization (days)	3.14 ± 1.23 (2–6)	2.55 ± 0.93 (1–5)	0.06[a]

[a] Mann–Whitney U test
[b] Fischer's exact test

Table 4 Modified Satava classification system of peri-operative complications

	No. of cases	Group 1	Group 2	*p*
Satava grade 1 (incidents without consequences)	1	1 (3.7%)	0	1.0*
Hyperkapnia	1	1	0	
Satava grade II (incidents repaired intraoperatively)	5	4 (14.8%)	1 (3.7%)	0.35*
Renal vein injury	1	1	0	
Ovarian vein injury	1	1	0	
Peritoneal tear	3	2	1	
Satava grade III (incidents requiring open conversion)	3	2 (7.4%)	1 (3.7%)	1.0*
Renal artery injury	1	1	0	
Inability to dissect pedicle	2	1	1	
Total	9	7 (25.92%)	2 (7.4%)	0.14*

* Fischer's exact test

Table 5 Postoperative complications, stratified according to the modified Clavien classification

	No. of cases	Group 1	Group 2	*p*
Grade I	2	1 (3.7%)	1 (3.7%)	1.0*
Subcutaneous emphysema	1	1	0	
Transient elevation in creatinine	1	0	1	
Grade II	8	6 (22.2%)	2 (7.4%)	0.25*
Blood transfusion	3	2	1	
Temporary ileus	2	2	0	
Elevated fever/infection	3	2	1	
Grade IIIa	0	0	0	NA
Grade IIIb	0	0	0	NA
Grade IV	0	0	0	NA
Grade V (death)	0	0	0	NA
Total	10	7	3	0.29*

* Fischer's exact test

negative outcome in patients with previous intra-abdominal surgery. Recently, published studies have emphasized the feasibility of salvage laparoscopic pyeloplasty and partial nephrectomy after previous renal surgery [24, 25]. However, previous studies underline the challenging nature of the procedure and necessity of experience and surgical skill. Patients with similar BMIs and ages, preoperative creatinine levels, and no previous renal surgery were matched to slightly eliminate the effects of these patient-related factors and to analyze the effect of renal calculi as a reason for nonfunctioning kidney on operative and post-operative parameters in the present study.

The presence of hydronephrosis, autosomal dominant PCKD, xanthogranulomatous PN, and genitourinary tuberculosis might complicate the RPN [3, 26, 27]. In their study, Challacombe et al. [26] compared the RPN of giant, hydronephrotic kidneys versus small, non-functioning kidneys. They concluded that RPN for giant hydronephrosis is associated with longer operation and hospitalization time and higher blood loss and, furthermore, requires technical modifications and surgical skills. In the present study, the patients with giant hydronephrosis, autosomal dominant PCKD, xanthogranulomatous PN or tuberculosis were excluded from the control group.

Urinary tract stones and urinary tract infection are strongly associated. This phenomenon is explained with three underlying important mechanisms: (1) stone formation subsequent to urinary infection, (2) complications arising from stone disease secondary to urinary tract infections (UTIs), and (3) urinary tract obstruction, such as ureteropelvic junction stenosis or ureteral stenosis, may lead to UTIs and subsequent development of infection stones. The metabolic evaluation or detection of the stone composition was not performed in our series. However, all patients had obstructive renal calculi leading to renal damage and loss of function.

Previous infections can lead to dense adhesions, especially in the perinephritic region. These adhesions complicate laparoscopic interventions significantly and, in line with the aforementioned statements, operating times are more prolonged. Manohar et al. [28] evaluated the data of 84 patients with benign inflammatory diseases such as xanthogranulomatous PN, pyonephrosis, tuberculous PN, and calculus pyelonephritis who underwent laparoscopic nephrectomy and compared the data with data from 94 matched patients undergoing open nephrectomy. They found that overall operative time was shorter in the open group but was statistically significant only in the calculus pyelonephritis group. In the present study, operation time was longer in patients with urinary stone disease. In another study, outcomes of laparoscopic nephrectomy were analyzed in 12 patients with inflammatory kidney condition and compared with that of patients with non-inflammatory condition who had undergone LN [29]. The authors reported longer operation times and higher conversion rates in the group with inflamed kidney.

Due to the risk of bleeding, dissections in the region of the renal hilum is the most important and challenging step of laparoscopic surgery. Adhesions developed secondary to calculous pyelonephritis around the renal pedicle and the kidney and compression of large pelvic stone might hinder dissection of the renal pedicle. In these conditions which might require open surgery, various laparoscopic alternatives might be considered. One of these alternatives is laparoscopic subcapsular nephrectomy. Moore et al. [30]

performed laparoscopic subcapsular nephrectomy because of the development of very dense fibrosis in one patient who had end-stage kidney disease secondary to vesicoureteral reflux and also recurrent pyelonephritic attacks. Kapoor et al. [27] reported their experiences with laparoscopic nephrectomy in patients with xanthogranulomatous PN. The investigators had preferred subcapsular nephrectomy, especially for upper polar region adhesions. In their study, when compared with open surgery, an 80% success rate had been achieved using laparoscopic approaches with relatively fewer complications. Although challenging dissections were anticipated in patients with renal calculi in the present study, the extracapsular approach (outside Gerota's fascia) was preferred because of lower rates of perioperative bleeding and potential clouded visualization when compared with subcapsular nephrectomy in our series. In the presence of large pelvic stone compressing and hindering the renal pedicle, the pelvis was suspended with the dissector.

Vascular injury is a major perioperative complication which was seen in three patients in Group 1 in the present study. One of them was converted to open surgery because of renal artery injury. Lacerations of renal and ovarian veins were repaired successfully with laparoscopic interventions (Table 4). The most important reasons for vascular injuries, reported in the literature as 0.8–2.7% [3, 31], are lack of meticulous dissection skill, malfunctions of clips or staplers, accidental thermal injury, and unrecognized aberrant vessels or severe adhesions around the hilar area. Adhesions that develop because of previous infections or open surgeries are the most significant predictive factors complicating laparoscopic interventions. The other reason for open conversion was inability to dissect the pedicle which was seen in one patient in each group. The meticulous dissection of the dense adhesions may be main factor leading to prolonged operation time in patients with renal stone disease.

The most frequently seen perioperative minor complication is peritoneal injury. Peritoneal rupture was detected in one patients ($n = 1$; 3.7%) in each group. Adhesion of the kidney to adjacent anatomical structures due to inflammation might cause peritoneal rupture during exploratory dissections. In the present study, ruptures often occurred accidentally during challenging dissections.

Although the incidence of Grade II postoperative complications was higher in patients with urolithiasis, when classified according to recommendations of Clavien et al. it was not statistically significant. Grade III and IV complications were not seen in both groups. Bleeding requiring blood transfusion was encountered in a total of three patients with ($n = 2$) or without ($n = 1$) renal calculi. Postoperative bleedings were managed successfully with conservatively measures. Higher pressure of insufflation used during laparoscopic operation might create a tamponade effect on venous bleeding points, thus masking their visualization. Therefore, after normalization of retroperitoneal pressure, prolonged bleeding can be seen postoperatively. Consequently, after termination of the operation, trocar entry sites and operative field should be checked under retroperitoneal pressure lowered below 5 mmHg.

Retrospective nature and the small sample size are regarded the main limitations of our study. The effect of renal calculi as a cause of nonfunctioning kidney on progress, outcome, and morbidity of RPN must be evaluated in further studies. The lack of metabolic evaluation or the detection of stone composition is considered as the limitation factor of the present study.

Conclusions

Our results have shown that RPN for non-functioning kidneys related to renal calculi is more challenging and necessitates meticulous dissection of dense adhesions secondary to previous pyelonephritis attacks. Although the procedure is associated with prolonged operation time it can be safely performed in experienced hands with similar perioperative and postoperative complication rates and hospitalization time. Advanced laparoscopic experience and skills are mandatory for better results.

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