Original Article

Technique and outcomes of robotic-assisted retroperitoneal radical nephrectomy

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Background: Robotic retroperitoneal partial nephrectomy (rRPN) has numerous advantages over transperitoneal surgery, including direct access to the renal hilum and posterior tumors, and avoidance of the peritoneal cavity in patients with a hostile abdomen. Although the use of the retroperitoneal approach has increased over the last decade, there is little literature on robotic retroperitoneal radical nephrectomy (rRRN), which has similar benefits over the transperitoneal approach. The aim of this study was to describe our technique for robotic retroperitoneal nephrectomy (rRN) and assess its feasibility and outcomes at a high-volume center.

Methods: A retrospective review of patients who underwent some form of rRN [rRRN, robotic retroperitoneal simple nephrectomy (rRSN), or robotic retroperitoneal nephroureterectomy (rRNU)] at a single institution between 2013 and 2023. Patient characteristics, operative data, and postoperative complication rates were assessed. The technique for rRN was detailed.

Results: A total of 13 renal units in 12 patients were included for analysis (7 rRRN, 5 rRSN, 1 rRNU). Median patient age was 64.0 years, and median body mass index (BMI) was 36.0 kg/m^2. Indications for retroperitoneal surgery were prior abdominal surgery in all patients, including three with bowel diversions, super morbid central obesity in two patients, and a large ventral hernia in one patient. Median operative time was 213 minutes and median estimated blood loss (EBL) was 85 cc. Median postoperative length of stay (LOS) was 3 days, and only one patient experienced a Clavien-Dindo grade ≥3 complication within 90 days of surgery.

Conclusions: The retroperitoneal approach for robotic-assisted nephrectomy is feasible and associated with similar outcomes as the transperitoneal approach. This approach may prove beneficial in select patients with significant prior abdominal surgery including those who are morbidly obese.

Keywords: Radical nephrectomy; robotic nephrectomy; retroperitoneal; renal mass

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Introduction

Nephrectomy is indicated in multiple circumstances including renal cell carcinoma (RCC), in the case of a chronically infected poorly functioning kidney, or when performed with total ureterectomy for upper tract urothelial cell carcinoma While multiple surgical approaches exist, robotic renal surgery has been shown to be safe, effective, and increasingly utilized over time (1-6). Robotic renal surgery is commonly performed through a transperitoneal approach. This is in part due to anatomic familiarity among surgeons and a smaller working space in the retroperitoneum (7). Abdominal surgery is common, with an estimated 44% lifetime risk in the U.S. population (8). Prior abdominal surgery can result in adhesions and deviations of normal anatomy that place patients undergoing transperitoneal open, laparoscopic, or robotic renal surgery at higher risk for surgical complications. This is particularly true in patients with a hostile abdomen from multiple or extensive prior abdominal surgeries, or in those with urinary or intestinal diversions. Along with a hostile peritoneal cavity, other relative indications for a retroperitoneal approach to kidney surgery include the presence of a peritoneal dialysis catheter, pregnancy, and morbid obesity (9-11).

The benefits of retroperitoneal renal surgery include avoidance of peritoneal cavity structures and more direct access to the renal hilum. These benefits potentially result in less pain, lower estimated blood loss (EBL), shorter operative times, and shorter length of stay (LOS) compared to the transperitoneal approach (12-14). As with the transperitoneal approach, retroperitoneal renal surgery can be performed open, laparoscopically, or robotically. Pure laparoscopic retroperitoneal renal surgery is feasible but not commonly performed in the U.S. because of a lack of familiarity compared to European and Asian countries. Robotic retroperitoneal partial nephrectomy (rRPN) has gained increased utilization and is increasingly used in select patients with hostile abdomens and/or posteriorly located tumors (15). Despite increasing interest in rRPN, there is a paucity of literature describing robotic retroperitoneal nephrectomy (rRN).

Using our experience with rRPN, we recently expanded the retroperitoneal robotic approach for highly selected patients undergoing rRN. These patients would be at a high risk for complication with a typical transperitoneal approach due to prior abdominal surgeries, including bowel diversions, morbid central obesity, or large ventral hernias. Herein, we describe our reproducible technique and report the initial safety and feasibility outcomes of patients undergoing rRN, which includes robotic retroperitoneal radical nephrectomy (rRRN), robotic retroperitoneal simple nephrectomy (rRSN), and robotic retroperitoneal nephroureterectomy (rRNU). We present this article in accordance with the STROBE reporting checklist (available at https://tau.amegroups.com/article/view/10.21037/tau-23-270/rc).

Highlight box

Key findings

- Thirteen renal units underwent robotic retroperitoneal nephrectomy (rRN) (7 radical nephrectomy, 5 simple nephrectomy, 1 nephroureterectomy).
- Median operative time was 213 minutes and median estimated blood loss was 85 cc.
- Median postoperative length of stay was 3 days. Only one patient experienced a Clavien-Dindo grade ≥3 complication within 90 days of surgery.

What is known and what is new?

- Retroperitoneal renal surgery provides direct access to the hilum while avoiding the peritoneal cavity, however there has been limited literature on technique and outcomes.
- This retrospective single-institutional review shows that rRN feasible with similar outcomes as the transperitoneal approach.

What is the implication, and what should change now?

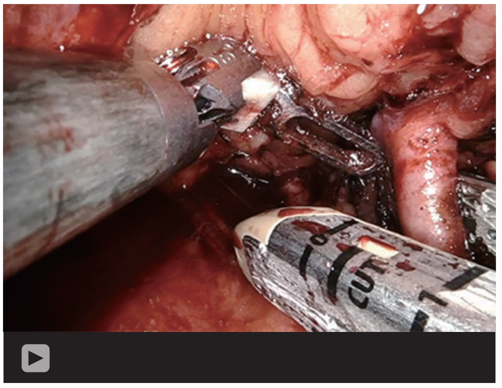
- rRN may prove beneficial for select patients who require radical nephrectomy, simple nephrectomy, or nephroureterectomy and have a history of significant prior abdominal surgery or morbid obesity which would make a transperitoneal approach challenging.

Methods

Data of patients who underwent rRN by one of three surgeons (PT Gellhaus, CR Tracy, and KG Nepple) between 2013 and 2023 were retrospectively collected and analyzed. All surgeons were fellowship-trained in either urologic oncology or minimally invasive urology and had been in practice at least 3 years after training. All patients underwent enhanced computed tomography or magnetic resonance imaging before surgery. Inclusion criteria included adults who underwent rRRN, rRSN, or rRNU. Indication for using the retroperitoneal approach was at the discretion of the surgeon, however predominantly included prior abdominal surgeries and/or morbid obesity.

Statistical analysis

Patient demographic and clinical data, as well as tumor characteristics were extracted from the electronic health record. Perioperative outcomes consisted of operative time, EBL, blood transfusion, rates of conversion to open surgery, postoperative LOS, and postoperative complications which were classified using the Clavien-Dindo classification. Descriptive statistics were performed using SPSS (IBM,



Video 1 Robotic-assisted retroperitoneal radical nephrectomy. Video demonstrating patient positioning, port placement, and surgical steps of robotic-assisted retroperitoneal radical nephrectomy.

Armonk, NY, USA).

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the institutional ethics board of the University of Iowa (No. 202104324) and individual consent for this retrospective analysis was waived.

Surgical technique (Video 1)

The three surgeons used some variations in surgical techniques, but the most common technique is as follows. The patient was placed in full flank position with the bed flexed until the space between the 12th rib and iliac crest was maximized. A small horizontal incision was made one fingerbreadth above the iliac crest a 12 mm laparoscopic trocar with a visual obturator and zero-degree camera under vision directly into the retroperitoneum. This technique allows visualization sequentially through Scarpa's fascia, the internal oblique and transversus abdominis muscle, lumbodorsal fascia, retroperitoneal fat, and the psoas, and may decrease retroperitoneal gas leakage. Another option is to bluntly enter the retroperitoneal space through this incision with a clamp, and confirm entry into the correct space by palpating the psoas muscle and underside of the iliac crest and 12th rib. The Spacemaker dissection balloon (Medtronic, Dublin, Ireland) was inserted posterior to the kidney and into the retroperitoneal space with the dilation expanding portions in a cranial-caudad orientation. Next, it was inflated under laparoscopic vision. The ureter and gonadal vein are occasionally visualized with expansion of the balloon ventral to the psoas muscle. The balloon was replaced with a 12 mm robotic stapler port with a 12-8 mm cannula reducer.

An 8 mm robotic trocar was placed in the posterior axillary line in a straight transverse plane approximately 6 cm lateral to the camera port. The peritoneum was reflected bluntly in a medial and downward direction off the anterior abdominal wall to allow for insertion of two additional 8 mm robotic trocars 6 cm medial from each port (*Figure 1A*). In two cases a hole was made in the peritoneum during reflection for port placement as the peritoneum becomes quite thin towards the midline. If a hole was made in the peritoneum, it was either opened widely or closed to prevent a postoperative internal hernia. An additional 12 mm assistant trocar was inserted one handbreadth caudal to the second-most anterior robotic port. This port was incised at an oblique angle as it served as the site of the Gibson-style incision used for specimen extraction after nephrectomy. We preferred to use the AirSeal (CONMED, Utica, NY, USA) insufflation system to allow for adequate suction without significant loss of insufflation pressure in the relatively smaller retroperitoneal space (16). Pneumoretroperitoneum was established at 12 to 15 mmHg. The robot was docked either from the lateral or medial side of the patient depending on room setup and instruments including a zero-degree robotic camera, monopolar scissors, fenestrated bipolar forceps, and prograsp forceps were inserted. We elected to place the prograsp through the port directly adjacent to the camera and to place the scissors (if performing a right-sided case) or bipolar forceps (if performing a left-sided case) through the medial-most port (17). As the prograsp is primarily used to elevate the kidney, and therefore the external portion of the arm is pointing down, this minimizes external collisions with the bedside assistant.

Given the limited anatomic landmarks compared to transperitoneal surgery, it is important to immediately identify the psoas muscle and fascia and align them with the bottom of the surgical field to maintain orientation. In addition, intraoperative ultrasound can be used early to identify the kidney location. The perinephric fat was dissected off the psoas muscle all the way to the diaphragm and upper pole of the kidney (*Figure 1B*) to develop the posterior renal space. This improved orientation and exposure and allowed the fourth arm to further elevate

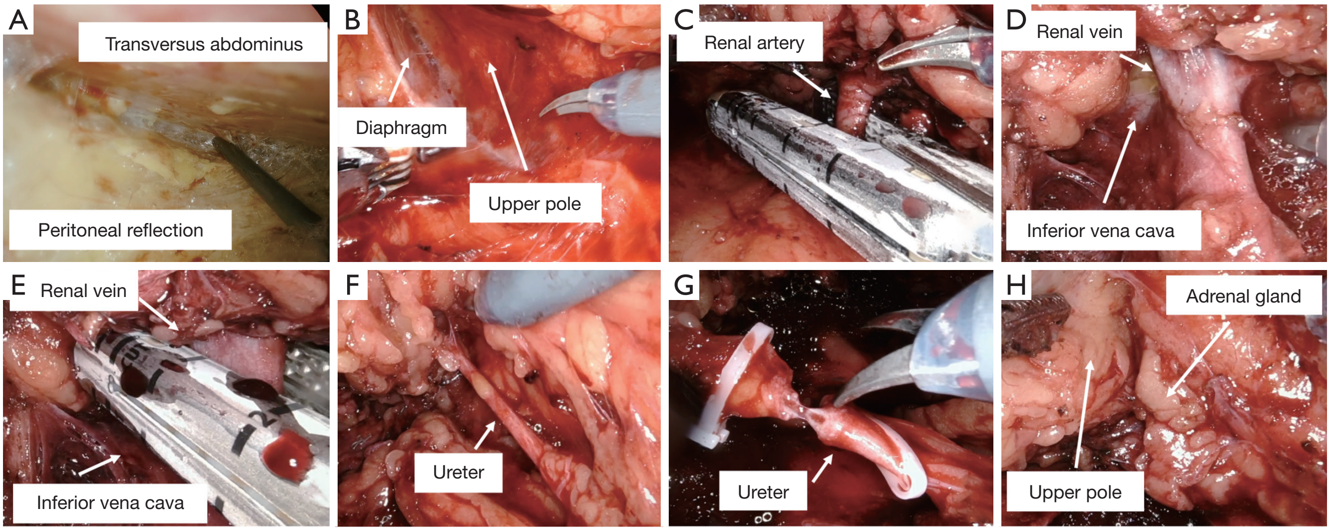


Figure 1 Intraoperative steps of right rRRN. rRRN, robotic retroperitoneal radical nephrectomy.

kidney putting the renal hilum on gentle traction. Next, the hilar vessels were encountered by cautiously dissecting between the renal poles. During this approach, the renal artery, which is located posteriorly, should be encountered first, with the anteriorly located renal vein behind (*Figure 1C-1E*). Once the hilar vessels were isolated, they were ligated either individually or *en bloc* with either a laparoscopic or robotic vascular stapler or Weck clips (Teleflex, Wayne, PA, USA). We routinely exposed the vena cava superior and inferior to the renal vein to ensure that the tip of the stapler was above the inferior vena cava (*Figure 1E*) to prevent vena caval injury including accidental complete vena caval ligation.

After the renal pedicle was controlled, the kidney was completely mobilized. We started with exposing the adrenal gland superior to the now ligated renal vessels. The adrenal gland can be spared or removed depending the surgical indication (*Figure 1E*). Next the ureter was isolated near the lower pole and divided between clips (*Figure 1F,1G*). After ureteral transection, dissection continued to release the medial attachments, being mindful of the adjacent medial and anterior intraperitoneal structures to avoid colon or pancreatic/duodenal injury. This can be accomplished by dissecting Gerota's fascia off the medial peritoneal attachment in a mostly avascular plane. Lastly, the kidney was separated off the superior and anterior attachments (*Figure 1H*), placed in a specimen bag, and extracted through an extension of the assistant port in a muscle sparing Gibson-type incision (*Figure 2*). If performing a rRNU, after the nephrectomy portion is complete, the robot is rotated 180 degrees without patient repositioning and the dissection of the lower ureter and bladder cuff are performed using a 3-arm approach as previously described (18). A surgical drain was placed only if there was suspected leak after bladder cuff closure when performing a rRNU or if performing a rRSN for a chronically infected kidney.

Results

Thirteen renal units in 12 patients who underwent rRN were included in the analysis. Patient demographics are outlined in *Table 1*. Seven patients underwent rRRN for masses that were not amenable to partial nephrectomy due to size of central location, four underwent rRSN for non-functional infected kidneys (one of whom underwent staged bilateral rRSN for end-stage renal disease and recurrent infections), and one underwent rRNU for high-grade upper tract urothelial cell carcinoma. The median age of the patients was 64.0 years [interquartile range (IQR), 51.0–78.5 years], and the median body mass index (BMI) was 36.0 kg/m^2 (IQR, 24.5–40.0 kg/m^2). Eight of the 12 patients were male, and all except one were Caucasian.

All patients in this study had previous abdominal surgery, and several patients had extensive intra-abdominal surgical histories and concerns for hostile abdomens (*Table 2*). Three patients had intestinal diversions with an ileostomy or colostomy, and one patient had a large ventral hernia with complete loss of abdominal domain.

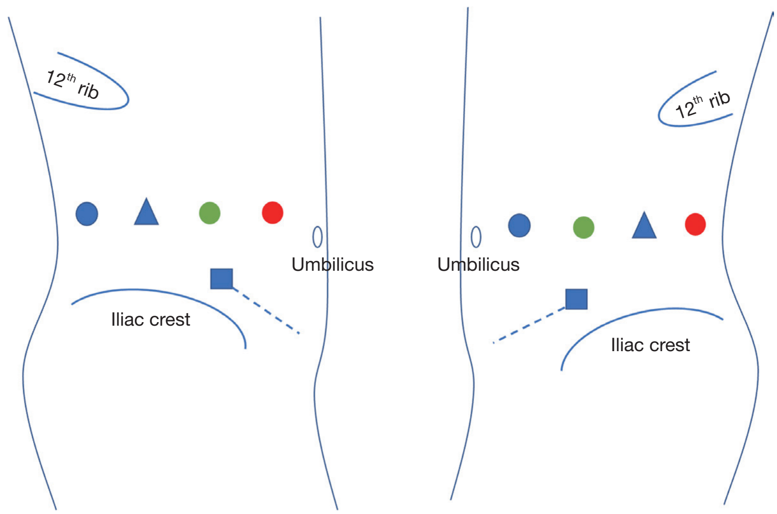


Figure 2 Port configuration for right and left-sided retroperitoneal kidney surgery. Triangle: 12 mm camera port; square: 12 mm assistant port; blue circle: 8 mm robotic trocar with fenestrated bipolar; red circle: 8 mm robotic trocar with scissors; green circle: 8 mm robotic trocar with prograsp. The dashed blue line represents the extraction incision which is extended from the 12 mm assistant port.

Table 1 Demographics and clinical information of patients undergoing retroperitoneal kidney surgery

Variables	Value
Age (years), median (IQR)	64.0 (51.0–78.5)
Gender, n (%)	
Male	8 (6.15)
Female	5 (38.4)
BMI (kg/m^2), median (IQR)	36.0 (24.5–40.0)
Preoperative eGFR (mL/min), median (IQR)	58.0 (37.0–83.5)

IQR, interquartile range; BMI, body mass index; eGFR, estimated glomerular filtration rate.

The median operative time for this cohort was 233 minutes (*Table 3*). One outlier case had an operative time of 366 minutes. This case was a radical nephrectomy after failed ablation in a super morbidly obese patient (BMI: 53 kg/m^2), and therefore took significantly longer than usual due to renal scarring on the body wall. The median EBL was 103.0 mL (IQR, 52.5–145.0 mL), and no patient required a blood transfusion intraoperatively or postoperatively. The median LOS was 3 days (IQR, 2–4 days). The longest LOS was 7 days, and this was predominantly due to medical comorbidities including acute-on-chronic congestive heart failure necessitating diuresis. Median change in estimated glomerlular filtration rate 6 months postoperatively was −13 mL/min/1.73 m^2 (IQR, −19 to 0 mL/min/1.73 m^2).

Of the seven patients who underwent rRRN for a renal mass or biopsy-confirmed RCC, the pathology was pT1 in four cases, pT3 in two cases, and oncocytoma in one case (*Table 2*). Patient #11 had planned to undergo a rRPN for a cT1b posterior renal mass, however this was converted to rRRN intraoperatively due to tumor margin concerns. All patients who underwent rRRN or rRNU had negative margins on final pathology.

Only three patients experienced any complication postoperatively. Patient #2 had an acute on chronic congestive heart failure exacerbation which was treated with diuresis (Clavien-Dindo grade 2). Patient #7 presented to the emergency department 1 week postoperatively with back pain and dyspnea. She was found to have a hydropneumothorax on the side of the operation that was managed conservatively with supplemental oxygen. She was readmitted again 5 days later after experiencing a seizure and was also found to have a mild non-ST-elevation myocardial infarction. She was treated with antiepileptics and antiplatelet therapy and experienced an unremarkable recovery (Clavien-Dindo grade 2). Patient #12 was readmitted 2 weeks after surgery with ileus which was successfully treated conservatively with temporary nasogastric tube placement (Clavien-Dindo grade 2).

Table 2 Pathologic outcomes for patients undergoing retroperitoneal kidney surgery and 30-day complications

Patient	Indication for RP approach	Final pathology	30-day complication
Patient #1	Prior abdominal surgery (subtotal colectomy, exploratory laparotomy, appendectomy)	pT1aR0 chromophobe RCC	–
Patient #2	Prior abdominal surgery (large ventral hernia repair with mesh, hysterectomy) Super morbid obesity (BMI: 53.3 kg/m^2)	pT3aR0 clear cell RCC	Congestive heart failure exacerbation requiring diuresis (Clavien-Dindo II)
Patient #3	Prior abdominal surgery (ileocolectomy, partial nephrectomy	pT1aR0 clear cell RCC	–
Patient #4	Prior abdominal surgery (open hemicolectomy, ventral abdominal hernia repair)	pT1bR0 clear cell RCC	–
Patient #5	Prior abdominal surgery (three previous partial small bowel resections)	End-stage kidney	–
Patient #6	Prior abdominal surgery (ileal resection, debulking of pelvic tumor, hysterectomy)	Xanthogranulomatous pyelonephritis	–
Patient #7	Prior abdominal surgery (total colectomy with ileostomy)	High-grade pTaR0 papillary urothelial carcinoma	Pneumothorax, seizure, NSTEMI (Clavien-Dindo IIIA)
Patient #8	Prior abdominal surgery (ventral hernia repair with mesh) Super morbid obesity (BMI: 52 kg/m^2)	pT1aR0 clear cell RCC	–
Patient #9	Prior abdominal surgery (several small bowel resections, ileostomy, ileostomy resiting)	Oncocytoma	–
Patient #10	Prior abdominal surgery (colostomy, open appendectomy, pyeloplasty)	End-stage kidney	–
Patient #11	Prior abdominal surgery (subtotal colectomy, exploratory laparotomy) Posterior renal mass	pT3aR0 mucinous RCC	Intraoperative conversion from partial to radical nephrectomy for tumor spillage
Patient #12	Prior abdominal surgery (ventral hernia repair with mesh, bladder augment, exploratory laparotomy)	End-stage kidney	–
Patient #13	Prior abdominal surgery (ventral hernia repair with mesh, bladder augment, exploratory laparotomy)	End-stage kidney	Ileus requiring temporary nasogastric tube (Clavien-Dindo II)

RP, retroperitoneal; RCC, renal cell carcinoma; BMI, body mass index; NSTEMI, non-ST elevation myocardial infarction.

Table 3 Perioperative data for patients undergoing retroperitoneal kidney surgery

Variables	Value
Operative time (min), median [IQR]	233 [191–292]
EBL (mL), median [IQR]	103.0 [52.5–145.0]
LOS (days), median [IQR]	3 [2–4]
Change in hemoglobin between surgery and discharge (g/dL), median [IQR]	−2.8 [−1.7 to 4.0]
Change in eGFR 6 months after surgery (mL/min/1.73 m^2), median [IQR]	−13 [−19 to 0]

IQR, interquartile range; EBL, estimated blood loss; LOS, length of stay; eGFR, estimated glomerular filtration rate.

Discussion

Patients who require nephrectomy can present with distinctive surgical challenges related to prior abdominal surgery that can place them at higher risk for complications if performed via a traditional transperitoneal approach. We describe our approach and evaluate outcomes of rRN in a highly selected group as a safe and feasible alternative approach to these specific challenges.

There are several indications where rRN may be preferred over a transperitoneal approach. rRN avoids the peritoneal cavity, which can be hostile in patients with prior abdominal surgery. All patients in this cohort had prior intra-abdominal surgery, and in most this was the primary indication for using a retroperitoneal approach. Patients with urinary or intestinal diversions are particularly well-suited for the retroperitoneal approach, as the stoma often interferes with transperitoneal port placement. When performing rRN in patients with lower abdominal ostomy, medial ports can be shifted more cephalad to avoid the stoma. In super-morbidly obese patients with significant truncal adiposity, the retroperitoneal approach avoids the abdominal pannus and voluminous visceral fat encountered during transperitoneal radical nephrectomy (11), which may shorten operative time and decrease the risk of rhabdomyolysis in this at-risk population. By extracting through an extension of the lower quadrant assistant port, a muscle-sparing Gibson incision can be used rather than an open flank incision through the oblique and transversalis muscles. This incision decreases postoperative pain and speeds recovery (19). Additionally, the extraction incision was routinely measured to be 6 cm or less depending on the volume of renal adipose tissue. This is a smaller incision than the common 8 cm "mini-flank incision" used in open retroperitoneal renal surgery (20). Larger patients commonly require an even larger incision to safely expose the surgical field. Thus, we felt this minimally-invasive approach reduced overall incisional pain compared to what would be expected during open surgery, as has been previously reported (21). In addition to decreased pain from the extraction incision, the lack of pneumoperitoneum may also decrease visceral pain and ileus rates and therefore improve recovery time, however this has not been proven.

Through our experience with rRN, we have learned several nuances and implemented some technique modifications that have increased the feasibility of the procedure. rRN necessitates greater range of motion of the robotic arms than rRPN, which can be challenging in the small retroperitoneal space. The improved arm spacing of smaller profile newer robotic platforms (Da Vinci Xi; Intuitive Surgical, Sunnyvale, CA, USA) allows for routine incorporation of the fourth arm to aid in retraction (22,23) and Airseal insufflator technology assists with maintaining pneumoretroperitoneum in a smaller working space. We find it helpful to review the cranial-caudal relationship of the kidney to the 12th rib and erector spinae muscles in order to tailor the location of the initial incision. One should avoid placing the ports too close to the iliac crest as this can limit arm mobility when dissecting around the upper pole of the kidney. A minimum of one finger breadth above the iliac crest is generally required. After the trocars and instruments have been inserted, we utilize a laparoscopic camera through the assistant port to withdrawal the trocars under vision so that they only extend 0.5 cm beyond the fascia, thereby maximizing the working spacing that is created. As stated in the methods section, placement of the "4th arm prograsp" that is used in the transperitoneal approach, in the trocar adjacent to the camera rather than the most anterior trocar also limits external collisions between the robotic arms and the bedside assistant. This configuration is only helpful when the 4th arm prograsp is elevating the kidney.

One must be careful of intraperitoneal structures such as the duodenum when releasing the medial attachments of the kidney. When performing a rRSN for a non-functioning kidney due to longstanding obstruction or infection, this medial plane is typically scarred or fibrotic, and clear identification of critical structures is challenging. We have found cases where it is beneficial to temporarily place the camera through the most medial port to obtain another viewpoint and facilitate safer dissection. The peritoneum can be opened if needed to more clearly visualize intraperitoneal structures and avoid them. If this is done, the peritoneum should either be opened widely or closed later to prevent internal hernias.

Although the safety and efficacy of rRN have been minimally studied, two randomized trials of retroperitoneal *vs.* transperitoneal laparoscopic radical nephrectomy (LRN) have demonstrated equivalent perioperative morbidity, complication rates, and pathological outcomes (24,25). While Nambirajan *et al.* found no significant differences between the two approaches, Desai *et al.* noted shorter time to renal artery control and shorter total operative time with the retroperitoneal approach. Gozen *et al.* reviewed 330 consecutive retroperitoneal LRN cases, and identified complications in 19% of patients, 13% of which were Clavien-Dindo grade ≤2 (26). The open conversion rate was 2.1%, largely due to uncontrollable intraoperative bleeding. The complication results in our study are similar, with an overall complication rate of 23%; however, no cases required open conversion and there was no uncontrollable intraoperative bleeding. Many nephrectomies can be performed laparoscopically, and one should be aware of the incremental cost associated with the robotic platform (27). There are, however, scenarios when robotic surgery may provide significant benefit over pure laparoscopy. Increased range of motion and degrees of freedom of robotic instruments facilitate easier dissection in the small retroperitoneal space, and this is particularly helpful in cases of a salvage nephrectomy following a previous partial nephrectomy or ablation. Suturing bleeding vessels or other structures is more reliably accomplished with robotic instruments over laparoscopy (28). Additionally, the robotic stapler is helpful when needing to staple the renal vessels at challenging angles.

There have only been three publications to our knowledge on the use rRN (18,29,30). Rose *et al.* reported on the use of the Da Vinci S platform to perform a retroperitoneal nephroureterectomy on two patients with a hybrid port technique (29). A study by Patel *et al.* described a robotic approach to retroperitoneal kidney surgery developed through porcine and cadaveric models (30). Ultimately 10 patients underwent retroperitoneal robotic kidney surgery, of whom 5 underwent rRN (3 rRRN, 2 rRSN). Average console time for those undergoing rRN was 198 minutes, and one patient undergoing rRSN requiring open conversion for non-progression. Lastly, Sparwasser *et al.* reported on five patients who underwent rRNU using a similar technique described in this current study (18). While mean operative time in that group was only 189 minutes compared to 233 minutes in our study, their average patient was not obese. Other studies have also illustrated the benefits of the robotic platform to perform RNU, both as it pertains to removing the kidney and ureter as well as performing the lymphadenectomy (31,32).

There have been no direct comparisons of rRRN to robotic transperitoneal radical nephrectomy (rTRN), however outcomes of rTRN have been extensively studied. A recent meta-analysis comprising over 64,000 patients from over 12 studies compared outcomes of rTRN to LRN and open RN (33). Mean operative times, EBL, and LOS for rTRN ranged from 139–371 minutes, 34–450 cc, and 2.5–5.0 days, respectively. Compared to LRN, rTRN was associated with longer operative times and shorter LOS, whereas compared to open RN, rTRN was associated with fewer complications and less EBL. In the current study, median operative time (233 minutes), EBL (103 cc), and LOS (3 days) is comparable to what has been published for rTRN. As robotic radical nephrectomy carries many similarities to robotic partial nephrectomy, the literature surrounding rRPN can be extrapolated to illustrate the potential benefits of rRRN (34-37). A recent meta-analysis compared 2,482 robotic retroperitoneal and 3,423 robotic transperitoneal partial nephrectomies (38). The retroperitoneal approach was superior to transperitoneal approach in terms of operative time, LOS (−0.46 days; 95% CI: −0.69, −0.23; P<0.01), and EBL. No significant differences were observed in warm ischemia time, positive surgical margins, or complication rates between the two approaches.

Our study has multiple limitations. Due to the retrospective nature and small sample size, unmeasured biases including selection bias may be present. There was no matched transperitoneal robotic radical nephrectomy group to act as a comparison arm as the focus of this manuscript was reporting the technique as well as the safety and feasibility of rRN. Outcomes of this cohort, however, are relatively comparable to published outcomes of transperitoneal robotic radical nephrectomy (2,33). Given the timeframe of follow-up, long-term oncologic outcomes were unable to be assessed. Finally, as surgeries were completed at academic centers by fellowship-trained high-volume robotic and retroperitoneal (particularly rRPN) surgeons, applicability to less-experienced robotic surgeons may be limited. We recommend surgeons become comfortable performing rRPN before attempting rRRN as the retroperitoneal space can be disorienting and RN requires more dissection than what is required for partial nephrectomy. The optimal approach to retroperitoneal robotic surgery training outside of fellowship training is not well established.

Conclusions

In conclusion, this series underlines the feasibility, reproducibility, and relatively low complication rate of rRRN. This described approach provides direct access to the renal hilum, avoids the intraperitoneal cavity, and avoids the significant abdominal pannus in morbidly obese patients. This approach has similar EBL and recovery times compared to a transperitoneal approach. This technique can be utilized in highly selected patients that require a non-traditional approach for radical nephrectomy, simple nephrectomy, and nephroureterectomy due to extensive prior abdominal surgery or morbid obesity. Further prospective, multi-institutional studies are needed to better assess long-term outcomes compared to transperitoneal robotic kidney surgery.

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Footnote

Reporting Checklist: The authors have completed the

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Data Sharing Statement: Available at https://tau.amegroups.com/article/view/10.21037/tau-23-270/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tau.amegroups.com/article/view/10.21037/tau-23-270/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the institutional ethics board of the University of Iowa (No. 202104324) and individual consent for this retrospective analysis was waived.

References

1. Ljungberg B, Albiges L, Abu-Ghanem Y, et al. European Association of Urology Guidelines on Renal Cell Carcinoma: The 2022 Update. Eur Urol 2022;82:399-410.
2. Asimakopoulos AD, Miano R, Annino F, et al. Robotic radical nephrectomy for renal cell carcinoma: a systematic review. BMC Urol 2014;14:75.
3. Jeong IG, Khandwala YS, Kim JH, et al. Association of Robotic-Assisted vs Laparoscopic Radical Nephrectomy With Perioperative Outcomes and Health Care Costs, 2003 to 2015. JAMA 2017;318:1561-8.
4. Carbonara U, Simone G, Capitanio U, et al. Robot-assisted partial nephrectomy: 7-year outcomes. Minerva Urol Nephrol 2021;73:540-3.
5. Amparore D, Pecoraro A, Piramide F, et al. Comparison between minimally-invasive partial and radical nephrectomy for the treatment of clinical T2 renal masses: results of a 10-year study in a tertiary care center. Minerva Urol Nephrol 2021;73:509-17.
6. Vuong NS, Ferriere JM, Michiels C, et al. Robot-assisted versus open surgery for radical nephrectomy with level 1-2 vena cava tumor thrombectomy: a French monocenter experience (UroCCR study #73). Minerva Urol Nephrol 2021;73:498-508.
7. McAllister M, Bhayani SB, Ong A, et al. Vena caval transection during retroperitoneoscopic nephrectomy: report of the complication and review of the literature. J Urol 2004;172:183-5.
8. Nunoo-Mensah JW, Rosen M, Chan LS, et al. Prevalence of intra-abdominal surgery: what is an individual's lifetime risk? South Med J 2009;102:25-9.
9. Khambati A, Fitzgerald MK, Perry KT, et al. Retroperitoneal Laparoscopic Radical Nephrectomy Allows Continuation of Peritoneal Dialysis in Patients with End-Stage Renal Disease. Perit Dial Int 2017;37:340-2.
10. Yin L, Zhang D, Teng J, et al. Retroperitoneal laparoscopic radical nephrectomy for renal cell carcinoma during pregnancy. Urol Int 2013;90:487-9.
11. Berglund RK, Gill IS, Babineau D, et al. A prospective comparison of transperitoneal and retroperitoneal laparoscopic nephrectomy in the extremely obese patient. BJU Int 2007;99:871-4.
12. Porpiglia F, Mari A, Amparore D, et al. Transperitoneal vs retroperitoneal minimally invasive partial nephrectomy: comparison of perioperative outcomes and functional follow-up in a large multi-institutional cohort (The RECORD 2 Project). Surg Endosc 2021;35:4295-304.
13. Zhu D, Shao X, Guo G, et al. Comparison of Outcomes Between Transperitoneal and Retroperitoneal Robotic Partial Nephrectomy: A Meta-Analysis Based on Comparative Studies. Front Oncol 2021;10:592193.
14. Hughes-Hallett A, Patki P, Patel N, et al. Robot-assisted partial nephrectomy: a comparison of the transperitoneal and retroperitoneal approaches. J Endourol 2013;27:869-74.
15. Strauss DM, Lee R, Maffucci F, et al. The future of "Retro" robotic partial nephrectomy. Transl Androl Urol 2021;10:2199-208.
16. Nepple KG, Kallogjeri D, Bhayani SB. Benchtop evaluation of pressure barrier insufflator and standard insufflator systems. Surg Endosc 2013;27:333-8.

17. Patel M, Porter J. Robotic retroperitoneal surgery: a contemporary review. Curr Opin Urol 2013;23:51-6.
18. Sparwasser P, Epple S, Thomas A, et al. First completely robot-assisted retroperitoneal nephroureterectomy with bladder cuff: a step-by-step technique. World J Urol 2022;40:1019-26.
19. Yang WH, Ou CH. A muscle-sparing modified Gibson incision for hand-assisted retroperitoneoscopic nephroureterectomy and bladder cuff excision--an approach through a window behind the rectus abdominis muscle. Urology 2012;79:470-4.
20. Diblasio CJ, Snyder ME, Russo P. Mini-flank supra-11th rib incision for open partial or radical nephrectomy. BJU Int 2006;97:149-56.
21. Burgess NA, Koo BC, Calvert RC, et al. Randomized trial of laparoscopic v open nephrectomy. J Endourol 2007;21:610-3.
22. Feliciano J, Stifelman M. Robotic retroperitoneal partial nephrectomy: a four-arm approach. JSLS 2012;16:208-11.
23. Abdel Raheem A, Sheikh A, Kim DK, et al. Da Vinci Xi and Si platforms have equivalent perioperative outcomes during robot-assisted partial nephrectomy: preliminary experience. J Robot Surg 2017;11:53-61.
24. Nambirajan T, Jeschke S, Al-Zahrani H, et al. Prospective, randomized controlled study: transperitoneal laparoscopic versus retroperitoneoscopic radical nephrectomy. Urology 2004;64:919-24.
25. Desai MM, Strzempkowski B, Matin SF, et al. Prospective randomized comparison of transperitoneal versus retroperitoneal laparoscopic radical nephrectomy. J Urol 2005;173:38-41.
26. Gozen AS, Gherman V, Akin Y, et al. Evaluation of the complications in laparoscopic retroperitoneal radical nephrectomy; An experience of high volume centre. Arch Ital Urol Androl 2017;89:266-71.
27. Sands KG, Figenshau RS, Vetter J, et al. Contemporary Pure Laparoscopic vs Robot-Assisted Laparoscopic Radical Nephrectomy: Is the Transition Worth It? J Endourol 2021;35:1526-32.
28. Zihni A, Gerull WD, Cavallo JA, et al. Comparison of precision and speed in laparoscopic and robot-assisted surgical task performance. J Surg Res 2018;223:29-33.
29. Rose K, Khan S, Godbole H, et al. Robotic assisted retroperitoneoscopic nephroureterectomy -- first experience and the hybrid port technique. Int J Clin Pract 2006;60:12-4.
30. Patel MN, Kaul SA, Laungani R, et al. Retroperitoneal robotic renal surgery: technique and early results. J Robot Surg 2009;3:1.
31. Veccia A, Carbonara U, Derweesh I, et al. Single-stage Xi® robotic radical nephroureterectomy for upper tract urothelial carcinoma: surgical technique and outcomes. Minerva Urol Nephrol 2022;74:233-41.
32. Wu Z, Li M, Wang J, et al. Pure retroperitoneoscopic extravesical standardized seeable (PRESS) excision of distal ureter and bladder cuff in radical nephroureterectomy: step-by-step technique. Minerva Urol Nephrol 2021;73:392-400.
33. Crocerossa F, Carbonara U, Cantiello F, et al. Robot-assisted Radical Nephrectomy: A Systematic Review and Meta-analysis of Comparative Studies. Eur Urol 2021;80:428-39.
34. Hu JC, Treat E, Filson CP, et al. Technique and outcomes of robot-assisted retroperitoneoscopic partial nephrectomy: a multicenter study. Eur Urol 2014;66:542-9.
35. Mittakanti HR, Heulitt G, Li HF, et al. Transperitoneal vs. retroperitoneal robotic partial nephrectomy: a matched-paired analysis. World J Urol 2020;38:1093-9.
36. Harke NN, Darr C, Radtke JP, et al. Retroperitoneal Versus Transperitoneal Robotic Partial Nephrectomy: A Multicenter Matched-pair Analysis. Eur Urol Focus 2021;7:1363-70.
37. Carbonara U, Crocerossa F, Campi R, et al. Retroperitoneal Robot-assisted Partial Nephrectomy: A Systematic Review and Pooled Analysis of Comparative Outcomes. Eur Urol Open Sci 2022;40:27-37.
38. Zhou J, Liu ZH, Cao DH, et al. Retroperitoneal or transperitoneal approach in robot-assisted partial nephrectomy, which one is better? Cancer Med 2021;10:3299-308.

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