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Bhayani, Sam B., ,"Laparoscopic partial nephrectomy: Fifty cases." Journal of Endourology.22,2. 313-316. (2008).
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JOURNAL OF ENDOUROLOGY
Volume 22, Number 2, February 2008
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DOI: 10.1089/end.2007.0128

Laparoscopic Partial Nephrectomy: Fifty Cases

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ABSTRACT

***Purpose*: Laparoscopic partial nephrectomy (LPN) is a technically challenging procedure. The goal of this study is to describe the outcomes of 50 consecutive patients undergoing LPN performed by one surgeon.**

***Materials and Methods*: Records were reviewed for clinical, pathologic, and follow-up information for patients undergoing LPN. Clinical parameters were assessed in both the first 25 and last 25 cases to see if there was a measurable learning curve.**

***Results*: Fifty-two patients underwent attempted LPN; 50 were successful and 2 were converted to open partial nephrectomy. Mean operating room time was 155 minutes, mean estimated blood loss was 172 mL, and mean pathologic size was 2.6 cm. Final pathology revealed malignancy in 60% of cases and oncocytoma in 22% of cases. Margins were clear for all of the primary lesions. Overall complications were 16%, with cardiopulmonary complications being the most common. There were no significant differences in the outcomes of the first 25 and the last 25 patients, with the exception of length of stay (3.1 days *v* 2.5 days).**

***Conclusions*: After laparoendoscopic fellowship training in LPN, acceptable outcomes are achievable, and the learning curve is minimal. Long-term studies are needed on the efficacy of LPN, and further studies need to be performed to optimize the learning process for this technique.**

INTRODUCTION

NEPHRON-SPARING SURGERY HAS BECOME A POPULAR APPROACH to treat suspicious renal neoplasms. Studies on open partial nephrectomy have shown equivalent oncologic control compared to radical nephrectomy for masses <4 cm in size.[1] Additionally, larger tumors have been successfully treated with partial nephrectomy, both in the emergent and elective settings.[2]

Laparoscopic partial nephrectomy (LPN) has emerged as an important alternative to open partial nephrectomy, and preliminary series have had reasonable outcomes.[3,4] Despite these outcomes, LPN is generally viewed as a technically demanding procedure requiring extensive expertise. As such, large series outlining the results of LPN have been authored by laparoscopic surgeons who pioneered the techniques.[3,4] The purpose of this study is to describe the outcomes and assess the learning curve of LPN immediately after intense fellowship training in the technique. We will compare the first 25 and the last 25 cases and examine the learning curve.

MATERIALS AND METHODS

After institutional review board approval, medical records and prospective databases were reviewed for all patients who underwent laparoscopic partial nephrectomy by one surgeon (SBB) from July 2004 to December 2006. Counseling on the risks and benefits of laparoscopic and open approaches to nephron-sparing surgery was given to all patients. Generally, laparoscopic partial nephrectomy was offered to patients with creatinine levels of <2.0 mg/dL, tumors <7 cm in size or exophytic tumors, and defects that would not require vascular reconstruction. All patients had a contralateral functioning kidney. All patients offered laparoscopic approaches were also offered open approaches, and in all cases a total nephrectomy was also discussed, with ablative approaches discussed with some patients. The choice of surgical technique was decided by the patient after this consultation.

The technique of laparoscopic partial nephrectomy was carefully choreographed, and was generally similar to that previous described,[5,6] but with the following alterations: No preopera-

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Table 1. Clinical Characteristics of the 50 Consecutive Patients in the Series

Parameter	*Mean (range)*
Number	50
Mean age (years)	58 (27–79)
Body mass index (kg/m^2)	30 (20.9–46.3)
ASA score	2.4 (1–3)
Preoperative creatinine (mg/dL)	0.9 (0.5–1.5)
Tumor size by x-ray (cm)	2.5 (0.6–11)
History of diabetes mellitus	8
History of hypertension	34

ASA = American Society of Anesthesiologists.

tive or intraoperative stents were placed in any patients. A transperitoneal approach was used in all cases, and the colon was reflected, the renal hilum was isolated, and the tumor was identified. For posterior tumors, the kidney was rotated. The kidney was extensively mobilized in all cases. Intraoperative laparoscopic ultrasonography was used to delineate margins and plan excision. Excision was performed with the renal vessels clamped with bulldog clamps. Frozen sections were taken of the base of the excised portion, and later the final specimen was examined grossly with the option of sending further frozen sections. The nephrotomy was oversewn and renorrhaphy completed over bolsters and hemostatic matrix (Floseal; Baxter, Deerfield, IL). Zero polyglactin (CT-1, Vicryl; Ethicon, Cincinnati, OH) and 2-0 polyglactin (SH needle) sutures were used on the parenchyma and collecting system, respectively. Absorbable or nonabsorbable clips were used to cinch down the nephrotomy closure. The renal vessels were unclamped and a suction drain was left in place. Patients were sent to the nursing ward and clear liquids were started on postoperative day 1. Diet was advanced once bowel function returned. Patients were generally discharged when they could tolerate a regular diet and had bowel movements. All patients were discharged directly to home. Medical records and prospective databases were examined to evaluate clinical, pathologic, and follow-up data. Additionally, the first 25 and the second 25 cases were compared to see if outcomes differed after appreciable volume was reached. Statistical analysis was performed with a *t*-test assuming unequal variances.

RESULTS

Table 1 describes the characteristics of the 50 patients undergoing completed laparoscopic partial nephrectomy (two were conversions to open partial procedures, as described below). Mean age was 58 years, and mean radiographic tumor size was 2.5 cm. Mean body mass index (BMI) was 30 kg/m^2. Hypertension was present in 68% of patients and 16% had a history of diabetes mellitus. None of the patients had pre-existing chronic renal insufficiency as defined by a serum creatinine level of $<$2.0 mg/dL. Table 2 describes the perioperative data. There were no emergent conversions to open surgery or radical nephrectomy. Two patients were electively converted to open partial nephrectomy. In one patient with an anterior mass, a history of Crohn's disease, and several intra-abdominal surgeries, conversion to an open procedure was necessary secondary to adhesions. An open partial nephrectomy was performed with negative margins. In another patient, with a mass in a horseshoe kidney, conversion to an open procedure was performed secondary to difficulty in evaluating the margins and depth of the mass in relation to aberrant vessels. Open partial nephrectomy was performed without difficulty, and pathology revealed negative margins. Both patients had uneventful recoveries. The analysis detailed here excludes these two elective conversions. Mean operative time was 155 minutes and mean estimated blood loss (EBL) was 172 mL. Mean warm ischemic time was 24 minutes, and there were no intraoperative complications. Perioperative complications included three cardiopulmonary issues (arrhythmia, pulmonary edema, and pneumonia), one postoperative hematoma requiring transfusion, two pseudoaneurysms (6 months and 4 months postoperative, both asymptomatic and found on routine follow-up imaging, and treated with arterial embolization), and two postoperative surgical complications. One surgical complication was a urine leak treated with a cystoscopy and ureteral stent, which sealed the leak in 6 weeks. There was one return to the operating room for exploration as outlined below.

A patient with a past history of coronary disease, hypercholesterolemia, and transient ischemic attack, was returned to the operating room for nephrectomy approximately 12 hours postoperatively. He had undergone an uncomplicated laparoscopic partial nephrectomy, but postoperatively developed severe acute flank pain uncontrolled with narcotic analgesia. He had stable laboratory examinations including serial blood counts. The kidney was explored, and multiple atheroembolic infarcts were grossly noted, likely from previous clamping and embolic showering of the patient's severely atherosclerotic renal artery. The kidney had previously appeared viable at the conclusion of partial nephrectomy, but Gerota's fascia was still covering a majority of the kidney at the time of the LPN. On return to the operating theater, nephrectomy of the nonviable kidney was performed and the patient had an uncomplicated recovery. Pathology revealed multiple embolic infarctions of the kidney, with no cancer remaining in the specimen.

Table 2. Intraoperative and Postoperative Data of the 50 Consecutive Patients in the Series

	Mean (range)
Total patients completing LPN	50/52 = 96%
Elective conversions to:	
Open partial	2
Open radical	0
Laparoscopic radical	0
Warm ischemia time (min)	24 (10–44)
Repair of pelvicaliceal system	29/50 = 58%
Estimated blood loss (mL)	172 (50–600)
Total operative time (min)	155 (82–254)
Total complications:	8 = 16%
Intraoperative	0 = 0%
Postoperative cardiopulmonary	3 = 6%
Postoperative transfusion	1 = 2%
Postoperative angiography	2 = 4%
Postoperative cystoscopy	1 = 2%
Postoperative surgery	1 = 2%

Table 3. Pathology Results of the 50 Consecutive Patients in the Series

Mean tumor size	2.6 cm (0.6–11)
Mean specimen size	4.2 cm (1–17)
Pathology:	
Renal cell	23
Papillary	7
Oncocytoma	11
Complex cyst	5
AML	3
Adenoma	1
Positive margin of primary tumor	0/50

AML, angiomyolipoma.

Table 3 describes pathologic outcomes. Mean pathologic tumor size was 2.6 cm (range 0.6–11 cm), and mean specimen size (greatest dimension) was 4.2 cm (range 1–17). The majority of cases were renal cell carcinoma (60%), oncocytoma (22%), or benign complex renal cysts (10%). One patient had a focal positive margin, but not of the original mass. This patient had separate microsatellite lesions that were not visible on preoperative imaging, ultrasound, or visual inspection. He elected observation, but recurred and subsequent nephrectomy was performed 18 months postoperatively, with negative margins. Clinical factors (Table 4) were examined to see if operative time, EBL, warm ischemia times, tumor size, specimen size, or outcomes differed in the first 25 *v* the last 25 cases, and none of these factors except length of stay were statistically significant by *t*-test with unequal variances (with significance defined as $P < 0.05$); however, EBL approached significance. Length of stay did significantly decrease in the second 25 cases after a clinical care pathway was introduced and narcotic patient-controlled analgesia was no longer routinely used. Postoperative complications were equally divided between the two groups.

DISCUSSION

Nephron-sparing surgery for small renal masses has become a complex treatment choice, as many different surgeries can be offered. Open partial nephrectomy is the historical gold standard, and it maintains a good long-term track record. LPN is emerging with initially promising results, though cryoablation is still controversial. This report adds to the literature regarding the reproducibility of LPN with acceptable results. The overall operative times and complications in this series are comparable to those of other larger series.[3,4] The issue of the learning curve is interesting, as in this series there does not appear to be a clinically significant learning curve in the first 50 cases after intense training. Although length of stay and possibly EBL were slightly less in the second 25 cases, the differences were of little practical significance. As such, even though LPN remains a technically demanding procedure, important skills may be acquired during adequate training in both open and laparoscopic renal surgery. Specific technical skills assessments have been suggested,[7] and these may help trainees conquer the learning curves prior to operating independently. We were unable to compare our results to those of physicians who lack fellowship training in the technique due to a lack of cases.

Despite the excellent results detailed in this report, it is necessary to outline its major limitations. First, this series only includes patients who were carefully selected for LPN, so this is not a randomized trial of all patients with renal masses. Therefore it does not include several patients who underwent open partial nephrectomy performed by the author, as they were not encouraged to undergo LPN. These patients had complex clinical and anatomic conditions (solitary kidneys with large tumors, existing severe renal insufficiency, and hilar vessel involvement requiring vascular reconstruction), and they chose open partial nephrectomy upon the advice of the surgeon. Although solitary kidneys and patients with renal insufficiency have been operated on laparoscopically,[8,9] it is prudent to tackle these cases after one has more experience with elective LPN. As such, this report is not meant to imply that LPN is appropriate for all tumors or all conditions. The author maintains that there will still be a role for open partial nephrectomy, and more difficult cases may be selected out of LPN series. Despite this limitation, it is likely that all existing reports on LPN are on carefully selected patients, as there are no randomized studies comparing LPN to open partial nephrectomy, and certain situations may require a surgeon to use an open procedure based on the size or location of the lesion.

Aside from issues concerning the learning curve or the results of a single surgeon, LPN continues to raise several concerns in the literature, but they were not problematic in this series. Some of the major concerns are for cancer control and margin status, warm ischemia time, and complications. Regarding cancer control, no conclusion can be made in this short-term series, but medium-term outcomes have been reported in other series, with favorable results.[8] When scrutinizing margin status, it is critical to recognize that the author favors a large resection and a more difficult reconstruction rather than a smaller resection with a potentially easier reconstruction. As cancer control is paramount, the author generally aims for a 5-mm to 1-cm margin, and hence caliceal entry was necessary in nearly 60% of the cases in this series, but the margins of the

Table 4. Outcomes of the First 25 Cases Versus the Second 25 Cases of Laparoscopic Partial Nephrectomy

	First 25 cases	*Second 25 cases*	P *value*
Age	59 years (40–77)	57 years (27–69)	0.53
Body mass index	30 (22.3–39.1)	30 (21.5–46.3)	0.50
Operative time	165 min (82–241)	145 min (95–254)	0.10
Estimated blood loss	214 mL (50–550)	104 mL (50–600)	0.05
Length of stay	3.1 days (1–5)	2.6 days (2–4)	0.01
Tumor size (pathologic)	2.7 cm (0.6–7)	2.5 cm (1–11)	0.84
Specimen size (pathologic)	4.4 cm (1.5–17)	4.1 cm (1–12)	0.53

primary mass were negative in all cases. The mean specimen size of >4 cm (not including peritumor fat) illustrates that the degree of resection was sizable. Unfortunately, no estimation of total volume of resection was performed prospectively. Cancer control was excellent with 100% overall survival and cancer-specific survival, but follow-up is not mature since the procedures were performed between 2004 and 2006. One recurrence is noted above, in a patient with multifocal disease who was salvaged with nephrectomy. One other caveat about cancer control is the high incidence of benignity in this series, which is largely a function of the small size of the lesions.

The second general concern of LPN is ischemia. The "safe" window of warm ischemia time is unknown despite several studies assessing its impact.[10–13] In this series none of the patients had preoperative baseline creatinine >2.0 mg/dL, so clearly the population was somewhat selected for tolerance of ischemia. Importantly, however, warm ischemia times were relatively short. The rapidity can again be attributed to the surgeon's comfort with intracorporeal suturing with both hands, and in both the forehand and backhand directions. Further time savings were secondary to the use of clipped sutures for renorrhaphy. Operating with vessels clamped produced a bloodless field, which subjectively made identification of collecting system entry and renorrhaphy easier.

The number of complications was reasonable in this series, but some lessons were learned. The historically common complications of urine leakage and hemorrhage were rare in this series. Medical complications were acceptable. The two pseudoaneurysms seen may imply that tighter suturing of the nephrotomy may be needed, or perhaps more use of adjunctive sealants would help. The cases with pseudoaneurysms were patients number 4 and 30, and they have had no recurrence. The incidence of this complication in a larger series was 1.7%.[14] Clearly, by carefully selecting patients for LPN a reasonable complication rate can be achieved. Currently the majority of nephron-sparing surgery performed by the author is via the laparoscopic/robotic route. This not only indicates the prevalence of smaller masses, but also the penetration and acceptance of LPN as a routine option in most patients.

CONCLUSIONS

After laparoendoscopic fellowship training in LPN, acceptable outcomes are achievable and the learning curve is minimal. Long-term studies are needed of the efficacy of LPN, and further studies need to be performed to optimize the learning process for this technique, and to assess cancer control methods and recurrence rates.

ACKNOWLEDGEMENT

This study was funded by the Midwest Stone Institute.

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ABBREVIATIONS USED

AML = angiomyolipoma; BMI = body mass index; EBL = estimated blood loss; LPN = laparoscopic partial nephrectomy.