Partial nephrectomy without hilar control or cooling: longitudinal data over 5 years

Anthony T. Corcoran, MD, Matthew H. Hayn, MD, Erin P. Gibbons, MD, Ryan Mori, MD, Ronald Hrebinko, MD, Benjamin J. Davies, MD
Department of Urology, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania, USA

CORCORAN AT, HAYN MH, GIBBONS EP, MORI R, HREBINKO R, DAVIES BJ. Partial nephrectomy without hilar control or cooling: longitudinal data over 5 years. The Canadian Journal of Urology. 2009;16(5):4820-4825.

Introduction: *Partial nephrectomy for the management of small renal masses has become a well accepted technique. Contemporary series have shown its safety and efficacy in well selected patients. We present our experience of partial nephrectomies exclusively without hilar control or parenchymal cooling stratified into imperative and elective patients.*

Methods: *We retrospectively reviewed our experience in 124 patients who underwent partial nephrectomy between December 1995 and September 2003. Patients were followed with regular radiographic and laboratory studies at 6 months postsurgery and then annually. Renal function was followed by serum creatinine.*

Results: *Of the 124 patients, 105 were performed without hilar control or renal cooling and met our criteria for analysis. The operation was elective in 78 patients (74%) and imperative in 27 patients (26%). Mean specimen size was 2.8 cm for elective cases and 3.3 cm for imperative cases. The mean estimated blood loss was 606 ± 533 cc and 950 ± 656 cc in elective and imperative cases respectively. Surgical margins were positive in 6.6% with an overall recurrence rate of 3.8%. At a mean follow up time of 31 months and 23 months in the elective and imperative groups respectively, there were no statistically significant differences between baseline and follow up serum creatinine levels in either elective or imperative cases at time intervals of 0-12, 13-24, 25-48 and > 48 months. The intraoperative complication rate was 5.7% and the postoperative complication rate was 4.7% including three patients requiring blood transfusions.*

Conclusion: *Partial nephrectomy without hilar control or renal cooling is a safe and reliable method of removing small renal tumors. In this cohort, intraoperative blood loss is slightly higher than historical series. However, blood transfusion rates, complications, renal function and oncologic outcomes are comparable to historical series of patients in whom vascular control and renal cooling are used.*

Key Words: partial nephrectomy, nephron sparing surgery, hilar control, parenchymal cooling, manual compression

Introduction

Partial nephrectomy has become a well-accepted modality for the management of small renal masses in patients with both imperative (bilateral tumors, solitary or atrophic contralateral kidney, chronic renal insufficiency, contralateral kidney is threatened by other medical condition)[1] and elective indications. Previous reports evaluating the long term follow up of imperative or elective partial nephrectomies have described the use of hilar clamping and/or parenchymal cooling. To our knowledge, this is the first report presenting long term follow up for partial nephrectomies performed exclusively without hilar control or cooling for both imperative and elective patients.

Accepted for publication June 2009

Address correspondence to Dr. Anthony T. Corcoran, Department of Urology, University of Pittsburgh School of Medicine, 3471 5th Avenue, Suite 700 Kaufmann Bldg., Pittsburgh, PA 15213 USA

Patients and methods

From July 1996 to September 2003, 124 patients consecutively underwent open partial nephrectomy for suspected renal cell carcinoma by a single surgeon. Of these, 105 were performed without hilar clamping or renal parenchymal cooling. All patients had adequate follow up (minimum of 3 months) to assess postoperative outcomes including complications, recurrence rates, change in hematocrit and creatinine from baseline. The patients included in our analysis were sorted into two categories as either imperative (n = 27) or elective (n = 78) partial nephrectomies. Our definition of imperative partial nephrectomy included patients with bilateral tumors, a solitary or atrophic contralateral kidney, inheritable tumor syndromes or chronic renal insufficiency due to comorbid medical condition.

All patients underwent preoperative evaluation including abdominal CT, chest radiograph, and renal and electrolyte laboratories. Estimated blood loss was compiled from dictated operative reports or anesthesia records. Tumor size and pathology was obtained from final pathology reports.

Complications were defined as postoperative events requiring procedural or surgical intervention, or readmission to the hospital. Patients listed as having urinary fistulas had persistent drain output and required ureteral stenting. To evaluate for acute renal insufficiency, serum creatinine was routinely checked on postoperative day 1 and at time of discharge. We defined an elevation from a baseline serum creatinine of 50% or greater as acute renal insufficiency. Furthermore, acute tubular necrosis was based on the findings of tubular or granular casts in a urine analysis. Postoperatively, patients were followed with CT scans and serum creatinine at 6 months and then annually. Data for postoperative creatinine, complications, and recurrence was obtained by reviewing clinic and hospital medical records.

The surgical technique for each partial nephrectomy included exposure and examination of the entire kidney surface followed by excision of the identified tumor with a 0.5 cm margin of normal parenchyma and the overlying perinephric fat. Dissection and clamping of the renal hilum or cooling of the renal parenchyma was not performed in any of the cases. Manual compression was used to control bleeding during excision of the tumor. Hemostasis within the defect was acquired using a variety of methods including argon beam coagulation, suture ligation of visible vessels, hemoclips, and tissue sealants (Tisseel, fibrin glue). We did not administer mannitol or furosemide during the procedure since the renal vasculature was not manipulated.

The two tailed unpaired t-test was used to test for differences among groups with continuous variables, with a $p < 0.05$ considered statistically significant. The two sided Fisher's exact test was used to test for differences between groups with categorical variables.

Results

Open partial nephrectomy without hilar clamping or parenchymal cooling was performed in 105 patients with a mean follow up of 31 and 29 months for elective and imperative cases respectively. Patient characteristics and results are summarized in Table 1. The mean age at time of surgery for the elective and imperative groups was 60 and 63 years (range 26-79 and 41-82 respectively). Our series includes 52 men and 26 women in the elective arm and 15 men and 12 women in the imperative arm. Partial nephrectomy was elective in 78 patients (74%) with a mean tumor size of 2.8 cm. Of these tumors, 12 (15%) had benign pathology and of the remaining 66 tumors, 60 (91%) were stage T1a, three (4%) were stage T1b, one (2%) was stage T2, and two (3%) were stage T3. Indications for partial nephrectomy were imperative in 27 patients (26%) with a mean tumor size of 3.3 cm. RCC accounted for 24 of the 27 tumors (89%) and of these 13 were stage T1a (54%), six (25%) were stage T1b, three (13%) were stage T2 and one (4%) was T3. Tumor growth pattern was exophytic or polar in 46 (60%) and eight (30%) versus central or deep in 22 (28%) and 15 (56%) in the elective and imperative groups respectively ($p = 0.004$). The mean estimated blood loss was 606 ± 533 cc and 950 ± 656 cc in elective and imperative cases respectively. The difference in EBL between the elective and imperative cases was determined to be statistically significant with a $p = 0.01$.

Intraoperative complications were limited to blood transfusion which was required in three patients each (6/105, 5.7%) in the imperative and elective group for blood loss greater than 2000 cc. The postoperative complication rate was 4.7% (4% for elective case and 7% for imperative cases). Postoperative blood transfusions were required in three patients for postoperative bleeding. All of these patients were in the elective group with a mean tumor size of 2.6 cm (range 1.5 cm-4.5 cm). Our overall transfusion rate was 8.6%. Urinary fistulas were identified in two patients. Both patients were in the imperative group and were treated within 4 days of their operation

TABLE 1. **Patient characteristics**

	Elective (n = 78)	**Imperative (n = 27)**	**p value**
Age (yrs.) ± SD	61 ± 14	63 ± 14	0.01
Sex (M:F)	52:23	15:12	NS
EBL (cc) ± SD	606 ± 533 median 400 range (50-3000)	950 ± 656 median 800 range (100-2900)	0.01
Blood transfusion	6 (8%)	3 (11%)	NS
Location (R:L:BL)	44:31:3	13:14: 0	NS
Tumor size (cm) ± SD	2.8 ± 1.3	3.3 ± 3.9	NS
Tumor growth pattern			
Exophytic or polar	47 (60%)	8 (30%)	0.004
Central or deep	22 (28%)	15 (56%)	0.004
Unknown	9 (12%)	4 (15%)	NS
Pathology			
Clear cell RCC (%)	44 (56%)	14 (52%)	NS
Papillary RCC (%)	12 (15%)	7 (26%)	NS
Oncocytic RCC (%)	7 (9%)	2 (7%)	NS
Chromophobe RCC (%)	3 (4%)	1 (4%)	NS
Benign disease (%)	12 (15%)	3 (11%)	NS
Baseline creatinine (mg/dl)	0.98 ± 0.18	1.82 ± 1.45	< .0001
Complications (%)	3 (4%)	2 (7%)	NS
Urinary fistula	0	2 (7%)	NS
Perinephric bleeding	3 (4%)	0	NS
Acute renal failure	0	0	NS
Avg. follow up (months)	31	29	NS
Avg. CR follow up (months) ± SD	31 ± 39	23 ± 26	NS
Positive surgical margin	5%	11%	NS
Recurrence (%)	1 (1.3%)	3 (11%)	NS
Local recurrence (%)	0	0	NS
Metastasis (%)	1 (1.3%)	3 (11%)	NS

with retrograde ureteral stenting. At 1 month follow up, both patients had their ureteral stents removed and were without any further complications. There were no reported cases of acute renal insufficiency in the immediate postoperative period. Additionally, no patients required readmission for acute renal insufficiency or dialysis.

The overall positive surgical margin rate was 6.6% (5% in elective and 11% in imperative cases) with an overall recurrence rate of 3.8% (1.3% in elective and 11% in imperative cases). Differences in positive surgical margin and recurrence rate between elective and imperative groups were not statistically significant. Kaplan-Meyer analysis of postoperative metastatic recurrence is presented in Figure 1.

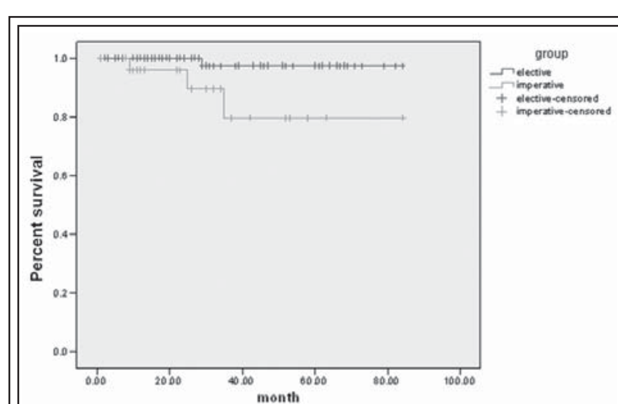

Figure 1. Metastatic free survival.

TABLE 2. **Baseline and follow up creatinine**

Time to follow up (months)	Baseline Cr (mg/dl)	Follow up Cr (mg/dl)	p value
Elective cases (n = 78)			
1-12 months (n = 78)	0.98 ± 0.18	0.98 ± 0.24	NS
13-24 months (n = 34)	0.93 ± 0.17	1.04 ± 0.2	NS
25-48 months (n = 31)	0.91 ± 0.17	1.02 ± 0.2	NS
> 48 months (n = 25)	0.96 ± 0.16	1.02 ± 0.23	NS
Imperative cases (n = 27)			
1-12 months (n = 27)	1.96 ± 1.15	2.0 ± 1.83	NS
13-24 months (n = 14)	2.09 ± 1.36	2.31 ± 2.19	NS
25-48 months (n = 14)	2.1 ± 1.34	2.31 ± 2.19	NS
> 48 months (n = 6)	1.58 ± 0.93	1.51 ± 0.65	NS

The mean preoperative serum creatinine was 0.98 ± 0.18 (median 0.9, range 0.7 to 1.7) mg/dl and 1.81 ± 1.45 (median 1.4, range 0.8 to 5.0) mg/dl in elective and imperative cases, respectively ($p = <0.0001$). The mean follow up (months) for postoperative creatinine was 31 for elective cases and 23 for imperative cases. Within the imperative cases, three patients progressed to end stage renal failure and required hemodialysis. The mean preoperative creatinine in these three patients was 4.3 mg/dl (range 4.0 to 5.0 mg/dl). Two of the patients had previously undergone orthotopic heart transplants. The third patient had a history of bilateral RCC and had a partial nephrectomy of the contralateral kidney 2 years prior.

Table 2 details the preoperative and follow up serum creatinine for elective and imperative cases at 0-12, 13-24, 25-48 and > 48 months. There was no statistical significance between baseline and follow up serum creatinine in either elective or imperative cases for any of these time periods.

Discussion

Partial nephrectomy is well established for the treatment of small renal masses. Formally implemented only in patients with imperative indications, partial nephrectomy is now used in patients with a normal contralateral kidney.[2,3] We present our data for long term follow up in patients undergoing nephron sparing surgery in both elective and imperative cases. Our series differs from previous reports in that our operative technique does not include hilar clamping and/or parenchymal cooling, but utilizes manual parenchymal compression during closure of the tumor defect. We have specifically analyzed patient outcomes in terms of surgical complications, tumor recurrence and long term renal function.

Contemporary partial nephrectomy series report estimated blood loss ranging from 376 cc to 555 cc for lesions less than 4 cm, postoperative bleeding ranging from 1%-5%, and transfusion rates as high as 30%.[3-8] A cohort of seven patients undergoing open partial nephrectomy for exclusively exophytic or polar tumors with selective parenchymal clamping yielded a mean EBL of 485 with a 15% transfusion rate. Similarly, reports on laparoscopic partial nephrectomy with "on demand" hilar clamping describe a 79% clamping, 20% transfusion and 5% conversion rates.[9] Our estimated blood loss was 606 ± 533 cc for elective and 950 ± 656 cc for imperative indications with an overall transfusion rate of 8.6%. We believe the increase in blood loss in the imperative cohort to be a result of the significantly higher percentage of central tumors in that group. However, we report low rates of postoperative bleeding (3%) in both elective and imperative cases, occurring all in the elective cohort. All such bleeding was managed with transfusions and no patient required surgical exploration. Some recommend hilar clamping to decrease blood loss and improve visibility as a means to decrease positive margin rates.[10] However, consistent with contemporary series, we report a positive surgical margin rate of 5% and 11% in the elective and imperative cohorts with no significant difference between groups.[11,12]

Urinary fistula, the most common postoperative complication of partial nephrectomy, has also been reported as an early complication of partial nephrectomy at a rate of 2% to 17%.[1,3-5,7] Urinary fistulas accounted for two complications in our series. Both urinary fistulas occurred in imperative cases and were managed with the placement of a ureteral stent. In a retrospective analysis, urinary fistulas occurred in 5.5% of imperative partial nephrectomies. The majority of these patients were treated with percutaneous drainage of the urinoma while only 1.1% were treated with ureteral stenting.[5] In our series, ureteral stenting was not used as a treatment after percutaneous drainage but rather as the primary treatment.

Patients were followed for an average of at least 2 years for recurrence of their renal cell carcinoma. The overall recurrence rate was 3.8%, all metastatic without any local recurrence. Other contemporary series have reported local recurrence rates of 9%-10% with mean follow up time from 3 to 10 years.[2-4] In one series, 29 patients who met criteria for elective partial nephrectomy, were followed for an average of 10 years and reported to have a cancer specific survival of 100%.[2] We report one elective case with a single metastasis to the lung. In this patient, the lung nodule was noted on chest radiographs from several years prior but did not begin to grow in size until after the initial surgery. It is possible that in this case the lung metastasis does not represent a new recurrence and was present at the time of initial presentation. In the imperative group, metastatic recurrence was 11%. However, 30% of patients in this group (2/3 with metastatic recurrence) had a history of contralateral radical nephrectomy for RCC and may represent a metastasis from a prior tumor. This in combination with the small cohort size may account for the increased metastatic rate compared to the elective group.

The mean follow up time for renal function was 31 and 23 months in elective and imperative cases respectively. Renal function was preserved in all 78 patients in the elective cases. In the imperative cases, three patients progressed to end stage renal disease and required hemodialysis. Of these patients, two had previously undergone orthotopic cardiac transplants and had preoperative serum creatinine ranging from 4.0 mg/dl to 5.0 mg/dl. The third patient had bilateral tumors and a preoperative serum creatinine of 4.0 mg/dl. In each case, the patients did not progress to hemodialysis until 1 year after their partial nephrectomy.

Our experience is similar to those previously described in patients with imperative indications for partial nephrectomy.[2,3,13] In a 10 year follow up, 93% of patients had sufficient renal function with a mean follow up of 10 years.[2] Additionally, of the patients who progressed to end stage renal disease, most had preexisting renal disease. In a 2 year follow up series examining imperative cases, the serum creatinine increased from 1.4 mg/dl to 1.8 mg/dl.[13] In our series, there was no statistically significance difference between baseline and follow up creatinine levels in over 48 months of surveillance at any time point. All patients had at least one measure of creatinine between 1 and 12 months postoperatively. We observed no significant change in the follow up creatinine in elective and imperative cases. In elective cases, mean follow up creatinine was 1.02 at > 48 months (25/78; 32% patients with creatinine levels). In the imperative cases with a follow up of 25-48 months, the change in serum creatinine was 0.21 mg/dl with > 50% of patients present at that follow up interval.

Previously, much of the data on warm ischemia time due to hilar clamping was derived from animal studies, showing complete recovery of renal function with 30 minutes of ischemia.[14] However, in recent years, as laparoscopic partial nephrectomy has become an alternative to open partial,[15,16] interest has been directed at the long term renal function as it relates to warm ischemia time. Recently, it has been shown that long term renal function is not adversely affected by a warm ischemia time up to 55 minutes.[17] Of note, the authors did advise that care must be taken during the procedure because theoretically there is a time limit at which warm ischemia does become relevant. In this study, we do not try to compare our series of open partial nephrectomies without hilar clamping to lapraroscopic partial nephrectomies with hilar clamping. However, both techniques do appear to provide long term preservation of renal function. Our technique does allow for added time for hemostasis and closure of the collecting system, if necessary, without the concern of prolonged hilar clamping.

We acknowledge the limitations inherent to all retrospective studies such as possible selection bias. We have attempted to minimize selection bias by reporting on consecutive cases. In our consecutive series, we were unable to compare patients that underwent partial nephrectomy without hilar clamping and parenchymal cooling to a cohort that received hilar clamping and parenchymal cooling due to the small sample size of the latter and low frequency of outcome events such as renal failure, local recurrence and positive surgical margins. Studies of prospective randomized nature are needed to enhance the validity of our results.

Partial nephrectomy is the preferred treatment of small renal tumors. In patients with compromised renal function, bilateral disease, or a solitary kidney, partial nephrectomy provides a low incidence of complications and recurrences while preserving renal function. For patients undergoing elective partial nephrectomy, the procedure should be curative and provide a low incidence of complications and maintain normal renal function. We believe our technique of partial nephrectomy without hilar clamping and/

or parenchymal cooling is an acceptable, safe and effective method of nephron sparing surgery for both elective and imperative indications.

Conclusion

Partial nephrectomy without hilar control or renal cooling is a safe and reliable method of removing small renal tumors. In this cohort, intraoperative blood loss is slightly higher than historical series. However, blood transfusion rates, complications, renal function and oncologic outcomes are comparable to historical series of patients in whom vascular control and renal cooling are used. □

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