Laparoscopic Partial Nephrectomy: Taipei Veterans General Hospital Experience

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Background: Laparoscopic partial nephrectomy (LPN) is a definitive therapy in patients with a small renal tumor. The aim of this study was to present our interim results of LPN with its complications and outcomes.

Methods: We conducted a retrospective chart review of 46 LPNs in 45 patients at Taipei Veterans General Hospital from April 2004 to September 2008. The perioperative data were prospectively collected. The follow-up data, including local recurrence, distant metastasis, and renal function, were recorded.

Results: The mean age of these 45 patients was 54.8 years (range, 26–85 years). Three (6.5%) LPNs were converted to laparoscopic radical nephrectomy. The mean tumor diameter was 3.81 cm (range, 2.0–7.5 cm). The mean operative time was 319 minutes (range, 180–660 minutes). The mean blood loss was 501 mL (range, 20–3,300 mL). Pedicle clamping was performed in 37 (80.4%) cases and the mean warm ischemic time was 56 minutes (range, 24–100 minutes). There were 17 (40.0%) benign cases and 26 (56.5%) renal cell carcinomas, which were stage pT1a in 19 (73.1%) cases, pT1b in 5 (19.2%) cases, pT2 in 1 (3.8%) case, and pT3a in 1 (3.8%) case. The major complication rate was 4.3% (delayed bleeding in 1 case and urine leakage in 1 case). All margins were free for the malignant cases. Neither distant metastasis nor mortality was found. Local recurrence was found in 1 patient. The mean preoperative creatinine was 1.04 mg/dL (range, 0.6–2.4 mg/dL) and the mean elevated creatinine level was 0.10 mg/dL at 3 months ($p < 0.05$) and 0.13 mg/dL at 6 months ($p < 0.05$) postoperatively. The function of the operated kidney was reduced by a mean of 21.9% at 3 months ($p < 0.05$) and 27.7% at 6 months ($p < 0.05$) postoperatively.

Conclusion: Although our warm ischemic time and operative time were longer than those of other LPN studies, the interim results of our oncologic and renal functional outcomes were encouraging. Further refinement of the procedure is needed to shorten the warm ischemic time and improve the hemostatic technique. In addition, based on postoperative renal function, LPN does not significantly influence long-term renal function. [*J Chin Med Assoc* 2010;73(7):364–368]

Key Words: laparoscopic partial nephrectomy, renal tumor

Introduction

Today, many options are available for patients with a small, localized renal tumor. Open partial nephrectomy provides excellent oncologic and renal functional outcomes at more than 10 years.[1] Since the first laparoscopic nephrectomy for benign kidney disease was performed in 1991 by Clayman et al,[2] laparoscopy has gained wide acceptance by urologists. For the last 6–7 years, many surgeons have begun developing laparoscopic partial nephrectomy (LPN). LPN is a technically challenging procedure with a steep learning curve. Initially, the renal tumors were limited to smaller tumors peripherally located and protruding from the surface. However, improvements in technique, equipment and accumulation of experience have allowed successful LPNs on larger centrally located tumors or even tumors in close proximity to hilar vessels.

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We present our interim results of LPN with its complications and outcomes.

Methods

A total of 46 LPNs were performed in 45 patients at Taipei Veterans General Hospital between April 2004 and September 2008. The procedure was performed for 45 renal masses in 44 patients. One patient who had bilateral renal masses underwent LPN twice. One patient received LPN due to duplication of the left collecting system. All of the research conformed to the Declaration of Helsinki's ethical principles for medical research involving human subjects. We prospectively collected preoperative baseline demographic data and perioperative data. Missing data were gathered from the medical records retrospectively. The patient characteristics are summarized in Table 1. All the patients underwent preoperative contrast-enhanced computed tomography (CT) with 3-dimensional volume reconstruction to evaluate tumor location, depth of invasion, proximity to the renal sinus or hilum and vascular anatomy. Most CT imaging studies were performed within our hospital according to the standard protocol for renal masses. Maximal tumor diameter was calculated on the preoperative CT images. A deep tumor was defined as the distance between the tumor and renal sinus being less than 5 mm on preoperative CT images. Preoperative serum creatinine was collected. All patients underwent comprehensive renal function studies to evaluate the separate renal function of both kidneys. Body mass index (BMI) was determined by the World Health Organization classification for BMI. The anesthesia risks were determined by the American Society of Anesthesiologists (ASA) Physical Status Classification.

Table 1. Demographic data of 44 patients*

Age (yr)	54.8 ± 15.9
Mean body mass index (kg/m^2)	25.5 ± 3.8
ASA	2.1 ± 0.5
Male	30 (68.2)
Left side/right side	24 (53.3)/21 (46.7)
Upper pole	9 (20.0)
Upper and middle interpolar	2 (4.4)
Middle pole	19 (42.2)
Middle and lower interpolar	6 (13.3)
Lower pole	9 (20.0)
Solitary kidneys	2 (4.5)
Tumor diameter (cm)	3.7 ± 1.4
Deep tumors	30 (68.2)
Intraoperative ultrasonographies	34 (79.1)
Endophytic tumors	3 (6.7)
< 50% exophytic tumors	19 (42.2)
> 50% exophytic tumors	24 (53.3)

**Data presented as mean ± standard deviation or n (%). ASA = American Society of Anesthesiologists Physical Status Classification.*

All surgery was recorded digitally. The operative procedures were similar to those of reported LPN series. Briefly, the transperitoneal approach was used for all cases. The hilar vessels and the kidney were dissected from the surrounding tissues while preserving the perirenal fat covering the tumor. Intraoperative ultrasonography was applied to locate the tumor and assess its size and depth, and whether any undetected satellite tumors were present. The hilar vessels were then clamped with laparoscopic bulldog clamps when needed. The renal arteries were clamped first, and then the renal veins were clamped if obvious bleeding was found while excising the tumor. Subsequently, the tumor was excised using cold scissors, which allowed clear visualization of the normal tissue, and thereby ensured an adequate safe margin. A frozen section of the tumor base was checked only in uncertain cases. The opened collecting system was repaired by intracorporeal free-hand suturing. Hemostasis was achieved by using argon beam coagulation, fibrin sealant, and bolster sutures.

The perioperative data were recorded, including intraoperative sonography, hilar vessel clamping, warm ischemic time, collecting system violation, operative time, estimated blood loss, postoperative hospital stay, and complications. The major complications were defined as urine leakage and/or bleeding requiring intervention. The cancer staging was according to the American Joint Committee on Cancer (AJCC) Cancer Staging Manual, 6th edition. The follow-up surveillance protocol comprised radiographic evaluation consisting of a CT scan of the kidney and chest, whole-body bone scan, as well as serum creatinine and comprehensive renal function studies in the patients diagnosed with renal cell carcinoma (RCC). All studies except for the whole-body bone scan were performed every 3 months in the 1st year, every 6 months in the 2nd year, and yearly thereafter. The whole-body bone scan was performed every year or when clinically indicated.

Paired *t* tests were used to analyze the functional outcomes. A p value less than 0.05 was considered significant.

Results

For the 45 patients, mean age was 54.8 ± 15.9 years (range, 26–85 years). Mean BMI was 25.5 ± 3.8 and mean ASA was 2.1 ± 0.5. Thirty-one (68.9%) patients

were male and 14 (31.1%) were female. Of the 46 LPNs, there were 45 LPNs for renal tumors and 1 LPN for duplication of the left collecting system. There were 24 (53.3%) tumors in the left kidneys and 21 (46.7%) tumors in the right kidneys. There were 2 (4.4%) tumors in the solitary kidneys. One patient had bilateral renal tumors. Mean tumor maximal diameter on preoperative CT images was 3.7 ± 1.4 cm (range, 2.0–7.5 cm). Thirty (68.2%) tumors were deep tumors.

Of these procedures, 3 (6.5%) LPNs were converted to laparoscopic radical nephrectomy. Two (4.3%) of them were due to a positive margin revealed by frozen section. The other LPN was converted due to ST depression just before tumor excision. These LPNs were excluded from the analysis. The perioperative data of the remaining 43 LPNs in 42 patients are summarized in Table 2. All patients underwent the transperitoneal approach. There was no open conversion. The mean operative time was 319.0 ± 87.3 minutes (range, 180–660 minutes). Laparoscopic sonography was used in 34 (79.1%) LPNs. There were 37 (86%) LPNs that needed hilar vessel clamping, and the mean warm ischemic time was 55.8 ± 17.5 minutes. Twenty-five (58.1%) LPNs had collecting system violation that needed repair. The mean estimated blood loss was 500.5 ± 589.9 mL (range, 20–3,300 mL), and 7 LPNs had a blood transfusion during the operation. The mean postoperative hospital stay was 6.9 ± 3.2 days. The reoperation rate was zero. There were 2 (4.3%) major complications. One patient suffered from bleeding 1 month postoperatively, and she therefore received angiographic embolization of the bleeding vessel. One patient experienced urinary extravasation requiring double-J stenting.

Pathological analysis of the 43 tumors showed 17 (39.5%) benign tumors, with angiomyolipoma (AML) in 12 (27.9%) and other benign tumors in 5 (11.6%), 26 (60.5%) RCC including clear cell RCC in 23 (53.5%), papillary RCC in 1 (2.3%), and chromophobe RCC in 2 (4.7%) (Table 3). In the 12 patients with AML, the indications for LPN were a large sized tumor in 6 patients, suspected RCC in 4 patients, and symptomatic AML in 2 patients. Surgical margins of malignant tumors were all negative. The pathological stages were pT1a in 19 (73.1%) patients, pT1b in 5 (19.2%) patients, pT2 in 1 (3.8%) patient, and pT3a in 1 (3.8%) patient.

During the follow-up (range, 7–62 months; mean, 21.2 months), 1 patient had bleeding 1 month after surgery. The remaining 41 patients had no complications. There were 26 patients with RCC. During a mean follow-up of 27.7 months (range, 7–56 months), local recurrence of RCC was found in 1 patient. The tumor size was 1.5 × 1.0 × 0.8 cm. During the operation, intraoperative sonography and frozen sectioning were not performed. The pathological report showed a tumor-free margin. Radiofrequency ablation was used for the recurrent tumor. No patients had distant metastasis. There was no mortality. The mean preoperative creatinine was 1.04 mg/dL (range, 0.6–2.4 mg/dL). The mean elevated creatinine level was 0.10 mg/dL at postoperative month 3 ($p < 0.05$), 0.13 mg/dL at postoperative month 6 ($p < 0.05$), and 0.13 mg/dL at postoperative month 12 ($p < 0.05$) (Figure 1). The effective renal plasma flow of the operated kidney was reduced by a mean of 21.9% at 3 months postoperatively ($p < 0.05$), 27.7% at 6 months postoperatively ($p < 0.05$), and 23.0% at 12 months postoperatively ($p < 0.05$; Figure 2).

Table 2. Perioperative data*

Transperitoneal approaches	43 (100)
Intraoperative ultrasonographies	34 (79.1)
Hilar vessel clamps	37 (86.0)
Warm ischemic time (min)	55.8 ± 17.5
Collecting system violations	25 (58.1)
Operative time (min)	319.0 ± 87.3
Estimated blood loss (mL)	500.5 ± 589.9
Blood transfusions	7 (16.3)
Postoperative hospital stay (d)	6.9 ± 3.2

Data presented as n (%) or mean ± standard deviation.

Table 3. Pathological data*

Benign	17	AML	12
		JG cell tumor	1
		Duplication	1
		Capsular leiomyoma	1
		Oncocytoma	1
		Metanephric adenoma	1
Malignant	26	Clear cell RCC	23
		Papillary RCC	1
		Chromophobe RCC	2

Data presented as n. AML = angiomyolipoma; JG = juxtaglomerular cell tumor; RCC = renal cell carcinoma.

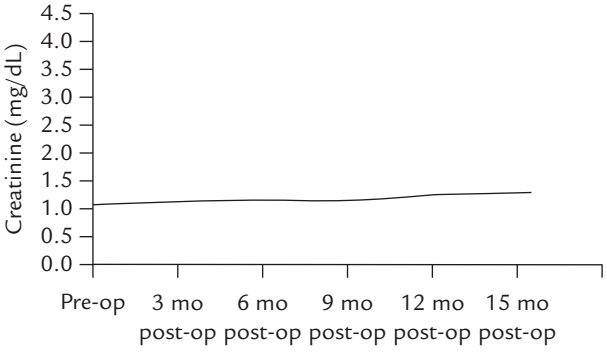

Figure 1. Postoperative serum creatinine levels.

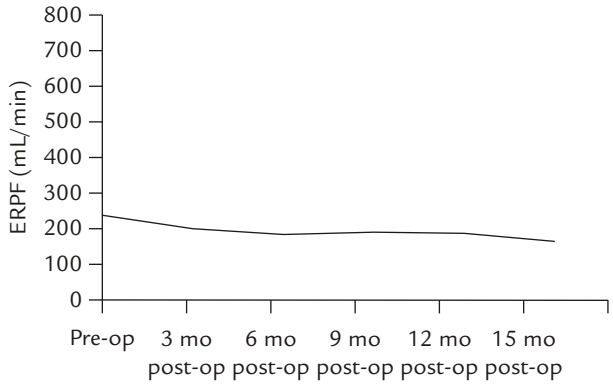

Figure 2. Postoperative effective renal plasma flow (ERPF).

Discussion

Robson first reported radical nephrectomy in 1963.[3] Radical nephrectomy has been the standard treatment for renal tumors. In recent years, some surgeons have investigated nephron-sparing surgery for solitary kidney or small sized renal tumors. Open partial nephrectomy provides excellent oncologic and functional outcomes.[4] Open partial nephrectomy also demonstrates similar outcomes compared with radical nephrectomy.[5,6] Clayman et al[2] performed the first laparoscopic nephrectomy for benign kidney disease in 1991 and the first LPN was reported in 1993.[7,8] However, LPN is a skill-challenging surgery. Reports of its long-term oncologic outcomes are limited. Some short-term survival evaluations have been reported. LPN is an alternative technique with mid-term oncologic results comparable to those for open partial nephrectomy.[9–11]

In this study, we presented our experience with LPN. The mean operative time was 319 minutes and the mean blood loss was 501 mL. Pedicle clamping was performed in 37 cases and the mean warm ischemic time was 56 minutes. Three patients were converted to laparoscopic radical nephrectomy. No patient was converted to the open method. No patient had a positive surgical margin. Ramani et al[12] reported 200 LPNs with a mean operative time of 199 minutes, mean blood loss of 247 mL, mean ischemic time of 28.7 minutes, and 2 LPNs that were converted to the open method. Venkatesh et al[13] reported 123 LPNs with a mean operative time of 204 minutes, mean blood loss of 269 mL, and 2 LPNs that were converted to laparoscopic radical nephrectomy. Permpongkosol et al[9] reported 143 LPNs with pathological stage pT1a. In their study, the mean operative time was 225.18 minutes, mean estimated blood loss was 436.9 mL, and mean ischemic time was 29.5 minutes. The surgical margins were positive in 2 (2.35%) patients. Yoshikawa et al[14] reported 17 patients who were treated with LPN. One required conversion to open surgery because of uncontrollable bleeding. The mean operative time was 270 minutes and mean estimated bleeding volume was 301 mL. The mean ischemic time was 25 minutes. A longer operative time and ischemic time, and larger volume of estimated blood loss were found in our study compared with these previous studies. A greater tumor size, higher BMI, and central tumor location are associated with a longer warm ischemic time.[15] In our study, the mean tumor size (3.7 cm) was relatively larger than that in the previous studies mentioned above (2.5 cm,[14] 2.6 cm,[13] and 2.9 cm[12]). The occurrence of deep tumors in our study (68.7%) was significantly higher than that in Ramani et al's study (25%)[12] and Venkatesh et al's study (6.5%).[13] These 2 factors (tumor size and depth) might increase warm ischemic time. They also influenced the operative time of our study. The learning curve for performing LPN probably influenced operative time as well. Our LPN data were collected since the first LPN was performed at our hospital. Gill et al[16] presented 800 consecutive LPNs of a single surgeon's series. A longer warm ischemic time was found in the first 34.5% of LPNs. Therefore, the surgeon's experience might also be a predictor of prolonged warm ischemia time. This was also our interim experience of LPN. The technique of LPN is still evolving. Our conversion rate to laparoscopic radical nephrectomy or the open method did not appear to be different from those of previous studies.

Our major complication rate was 4.3%. There was delayed bleeding in 1 patient and urine leakage in 1 patient. Ramani et al[12] reported hemorrhage in 19 (9.5%) patients and urine leakage in 9 (4.5%) patients. Permpongkosol et al[9] reported a major complication rate of 5.8%. Simon et al[17] presented the Mayo clinic experience, with a major complication rate of 5.6%. Our complication rate is similar to that of these other studies. The learning curve of LPN did not increase the complication rate. Our surgical techniques of LPN were favorable. Embolization was performed in the patient with delayed bleeding. The patient with urine leakage received a double-J stent. The management of complications was similar to that in other studies.

With regard to functional outcomes, our study showed elevated postoperative serum creatinine levels and decreased effective renal plasma flow in the operated kidneys. Lane and Gill[18] reported that no patients with normal baseline serum creatinine undergoing elective LPN had postoperative chronic renal insufficiency. Bhayani et al[19] showed that based on postoperative serum creatinine levels, warm ischemic time up to 55 minutes did not significantly influence long-term

renal function after LPN. Although our mean warm ischemic time was 56 minutes, we found an elevation of serum creatinine levels. The normal tissue of the operated kidney was also partially excised. A slight loss of renal function would be predicted. During the follow-up, serum creatinine levels and effective renal plasma flow showed no significant change between postoperative month 3 and month 6 ($p > 0.05$), and between postoperative month 3 and month 12 ($p > 0.05$). The renal function of the operated kidney was stabilized from postoperative month 3 in our study. The warm ischemic time did not result in a prolonged influence on renal function.

There were several limitations to this study. The first limitation was the retrospective nature of the data analysis. All data were collected into our database prospectively. Second, the number of patients was relatively fewer than in other studies. Patients within the learning curve of LPN were also enrolled in our study. However, this data reflects the learning experience of a single surgeon. Third, this study presented only interim oncologic and functional outcomes. Longer follow-up data of oncologic outcomes are needed.

In conclusion, the technique of LPN is still evolving. Although our warm ischemic time and operative time were longer than those of other LPN studies, the interim results of our oncologic and functional outcomes were encouraging. Further refinement of the operative procedures is needed to shorten the warm ischemic time. Additionally, based on postoperative renal function, LPN does not significantly influence long-term renal function.

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