Laparoscopic Wedge Resection and Partial Nephrectomy - The Washington University Experience and Review of the Literature

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ABSTRACT

Open partial nephrectomy is an accepted form of treatment for a variety of benign conditions and for localized renal cell carcinoma. To date, there is limited experience with the clinical application of laparoscopic partial nephrectomy and wedge resection for benign and malignant disease of the kidney. Herein, we report our clinical experience with laparoscopic partial nephrectomy and a review of the current literature.

Twelve patients (27 - 81 years) have undergone laparoscopic wedge resection (3) or attempted polar partial nephrectomy (9) since 1993. In the group of 12 patients, 5 had a mass suspicious for a malignancy, 4 patients had symptomatic polar calyceal dilation with or without stone disease, and 3 patients had an atrophic or hydronephrotic upper pole moiety.

Among the patients in the polar nephrectomy group, a third were converted to an open procedure. The remaining 6 patients had a mean operative time of 6.5 hours (5.7 - 8.3 hours). These patients resumed their oral intake on average 0.8 days postoperatively. In the 2 patients with a mass, the final pathology was oncocytoma (1), and xanthogranulomatous reaction in a renal cyst (1). Postoperative complications included a nephrocutaneous fistula which was endoscopically fulgurated, a retroperitoneal urinoma which was percutaneously drained, and a two-day bout of ileus. The mean hospital stay was 5.3 days (2 - 9). Their full convalescence was completed in a mean of 4.2 weeks (2 - 8).

Three patients underwent a wedge resection for a superficial < 2 cm mass. The average operative time in this group was 3.5 hours (2 - 5.4). The mean time to resuming oral intake was 0.7 days (0.3 - 0.7). The final pathology was oncocytoma (1), oncocytic renal cell cancer (1), and old infarction (1); none of the patients had any complications. The mean hospital stay was 2.7 days (2- 4). Convalescence was completed in 4 weeks (range 1 - 8).

Laparoscopic wedge resection and polar partial nephrectomy are feasible, albeit currently tedious techniques. While wedge excision of a < 2 cm superficial lesion is relatively straightforward and efficient, laparoscopic polar partial nephrectomy remains a difficult technique and at present remains in evolution. Further development of instrumentation to provide for a reliable, expeditious, and hemostatic partial nephrectomy is needed.

Key Words: Partial nephrectomy, Laparoscopy, Kidney tumor.

INTRODUCTION

Partial nephrectomy has become an acceptable surgical treatment for a variety of benign diseases as well as for localized renal cell carcinoma when preservation of renal function is necessary.[1] More recently, nephron sparing surgery has been applied to select patients with unilateral renal cell carcinoma and a normal contralateral kidney with satisfactory cancer-free survival and minimal associated morbidity.[1,2]

Laparoscopic surgery has become accepted as an alternative to open nephrectomy for benign disease and has been used extensively at some institutions to remove malignant renal disease.[3,4] However, there is limited experience with the clinical application of laparoscopic partial nephrectomy for benign disease and only one report of a successful laparoscopic partial nephrectomy for malignant disease.[5,6] Herein, we present our clinical experience with laparoscopic wedge resection and partial nephrectomy.

MATERIALS AND METHODS

Twelve patients have undergone laparoscopic wedge resection (3) or attempted partial nephrectomy (9) since 1993.

In the group of 9 partial nephrectomy patients, 2 had a mass suspicious for a malignancy (1 upper pole and 1

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lower pole), and 4 patients had symptomatic polar calyceal dilation with or without stone disease; 2 patients had upper pole atrophy associated with a duplicated collecting system and 1 patient had a nonfunctioning upper pole. The average age of this group was 52 years. Two patients underwent an extraperitoneal partial nephrectomy, and 7 patients underwent a transperitoneal approach. Both the extraperitoneal and transperitoneal approaches to laparoscopic renal surgery have been previously described.[7,8]

The mean age of the 3 patients who underwent laparoscopic wedge resection was 68 years. These patients had incidentally been discovered to have 1 cm to 1.5 cm masses on computed tomography evaluation of the abdomen. In one patient the 1 cm mass demonstrated calcification within the lesion. All of these masses were superficial lesions on the posterior aspect of the kidney, located at the mid-polar region (1) and on the lower half of the kidney (2). Two of these patients underwent an extraperitoneal approach to their laparoscopic wedge resection, and the third patient was approached transperitoneally.

The renal vessels were not isolated or controlled in any of the cases. In two patients with < 2 cm exophytic masses suspicious for malignancy, Gerota's fascia was dissected to expose the lesion. Under direct visualization the lesion was excised with a 5 mm to 10 mm margin. Frozen section analysis was performed of a biopsy taken from the bed of excision site to confirm complete excision of the lesion. In the 2 patients with polar masses, Gerota's fascia was dissected only at the level of the proposed transection of the renal parenchyma which was determined using intraoperative laparoscopic ultrasound (Tetrad Corp., Englewood, CO) or fluoroscopic injection of contrast to delineate the polar extent of the collecting system as guidance for the line of excision.

Nine of the patients had an upper (6) or lower (3) pole partial nephrectomy using electrosurgical scissors (5), an electrosurgical snare (3), or an Endo GIA stapling device (1) (U.S. Surgical Corp., Norwalk, CT). The kidney was dissected from Gerota's fat, and the line of the planned parenchymal incision was marked on the renal capsule using electrocautery. The parenchyma was then incised with the electrosurgical scissors and the exposed parenchymal surface was fulgurated with the argon beam coagulator (ABC) **(Figure 1)**. The process of extending the parenchymal incision and fulgurating with the ABC was continued until the polar excision was completed. A preplaced external ureteral catheter was injected with indigo carmine stained saline, and the site of leakage from the collecting system was closed with intracorporeal suturing in figure-of-

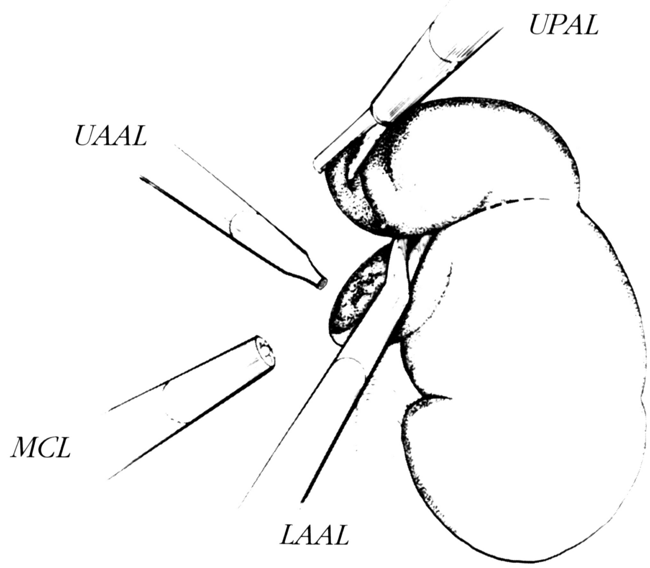

Figure 1. The exposed renal capsule is demarcated along the proposed line of transection with electrocautery. The electrosurgical scissors are used to transect the renal parenchyma as the argon beam coagulator fulgurates the transected surface.

eight fashion with O absorbable suture. Three of the patients had a partial nephrectomy with a newly developed electrosurgical snare electrode.[6] This technique included dissection of the kidney within an intact Gerota's fascia. The Gerota's fascia and fat were then incised and dissected to expose the renal capsule circumferentially at the level of the proposed transection. The wire loop of the electrosurgical snare electrode was then placed around the kidney and tightened securely at the level of exposed renal capsule **(Figure 2)**. Simultaneous injection of radioopaque contrast material provided fluoroscopic visualization of the collecting system which assisted in determining the appropriate placement of the electrosurgical snare with respect to the upper or lower pole lesion. The electrosurgical snare was placed to insure a 1 cm margin of normal tissue. It was then connected to an electrosurgical generator unit (ERBE) and activated; the wire was progressively tightened on the parenchyma resulting in transection of the tissue. Hemostasis of the transected surface was established with the ABC and the collecting system was closed with O absorbable suture. Two of the three snare procedures required conversion to an open technique; one for inadequate excision of the stone containing lower pole renal tissue and one for control of arterial bleeding at the transected surface of the renal parenchyma. Three patients also had Avitene applied to the transected renal surface to aid hemostasis. In one patient, who had a refluxing upper pole ureter of a duplicated collecting sys-

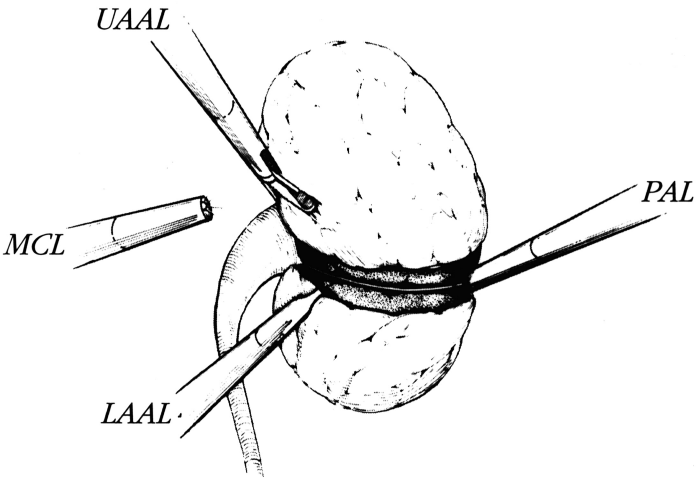

Figure 2. When using the electrosurgical snare, the renal capsule at the level of the proposed transection is exposed, leaving Gerota's fascia intact over the polar lesion to be removed. The snare is placed around the kidney at the line of excision, and simultaneously tightened down into the parenchyma as the electrical energy incises and coagulates the tissue.

tem, the small amount of nonfunctioning upper pole renal tissue was excised using the Endo GIA stapling device. An indwelling double pigtail ureteral stent was placed at the completion of the procedure in these patients and maintained until the absence of extravasation was confirmed on intravenous pyelography. Drains were not routinely used in either group of patients.

The patients were divided into two groups: the three patients undergoing laparoscopic wedge resection and the nine patients undergoing laparoscopic polar partial nephrectomy. Each group was evaluated with respect to patient demographics, operative time, estimated blood loss, complications, postoperative use of analgesics, the time to resume normal oral intake, hospital stay, and time to complete convalescence. The hospital charts, office charts, and direct patient interviews were used to obtain the aforedescribed data.

RESULTS

Among the laparoscopic wedge resection group of patients, the mean operative time was 3.5 hours (range 2 - 5.4) **(Table 1)**. The mean intraoperative estimated blood loss was 92 cc (75 - 100). These patients required an average of 21 mg of morphine sulfate for postoperative pain management (range 12-34 mg). These patients resumed normal oral intake at a mean of 0.6 days and had a mean hospital stay of 2.7 days. The final pathologic diagnosis was an oncocytoma in one patient, an old infarction with nephrosclerosis in one patient, and an oncocytic renal cell carcinoma (Grade I-II) in the third patient. Their mean time to complete convalescence was 4 weeks (range 1 - 8). There were no intraoperative or postoperative complications in any of these patients, and they have been followed up for a mean of 46 months postoperatively.

Nine patients have undergone polar partial nephrectomy for symptomatic calyceal dilation with or without nephrolithiasis (4 patients), a 2 cm or 3 cm lower pole mass assessed to be suspicious for carcinoma (2 patients), and a dilated or refluxing upper pole moiety of a duplicated collecting system (3 patients) **(Table 2)**. Three patients in the polar partial nephrectomy group were converted to an open procedure, and all of these patients had calyceal dilation with nephrolithiasis. In one patient the conversion to an open procedure was due to extensive lower pole fibrosis, and in another patient, for control of arterial bleeding from the parenchymal surface of the kidney following transection with the electrosurgical snare. In the third patient, technical problems in accurately identifying the diseased renal tissue necessitated conversion to an open procedure. Due to their open conversion, these three patients were eliminated from the evaluation of the clinical data on the polar partial nephrectomy group.

The mean operative time in the polar partial nephrectomy group was 6.5 hours (range 5.7 - 8.3). The mean estimated blood loss was 217 cc (range 50 - 600). In all of these patients a preliminary cystoscopic procedure was performed to place a stent in the affected collecting system. Eight of these patients underwent a transperitoneal approach and in one patient, with benign disease, an extraperitoneal approach was used for performing the laparoscopic partial nephrectomy.

In one patient, the Gill sling, in combination with the electrosurgical scissors and ABC, was used to transect the upper pole.[18,19] Application of Avitene was required to achieve complete hemostasis following the parenchymal transection. In three patients the newly developed electrosurgical snare electrode in combination with the ABC was used to complete the partial nephrectomy and achieve hemostasis.[6] In one patient the atrophied upper pole renal tissue was excised using the Endo GIA stapling device. In the remaining four patients, electrosurgical scissors were used to transect the dilated upper pole, and in three of these patients the ABC was used to achieve complete hemostasis.

The final pathology in the 6 laparoscopic polar partial nephrectomy patients included chronic pyelonephritis with obstructive uropathy in 4 patients, xanthogranulomatous pyelonephritis in 1 patient, and oncocytoma in 1 patient. In the 6 patients, a mean of 52 mg of morphine sulfate equivalent (range 8 - 120 mg) was required for postoperative pain management. The mean time to oral intake in the

Table 1.
Laparoscopic Wedge Resection - Summary of Clinical Data

Pt	Age	Preop Diagnosis	Intraop Imaging	Cutting Modality	OR Time	EBL
VH	70	1.5 cm mass posterior	Lap Visual	ABC & EC	2 hrs	75 cc
JH	54	1 cm mass lower pole	Lap Visual	ABC & EC	3.2 hrs	100 cc
MJR	81	1 cm mass lower pole	Lap Visual	ABC & EC	5.4 hrs	100 cc
Mean	**68 yrs**				**3.5 hrs**	**92 cc**

Lap Visual = Laparoscopic Visualization
ABC = Argon Beam Coagulator
* not included in data analysis

polar partial nephrectomy group was 18 hours (range 8 - 48 hrs.). The mean hospital stay was 5.3 days (range 2 - 9). The mean time to complete convalescence in this group was 4.2 weeks (range 2 - 8 weeks).

Of the 6 patients who underwent successful laparoscopic polar partial nephrectomy, 3 complications were noted. One patient developed a nephrocutaneous fistula, despite an indwelling ureteral stent, which required placement of a percutaneous nephrostomy tube and endoscopic fulguration. One patient developed a postoperative fever, and a retroperitoneal urinoma was identified on CT scan. This was drained percutaneously, and the patient recovered without incident. The fourth patient had a postoperative ileus which required 2 days for resolution with conservative management.

DISCUSSION

The development of transabdominal sonography, computed tomography (CT) and magnetic resonance imaging (MRI) as screening studies for intra-abdominal and retroperitoneal disease has resulted in an increased incidence of detection of asymptomatic renal tumors.[9-11] These asymptomatic tumors tend to be smaller (< 4 cm) and of lower stage than symptomatic tumors and are typically suitable for partial nephrectomy.

Recently, investigators have demonstrated that nephron-sparing surgery for these small tumors can provide satisfactory early cancer-free survival and morbidity similar to radical nephrectomy.[1,2,12,13] Partial nephrectomy is the most widely accepted procedure for removal of renal malignancy when conservation of the parenchyma is of importance. During partial nephrectomy a margin of normal parenchyma is removed with the tumor. The overlying perirenal fat and Gerota's fascia are removed intact with the specimen. This technique theoretically should help prevent incomplete resection and possible tumor spillage. Recent reports suggest that intraoperative ultrasonography offers no improvement over CT or intraoperative inspection for the evaluation of tumor focality; however, it does appear to provide useful information for guiding nephron-sparing surgery, particularly in patients with intrarenal tumors or tumors extending deep into the parenchyma.[13] Unfortunately, it has been our experience that the use of the laparoscopic ultrasound probe has not facilitated 3-dimensional localization of deep parenchymal lesions during laparoscopic partial nephrectomy. Instead, the use of fluoroscopic evaluation of the collecting system and its relationship to the parenchymal lesion to be excised was found to be most useful in positioning when utilizing the electrosurgical snare for the partial nephrectomy to insure an adequate margin of normal renal tissue.

Technical problems with partial nephrectomy arise mainly from dissection of the renal parenchyma, transection of the intrarenal vessels and control of parenchymal bleeding, and closure of the collecting system. The technical difficulties account for the morbidity associated with partial nephrectomy: intraoperative or postoperative bleeding, renal fistula formation and renal insufficiency.[14,15]

In 1991 we reported the initial experience with laparo-

Analgesic (Morphine)	Time to P.O. Intake	Hospital Stay	Convalescence	Time of Follow-Up	Complication
12 mg	16 hrs	2 days	1 wk	57 mos	None
34 mg	8 hrs	4 days	3 wks	52 mos	None
18 mg	24 hrs	2 days	8 wks	28 mos	None
21 mg	**16 hrs**	**2.7 days**	**4 wks**	**46 mos**	

Tetrad U/S = Laparoscopic Ultrasound Probe
EC = Electrocautery
Snare = Electrosurgical Snare

scopic partial nephrectomy in the pig model.[16] The technique developed in the laboratory utilized a plastic cable tie to compress the renal parenchyma and an ABC to fulgurate the transected surface. Also, in these animals, transient en-mass control of the renal pedicle was achieved using a vessel loop. Subsequently, Winfield and colleagues performed the first clinical transperitoneal laparoscopic partial nephrectomy in a 31-year-old woman with a chronically infected, stone-bearing lower pole of the right kidney.[17] In this case report the renal vessels were not occluded; however, a single loop of umbilical tape was used to secure the renal parenchyma prior to transection with electrosurgical scissors. Shortly thereafter, Gill and colleagues performed a completely retroperitoneal laparoscopic partial nephrectomy in a 24-year-old woman with a scarred lower pole and history of recurrent urolithiasis **(Table 3)**.[18] Their technique included a newly-designed double loop sling apparatus and the ABC to achieve renal parenchymal hemostasis, thereby negating the necessity for renal hilar vessel occlusion. Other authors have reported laparoscopic partial nephrectomy and ureterectomy in patients with nonfunctioning moieties secondary to duplicated anomalies of the kidney.[20,21]

In our group of 9 laparoscopic polar partial nephrectomy patients, 3 required conversion to an open procedure for completion of the surgical procedure. Recently, Winfield and colleagues have similarly reported a 30% conversion rate in 6 patients undergoing laparoscopic partial nephrectomy for benign disease. The conversion to open partial nephrectomy was required in 2 patients due to extremely difficult dissection, in 1 patient due to uncontrolled bleeding, and in 1 patient due to discovery of a renal cell cancer **(Table 3)**.[5] On review of the literature, there have been only 16 successfully completed laparoscopic partial nephrectomies. The mean operative time was 4.9 hours and the patients had a mean hospital stay of 5.2 days. The complication rate was 56% and included persistent flank drainage for 14 days (1), ureteral injury (1), wound infection (1), recurrent urinary tract infections (1), perinephric abscess (1), nephrocutaneous fistula (1), perinephric urinoma (1) and postoperative ileus (1) **(Table 3)**.

In our group of 6 completed laparoscopic partial nephrectomy patients, a major complication occurred in 50%. Two of these cases were likely due to incomplete closure of the collecting system and/or postoperative obstruction of the external ureteral stent resulting in urinoma formation or development of a nephrocutaneous fistula. Urinary extravasation and fistula can occur after major tumor resections in which the collecting system has been entered. Most such fistulae resolve spontaneously with conservative management provided that ureteral obstruction is not present. In one of our cases, the association of fever with urinary extravasation prompted percutaneous nephrostomy drainage; the fistula spontaneously closed. In the other patient, a nephrocutaneous fistula persisted, despite an indwelling ureteral stent; this problem resolved after endoscopic fulguration of the fistula tract.

We have been investigating the development of an electrosurgical snare electrode to perform partial nephrectomy. The loop mechanically provides a clean cut surface which does facilitate identification of the collecting system for sub-

Table 2.

Laparoscopic Partial Nephrectomy - Summary of Clinical Data

Pt	Age	Preop Diagnosis	Intraop Imaging	Cutting Modality	OR Time	EBL	
DY*	53	lower pole atrophy + stones	Lap Visual	EC	7 hrs	500 cc	
LS*	51	upper pole hydro + stones	Lap Visual	Snare + ABC	8.3 hrs	600 cc	
LAB*	27	lower pole cystine stones	Lap Visual	Snare + ABC	6.3 hrs	400 cc	
RV	40	upper pole hydro + stones	Lap Visual + Tetrad U/S	ABC + EC	5.8 hrs	400 cc	
CD	73	3 cm mass upper pole	Lap Visual	ABC + EC	6.9 hrs	300 cc	
WB	80	2 cm mass lower pole	Lap Visual + Fluoroscopy	Snare + ABC	7.3 hrs	150 cc	
KH	39	upper pole non-function	Lap Visual	ABC & EC	5.7 hrs	200 cc	
BA	45	upper pole hydro + atrophy	Lap Visual	-	7.0 hrs	50 cc	
AC	34	refluxing upper pole duplex system	Lap Visual	EndoGIA Stapler + EC	6.0 hrs	200 cc	
Mean	**52 yrs**				**6.5 hrs**	**217 cc**	

Lap Visual = Laparoscopic Visualization
ABC = Argon Beam Coagulator
* not included in data analysis

Analgesic (Morphine)	Time to P.O. Intake	Hospital Stay	Convalescence	Time of Follow-Up	Complication
					Converted to open
					Converted to open
					Converted to open
8 mg	8 hrs	6 days	3 weeks	18 mos	Nephrocutaneous fistula endoscopic fulgurate
90 mg	48 hrs	5 days	2 weeks	13 mos	Ileus x 2 days
60 mg	16 hrs	9 days	8 weeks	21 mos	Urinoma - perc drain
15 mg	18 hrs	8 days	6 weeks	12 mos	None
120 mg	8 hrs	2 days	2 weeks	30 mos	None
20 mg	8 hrs	2 days	-	-	None
52 mg	**18 hrs**	**5.3 days**	**4.2 weeks**	**19 mos**	

Tetrad U/S = Laparoscopic Ultrasound Probe
EC = Electrocautery
Snare = Electrosurgical Snare

Table 3.
Laparoscopic Partial Nephrectomy - Review of the Literature

	Number of Patients	OR Time	Postop Analgesia	Hospital Stay	Complication Rate	Follow-Up
Gill et al.,[18] 1994	1	5 hours	8 mg	5 days	100%	7 mos
Winfield et al.,[5] 1995	6	6.1 hours	20.2 mg	8.3 days	67%	—
Gasman et al.,[23] 1996	1	2 hours	0	2 days	100%	—
deCanniere et al.,[24] 1997	2	not specified	0	not specified	not specified	—
McDougall et al., 1997	9	6.5 hours	52 mg	5.3 days	50%	19 mos
Mean	**1**	**4.9 hours**	**16 mg**	**5.2 days**	**56%**	

subsequent placement of sutures. However, the electrosurgical cutting and coagulation has been inconsistent, resulting in unreliable simultaneous cutting and coagulation of the tissue. Indeed, one patient in whom this device was used required conversion to open surgery for control of arterial bleeding from the transected parenchymal surface.

The largest reported single center experience with open nephron sparing surgery for small, unilateral renal cell cancer included 46 patients with a mean tumor size of 2.5 cm.[2] The operative time and postoperative analgesic requirement in this group were not reported. The mean hospital stay for the open partial nephrectomy group was considerably longer than that for the laparoscopic partial nephrectomy group, 9.2 days versus 5.3 days, respectively. The perioperative complications in the open partial nephrectomy group included urinary fistula (3) which resolved spontaneously, acute renal failure requiring temporary dialysis (1), superficial wound infection (1), and superficial wound seroma (1). In addition, one perioperative death occurred in this group of patients. This was associated with a deep vein thrombosis necessitating anticoagulation, resulting in a retroperitoneal hemorrhage and ultimately infection. The patient gradually deteriorated and died of cardiac arrest 41 days postoperatively. Overall, the open partial nephrectomy group had less perioperative morbidity compared to the laparoscopic partial nephrectomy, with complication rates of 15% compared to 50%, respectively. At present, the laparoscopic partial nephrectomy may be in contention with the open partial nephrectomy with regards to equanimity—vis-à-vis postoperative pain and hospital stay. However, the development of the laparoscopic partial nephrectomy has a long way to go to compare to the efficacy, efficiency and economy of the open partial nephrectomy. In contrast to laparoscopic partial nephrectomy, from our experience to date, laparoscopic wedge resection of < 2 cm superficial renal masses may be a reasonable surgical alternative. However, the accurate excision and hemostasis required for laparoscopic wedge resection of tumors between 2 and 4 cm or deep parenchymal lesions appears still to be too difficult for the laparoscopic approach. The high conversion to open rate and the major complication rate in the partial nephrectomy patients with a 2 to 4 cm lesion presently makes this technique clinically unacceptable. For those lesions > 4 cm our recommendation has been laparoscopic radical nephrectomy in view of the relatively high risk for multifocality and possibly incomplete tumor resection with a partial nephrectomy technique.

Consideration of several points may eventually render laparoscopic partial nephrectomy a feasible clinical technique. Intraoperative control of the renal vessels may improve the ability to control hemostasis during the transection of the renal parenchyma. In this regard, the development of laparoscopic vascular clamps appears to be a feasible concept.[22] Closure of the collecting system is important to minimize postoperative complications associated with urinary extravasation. It would seem prudent to utilize an indwelling or external ureteral stent and bladder drainage in those patients requiring closure of the collecting system to ensure adequate urinary drainage in the immediate postoperative period. The development of tissue sealants, such as fibrin glue, may also assist in minimizing the time necessary for complete healing of the transected collecting system. The investigation of alternative energies for transection of the renal parenchyma may eventually provide more effective techniques for incising and coagulating renal tissues.

CONCLUSION

In our experience, laparoscopic wedge resection for small (< 2 cm) superficial parenchymal tumors has been feasible and resulted in minimal patient morbidity and no significant complications. However, laparoscopic partial nephrectomy is a technically intensive procedure with significant surgical difficulties and complications and at this time should not be considered as a routine line of treatment. While it is feasible to perform laparoscopic partial nephrectomy in patients with benign renal disease, its extension to patients with renal tumors remains anecdotal and controversial. Improved instrumentation for parenchymal transection, hemostasis, and intracorporeal suturing are needed before this procedure can become clinically acceptable.

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