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CURRENT STATUS OF NEPHRON-SPARING ROBOTIC PARTIAL NEPHRECTOMY

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Abstract

Purpose of review: Partial nephrectomy has become the standard of treatment for renal tumors less than 4 cm in size. Recent reports have even applied this technique for T1b lesions as well. With advancement in minimally invasive techniques, laparoscopic and robotic surgeries are performed with the advantage of decreased morbidity while maintaining the same oncologic principles as open surgery.

Recent Findings: Feasibility studies confirmed that robotic partial nephrectomy can be performed safely. Short-term outcomes are similar to laparoscopic and open partial nephrectomy. Complex renal tumors, such as hilar and endophytic lesions, have also been performed robotically.

Summary: Robotic partial nephrectomy is feasible with comparable short-term results to open and laparoscopic surgery. With challenges of pure laparoscopic surgery, robotic assistance may provide more opportunities for minimally invasive nephron sparing surgery.

Keywords

partial nephrectomy; robotic; laparoscopic surgery

Introduction

With the widespread use of modern imaging, there is an increased detection of asymptomatic, small renal tumors in the United States [1]. Renal cell carcinoma accounts for up to 83% of all T1a renal masses [2]. Open nephron sparing surgery has shown comparable oncologic outcome for the treatment of T1a tumors compared to radical nephrectomy [3]. Nephron sparing surgery has been shown to reduce the risk for chronic renal insufficiency in patients with renal tumors [4]. This is important when treating patients with renal cell carcinoma since the link between chronic kidney disease and cardiovascular morbidity is well documented [5]. Advancement in minimally invasive techniques has resulted in the

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benefit of improved postoperative convalescence while following principles of open surgery [6]. Laparoscopic partial nephrectomy (LPN) is the standard of care for the treatment of small renal tumors at many academic institutions [7]. However, reconstructive laparoscopic surgery, such as partial nephrectomy, is technically challenging with a steep learning curve. Some believe that laparoscopic radical nephrectomy is technically less demanding and being offered over partial nephrectomy for the management of small renal tumors [8]. Data now show an underutilization of laparoscopic partial nephrectomy for the treatment of T1a renal lesions [9]. There has been a wide adaptation of robotic-assisted laparoscopic surgery. It has enabled surgeons with little or no laparoscopic experience to perform difficult operations, such as laparoscopic radical prostatectomy. Robotic-assisted partial nephrectomy (RPN) has emerged to be an alternative to traditional LPN for the novice laparoscopic urologists providing a mechanical advantage to this reconstructive operation. In addition, RPN has been utilized by experienced laparoscopic surgeons to perform more challenging cases.

Surgical technique

RPN can be performed in both trans-peritoneal and retroperitoneal fashion. Performing partial nephrectomy for complex lesion (endophytic, hilar), cystoscopy and ureteral catheter placement can be performed to aid in the repairing of collecting system after tumor excision. When performing trans-peritoneal RPN, the patient is placed in modified or true flank position and a pneumoperitoneum of 15 mm Hg is established [Figure 1]. Port configuration is based on the triangulation principle of laparoscopy and usually modified based on the number of robotic arm used, model of robot, surgeon's preference and patient's anatomy [port placement figure 2][10]. For docking, the robot is brought in posteriorly at approximately 20° angle toward the head of the patient. When performing retroperitoneal RPN, the patient is positioned in true flank position. Pneumoperitoneum and port placement is established as previously reported [11]. The robot is positioned at the head of the patient and docked as shown in figure 4. The assistant surgeon is positioned at the patient's side with the following responsibilities: changing the robotic arm instruments, assisting via the assistant port for retraction and suction, passage of sutures and hemostatic material, and placing of vascular clamps.

RPN can be performed via a hybrid technique: surgeon performs the initial dissection laparoscopically and uses robotic-assistance only for tumor excision and renal reconstruction. We prefer to perform the entire operation robotically. Intraoperative laparoscopic ultrasound can facilitate the identification of tumor and the planning of the resection margin. In addition, it can also help with identification of vascular anatomy. Tumor excision can be performed with or without renal hilar clamping at the surgeon's discretion. For the ischemic technique, laparoscopic bulldog clamps can be used to selectively occlude the renal artery and/or renal vein. En bloc hilar clamping can be performed using laparoscopic Statinsky clamp. Robotic scissors are used to excise the tumor in an athermic fashion. This can help the pathologist in their determination of margin status. Frozen section evaluation of the tumor bed is performed at the surgeon's discretion.

Hemostasis is achieved via a combination of hemostatic agents and suturing. Entry of collection system can be assessed using methylene blue administered in retrograde fashion

via ureteral catheter. The collecting system is repaired with absorbable sutures. A combination of hemostatic agents, such as FloSeal™ and oxycellulose bolsters, is placed in the renal defect prior to parenchymal reconstruction. After confirmed hemostasis, Gerota's fascia is approximated over the defect and a drain is placed in the perirenal space. The tumor is removed via laparoscopic retrieval bag through the 12 mm port site with extension if needed.

Initial experience

The first feasibility study on RPN was the Mayo clinic experience published in 2004 [12]. Thirteen highly-selected patients with small exophytic renal tumors (average tumor size was 3.5 cm) underwent RPN. Transperitoneal approach was performed in all but 2 patients whom underwent retroperitoneal approach due to posterior location of their renal tumors. Renal cooling was utilized via intra-arterial catheter in 8 patients. Mean operative time was 215 minutes with estimated blood loss (EBL) of 175 mL. Mean warm ischemia time (WIT) was 22 minutes and mean cold ischemia time was 33 minutes.

One patient experienced a positive margin despite negative intraoperative biopsy on frozen section analysis. The authors concluded RPN was feasible but recommended using this technique only for small, exophytic renal lesions. With additional experience, they envisioned utilizing RPN for larger tumors.

In 2006, ten patients who underwent RPN were compared with matched LPN patients with mean tumor size of 2 cm [13]. There was no difference in EBL, WIT, hospital stay or change of creatinine between the 2 groups. Two cases of RPN were converted to open and hand-assisted approach due to hilar bleeding and poor visualization. The authors concluded that there was no benefit of RPN over LPN and did not recommend routine use of robotic-assistance.

Complex tumors

With enhanced visibility and reconstructive ability from the pilot experience, RPN was applied to the management of complex renal tumors. The goal was to provide patients with minimally invasive nephron sparing surgery whom otherwise would have undergone laparoscopic radical nephrectomy or open partial nephrectomy. Our series included robotic-assisted resection of 14 tumors with complex features such as endophytic, hilar and multiplicity. Mean operative time was 182 minutes with WIT of 31 minutes. EBL was 230 mL, and no patient experienced positive margin, complication or change in estimated glomerular filtration rate (GFR) at 3 month follow-up [10].

RPN for hilar tumors was analyzed in a series of 11 patients from 2 institutions. Average tumor size of 3.8 cm with mean operative time and WIT of 202 and 28.9 minutes. No positive margin or significant increase in estimated GFR was experienced. Urinary leak was found in 2 patients and managed with ureteral stent placement [14]. There were no conversions to open surgery or radical nephrectomy. Both series concluded that RPN is feasible in selected patients with these challenging renal tumors.

Multi-institutional review

The largest series of initial experience with RPN included 148 patients from 6 institutions [15]. In these selected patients with small exophytic masses (average tumor size of 2.8 cm), surgery was performed by experienced laparoscopic urologists with mean operative time of 197 minutes and WIT of 27.8 minutes. EBL was 183 mL with a positive margin and complication rate of 4 and 6%. Numerous studies have been published and are summarized in Table 1. All reached the conclusion of enhanced ability during renal reconstruction with emphasis on patient selection and team approach in robotic surgery.

Robotic versus Laparoscopic partial nephrectomy

It is difficult to compare pure laparoscopic and robotic-assisted LPN without any randomized, prospective study with long term follow-up. Cleveland clinic published a retrospective, case-matched comparison study of their 12 RPN versus 12 LPN patients. With average tumor size of 2.7cm, there was not a statistically significant difference in perioperative outcome: WIT, EBL, renal functions at 3 month postoperatively. When applying their “early unclamp” technique in 6 patients, RPN was associated with an increased WIT of 14 vs. 21 minutes [19]. Another case-matched series of more than 100 patients observed a benefit of RPN over LPN: shorter operative time (140 vs. 156 minutes), WIT (19 vs. 25 minutes), and length of hospital stay (2.5 vs. 2.9 days) [20]. In both papers, experienced laparoscopic surgeons agreed that RPN is feasible with caveats. First, the primary surgeon lost the control of hilar clamping which becomes the role of the assistant in RPN. Hence the procedure required a second experienced surgeon to perform safely. Secondly, RPN was associated with increased cost that might not be justifiable with minimal improvement of perioperative outcome. Third, half of the case-matched patients had benign pathology. Prospective study of cancer patients with long term follow-up is required to answer the question of oncologic efficacy and superiority between the two procedures.

Recently, we reviewed our 40 most recent LPN versus our initial 40 RPN in the treatment of complex (endophytic and hilar) renal tumors [21]. 36 complex RPN cases and 33 complex LPN cases were identified. With an average tumor size of 2.7cm, there was not a difference in WIT, EBL, operative time, complication rate and change of renal function. When performing nephron sparing surgery for such challenging lesions, our initial RPN experience was able to achieve outcomes comparable to our most mature LPN series.

Future Directions

Laparoscopic single port surgery has a potential for further improvement of postoperative outcome and cosmesis by limiting the number of incisions. However, the ideal platform for this procedure has not been identified. With articulating instruments and improved ergonomics, robotic-assisted single port surgery has shown promising results in the early study [22]. Robotic-assisted single port pyeloplasty, radical and partial nephrectomy have been completed without complication. The experience of robotic single port surgery provided background for the natural orifice transluminal procedure. In animal model, transvaginal robotic renal surgeries have already been performed [23]. As technology

continues to advance, robotic assistance has the hope of simplifying these surgical techniques.

Conclusion

For T1a and select T1b renal lesions, the goal is to avoid radical nephrectomy and perform nephron sparing surgery. Despite the adaption of laparoscopic renal surgery, partial nephrectomy is still underutilized. Multiple institutions have now reported their experience with RPN and have shown this technique to be safe and feasible. RPN has become an alternative for surgeons with limited laparoscopic experience, allowing them the opportunity to offer minimally invasive nephron sparing surgery. Based on our experience, RPN is our first choice for treating patients with complex renal tumors.

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Figure 1.
Patient position for right robotic partial nephrectomy.

Figure 2.

Port site placement for left transperitoneal robotic partial nephrectomy.

A: robotic instrument ports

B: assistant ports

C: periumbilical camera port

Previously published in European urology [10]

Rogers CG, Singh A, Blatt AM, et al. Robotic partial nephrectomy for complex renal tumors: surgical technique. *Euro Urol* 2008;53,514–23.

Figure 3.
Port site placement for left retroperitoneal robotic partial nephrectomy.
A: assistant port
C: balloon tip camera port
R: robotic instrument ports

Table 1:

Published series of initial robotic partial nephrectomy experience

Authors	No. RPN	No. LPN	Tumour size (cm)	OT	WIT	EBL	Compl no. (%)	Pos margins	Hospital stay
Patel <i>et al.</i> [8*] <4 cm	56	–	2.1	238	20.0	100	5 (8.9)	3	2.0
Patel <i>et al.</i> [8*] >4 cm	15		5.0	275	25.0	100	4 (26.7)		2.0
Boris <i>et al.</i> [9*]	10	-	Multiple tumours	257	29.6	360.0	1 (10)	NN	4.0
Lee <i>et al.</i> [10*]	9	-	Nononco	275	N/A	49	0 (0)	N/A	2.9
Rogers <i>et al.</i> [16]	24		N/A	255	N/A	N/A			
White <i>et al.</i> [18]	8	-	2.4	167	0.0	569	2 (25)	0	3.75
Michli and Parra [22]	20	-	2.7	142	28.0	263	3 (15)	0	2.8
Scoll <i>et al.</i> [23]	98	-	2.8	203	25.5	127	14 (14.3)	5	NN
Wang and Bhayani [24]	40	62	2.5	140	19.0	136	8 (20)	1	2.5
Jeong <i>et al.</i> [25]	31	26	3.4	170	20.9	198.3	1 (3.2)	NN	5.2
Benway <i>et al.</i> [26**]	129	118	2.9	189	19.7	155	11 (8.7)	5	2.4
Kural <i>et al.</i> [27]	11	20	3.21	185	27.3	286.4	0 (0)	0	3.9
Yang <i>et al.</i> [28]	8	-	2.3	160	33.0	165	1 (12.5)	1	4.3
Gong <i>et al.</i> [20]	29	-	3.0	197	25.0	220	0 (0)	0	2.5
Benway <i>et al.</i> [29**]	183	-	2.87	210	23.9	131.5	15 (8.2)	4	

Compl, complications; EBL, estimated blood loss (ml); LPN, laparoscopic partial nephrectomy; OT, operative time (min); RPN, robotic partial nephrectomy; WIT, warm ischaemia time (min). Hospital stay in days.

Overview of the recently published series of robotic partial nephrectomy