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TOPIC PAPER

Feasibility of adopting retroperitoneal robotic partial nephrectomy after extensive transperitoneal experience

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Abstract
Purpose Adoption of robotic retroperitoneal surgery has lagged behind robotic surgery adoption in general due to unique challenges of access and anatomy. We evaluated our initial results with robotic retroperitoneal robotic partial nephrectomy (RRPN) after transitioning from exclusively transperitoneal robotic partial nephrectomy (TRPN) to evaluate safety and any identifiable learning curve.
Methods We evaluated our single-surgeon (RA) prospective partial nephrectomy database since adopting RRPN routinely for posterior tumors in 2017. The surgeon had previously performed 410 partial nephrectomies by this time. Outcomes were compared after the initial 30 RRPN.
Results Of 137 patients since adopting RRPN, two attempted RRPN were converted to TRPN without complications due to morbid obesity affecting access, and 30 RRPN were completed (107 TRPN). There were no statistically significant differences in demographics, mean tumor size, or RENAL score between groups. Mean blood loss was lower in RRPN (53 mL vs 99 mL, $P < 0.05$), but there were no transfusions in either group. There was no difference in mean operative (127.8 min vs 141.2 min, $P = 0.06$) or ischemia time (11.1 min vs 10.8 min, $P = 0.98$). There were no positive margins in either group. Mean length of stay was lower in RRPN due to more same-day discharges (0.7 vs 0.9 days). There were no 90-day Clavien III–V complications. One RRPN patient was readmitted POD#8 overnight for hypoxia, and one visited the emergency room POD#7 for persistent pain. All three TRPN complications were managed as outpatients.
Conclusions Successful adoption of RRPN can be achieved readily after experience with TRPN. Outcomes were immediately comparable without any identifiable learning curve.

Keywords Partial nephrectomy · Kidney tumors · Robotic surgery · Retroperitoneal approach

Abbreviations

RRPN	Retroperitoneal robotic partial nephrectomy
TRPN	Transperitoneal robotic partial nephrectomy
TP	Transperitoneal
RP	Retroperitoneal
WIT	Warm ischemia time
eGFR	Estimated glomerular filtration rate
LOS	Length of stay
EBL	Estimated blood loss
OT	Operative time
BMI	Body mass index
ASA	American society anesthesiologist
IQR	Interquartile range

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Introduction

Nephron sparing surgery (NSS) or partial nephrectomy (PN) is the current gold standard surgical treatment for small renal masses [1]. Robotic surgery has provided a minimally invasive platform for surgeons to perform increasingly complex and larger tumors with excellent oncological and renal functional outcomes [2]. Traditionally, the more common approach for robotic or laparoscopic PN has been transperitoneal (TP) because it provides a larger working space for the surgeon and more familiar anatomic landmarks. However, the TP approach may increase the risk of bowel or colon injury particularly in those with previous abdominal surgery and may contribute to more pain associated with pneumoperitoneum or a higher risk of ileus [3]. Additionally, accessing posterior renal masses transperitoneally presents a challenge as the kidney must be entirely mobilized to access the posterior aspect of the kidney.

The retroperitoneal approach (RP) is an alternative approach to robotic PN that has a particular advantage for posterior tumors. In addition to providing better access to the posterior kidney for tumor visualization, resection, and renorrhaphy, the RP approach also enables direct access to the renal hilum and minimizes risk of injury to intraperitoneal organs [4]. Adoption of robotic retroperitoneal surgery has lagged behind the traditional TP approach likely due to the unique access techniques otherwise unfamiliar to a strictly TP robotic surgeon as well as an entirely different view of the anatomy [5]. However, given the significant theoretical advantages for posterior renal masses, we transitioned to the RP approach for posterior renal tumors over the past 2 years and now perform it routinely for posterior tumors. We evaluated our initial results with robotic retroperitoneal robotic partial nephrectomy (RRPN) after transitioning from exclusively transperitoneal robotic partial nephrectomy (TRPN) to evaluate the safety of this transition after extensive experience with TPRN. We also evaluated whether any identifiable learning curve could be detected in order to guide other TP surgeons contemplating adopting RPRN.

Methods

We reviewed the outcomes of RRPN performed by a single surgeon (RA) from our prospectively-maintained PN database, including all RRPN cases since the adoption of RRPN for all posterior tumors in January 2017. Anterior and lateral tumors continued to be managed with TRPN as were some lower pole tumors felt easily accessible without flipping the kidney. At time of retroperitoneal approach adoption, the surgeon had performed over 400 TPRN procedures.

The da Vinci Xi robot (Intuitive Surgical Inc, Sunnyvale, CA) was used in all procedures whether TRPN or RRPN. Access was obtained using a visual balloon dilator to create the retroperitoneal working space followed by placement of a balloon-tipped Hasson trocar with blunt dissection of the peritoneal reflection for placement of medial ports. A four-arm approach was used in all cases with a single 12-mm Airseal port (Conmed, Inc) for the assistant. Early unclamping of the renal hilum was routinely used with reperfusion of the kidney after completion of an initial deep layer of renorrhaphy. All tumors were sharply excised without enucleations.

Preoperative variables studied included age, gender, body mass index (BMI), R.E.N.A.L. (Radius, Exophytic/Endophytic, Nearness, Anterior/Posterior, Location) nephrometry score, preoperative estimated glomerular filtration rate (eGFR), laterality and American Society of Anesthesiologists (ASA) score. Operative and postoperative variables studied included operative time (OT), warm ischemia time (WIT), estimated blood loss (EBL), blood transfusions, immediate postoperative eGFR and length of stay (LOS). Pathologic factors included histologic type, tumor and specimen size, and surgical margins. Complications (classified by Clavien–Dindo grade) and readmissions were assessed within the first 90 postoperative days.

The outcomes of RRPN were compared with TRPN procedures performed during the same time period following the initial 30 RRPN to assess the safety of adoption during this initial period and whether outcomes differed from that expected for TRPN by the same surgeon. Categorical variables were analyzed using χ^2 or exact Fisher test as appropriate. Depending on the results of Kolmogrov–Smirnov Testing of normality, either the *T* test or Mann–Whitney test were used for continuous variables. Statistical significance was assigned at the level of $P < 0.05$ (JASP Version 0.9, JASP Team, 2018).

Results

A total of 137 robotic partial nephrectomies were performed since adopting RRPN between January 2017 and December 2018. Of these 30 were RRPN and 107 were TRPN. Two attempted RRPN were converted to TRPN due to morbid obesity precluding successful access and were excluded. There was no statistically-significant difference between groups in terms of mean age, gender, tumor laterality, BMI, ASA score, or frequency of previous abdominal surgeries (Table 1). There was also no statistically-significant difference between RRPN and TRPN patients in terms of median tumor size (3.0 cm vs 3.5 cm, $P = 0.1$) or R.E.N.A.L. nephrometry score (7.2 vs 7.2, $P = 0.70$).

There was no significant difference in OT and WIT in TRPN vs RRPN patients (141.2 min vs 127.8 min, $P = 0.09$; 11.1 min vs 10.8 min, $P = 0.98$, respectively). The mean length of stay was less than 1 day in both groups but was shorter in RRPN patients such that more patients were discharged on the day of surgery (0.7 days for RRPN vs 0.9 days for TRPN, $P = 0.01$). The estimated blood loss was greater in the TRPN cohort (99 mL vs 53 mL, $P < 0.05$), but no transfusions were required in either group (Table 2).

Mean immediate postoperative change in eGFR (as measured during postoperative hospitalization) was from 92.6 mL/min/1.73 m^2 before surgery to 76.3 mL/min/1.73 m^2 in RRPN patients and fell from 87.9 mL/min/1.73 m^2 to 74.1 mL/min/1.73 m^2 in TRPN patients with no statistically significant difference in eGFR change between groups ($P = 0.3$ and $P = 0.78$). Overall, postoperative eGFR was > 60 mL/min/1.73 m^2 in 86% of patients (75% for RRPN vs 88% for TRPN, $P = 0.16$).

Overall, 5 (3.6%) patients had Clavien-Dindo grade I or II complications within 90 days with no Clavien III–V complications in either group. Three postoperative

Table 1 Preoperative PN patient characteristics of PN procedures

Variable	Overall	Retroperitoneal	Transperitoneal	*P* value
n (%)	137	30 (22)	107 (78)	
Mean age, years (range, IQR)	56.7 (35–78, 48–65)	54.1 (21–81, 42.2–65)	56.3 (27–83,48–65)	0.38
Mean BMI, kg/m^2 (range, IQR)	32.5 (18–59, 27.8–36.7)	30.6 (18–49, 26.5–35.1)	32.7 (20–59, 27.8–36.7)	0.13
Gender *n* (%)				0.54
Female	63 (41)	12/30 (39)	51/107 (48)	–
Male	74 (59)	18/30 (61)	56/107 (52)	–
Laterality *n* (%)				0.69
Right	63 (46)	15/30(50)	48/107 (45)	–
Left	74 (54)	15/30 (50)	59/107 (55)	–
ASA score *n* (%)				
ASA 2	52 (38)	9/30 (32)	43/107 (40)	0.3
ASA 3	84 (61)	21/30 (68)	63/107 (59)	0.3
ASA 4	1 (1)	0	1/107 (1)	–
Prior abdominal surgery *n* (%)	73 (53)	20/30 (67)	53/107 (49.5)	0.16

BMI body mass index, *ASA* American society of anesthesiologists

Table 2 Operative and perioperative outcomes

Variables	Overall	Retroperitoneal	Transperitoneal	*P* value
Mean (range, IQR) OT	138.2 min (70–235, 111.5–162.5)	127.8 min (107–218, 108–146)	141.2 min (70–235, 113–166)	0.063
Mean (range, IQR) EBL[a]	135.9 mL (50–400,50–100)	53.6 mL (5–175, 25–50)	99 mL (20–650, 50–100)	0.001
Mean (range, IQR) WIT	11.8 min (0–26, 10.3–14.7)	10.8 min (0–21, 9.69–14.63)	11.1 min (0–26, 10.4–14.9)	0.98
Mean LOS (range)[a]	0.9 day (0–2)	0.7 day (0–1)	0.9 day (0–2)	0.01
Mean (range, IQR) R.E.N.A.L score[a]	7.2 (4–11, 6–8)	7.2 (4–11, 5.75–8.25)	7.2 (4–10, 6–8.5)	0.76
Mean (range, IQR) tumor size[a]	3.3 cm (1–15.7, 2.5–4.2)	3.0 cm (1.3–5.2, 2.3–2.7)	3.5 cm (1–15.7, 2.5–4.3)	0.07

OT operative time, *EBL* estimated blood loss, *WIT* warm ischemia time, *LOS* length of stay, *IQR* interquartile range

[a]Data not normally distributed; Mann–Whitney test applied

complications occurred among TRPN patients requiring unscheduled office visits but were successfully managed as outpatients (one for wound infection, one for acute kidney injury (AKI), and one minor urine leakage that required Foley catheter placement only). Two RRPN patients had complications with one readmission for hypoxia on postoperative day #8 and one emergency department visit for evaluation of persistent abdominal pain on postoperative day #7 without requiring readmission. All 137 patients had negative surgical margins with malignant pathology identified in 86% of TRPN and 100% of RRPN). In comparing the initial 15 with the subsequent 15 RRPN patients, no difference was seen in mean OT (247 min vs 250 min, $P=0.9$), WIT (10.5 min vs 12.4 min, $P=0.058$), EBL (50 cc vs 50 cc, $P=0.74$), or LOS (0.6 days vs 0.6 days, $P=0.98$).

Discussion

Robotic assisted partial nephrectomy (RAPN) for small renal masses has been increasingly utilized over the last decade, becoming the preferred minimally-invasive treatment option for kidney masses amenable to nephron sparing surgery [6]. While RAPN can be performed with a transperitoneal or retroperitoneal approach,TRPN has been most commonly performed likely due to surgeon preference for a larger working space, the more familiar anatomic orientation, and the simpler and more familiar access [2].

However, posterior renal tumors are particularly challenging utilizing the transperitoneal approach as the kidney must be fully mobilized and flipped to identify the tumor. For these tumors, a retroperitoneal approach offers direct access to the target anatomy, which may reduce operative time particularly for the less experienced surgeon for whom kidney mobilization may be less efficient. Although the surgical principles of resection and reconstruction are identical to that of TRPN, the retroperitoneal approach has several particular challenges requiring consideration prior to adoption of this technique. Primarily these include a unique method for establishing access, port placement and creating the working space to perform the operation as well as a difference in anatomic orientation and landmarks. Once these challenges are overcome by the surgeon and team, the remainder of the procedure is not materially different than TRPN, including performing the tumor resection and renal reconstruction.

The adoption of RRPN by traditionally transperitoneal surgeons would be expected to require an adaptation period during which operative outcomes might suffer or complications might occur more frequently. The learning curve for this transition from TRPN by an experienced surgeon to RRPN has not been defined nor has the optimal training required for a safe transition [7]. Assessing postoperative outcomes is a valid method of determining the learning curve for a particular procedure and has been used as such in the study of robotic partial nephrectomy adoption [4, 7]. We evaluated the outcomes on our initial 30 RRPN procedures after extensive experience with TRPN to determine whether a learning curve effect could be seen and to help guide other surgeons contemplating such a transition. We did not observe any difference in perioperative outcomes when comparing our initial 15 with the subsequent 15 RRPN cases. The length of the learning curve for any procedure can be influenced by many factors, but it seems that extensive experience with similar techniques or overarching principles may make for an easier transition with a flatter learning curve. Of course, further studies with more surgeons and larger cohorts would be required to demonstrate this unequivocally.

In comparing the 30 RRPNs in this study with 107 TRPNs, there were no differences in demographics or tumor characteristics between groups. 54% of RRPN and 56% of TRPN classified as intermediate severity by R.E.N.A.L. nephrometry score, reflecting a representative sample of tumors as compared with other series [8]. Despite no differences in baseline characteristics between groups and the relative novelty of the retroperitoneal approach to the surgeon, perioperative outcomes did not differ significantly. Operative time was on average 13 min shorter in RRPN, but this was not statistically significant, and WIT was the same between groups as might be expected given that the actual tumor resection and renorrhaphy does not materially differ between approaches.

Tanaka et al. and Hughes-Hallett et al., reported that RRPN had shorter OT (239 mi vs 193 min, $P=0.07$ and 195 min vs 148 min, $P<0.01$, respectively) but not WIT (24.3 min vs 24.7 min, $P=0.58$ and 20.4 vs 19.1 min, $P=0.09$, respectively) [3, 9]. Choo et al. also showed decreased OT and WIT favoring RRPN [2]. Shorter OT with RRPN may be related to a faster approach to the renal artery or omission of the need to reflect the colon,but it is possible that this was less pronounced in our series due to the small number and perhaps additional time to achieve access that will improve with experience [10]. Unfortunately, our prospective database did not include details on the operative time such as the access time, console time, and closure time. Since there was no difference in mean OT between groups, we do not believe that there was likely a large difference in access time particularly as we have continued to gain experience and now find ourselves equally facile at both.

Similarly, we found that EBL was slightly lower in RRPN group and while statistically significant was not clinically important with no patients requiring transfusions in either group. This finding is also demonstrated in the majority of the reviewed literature although the reasons are unclear [11]. It is possible that this could relate to less tissue dissection needed to reach the hilum, or may be related to better identification and control of the renal artery or branches due to its posterior position,but since no studies have distinguished EBL during dissection from EBL during tumor resection, this would be difficult to determine [1, 11].

In a multi-institutional study that included data from 14 different centers, Arora et al. found no difference in the rates of positive surgical margins at 2%, and 2.1% for transperitoneal and retroperitoneal approach, respectively [1]. Stroupt et al. also reported no significant differences in the rate of positive surgical margins between RRPN and TRPN ($P=0.59$) at 2.8% and 4.2%, respectively [8]. Historically, our positive margin rate has consistently been < 1%, and this was not compromised in transitioning to the RRPN approach for posterior tumors confirming that nothing about the RRPN approach is materially different once the hilum is dissected and the tumor prepared for resection as these subsequent steps of partial nephrectomy are identical to TRPN.

As would be hoped in the adoption of a new technique, there was no increase in complications observed upon adopting RRPN. The complications rate was similar for both groups ($P=0.3$) without any Clavien–Dindo III–V complications in either group. Similarly, other studies have found no difference in overall complication rates between TRPN and RRPN [2, 3]. While our complication rate was low and reflective of hundreds of cases of experience as well as thousands of robotic procedures performed overall and may not be shared by a less experienced robotic partial nephrectomy surgeon, the lack of a difference between groups upon adopting RRPN routinely may suggest that other surgeons can make the same transition without expecting more complications than their baseline rate with TRPN.

We also found no difference in the immediate postoperative eGFR, reflecting no difference in acute kidney injury that may predispose to chronic kidney disease [12]. Long-term renal function after partial nephrectomy is a combination of patient and surgical factors [13–15]. Even if not required by any evidence-based guidelines, patients with prolonged or significant postoperative eGFR reduction may benefit from more close monitoring postoperatively and referral to a nephrologist when necessary [16, 17]. Patients at higher risk for developing chronic kidney disease may be identifiable using the nomogram proposed by Martini et al. [18].

Although, TRPN can be chosen by a surgeon for all tumors, we adopted use of routine RRPN for any posterior tumor regardless of complexity. The retroperitoneal approach seems to be easier for posterior tumors due to the direct access to the hilum and the tumor, but it might be advisable for a surgeon new to RRPN, particularly if less experienced with robotic partial nephrectomy in general, to start with less complex tumors and advance to more complex cases over time [19]. In addition, it could be useful for a less-experienced robotic surgeon to arrange case observations of RRPN surgeries performed by experienced surgeons in order to become more confident in strategies for obtaining and troubleshooting access as well as becoming familiar with the retroperitoneal anatomical landmarks.

One of the significant findings in our study was a reduction in LOS among RRPN patients (mean of 0.7 days vs 0.9 days, $P = 0.01$). We routinely offer same-day discharge to robotic partial nephrectomy patients but have had less success with this than among our robotic prostatectomy patients in whom the majority now go home on the day of surgery. We did not change our perioperative care strategy or discharge protocol upon adopting RRPN such that the increased proportion of patients choosing to go home on the day of surgery, an additional 20%, is likely a reflection of a true difference in patient comfort rather than surgeon bias. Since we did not measure pain scores or analgesic use to compare between groups, it is unclear why patients felt more comfortable opting for same-day discharge in the RRPN group, but other groups have found that their ability to discharge patients earlier with RRPN is enhanced [3, 20].

Arora et al. found that RRPN was associated with a shorter LOS than TRPN in a multi-institutional data set with median LOS for TRPN of 3.0 days [Interquartile range (IQR) 2.0–4.0] vs 1.0 day (1.0–3.0) for RRPN ($P < 0.001$) [1]. Our mean LOS was less than 1 day even for TRPN patients in contrast with this series such that the reason for prolonged LOS for TRPN patients is unclear and may reflect a surgeon bias in discharge decision making, but our routine protocol calls for offering (but not mandating) same-day discharge to all patients and letting them decide such that we are confident that there was no surgeon bias involved in the reductions seen with RRPN.

This study has several limitations including the retrospective design, small sample size and lack of randomization between groups in addition to being a single-surgeon series such that the favorable findings regarding the adoption of RRPN may not be generalizable to all surgeons. While not possible to determine from the study design, we do believe that previous experience with robotic surgery in general and several hundred TRPN procedures in particular was beneficial in allowing a safe transition to RRPN. Nevertheless, we do not believe that this should be a barrier to other surgeons considering adopting RRPN although they might choose more simple cases to begin with such as smaller tumors, thinner patients, and lower R.E.N.A.L. nephrometry scores. Another potential barrier to adopting RRPN could be the adjustment needed from the bedside assistant, but a sufficiently experienced surgeon can overcome this since during the study period we transitioned to a new bedside assistant without previous surgical robotic experience without noticing any effect on perioperative outcomes.

Multi-institutional series with multiple surgeons would be beneficial to demonstrate the reproducibility of our experience, and continued experience with larger number of RRPN procedures may identify differences in outcomes like operative time as we gain more experience.

Conclusions

Successful adoption of RRPN was achieved readily by a surgeon experienced in TRPN indicating that surgeons contemplating a transition to RRPN may not require special training to do so. The outcomes of RRPN were immediately comparable to those of TRPN by the same surgeon without any identifiable learning curve suggesting that the adoption was achieved safely and without compromising results.

Author contributions RA: Project development, manuscript writing/editing. RG: Manuscript writing/editing, data analysis. OM: data collection. Data management, data analysis, manuscript writing.

Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest.

Ethical standards Ethical standards have been met and this study is IRB approved.

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