Comparison of laparoscopic versus robotic assisted partial nephrectomy: one surgeon's initial experience

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Introduction/objective: *Partial nephrectomy is an effective surgical treatment for small renal masses. We compare a single surgeon's experience with consecutive laparoscopic and robotic partial nephrectomy to assess potential perioperative outcomes. A review of the literature is provided.*

Materials and methods: *A retrospective review was performed comparing 15 consecutive patients undergoing laparoscopic partial nephrectomy to the subsequent consecutive 13 patients undergoing robotic assisted partial nephrectomy for small renal tumors. All patients had normal contralateral kidney appearance on cross sectional imaging. A similar transperitoneal technique was employed for both cohorts. A 4-arm technique was used for the robotic cases using the da Vinci (Intuitive Surgical, Sunnyvale, USA) surgical system. Patient demographics, tumor characteristics, intraoperative, and postoperative data including tumor size, warm ischemia time, and estimated blood loss (EBL) were compared using Student t-test, Wilcoxon rank-sum, or Chi square test as appropriate.*

Results: *All cases were completed laparoscopically or with robotic assistance without conversion to open surgery. Demographic data were not statistically different between the two groups. Warm ischemia time (WIT) was shorter in the robotic group: 29.7 minutes versus 39.9 minutes for the laparoscopic group ($p < 0.0001$). Operative time was longer in the robotic group: 253 versus 352 minutes ($p < 0.0001$). Mean hospital stay and postoperative complication rates were not statistically different. Two (13%) of patients in the laparoscopic group required conversion of partial nephrectomy to radical nephrectomy while none did in the robotic group. Final pathology revealed negative margins in all cases.*

Conclusions: *Robotic partial nephrectomy resulted in decreased WIT as compared to the conventional laparoscopic approach. Total operating time was increased in the robotic group.*

Key Words: partial nephrectomy, laparoscopy, warm ischemia, robotic

Introduction

The frequent use of radiographic imaging for the evaluation of abdominal complaints has led to an increase in the detection of small asymptomatic renal tumors. Consequently, various treatment options have evolved for the management of small renal tumors including active surveillance, ablative therapy, and partial nephrectomy. Nephron sparing surgery (NSS) has become an acceptable standard for the treatment of select renal tumors.[1-3] Partial nephrectomy may be accomplished with open surgery, a laparoscopic approach, or with robotic assistance. Challenges to the minimally invasive approach are primarily related to the need for hemostasis during resection leading to potential concerns with warm ischemia

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time (WIT) and hemostatic control. Comparison of the robotic approach to the laparoscopic approach for partial nephrectomy has yielded mixed results in the literature regarding the advantage of one technique over the other.[4-8]

In this study, we sought to determine any advantages of robotic assisted over laparoscopic partial nephrectomy in the hands of a fellowship trained surgeon. We present our data comparing 15 consecutive laparoscopic with 13 consecutive robotic assisted partial nephrectomies performed by the same surgeon.

Methods and materials

Twenty-eight consecutive patients underwent laparoscopic or robotic assisted partial nephrectomy by the same surgeon over a 3 year interval and were evaluated in retrospective fashion. IRB institutional approval was obtained. All patients were evaluated by computed tomography and found to have a small (< 5cm), solitary enhancing renal mass suspicious for carcinoma. There was no evidence of metastatic disease at the time of surgery. The transperitoneal approach was employed in all patients. Tissue specimens were processed in a standard fashion and the 1997 TNM system was used for pathologic assessment. Patient demographic and perioperative data were collected. In all patients, demographic data including age, gender, height and weight were recorded for comparison. Intraoperative data including EBL, WIT, and total operative time were recorded. Postoperative data including length of hospital stay and follow up were recorded. Patients were followed up at 6 weeks with physical exam and blood work, and at 6 months with cross sectional imaging.

Data were compared between groups using the Student t-test, the Wilcoxon rank-sum test, or Chi square test where appropriate to determine statistical significance.

Robotic assisted technique

Nine of 13 patients underwent cystoscopy with insertion of open ended ureteral catheter placement up to the level of the renal pelvis. The patient was repositioned in a 45 degree modified flank position. Pneumoperitoneum was established. Trocars were then placed in a standard fashion, employing a 4-arm robotic technique, with two assistant trocars. A total of seven trocars were used for right sided procedures compared to six trocars for left sided procedures. The da Vinci robot was docked and used for the remainder of the procedure. After identification of the ureter, the renal artery and vein were dissected to allow for renal vascular bull dog placement. Intraoperative ultrasound was performed by the assistant at the bedside to measure tumor size and location and to aid in identification of margins around the mass. Lasix and mannitol were administered. Bull dog clamps were placed on the renal artery and vein for hilar control. The tumor was then excised in a bloodless field. Following excision, any entry into the collecting system was closed with 2-0 Vicryl (Ethicon, Cincinnati, USA) suture. Hemostasis was obtained with 0-Vicryl parenchymal sutures prefabricated with hem-o-lock clips and Lapra-Ty (Ethicon, Cincinnati, USA). These were tied in mattress fashion with Floseal on the defect with or without Surgicel (Ethicon, Cincinnati, USA) bolster at the discretion of the surgeon. The renal hilum was unclamped. The specimen was placed in an EndoCatch (Coviden, Mansfield, MA, USA) bag and removed through extension of a trocar site.

Pure laparoscopic technique

Identical steps were employed as with robotic technique noted above with few exceptions. All 15 patients had insertion of ureteral catheters. Five trocars were used for the left side tumors and six trocars for the right side tumors. Renal hilar dissection was only performed to allow placement of Satinsky Clamp en-bloc. Bull dog vascular clamps were not used for the standard laparoscopic procedures.

Results

Fifteen consecutive patients underwent laparoscopic partial nephrectomy followed by 13 consecutive patients who underwent robotic assisted partial nephrectomy by the same surgeon. All procedures were completed in a minimally invasive fashion without conversion to laparoscopy (for the robotic group) or open surgery. Preoperative demographic data were compared and no statistically significant differences were noted for age, body mass index (BMI), sex, ASA class or tumor size, Table 1. In addition, there was no statistically significant difference between groups with respect to EBL. WIT was found to be significantly longer in the laparoscopic group: 39.9 minutes versus 29.7 minutes in the robotic assisted group ($p = 0.00006$). Total time in the operating room was longer in the robotic group: 344 versus 254 minutes ($p < 0.0001$). Mean postoperative hospital stay was not statistically different between the two groups, Table 1. Median follow up for the robotic group was 6.3 months (range 1-17); for the laparoscopic group 9 months (range 4-14). At last follow up no patients had cancer recurrence on cross sectional imaging. One patient in the laparoscopic group died 1 year after surgery as a result of pneumonia.

TABLE 1. **Patient demographic data and perioperative data**

Parameter	Laparoscopic	Robotic	p-value
n	15	13	
Patient gender			
Male	8	8	0.661
Female	7	5	
Patient age (yrs-mean)	53.6	59.7	0.299
ASA class (median)	2.3	2.3	
Tumor size (cm-mean)	2.8	2.6	0.594
Tumor side			
Right	8	7	0.978
Left	7	6	
Number malignant	9 (60%)	13 (100%)	0.01*
BMI	26.6	28.9	0.20
EBL (mL-median)	150	100	0.628
WIT (min-mean)	39.9 (range 24-51)	29.7 (range 21-45)	0.00006*
Operative time (min-mean)	254	344	0.00002*
Median post discharge (days-median)	2	2	0.76
Case converted to radical nephrectomy	2	0	-

values represent means unless otherwise noted
*statistically significant

Two patients (13%) in the laparoscopic group required conversion of partial nephrectomy to radical nephrectomy due to continued bleeding after hilar unclamping (intraoperative complication). In both cases, the warm ischemia time was greater than 50 minutes at the time of unclamping. There were no intraoperative complications in the robotic group. Postoperative complications in the robotic group included: readmission for congestive heart failure which resolved after diuresis, urinary tract infection requiring outpatient antibiotics, and readmission for postoperative bleeding. The patient with postoperative bleeding was a 47-year-old male who noted acute abdominal pain after moving pool furniture and cleaning supplies at home 5 days after surgery. He was treated with bed rest and blood transfusion and did not require further intervention. Postoperative complications for the laparoscopic group included: COPD exacerbation requiring readmission and one patient with urinary tract infection treated with outpatient antibiotics. Final pathology revealed 9 of the 15 patients in the laparoscopic group had malignant tumors: 8 clear cell carcinoma and 1 papillary renal cell carcinoma. The remaining 6 were oncocytoma (3), leiomyoma (1), angiomyolipoma (1), and cystic nephroma (1). In the robotic assisted group, all 13 patients were found to have renal cell carcinoma.

Discussion

Although open partial nephrectomy remains a standard for comparison, published data has demonstrated that laparoscopic partial nephrectomy is an acceptable alternative in experienced hands.[9,10] Studies have favorably compared open and laparoscopic partial nephrectomy for a variety of tumors including hilar or intraparenchymal locations, multiple tumors, and tumor in solitary kidney.[11] The main challenge with laparoscopic partial nephrectomy remains operating "under-the-gun" of warm ischemia secondary to renal hilar clamping. Advances in robotic assisted surgery have provided surgeons with a viable option to pure laparoscopy, the robotic assisted partial nephrectomy.[3] To date, including our study, over 300 cases of robotic assisted laparoscopic partial nephrectomy have been reported. All institutions thus far have been from the United States. The articulating wrist-like action using the da Vinci robot "endo-wrist" and three dimensional visualization would offer potential advantages that may be of benefit during a partial nephrectomy. In particular, tumor excision and intracorporeal suture repair may be facilitated. Ease of tumor excision and suture repair may translate into shorter WIT and less issues with bleeding after unclamping. However, the perceived potential benefits of robotic assisted partial nephrectomy over pure laparoscopy have not been consistently demonstrated in the literature.[4-8]

In the first published experience in 2004 (n = 13), Gettman et al, found that robotic assisted partial nephrectomy was a feasible alternative to traditional

TABLE 2. **RPN series to date***

First Author	RPN (n)	LPN (n)	Mean OR time (min)	Mean WIT (min)	EBL (mL)	Positive margins (%)	Malignant (%)	LOS (days range)	Complications intraop (%)	Complications postop (%)
Gettman[3]	13	0	215	22	170	8	77	4.3 (2-7)	0	16
Comment on manuscript: First reported series of RPN										
Caruso[6]	10	10	279 v 253	26.4 v 29.3	240 v 200	0 v 10	80 v 50	2.6 v 2.5	20 v 10	10 v 10
Comment on manuscript: RPN did not confer any advantages over standard laparoscopy										
Kaul[15]	10	0	155	21	92	0	80	9 of 10 ≤ 48h (1-21)	0	30
Rogers[12]	8	0	192	32	230	NA	63	2.6	NA	NA
Comment on manuscript: Authors reported feasibility of RPN for 8 complex renal masses										
Aaron[4]	12	12	242 v 256	23 v 22	329 v 300	0	83 v 83	4.7 v 4.4	17 v 0	8 v 0
Comment on manuscript: Increased WIT noted for the RPN group compared to standard laparoscopy										
Deane[7]	10	11	228 v 289	32.1 v 35.3	115 v 198	0	100 v 55	**2 v 3.1**	0	10 v 9
Comment on manuscript: Similar results between two groups; authors conclude a potential decreased learning curve for RPN										
Wang[8]	40	62	**140 v 156**	**19 v 25**	136 v 173	2.5 v 1.6	62 v 60	**2.5 v 2.9**	0	15 v 15
Comment on manuscript: Better overall results for the RPN as compared to standard laparoscopy										
Michli[16]	20	0	142	28	263	0	70	**2.8**	5	25
Comment on manuscript: Surgeon's initial experience demonstrating feasibility										
Benway[5]	129	118	189 v 174	**19.7 v 28.4**	**155 v 196**	3.9 v 0.8	67 v 75	**2.4 v 2.7**	1.6 v 4.5	8.5 v 10.2
Comment on manuscript: Results favor RPN over standard laparoscopy. Study may include duplicate patients from reference[8,12,13]										
Present study	12	15	**352 v 253**	**29.9 v 39.9**	100 v 150	0	100 v 60	3 v 3	0 v 13	23 v 13
Comment on manuscript: RPN decreases WIT but increase total operating time										

*Studies published with same data set more than once omitted except for study by Benway et al.
[1]All comparative studies (shaded boxes) are robotic v laparoscopic
RPN = robotic partial nephrectomy; LPN = laparoscopic partial nephrectomy; WIT = warm ischemia time; EBL = estimated blood loss; LOS = length of stay; NA = not applicable; NS = not significant
Bold = statistically significant difference

laparoscopy.[3] A subsequent study by Stifelman compared 10 laparoscopic to 10 robotic assisted partial nephrectomies, Table 2. The authors concluded that although safe, robotic assisted partial nephrectomy offered no advantage over traditional laparoscopy.[6] In fact they noted that the removal of the primary surgeon from the bedside necessitating an experienced assistant could be problematic. In contrast, Rogers et al, concluded that robotic assistance could be advantageous for renal hilar tumors, and demonstrated that robotic assisted partial nephrectomy could be both safe and effective in eight patients judged to have complex renal masses.[12] Aron et al from Cleveland Clinic compared 12 matched robotic and laparoscopic partial nephrectomy cases at a single high volume center. Although the robotic partial nephrectomy was feasible, the authors concluded that the warm ischemic time was significantly increased in the robotic group (21 minutes) as compared to the laparoscopic group (14 minutes).[4] More recently, Deane et al, compared 11 patients who underwent laparoscopic partial nephrectomy by two experienced laparoscopic surgeons to 10 patients who underwent robotic partial nephrectomy by one surgeon with no prior minimally invasive partial nephrectomy experience. Mean warm ischemia times were 35 and 32 minutes respectively ($p = 0.501$). The authors concluded that given the relative similarity in outcomes between the groups, the robot may help decrease the learning curve in the minimally naïve surgeon population.[7]

Benway et al, recently published the largest series to date, compiling a retrospective review of three surgeon's experience at three institutions over a 4 year period.[5] The data includes patients already published in other manuscripts[8,12,13] with an update of their most recent experience. In this pooled study, the authors compared 129 robotic partial nephrectomies with 118 laparoscopic procedures performed by the same surgeons. Of note, they found that hospital stay was significantly shorter in the robotic group, 2.4 versus 2.7 days, as well as WIT (19.7 minutes versus 28.4 minutes respectively), Table 2. The clinical significance of a 0.3-day hospital discharge is debatable; however the reduction in warm ischemic time is significant. Estimated blood loss was also less in the robotic group, however neither the postoperative hematocrit nor transfusion requirement were different. These surgeons also experimented with slightly different techniques, specifically with clamping; initially hilar clamping was left to the assistant however control was eventually given over to the console surgeon. This is particularly advantageous as it obviates the need for a highly trained assistant.

In 2007, given our robust experience with robotic prostatectomy and pyeloplasty, and the perceived potential advantages of the robotic system, we transitioned to robotic assisted partial nephrectomy. Contrary to the manuscripts from Gill[4] and Stifelman,[6] we noted two significant advantages in the robotic cohort. First, warm ischemia time was significantly decreased with the robotic group (29.7 minutes) as compared with the laparoscopic group (39.9 minutes). We believe this decreased warm ischemia time may be related to the simplified excision and suturing afforded by the robot. Second, the suturing made possible by robotic assistance may have led to improved hemostasis. With both cohorts, we employed nearly identical operative techniques including conventional renal hilar unclamping after suture reconstruction. However, in the laparoscopic group, two cases were converted to laparoscopic radical nephrectomy, given continued bleeding after unclamping with extended warm ischemia time of over 50 minutes. Our findings are in line with the more recent comparative publications on this topic.[5,8] Long term renal function was preserved in both groups.

Given these results, any patient recommended to undergo laparoscopic partial nephrectomy would generally be eligible for the robotic assisted technique. Likely more complex tumors that would previously have been amenable only for open excision will now be considered for robotic assisted excision.

Several potential disadvantages of the robotic application were delineated in our study. A perceived disadvantage of the robotic assisted partial nephrectomy was increased total operative time (344 versus 254 minutes, p value < 0.0001). Operating time may likely be shortened with continued surgeon experience. However, it may also be related to the different technique used to dissect the renal hilum for robotic surgery as compared to the laparoscopic approach. With the robotic cohort it was necessary to completely dissect the renal hilum for the application of bull dog clamps as opposed to minimal hilar dissection afforded with en-bloc Satinsky application with the laparoscopic group. Although no direct cost analysis was performed, previous work has demonstrated that laparoscopy is relatively less expensive as compared to the robotic approach.[11] Whether the extra cost is justified for decreased WIT is a matter of future debate.

Unlike many of the prior publications discussed, a confounding variable of multiple surgeons in this comparison was minimized as the same surgeon performed all surgeries. In addition, nearly identical surgical techniques were carried out for each group by the same surgeon. As with any retrospective non-randomized report, there are several potential shortcomings. Surgeries were completed in a consecutive fashion and therefore the potential for a learning curve exists, which may partly account for the decreased warm ischemia times in the robotic assisted group. Such a curve is not demonstrable within the 13 cases performed in this series, and we recognize that although improved, the WIT remains longer when compared with comparable series. We have not yet incorporated the early unclamping technique described by Nguyen and Gill which would significantly decrease our overall WIT.[14] The senior author had however, participated in over 65 laparoscopic partial nephrectomies during his fellowship which may offset the concerns of learning curve. From an oncologic standpoint, all 28 patients had negative surgical margins and did not require additional surgical procedures.

Conclusion

Our data suggest that robotic assisted partial nephrectomy is a feasible alternative to the laparoscopic approach for selected patients with shorter warm ischemia times as compared to conventional laparoscopic surgery. Possible hindrances towards acceptance of RPN may include increased operative time and potential for increased cost. □

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