Laparoscopic Nephron-Sparing Surgery for the Small Exophytic Renal Mass

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ABSTRACT

Objectives: Nephron-sparing surgery has emerged as the treatment of choice for the incidentally detected small renal mass, especially those less than 4 cm in size. We describe our technique and experience with the laparoscopic excision of these lesions.

Methods: Between June 2001 and October 2003, 20 patients underwent nephron-sparing surgery at our institution. Twenty-one laparoscopic partial nephrectomy procedures were performed. All tumors were detected incidentally by cross-sectional imaging. All patients had a solid renal mass or a complex cystic renal mass of Bosniak category III or greater. All solid tumors were exophytic and less than 4cm in diameter. Both transperitoneal and retroperitoneal approaches were used. Hemostasis was achieved without hilar control in 20 of the 21 cases.

Results: Twenty renal units were approached transperitoneally, and 1 retroperitoneally. Mean tumor size was 2.6 cm (range, 1.2 to 4). Mean estimated blood loss was 211 mL (range, 50 to 500), and mean operative time was 165 minutes. Pathology revealed renal cell carcinoma in 14 (70%). No intraoperative complications occurred. Two patients required blood transfusions postoperatively.

Conclusion: Carefully selected patients with small, exophytic renal masses can safely undergo laparoscopic excision. When achievable, this procedure can be a more logical alternative to ablative techniques for the minimally invasive management of such lesions.

Key Words: Nephron sparing, Laparoscopic, Partial nephrectomy, Ablative, Kidney.

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INTRODUCTION

Nephron-sparing surgery is indicated for imperative indications, such as renal tumor in an anatomically or functionally solitary kidney or in patients with bilateral synchronous tumors. Relative indications include those patients with a solitary renal mass where contralateral function is compromised or in patients at risk for developing tumors in the contralateral kidney. Long-term results show disease-free survival comparable to that with radical nephrectomy, when compared stage for stage.[1] The goal is to preserve renal function without compromising tumor control. Today, nephron-sparing surgery can be viewed as the standard of care for tumors less than 4cm in size that are amenable to partial nephrectomy.[1–4] This approach offers many advantages over the ablative techniques of cryoablation, radiofrequency ablation, and high-intensity focused ultrasound including more accurate pathological diagnosis. Laparoscopic nephrectomy is routinely performed at many institutions worldwide following its original description by Clayman in 1991.[5] Since then, primary series of laparoscopic partial nephrectomy have been reported, and the procedure has been shown to be safe with acceptable morbidity in carefully selected patients.[6–9]

Laparoscopic excision of centrally located and larger tumors with both hilar control and hypothermia has been described by a few groups.[10] However, laparoscopic partial nephrectomy is a highly demanding procedure requiring a high level of laparoscopic skill. To overcome the technical hurdles, some have advocated minimally invasive ablative approaches for the management of such lesions including radiofrequency ablation, cryotherapy, or high-intensity focused ultrasound. Yet in many patients, these lesions are peripherally located and are easily excisable by the pure laparoscopic excision technique using current hemostatic measures. This offers the theoretical advantage of complete tumor removal and pathological review. We report our experience on laparoscopic partial nephrectomy in 21 cases.

METHODS

Between June 2001 and October 2003, 21 laparoscopic partial nephrectomy procedures were performed at our

institution in 20 patients by 2 surgeons. The medical records were reviewed regarding operative techniques and preliminary postoperative outcomes. Preoperative evaluation included chest x-ray, complete blood count, and metabolic panel, and either computed tomography (CT) scan with intravenous (IV) contrast or magnetic resonance imaging (MRI) with gadolinium. Indications included enhancing exophytic solid renal masses up to 4cm in size with a normal contralateral kidney in 14, Bosniak III complex renal cysts in 4, and bilateral synchronous enhancing renal masses in one. All renal masses were ≥50% exophytic as evaluated by preoperative imaging. The clinical parameters analyzed included patient demographics, location of tumor, pathological description, margin status, hemostatic techniques, preoperative serum hemoglobin levels, operative time, estimated blood loss, complications, length of stay, body mass index, and pain score. Serum creatinine measurement were analyzed comparing preoperative, postoperative, and those on most recent follow-up by using the Student t test. Average postoperative pain scores were determined by using a visual analog scale from 0 to 10, with 0 being no pain and 10 being most severe pain. The transperitoneal approach was utilized in all but 1 patient, who was approached retroperitoneally. Repeat imaging including computed tomography, renal ultrasound, or magnetic resonance imaging was available in 9 of the 14 patients with renal cell carcinoma.

For the transperitoneal approach, patients were positioned in a modified flank position, with a Veress needle used to achieve pneumoperitoneum in the majority of cases. Four port sites were used. With Gerota's fascia incised, the renal fat overlying the tumor was dissected free from the tumor and sent to pathology. Once the kidney was mobilized for optimum visualization of the lesion and kidney surface, the tumor was enucleated or excised with a 0.5-cm margin via wedge resection. The renal hilum was exposed in all cases, but the renal vessels were clamped in only 1 patient due to the depth of the lesion. A combination of electrocautery and sharp dissection were used to excise the lesion. Following removal of the tumor, frozen sections were sent from the deep tumor crater and peripheral margin to ensure complete resection. Bipolar electrocautery was used to fulgurate any obvious bleeding vessels. Indigo carmine was given intravenously to detect collecting system entry. The argon beam coagulator was used to 'paint' the cut surface and Surgicel (Ethicon, Somerville, NJ) was applied. The argon beam coagulator was used to 'weld' the Surgicel to the cut surface.

The hemostatic methods used changed as experience was gained. Initially, the combined modalities of Surgicel and the argon beam coagulator were used alone as described above. As more cases were performed, one surgeon gained experience with the addition of fibrin glue (Tisseel, Baxter Healthcare Corp., Irvine, CA), while the other surgeon utilized the TissueLink radiofrequency coagulator (TissueLink Medical, Dover, NH).

In the cases where fibrin glue was an additional hemostatic aid, it was applied to the entire surface after the Surgicel and argon beam coagulator in a relatively dry field. In those cases where the TissueLink radiofrequency coagulator was used, the TissueLink was able to help in blunt dissection of the tumor from adjacent parenchyma, although the majority of the tumor was dissected sharply. Upon removal of the tumor, a combination of the TissueLink radiofrequency coagulator and argon beam coagulator were used to achieve hemostasis of the cut surface. Once the results of the frozen biopsy specimens were obtained, Surgicel was applied, and the argon beam coagulator was used to 'weld' the Surgicel to the cut surface. The collecting system was not entered in any case. In the one patient where the renal hilum was clamped, retrograde chilled saline was irrigated via a ureteral catheter.

The specimen was excised by using a laparoscopic scissors, and the collecting system was closed primarily followed by suture repair of the renal cortex. The specimen was removed in a laparoscopic specimen bag. The insufflating pressure was reduced to one half, and the cut surface of the kidney was again examined to ensure hemostasis.

RESULTS

Twenty-one laparoscopic partial nephrectomy procedures were performed in 20 patients, 14 men (66%) and 6 (33%) women. Patient characteristics and operative variables are listed in **Table 1**. Patient ages ranged from 47 to 82 years. Five (26%) patients had evidence of compromised renal function with serum creatinine levels >1.5 mg/dL preoperatively. No statistical difference existed between serum creatinine comparing preoperative, postoperative, and on most recent follow-up. Body mass index (BMI) ranged from 20.2 to 49.9 (median, 29.1; mean, 26.6). Three (14%) patients were severely obese (BMI, 35 to 40), and one (5%) was morbidly obese (BMI >40). Bilateral synchronous tumors measuring 2.3 cm (right kidney) and 1.5cm (left kidney) were removed in 1 patient. Removal of the tumors was staged, with the larger lesion removed first, followed by the remaining lesion 2 months later.

Table 1.
Patient Characteristics and Intraoperative Variables

Patient	Sex	Age (years)	BMI*	Tumor Size (cm)	Operative Time (minutes)	EBL* (mL)	Hemostatic Methods Used	Complications	Mean Pain Score	LOS* (days)	Follow-up (months)
1	M	82	25.6	4	185	400	Argon beam, thrombin soaked Surgicel	none	2	4	32
2	M	47	29.6	4	160	200	Argon beam, thrombin soaked Surgicel	none	2	4	31
3	M	63	38.7	2.5	130	50	Argon beam, thrombin soaked Surgicel	2 unit PRBC's*	3	5	30
4	M	61	20.8	2.7	140	500	Argon beam, thrombin soaked Surgicel	none	3	3	28
5	M	87	28.7	3	140	50	Fibrin glue, argon beam, thrombin soaked Surgicel	none	0	2	23
6	M	74	37.2	2.3	165	100	Argon beam, thrombin soaked Surgicel	none	0	4	22
7	M	74	37.2	1.5	190	50	Argon beam, thrombin soaked Surgicel	none	2.5	3	20
8	M	58	38.6	2.5	210	100	Fibrin glue, argon beam, thrombin soaked Surgicel	none	2	2	19
9	F	65	20.2	3	170	50	TissueLink, Argon beam, thrombin soaked Surgicel	none	4.5	3	17
10	M	77	25.4	2	135	350	Fibrin glue, argon beam, thrombin soaked Surgicel	none	2.3	3	15
11	M	48	28.1	3	180	200	TissueLink, Argon beam, thrombin soaked Surgicel	none	5	3	13
12	F	60	27.4	3.4	220	400	Vessel clamp, Argon beam, fibrin glue	none	2.7	5	12
13	F	52	49.9	4	185	50	TissueLink, Argon beam, thrombin soaked Surgicel	none	2.5	3	12
14	M	68	25.5	1.5	180	300	Fibrin glue, argon beam, thrombin soaked Surgicel	none	2	3	12
15	M	60	23.5	2.5	140	400	TissueLink, Argon beam, thrombin soaked Surgicel	none	2	6	12
16	F	66	28.8	1.2	160	200	Fibrin glue, argon beam, thrombin soaked Surgicel	none	1.2	4	11
17	M	79	22.5	2	160	500	Argon beam, thrombin soaked Surgicel	2 unit PRBC's*	2.3	2	9
18	M	59	25.1	1.6	94	50	TissueLink, Argon beam, thrombin soaked Surgicel	none	4	2	9
19	F	78	23.6	1.2	120	50	Fibrin glue, argon beam, thrombin soaked Surgicel	none	1	3	7
20	M	58	27.8	3.5	195	200	TissueLink, Argon beam, thrombin soaked Surgicel	none	1.4	3	7
Mean		65.8	29.2	2.63	163	210.0			2.3	3.4	9.7
Median		65	27.40	2.50	160	200			2.3	3	7

*BMI=body mass index; EBL=estimated blood loss; LOS=length of stay; PRBC=packed red blood cells.

Tumors were approached transperitoneally in 20 and retroperitoneally in one. Hemostasis was achieved intraoperatively with at least 2 separate modalities. Thrombin soaked Surgicel and argon beam coagulation were used in all cases, with the TissueLink and fibrin glue added in the latter part of the series and represented the preference of the respective surgeon. Ischemia time was 40 minutes in the one case where the hilum was clamped and chilled saline was irrigated via a ureteral catheter. Preoperative, postoperative, and serum creatinine at 14-month fol-

low-up were 0.9 mg/dL, 0.9 mg/dL, and 1.0 mg/dL, respectively. The collecting system was not entered in this case.

Pathologic variables are presented in **Table 2**. Fourteen (67%) of the resected tumors were renal cell cancer, 2 (10%) were oncocytomas, and 4 (19%) were other diagnoses as listed. Most renal cell carcinomas were of low grade (I-II, 79%).

Margin status by frozen section was negative for all specimens. Margin status on final pathology was also negative. No intraoperative complications occurred. Two patients required blood transfusions (2 units) postoperatively. In both cases, only argon beam coagulation and thrombin soaked Surgicel were used for hemostasis. In the cases where another hemostatic aid was added (fibrin glue or TissueLink), no bleeding complications occurred. No

other complications occurred. Length of stay ranged from 2 days to 6 days (mean, 3.4; median, 3). The postoperative pain score was calculated as the average of the pain scores from postoperative day number one. The mean (median) average postoperative pain score was 2.2 (2.3) (range, 0 to 5). The majority of patients were discharged on postoperative day #2. Patient #12 had a longer length of stay to allow sequential removal of a ureteral stent, Foley catheter, and Jackson Pratt drain, with interval observation for potential urine leak, which did not occur. Patient #15 incurred a longer length of stay for medical reasons. Follow-up imaging available in 9 of the 14 patients with renal cell carcinoma (mean, 18 months; median, 21 months; range, 5 to 30) revealed no evidence of recurrence.

Data regarding time to convalescence, time until back to normal routine, and time to full recovery were not acquired.

DISCUSSION

Nephron-sparing surgery in the setting of a normal contralateral kidney is a well-established treatment modality for suspected renal cell cancer with proven safety and efficacy.[3] Fundamentals of nephron-sparing surgery include tissue removal under direct vision with adequate tumor-free margin and assessment of margin status intraoperatively. Use of novel techniques of hemostasis when performing laparoscopic partial nephrectomy have been described; vessel clamping to maintain a bloodless field although feasible, is technically difficult.[7] Hemostasis by coagulation can be achieved laparoscopically; however, the depth of coagulation cannot be predicted, and a risk exists of secondary bleeding due to necrosis of the coagulated surface area. Also, hypothermia via the laparoscopic approach, although feasible,[10] is a hurdle not yet overcome, limiting the acceptable ischemia time after which renal function may be significantly compromised.

The transperitoneal and retroperitoneal approaches to laparoscopic partial nephrectomy were first described by Winfield in 1993[6] and by Gill in 1994.[9] Careful patient selection for laparoscopic nephron-sparing surgery is mandatory for both safety and potential cure. All tumors in our series were exophytic and amenable to laparoscopic excision. A ureteral stent was not placed routinely because major disruption of the collecting system was not anticipated. No complications occurred related to urinary leakage or fistula formation. A retroperitoneal approach was chosen in one patient. This approach was selected in this case due to the posterior location of the renal tumor and past surgical history of abdominal surgery.

Table 2.
Pathologic Variables

Histology	Number (%)
Renal Cell Cancer	14 (70)
Clear Cell, TNM* Stage pT1NxMx	10 (50)
Histologic Grade†	
I	4
II	5
III	1
IV	0
Chromophobe, TNM* Stage pT1NxMx	2 (10)
Histologic Grade†	
III	1
IV	1
Papillary, TNM* Stage pT1NxMx	2 (10)
Histologic Grade†	
I	1
II	1
Oncocytoma	2 (10)
Other Diagnoses	4 (20)
Lymphoma	1
Cystic Nephroma	1
Leiomyoma	1
Benign parenchyma with cysts	1

*Tumor, node, metastasis staging as put forth by the American Joint Committee on Cancer.
†Based on Fuhrman grading system.

Our study included 3 patients with severe obesity and 1 with morbid obesity. Prior reports have demonstrated that the laparoscopic approach is more beneficial in obese patients, enabling a significant decrease in length of hospitalization, analgesic requirements, and decreased wound complications.[11]

Currently, no "standard" technique exists for laparoscopic partial nephrectomy. During the course of the study, the techniques used to achieve hemostasis evolved as experience was gained. The Harmonic scalpel has been shown to be inadequate when used alone to achieve adequate hemostasis for controlling renal parenchymal bleeding. It was used in dissection but not as a hemostatic tool in our study.[7,12]

Fibrin glue (Tisseel, Baxter Healthcare Corp., Irvine, CA) has been shown to be effective for both hemostasis in general and as a urinary tract sealant.[13] Its successful application for laparoscopic nephron-sparing surgery as a hemostatic aid has been reported.[6,14] No bleeding complications occurred with the use of fibrin glue in our series. Other means of hemostasis, as described, were used to develop a relatively dry field for the fibrin sealant to promote the final steps of the coagulation cascade. It is not effective for high-pressure bleeding, but will prevent oozing from renal parenchyma. The TissueLink Floating Ball (TissueLink Medical, Dover, NH) incorporates a water-cooled, high-density, monopolar current. Saline irrigates the floating ball to avoid excessive increase in tissue impedance to produce a more predictable pattern of coagulation than conventional monopolar current at greater depths of the parenchyma, reducing the risk of secondary bleeding from necrosis of the coagulation bed. Resection with this device is slower than resection with vascular control and has an associated learning curve that must be overcome to prevent inadequate treatment.[15]

The only complication encountered in this series was bleeding, requiring 2 units of packed, red blood cells postoperatively in 2 patients. This occurred in patients treated with only argon beam coagulation and thrombin-soaked Surgicel.

Pathologic examination revealed a majority of low-grade tumors and a significant amount of benign disease. Studies have shown that about 10% to 18% of small renal masses are benign.[4] Although intraoperative frozen section of the tumor has been proposed as a means to decrease the amount of benign lesions removed, the results to date are discouraging.[16] With the increased diagnosis of incidental renal masses, a minimally invasive approach is certainly of benefit given the substantial risk of over treating a benign lesion.

Minimally invasive ablative approaches include cryoablation, radiofrequency ablation, and high-intensity focused ultrasound. These can be done laparoscopically or percutaneoulsy. Histology, grade, and stage are important prognostic indicators for renal cell cancer. An important limitation of these techniques includes the lack of pathologic specimens to allow accurate histologic evaluation. While some advocates have biopsied these lesions preoperatively, needle biopsy of renal masses, even as performed at the time of surgical removal, has shown a high nondiagnostic rate and low specificity, and its routine use is not advocated.[17] With ablative procedures, the margin status is unknown. Long-term results are largely unknown. Successful outcomes have been defined as radiographic evidence of infarction, hemorrhage, reduction in size, or absence of growth on follow-up.[18] Gervais et al[19] used percutaneous radiofrequency ablation to treat 9 patients with CT or ultrasound guidance. Four required repeat treatment based on residual tumor on repeat imaging. The best modality to both target and monitor therapy and to follow-up treated lesions has yet to be established.[20] With these limitations for ablative procedures, the indications for their clinical application in the treatment of the incidentally found renal mass is yet to be defined.

CONCLUSION

Laparoscopic nephron-sparing surgery is feasible with a low complication rate and is emerging as a viable option in carefully selected patients. Benefits include shorter hospitalization, decreased analgesia requirements, and more rapid convalescence. Hilar control and renal surface hypothermia, while technically more demanding, will eventually increase the application of the laparoscopic approach to more tumors by allowing treatment of centrally located lesions. However, the current experience confirms the ability to perform laparoscopic nephron-sparing surgery for small, exophytic, peripherally located small tumors, with a high degree of technical success and low morbidity. If these lesions are exophytic and amenable to partial nephrectomy with minimal parenchymal entry, laparoscopic partial nephrectomy provides an attractive approach and should be considered before ablative approaches in those patients with appropriate surgical risks.

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