

COMPARISON OF LAPAROSCOPIC PARTIAL NEPHRECTOMY AND LAPAROSCOPIC CRYOABLATION FOR RENAL HILAR TUMORS

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ABSTRACT

Objectives. To compare laparoscopic partial nephrectomy (LPN) and laparoscopic cryoablation (LC) for the management of small renal tumors located near the renal hilum.

Methods. A retrospective chart review was performed on all patients who underwent LPN and LC. A total of 23 patients (12 LPN and 11 LC) had tumors located within 5 mm of the renal hilar vasculature. Patient data were retrospectively analyzed for specific parameters, including operative time, efficacy, morbidity, and postoperative course.

Results. All 23 cases were successfully completed laparoscopically. The mean operative time for LPN and LC was 2.8 hours and 2.3 hours, respectively ($P = 0.03$). The mean estimated blood loss was 197 mL for LPN and 70 mL for LC ($P < 0.01$). The analgesic requirement for those undergoing LPN and LC was 29 mg morphine equivalent and 23 mg morphine equivalent, respectively ($P = 0.41$). The hospital stay for patients in the LPN and LC groups was 3.9 days and 3.2 days respectively ($P = 0.55$). No intraoperative complications occurred in either group. Six patients experienced nine complications in the LPN group. The complications included hemorrhage in 1, fever in 1, ileus in 1, urinary tract infection in 1, urine leak in 4, and transient postoperative neuropathy in 1. The LC group had no postoperative complications. In the LC cohort, no disease recurrence developed during the 11.3 months of follow-up. No positive margins were found in the LPN cohort, and with a mean follow-up of 12 months, none have developed recurrence.

Conclusions. LPN for hilar tumors is a reasonable surgical option but carries an increased risk of urine leak. LC for hilar tumors has a shorter operative time and results in significantly fewer postoperative complications. Long-term follow-up data for both techniques remain unavailable. *UROLOGY* 67: 50–54, 2006. © 2006 Elsevier Inc.

Modeled after established surgical principles of open radical nephrectomy, laparoscopic radical nephrectomy is now an accepted standard of care for patients with Stage T1 tumors.¹ Laparoscopic radical nephrectomy has offered patients excellent oncologic efficacy, with the established benefits of a minimally invasive approach.² However, advances in nephron-sparing procedures, such as open and laparoscopic partial nephrectomy (LPN), have led to an evolution in the standard of care for small renal

masses. Open partial nephrectomy has become accepted for nonimperative indications and even for carefully selected tumors larger than 4 cm in diameter.³ Similarly, in the hands of very experienced laparoscopic urologists, LPN has emerged as an effective minimally invasive alternative for the management of small renal masses.⁴

In the continued evolution toward a minimally invasive approach for nephron-sparing surgery, ablative technologies such as laparoscopic cryoablation (LC) have recently been added to the urologist's alternatives for the treatment of small renal masses. Although long-term follow-up and greater experience with laparoscopic cryotherapy for small renal masses is required, renal cryoablation has been shown to be a feasible and safe treatment for patients with small renal masses in the short and intermediate term.⁵

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Technological advancements and increased surgical expertise have allowed minimally invasive treatment of larger and anatomically more complex renal tumors using laparoscopic nephron-sparing procedures.⁶⁻⁹ Small renal masses in close proximity to the hilar vasculature present a particularly difficult management challenge. Prior technical difficulties of collecting system reconstruction, hemostasis, and renal ischemia are being addressed by advanced urologic laparoscopists. Reisiger and colleagues¹⁰ recently reported the first application of LPN for complex hilar tumors within 5 mm of the renal vasculature. With the development of increasingly smaller cryoablation probes, cryoablation of centrally located renal tumors has become increasingly feasible.¹¹ We evaluated our experience with minimally invasive management of renal masses located within 5 mm of the renal vasculature, comparing LPN and LC.

MATERIAL AND METHODS

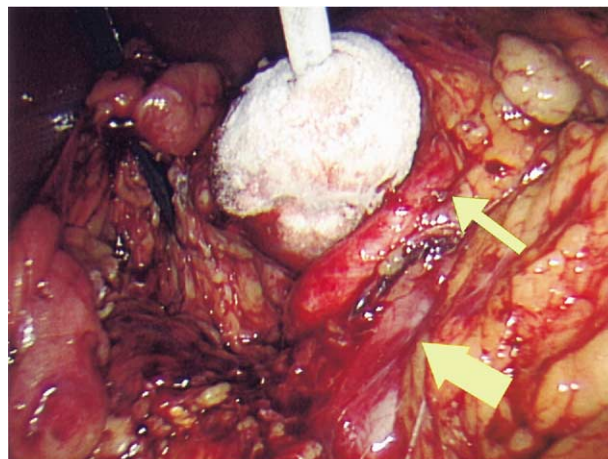
With the permission of the Washington University School of Medicine Human Studies Committee, we performed a retrospective chart review of all patients with hilar tumors who underwent LPN and LC for tumors located within 5 mm of the renal vasculature. The evaluated parameters included preoperative, operative, and follow-up data. Between July 2000 and December 2004, 136 patients underwent LPN, with 12 (8.8%) undergoing LPN for hilar tumors by four surgeons. During this same study period, 75 patients underwent LC, with 11 (14.6%) undergoing LC for hilar tumors by three surgeons.

The decision to perform LPN or LC was made by the individual surgeon after discussion and explanation of all available options with the patient. Each patient was offered all appropriate surgical approaches, including open and laparoscopic radical nephrectomy, open partial nephrectomy and LPN, and LC.

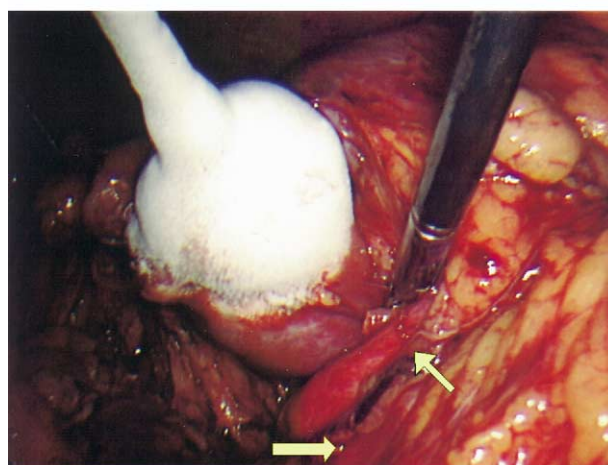
Both retroperitoneal and transperitoneal approaches were used for LPN (n = 3 and 9, respectively) and LC (n = 5 and 6, respectively). The optimal surgical approach was decided by each surgeon after consideration of the individual patient characteristics, such as previous abdominal surgery, anatomic location of the renal mass, and a previous history of peritonitis.

LPN was completed using a standard transperitoneal and retroperitoneal approach.¹² Because of the complex anatomic location of hilar tumors, a precise dissection of the renal hilum was performed in each case. After complete exposure of the renal vessels, the main renal artery was clamped in 11 (92%) of 12 patients. Because of the tumor location, in 4 patients, selective segmental artery and vein ligation was performed to ensure a negative tumor margin. Collecting system entry was apparent in 5 of the patients, and closure was completed with interrupted or figure-of-eight Vicryl sutures using an intracorporeal suturing technique.¹⁰

Early in the series, LC therapy was completed using a 3.4-mm cryoablation probe (Oncura, Plymouth Meeting, Pa) for single stick ablation (n = 6). Later, 1.47-mm cryoprobes (IceRod, Oncura) were used (n = 5). In all patients, extensive dissection of the renal hilum and tumor was performed. The renal artery and vein were maximally mobilized to optimize the distance between the renal mass and vascular structures and minimize the local thermal effects on surrounding tissues during cryoablation. *Figure 1A* demonstrates the dissected renal vasculature. *Figure 1B* shows renal vasculature mobili-



A



B

FIGURE 1. (A) Peripheral component of iceball making contact with inferior margin of renal artery during LC procedure. Large arrow indicates renal vein; smaller arrow indicates position of renal artery. (B) Renal artery with cephalic retraction away from iceball. Small arrow indicates renal artery; large arrow indicates renal vein.

zation and retraction to maximize the distance from the cryoprobe and iceball. Clamping of the renal vein or artery was not performed in any LC cases.

Tumor localization and targeting was accomplished in all 11 LC cases with the assistance of a flexible laparoscopic ultrasound probe (Aloka Dynaview II, Americanlab, Miami, Fla). Once the tumor was well characterized, a single 3.4-mm cryoprobe or one to three 1.47-mm cryoprobes were deployed under laparoscopic ultrasound guidance. A double-freeze cycle with an intervening active thaw was performed in all cases. Freezing was completed until the iceball was noted to extend beyond the tumor margin. For the tumor margin closest to the renal vasculature, the iceball was allowed to extend up to, and make contact with, the renal artery or vein. After the second freeze cycle, hemostasis was achieved by application of fibrin glue into the tract of the 3.4-mm cryoprobes (n = 6). Surgicel (Johnson & Johnson, Irvin, Calif) was placed on the renal surface, and gentle pressure was applied to help control bleeding when the 1.47-mm cryoprobes were used (n = 5). Postoperative contrast-enhanced computed tomography (CT) was obtained in all 11 patients. Contrast-enhanced CT scans

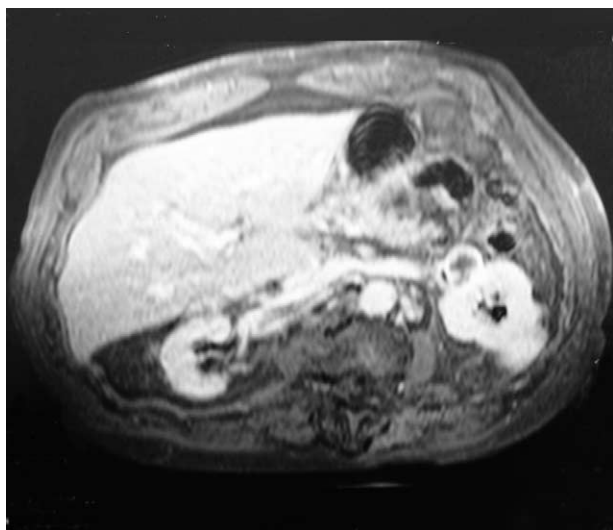


FIGURE 2. *Posterior hilar tumor.*

were performed on postoperative day 1, 3, 6, 9, and 12 months postoperatively, and annually thereafter to confirm complete tumor ablation. Complete tumor ablation was defined as a complete lack of enhancement of the ablated area. Figure 2 shows a representative preoperative CT image of a hilar tumor ablated using the 1.47-mm cryoprobes.

The operative time, intraoperative and postoperative complications, estimated blood loss, postoperative analgesic requirement, length of hospital stay, time to oral intake, and time to ambulation were all recorded. The LC and LPN data were statistically analyzed by a biostatistician (Y.Y.). Statistical Analysis Systems software was used to analyze the statistical differences between our two groups. This system uses a chi-square nonparametric comparison to identify statistical differences.

RESULTS

All 12 LPN and 11 LC cases were successfully completed without conversion to a hand-assisted or open approach. The mean operative time for LPN was 2.8 hours (range 2.5 to 3.5), and the mean estimated blood loss was 197 mL (range 30 to 700). Hilar vessels were exposed in all procedures, and hilar vascular clamping was performed during resection of 11 of 12 masses. The mean lesion size was 1.9 cm (range 0.9 to 2.7), and the mean warm ischemia time was 23 minutes (range 20 to 34). Tumor margins were negative in all cases. The mean distance to the hilar vessels was 2.45 mm (range 0 to 5). The mean minimal tumor margin (tumor margin closest to the edge of normal parenchyma) was 1.9 mm (range 1 to 3), with no positive margins on intraoperative frozen section analysis or final pathologic examination. The proximity of the renal vasculature in these selected hilar tumors necessitated the small margins. In the LPN cohort, no significant difference was found between the mean preoperative (0.9 mg/dL) and postoperative (1.1 mg/dL) serum creatinine ($P = 0.066$). The mean analgesic requirement was 29 mg morphine equivalent. The hospital stay for patients in the

LPN and LC groups was 3.9 days and 3.2 days respectively ($P = 0.55$).

During a mean follow-up of 11.3 months, no disease recurrence developed. However, several postoperative complications occurred. The most significant was postoperative urine leakage ($n = 4$). Other complications included hemorrhage in 1, fever in 1, ileus in 1, urinary tract infection in 1, and transient postoperative neuropathy in 1. The patient who experienced hemorrhage required a postoperative transfusion of 2 U packed red blood cells. One leak was resolved with observation and two others with temporary double-J stent decompression. The fourth patient developed an infected urinoma, despite double-J stent decompression and percutaneous drainage. This patient requested and underwent laparoscopic complete nephrectomy for persistent urine leak. The final pathologic examination for the LPN patients revealed two with grade 2–4 papillary renal cell carcinoma (RCC), five with grade 2–4 clear cell RCC, one with grade 3–4 clear cell RCC, and one with grade 4–4 clear cell RCC. One patient had an oncocytoma and two had a benign cyst.

The mean operative time for LC was 2.3 hours (range 1.5 to 3.2), and the mean estimated blood loss was 70 mL (range 10 to 250). The mean lesion size was 2.4 cm (range 1.0 to 3.2). The mean distance to the hilar vessels was 1.81 mm (range 0 to 5). Needle biopsy was performed intraoperatively in all 11 cases. The histopathologic findings of the needle biopsies revealed grade 2–4 papillary RCC in 4 patients. One patient had an oncocytoma and six had indeterminate results on biopsy. With a mean follow-up of 12 months, no disease recurrence has developed, as documented by enhancement in the area of cryoablation on follow-up CT.

All LC patients resumed oral intake and ambulated within 24 hours after surgery. The mean analgesic requirement was 23 mg morphine equivalent (range 0 to 66.67). The mean hospital stay was 3.2 days (range 2 to 5), and patients returned to full activity within 3 weeks. No significant difference was found between the mean preoperative (0.9 mg/dL) and postoperative (1.0 mg/dL) serum creatinine ($P = 0.43$). No intraoperative or postoperative complications occurred in the LC cohort.

COMMENT

The current, relatively large, series of 23 cases of hilar renal masses represents 11% of renal masses treated by a minimally invasive approach at Washington University during this study period. In contrast, Brown and colleagues¹³ reported on 8 patients with centrally located tumors, representing 27% of cases in their experience. The relatively low percentage of hilar renal masses treated in the cur-

rent series represents our early patient selection, which did not include hilar renal masses. Given the technically challenging nature of hilar LPN, considerable laparoscopic expertise is essential to minimize the ischemic time. After hilar control, expeditious and precise tumor resection, collecting system closure, and parenchymal reconstruction are essential to preserving renal function. A bloodless field, achieved by clamping of the renal pedicle, is absolutely essential to achieve these surgical objectives successfully.¹⁰

LC in the setting of hilar tumors is somewhat less technically demanding, but continues to have challenges. For successful cryoablation, the iceball must extend beyond the tumor margin. Ideally, this distance includes a full 1 cm in every direction to allow for the "indeterminate zone" (area on the periphery of the iceball with potentially viable cells) and for a margin of normal tissue. Viable tissue is most often observed at the periphery of the iceball.¹⁴ Clearly, a 1-cm margin cannot be achieved with hilar tumors. In these cases, surgeons using LC have optimized the distance between the tumor and renal vasculature by performing an extensive opercular (region around the hilum) dissection. Commonly, the hilar dissection includes mobilization of the segmental arteries to optimize exposure and ablation. The iceball is then allowed to extend up to, and make contact with, the renal artery or vein when necessary (Fig. 1). As the most peripheral portion of the iceball is at a nonablative temperature (0°C), the vasculature is not traumatized. As anticipated, no damage to the renal hilum resulted in any of our cases.

A theoretical concern with cryoablation near the hilar vasculature is the heat sink effect of these large vessels. This has previously been viewed as a contraindication for cryoablation of such lesions. However, as with all our cryoablation procedures, we used laparoscopic ultrasonography to ensure that the iceball (hypoechoic area on ultrasonography) extended completely over the renal lesions, with a margin around each mass. Despite this theoretical concern, we have seen excellent short-term results without any evidence of recurrence as defined by enhancement on postoperative contrast-enhanced axial scans (CT or magnetic resonance imaging).

For the LPN group, our postoperative complication rate was greater than that seen with peripheral partial nephrectomy. Finelli and Gill¹⁵ found that the postoperative complication rate was 14% for 100 patients undergoing LPN. In our series, four (50%) of the complications were self-limiting (ileus, fever, neuropathy, and small urinoma). The most common complication encountered was postoperative urine leakage, which occurred in all four of the patients whose collecting systems were entered during surgery. Four (33%) of 12 patients experienced this complication. In a recent series of

open partial nephrectomy for centrally located tumors, Black and coworkers¹⁶ reported a 27% urinary fistula rate. Similarly, Hafez and colleagues¹⁷ reported a urinary fistula rate of 14% after open partial nephrectomy for centrally located hilar tumors in the Cleveland Clinic experience. It should be noted that our definition of urine leak was very strict, with any patient having an elevated drain output (with elevated drain creatinine) 48 hours after surgery considered to have a urine leak. Urine leakage was addressed with a double-J stent and Foley catheter placement. It is feasible that some of these leaks might have resolved without intervention.

Later in this series, we used preoperative pigtail catheter placement with retrograde saline injection during the procedure to delineate better any collecting system violation.⁹ This technique modification has allowed us to identify and close defects in the collecting system better and prevented any additional urine leaks in the series. In contrast, no intraoperative or postoperative complications occurred in the LC cohort.

The average patient age for the LPN and LC groups was 52 and 68 years, respectively ($P = 0.02$). Younger patients were generally selected for LPN, because the technique has a longer follow-up experience and younger patients were believed to have a greater tolerance for potential adverse events. As anticipated, patients in the LPN cohort manifested fewer comorbidities.

Patients in both groups experienced an expeditious convalescence characteristic of a laparoscopic approach. Both LPN and LC patients demonstrated short-term oncologic efficacy with negative margins on final histopathologic examination for the LPN group and no short-term radiographic evidence of enhancement for the LC group. However, continued active surveillance of all patients is in progress. Long-term follow-up data are still needed.

CONCLUSIONS

With adequate laparoscopic experience, LPN for hilar tumors is a reasonable surgical option but carries an increased risk of urine leak. Preoperative placement of a ureteral catheter to optimize identification and precise closure of defects in the renal collecting system reduced the incidence of urine leakage in our series.

We present evidence of the short-term efficacy of cryotherapy for hilar tumors, and believe that LC should be considered as a treatment option in selected patients. Renal cryoablation for hilar tumors had a shorter operative time and resulted in significantly fewer postoperative complications. During a short follow-up period, LC demonstrated good oncologic efficacy. Long-term follow-up data for both modalities are still lacking as applied to hilar tumors.

REFERENCES

1. Novick AC: Laparoscopic and partial nephrectomy. *Clin Cancer Res* 10: 6322S–6327S, 2004.
2. Portis AJ, Yan Y, Landman J, *et al*: Long-term followup after laparoscopic radical nephrectomy. *J Urol* 167: 1257–1262, 2002.
3. Russo P, Goetzl M, Simmons R, *et al*: Partial nephrectomy: the rationale for expanding the indications. *Ann Surg Oncol* 9: 680–687, 2002.
4. Gill IS, Matin SF, Desai MM, *et al*: Comparative analysis of laparoscopic versus open partial nephrectomy for renal tumors in 200 patients. *J Urol* 170: 64–68, 2003.
5. Moon TD, Lee FT, Hedican SP, *et al*: Laparoscopic cryoablation under sonographic guidance for the treatment of small renal tumors. *J Endourol* 18: 436–440, 2004.
6. Novick AC: Nephron-sparing surgery for renal cell carcinoma. *Annu Rev Med* 53: 393–407, 2002.
7. Mabweesh NJ, Avidor Y, and Matzkin H: Emerging nephron sparing treatments for kidney tumors: a continuum of modalities from energy ablation to laparoscopic partial nephrectomy. *J Urol* 171: 553–560, 2004.
8. Bernardo NO, and Gill IS: Laparoscopic partial nephrectomy: current status. *Arch Esp Urol* 55: 868–880, 2002.
9. Finelli A, and Gill IS: Laparoscopic partial nephrectomy: contemporary technique and results. *Urol Oncol* 22: 139–144, 2004.
10. Reisinger K, Venkatesh R, Figenschau RS, *et al*: Complex laparoscopic partial nephrectomy for renal hilar tumors. *Urology* 65: 888–891, 2005.
11. Ames CD, Vanlangendonck R, Venkatesh R, *et al*: Enhanced renal parenchymal cryoablation with novel 17-gauge probes. *Urology* 64: 173–175, 2004.
12. Kane CJ, Mitchell JA, Meng MV, *et al*: Laparoscopic partial nephrectomy with temporary arterial occlusion: description of technique and renal functional outcomes. *Urology* 63: 241–246, 2004.
13. Brown JA, Hubosky SG, Gomella LG, *et al*: Hand assisted laparoscopic partial nephrectomy for peripheral and central lesions: a review of 30 consecutive cases. *J Urol* 171: 1443–1446, 2004.
14. Hoffmann NE, and Bischof JC: The cryobiology of cryosurgical injury. *Urology* 60: 40–49, 2002.
15. Finelli A, and Gill IS: Laparoscopic partial nephrectomy: contemporary technique and results. *Urol Oncol* 22: 139–144, 2004.
16. Black P, Filipas D, Fitchner J, *et al*: Nephron sparing surgery for central renal tumors: experience with 33 cases. *J Urol* 163: 737–743, 2000.
17. Hafez KS, Novick AC, and Butler BP: Management of small solitary unilateral renal cell carcinomas: impact of central versus peripheral tumor location. *J Urol* 159: 1156–1159, 1998.