Clinical Urology

International Braz J Urol
Official Journal of the Brazilian Society of Urology

Vol. 28 (6): 504-509, November - December, 2002

LAPAROSCOPIC TOTAL AND PARTIAL NEPHRECTOMY

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ABSTRACT

Laparoscopic radical nephrectomy has established its role as a standard of care for the management of renal neoplasms. Long term follow-up has demonstrated laparoscopic radical nephrectomy has shorter patient hospitalization and effective cancer control, with no significant difference in survival compared with open radical nephrectomy. For renal masses less than 4cm, partial nephrectomy is indicated for patients with a solitary kidney or who demonstrate impairment of contralateral renal function. The major technical issue for success of laparoscopic partial nephrectomy is bleeding control and several techniques have been developed to achieve better hemostatic control.

Development of new laparoscopic techniques for partial nephrectomy can be divided into 2 categories: hilar control and warm ischemia vs. no hilar control. Development of a laparoscopic Satinsky clamp has achieved en bloc control of the renal hilum in order to allow cold knife excision of the mass, with laparoscopic repair of the collecting system, if needed. Combination of laparoscopic partial nephrectomy with ablative techniques has achieved successful excision of renal masses with adequate hemostasis without hilar clamping. Other techniques without hilar control have been investigated and included the use of a microwave tissue coagulator.

In conclusion, laparoscopic radical nephrectomy for renal cell carcinoma has clearly demonstrated low morbidity and equivalent cancer control. The rates for local recurrences and metastatic spread are low and actuarial survival high. Furthermore, laparoscopic partial nephrectomy has demonstrated to be technically feasible, with low morbidity. With short term outcomes demonstrating laparoscopic partial nephrectomy as an efficacious procedure, the role of laparoscopic partial nephrectomy should continue to increase.

Key words: kidney; nephrectomy; laparoscopy; hemostatic techniques
Int Braz J Urol. 2002; 28: 504-9

INTRODUCTION

Laparoscopic radical nephrectomy has established its role as a standard of care for the management of renal neoplasms. Long term follow-up has demonstrated laparoscopic radical nephrectomy has shorter patient hospitalization and effective cancer control with no significant difference in survival compared with open radical nephrectomy (1). For renal masses less than 4cm, partial nephrectomy is indicated for patients with a solitary kidney or who demonstrate impairment of contralateral renal function. Open partial nephrectomy has an overall local recurrence rate of 0-10% (2). The major technical issue for success of laparoscopic partial nephrectomy is bleeding control. Several techniques including radiofrequency pretreatment, laparoscopic hilar clamping with bulldog clamps or Satinsky clamp, argon beam coagulation, electrocautery, harmonic scalpel, fibrin glue, ultrasonic dissection, Surgicel™, Avitene™, fibrin-soaked Gelfoam™ activated by thrombin, pledget reinforced sutures, hydrojet dissec-

tion, microwave tissue coagulation, and cable ties have been developed to achieve better hemostatic control. Development of new laparoscopic techniques for partial nephrectomy can be divided into 2 categories: hilar control and warm ischemia vs. no hilar control.

TECHNIQUE

Preoperative workup includes abdominal computed tomography (CT) scan with intravenous contrast, in order to delineate anatomy. Staging workup further includes chest X-ray, electrolyte panel, CBC, and liver function tests. If the alkaline phosphatase is increased, a bone scan is necessary to assess metastatic disease. A renal scan determines percent function. If renal function is less than 10 percent, the patient is better served with radical nephrectomy.

A 5F ureteral catheter is cystoscopically placed at the beginning of the case, to allow retrograde injection after excision of the mass to determine if the collecting system has been violated. The ureteral catheter is tied to a 16F Foley catheter with a silk tie. A 60cc syringe with dilute indigo carmine is affixed to the ureteral catheter for subsequent retrograde injection.

Three trocars are used in a transperitoneal approach. After initial insufflation with a Veress needle, an 11mm trocar is placed under direct visualization using the Optiview trocar (Ethicon, Cincinati, Ohio). This trocar has a cutting element, which dissects through fascia under direct visualization to perform the pneumoperitoneum. The second 12mm trocar is placed lateral to the rectus in the midclavicular line, at the level of the umbilicus. The third 5mm trocar is placed halfway between xyphoid process and umbilicus. After incising along the line of Toldt, the colon is reflected medially. On the right, the lateral colonic peritoneal reflection is incised from the right common iliac artery up to the hepatic flexure. The anterolateral surface of the right kidney is often not entirely behind the ascending colon, and is usually covered by the lateral peritoneum. The right triangular and anterior coronary ligaments must be divided. The colorenal attachments must then be sharply divided to allow the ascending colon and hepatic flexure to be rolled medially. The duodenum is exposed and then mobilized medially, by means of the Kocher maneuver, until the vena cava is clearly visualized. On the left, mobilization must take place from the splenic flexure down to the level of the common iliacs.

Exophytic renal masses can often be localized by mobilizing the kidney within Gerota's fascia, being conscious to keep a layer of fascia over the mass (Figure-1). Laparoscopic ultrasonography can also aid in identifying the location of the renal mass. Detailed information about tumor size, tumor depth, extension into the parenchyma, distance from the adjacent calyx, and presence of satellite lesions can be determined from real time ultrasonography (Figure-2).
The radiofrequency probe, (RITA Medical systems, Mountain View, CA) is then percutaneously positioned within the mass, and deployed to coagulate a spherical area including both the lesion and a margin of normal parenchyma (margin). Settings for the radiofrequency probe for a 3cm lesion are temperature based, with a target temperature of 105 degrees Celsius, 90 watts, treatment time of 5.5 minutes, dual cycle. The energy is delivered at 90 W until the average of the 5 temperature gauges was greater than 105 degrees Celsius, and then autoregulated to maintain the temperature at this level for 5.5 minutes (per the manufacturer's recommendations). At the conclusion of the second cycle, the Harmonic scalpel (Ethicon, Cincinnati, OH) is used to excise the mass together with a 0.5cm margin of normal parenchyma (Figure-3). The lesion is placed in an Endocatch bag, and the parenchymal resection margin is biopsied (Figure-4). Argon beam coagulation is applied to the cut the surface. The argon beam is essential for hemostatic control. Argon is an inert gas that does not support combustion, and is rapidly cleared from the body. Retrograde injection of indigo carmine dye is performed to determine collecting system viability. If the collecting system has been entered, a CT-1 needle with 3-0 polyglactin is used to perform a running suture repair. Oxidized cellulose or fibrin glue can be placed over the resected base to help maintain hemostasis (Figure-5). Follow-up monitoring includes physical exam, serum creatinine, chest X-ray and abdominal CT scan at 6 months, and annually thereafter.

Figure 1 *- Exposure of the exophytic renal mass with preservation of Gerota's fascia over the mass.*

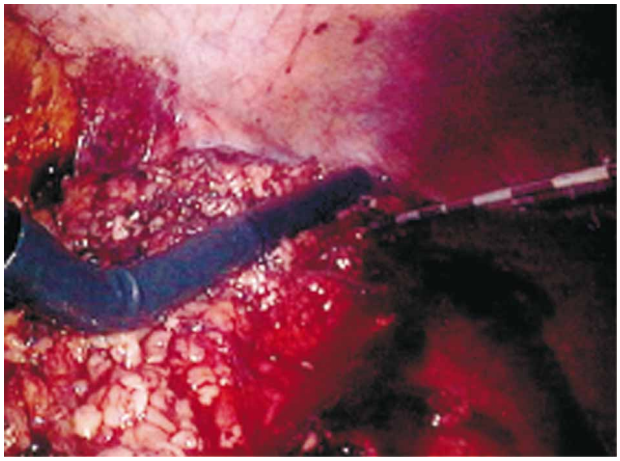

Figure 2 *- Laparoscopic ultrasound helps localize the renal mass, as well as determine tumor size, extension into the parenchyma and presence of satellite lesions.*

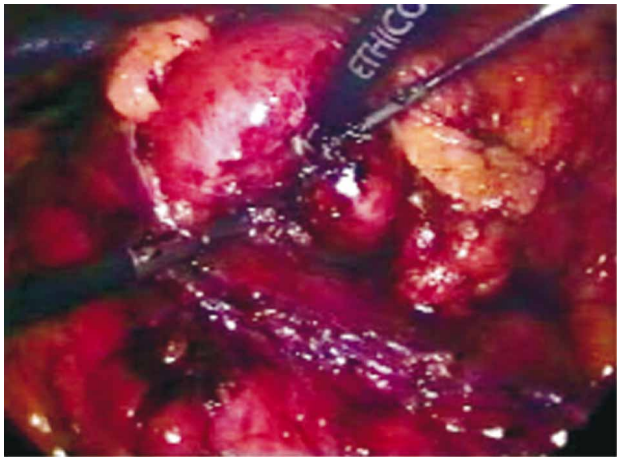

Figure 3 *- The Harmonic scalpel utilizes ultrasonic energy to coagulate as well as ligate vessels as it transects parenchyma.*

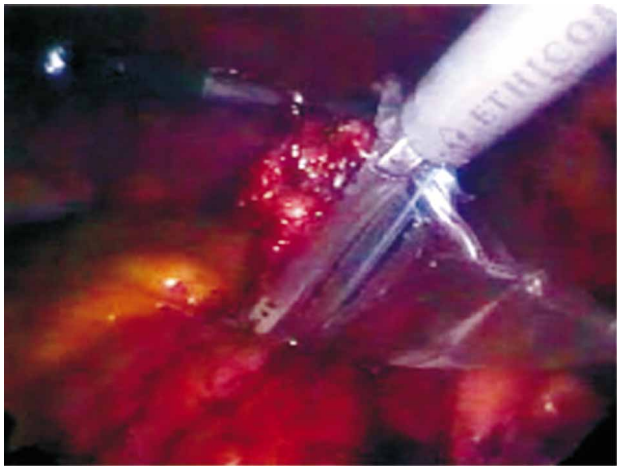

Figure 4 *- Retrieval of the excised mass. Frozen section is performed on the base of the mass to determine margin status.*

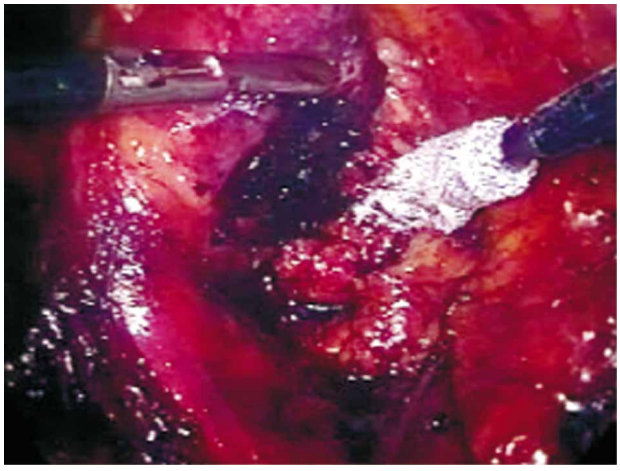

Figure 5 *- Surgicel, fibrin soaked gelfoam, or fibrin glue can be applied to the base of the mass for maintenance of hemostasis.*

Table 1 *- Intraoperative data of laparoscopic partial nephrectomy.*

Author	Number of Patients	OR Time	EBL Mean (range)	Warm Ischemia Time in Minutes
Gill et al., 2002	50	3.0 hrs	270.4cc (40-1,500)	23 min (9.8-40)
Gettman et al., 2002	10	2.8 hrs	125	
Winfield et al., 1993	1	6 hrs, 10 min	300	-
Yoshimura et al., 2001	6	3.1 hrs	Min	-
Janetschek et al., 2000	25	2.7 hrs	287	-
Rassweiler et al., 2000	53	3.2 hrs	725 (20-1500)	-

OR time = operative time; EBL = estimated blood loss

DISCUSSION

Laparoscopic partial nephrectomy was first reported in 1993 by Winfield et al. (3), in a patient with a lower pole calyceal diverticulum containing a calculus. Hemostasis was aided through use of a renal tourniquet cinched down around the lower pole of the kidney. Further application of this concept of parenchymal compression was investigated by Cadeddu et al. (4), with application of cable ties circumferentially to the kidney to aid in hemostasis. Reversible, regional hypoperfusion was achieved in the porcine model. However, in clinical evaluation of these modalities, adequate hemostasis has been unreliable with intermittent arterial bleeding from the cut edge of the kidney despite application of the tourniquet. If excessive force is applied, as the tourniquet is tightened, cutting, and subsequent fracture of the renal parenchyma occurs. Alternatively, if the tourniquet is too loose, significant hemorrhage can occur.

Laparoscopic partial nephrectomy continues to evolve along 2 therapeutic technical avenues: hilar clamping with ischemia vs. no hilar clamping. Development of a laparoscopic Satinsky clamp has achieved en bloc control of the renal hilum in order to allow cold knife excision of the mass, with laparoscopic repair of the collecting system if needed. Gill et al. (5) reported their experience with this technique in 50 patients, mean tumor size 3.0cm, with warm ischemia time of 23 $\pm$ 7.4 minutes (range 9.8-40 minutes). Caliceal entry was demonstrated in 18 patients, with immediate repair of the collecting system performed. Two patients required post operative transfusion, with a mean hospitalization stay of 2.2 days. Three complications were reported: intraoperative hemorrhage (n=1), delayed hemorrhage plus nephrectomy (n=1), urine leak (n=1). This technique is appealing with its goal of duplicating the open surgical technique. Renal function following this procedure was preserved, with 100% negative margins.

Combination of laparoscopic partial nephrectomy with ablative techniques has achieved successful excision of renal masses with adequate hemostasis without hilar clamping. In patients undergoing excision without hilar control, combination radiofrequency ablation with immediate excision of the mass has been reported in 10 patients. Mean tumor size was 2.1cm (range 1.0-3.2cm), mean operative time was 170 minutes and median blood loss was 125cc. No perioperative complications were reported, and a final diagnosis of renal cell carcinoma (n=9) and angiomyolipoma (n=1), with 100% negative margins, was reported. The benefit of hemostasis without hilar clamping decreases the risk of warm renal ischemia. Furthermore, excisional partial nephrectomy provides clear pathological analysis and confirmation of clear margins, and a better oncological approach over ablative techniques such as cryosurgery or radiofrequency ablation alone.Other techniques without hilar control have been investigated. Yoshimura et al. (6) reported use of a microwave tissue coagulator for laparoscopic partial nephrectomy without hilar clamping. In 6 patients with mean tumor size of 1.7cm, mean operating time was 186 minutes, blood loss was minimal. In this approach, multiple insertions of the probe, range 5-23

Table 2 *- Results.*

	Hospital Stay (range)	Complications (N cases or %)	Pathology (N cases)	Margins
Gill et al., 2002	2.2 days (1-9)	Total = 6% Intraoperative hemorrhage (n=1) Nephrectomy (n=1) Urine leak (n=1)	Renal cell carcinoma (n=34) Angiomyolipoma (n=8) Oncocytoma (n=5) Other (n=3)	100% negative
Gettman et al., 2002	—	Intraoperative hemorrhage (n=1)	Renal cell carcinoma (n =10)	100% negative
Rassweiler et al., 2000	5.4 days	Intraoperative hemorrhage (8%) Conversions (8%) Reintervention (12%)	Renal cell carcinoma (n=37) Angiomyolipoma (n=2) Oncocytoma (n=3) Multilocular cyst (n=7) Adenoma (n=3) Malignant lymphoma (n=1)	
Janetschek et al., 2000	5.8 days	Pneumothorax (n=1) Fistulae (n=2)	Renal cell carcinoma (n=19) Oncocytoma (n=1) Angiomyolipoma (n=1) Cysts (n=4).	
Winfield et al., 1993	7 days	None	—	—

coagulations, 5-8mm apart were conducted, prior to excision of the mass (Tables 1 and 2).

The benefits of laparoscopy for the kidney have clearly been demonstrated in terms of less pain, decreased convalescence, and decreased narcotic requirements. The benchmarks for long term success of both laparoscopic approaches for radical nephrectomy and partial nephrectomy will be defined by oncologic principles. Five year outcome data on actuarial disease free survival will assess the success of these procedures. Janetschek et al. (7) reported 13.3 month follow-up for laparoscopic radical nephrectomy and 22.2 month follow-up for wedge resection. One patient had distant metastases to the lung, a different patient demonstrated multilocular tumor 1 year postoperatively. There were no local recurrences reported. For laparoscopic radical nephrectomy, a multiinstitutional study of 157 patients reported an actuarial 5 year cancer free rate of 89% for clinical T2 and 100% for clinical T1 disease (8).

Chan et al. (1) recently reported a comparison of laparoscopic nephrectomy for renal cell carcinoma to open nephrectomy. At follow-up of 35.6 months vs. 44 months, respectively, no statistical dif-

ference was determined on Kaplan Meier actuarial survival analysis. Patients were matched for age and side, with mean tumor size 5.1cm (1-13cm). Clearly, the laparoscopic radical nephrectomy for T1/T2 lesions is equivalent to that of open surgery in both efficiency and efficacy.

Laparoscopic radical nephrectomy for renal cell carcinoma has clearly demonstrated low morbidity and equivalent cancer control. The rates for local recurrences and metastatic spread are low and actuarial survival high. Furthermore, laparoscopic partial nephrectomy has demonstrated to be technically feasible, with low morbidity. With short term outcomes demonstrating laparoscopic partial nephrectomy as an efficacious procedure, the role of laparoscopic partial nephrectomy should continue to increase.

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Received: May 20, 2002
Accepted: April 20, 2002

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