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ROBOTIC PARTIAL NEPHRECTOMY FOR RENAL HILAR TUMORS: A MULTI-INSTITUTIONAL ANALYSIS

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INTRODUCTION

Kidney tumors are being increasingly detected incidentally at smaller sizes when they are potentially amenable to nephron sparing surgery.¹ Evidence of the potential for deterioration of renal function after radical nephrectomy², and the association of deteriorating GFR with cardiovascular morbidity, hospitalization and death³, support an increasing role for partial nephrectomy. Laparoscopic partial nephrectomy (LPN) has demonstrated benefits compared to open partial nephrectomy (OPN), such as less blood loss and quicker recovery, with similar intraoperative complication rates, negative margins, and oncological and renal functional outcomes^{4, 5}. However, advanced laparoscopic skills are required to achieve precise tumor resection and renal reconstruction during LPN. Renal hilar tumors may pose additional technical challenges for LPN. Although LPN for renal hilar tumors has been reported⁶, this was a series from a senior surgeon with considerable laparoscopic experience. We hypothesized that robotic assistance might facilitate a minimally invasive approach to partial nephrectomy for renal hilar tumors. Robotic partial nephrectomy (RPN) has been reported by several centers as small, single-institution series⁷⁻¹¹ and have not focused specifically on tumors located solely at the renal hilum. We describe our multi-institutional experience with robotic partial nephrectomy in the setting of renal hilar tumors.

METHODS

We evaluated 11 patients with renal hilar tumors who underwent robotic partial nephrectomy between March, 2007 and December, 2008. Our study included two institutions (NCI and HFHS) and two surgeons (PAP and CGR). The first seven cases were performed by an experienced laparoscopic surgeon (PAP) using a daVinci standard robotic system and a fellow (CGR) as an assistant. The remaining four cases were performed by CGR following completion of fellowship training and as a new staff at the other institution (HFHS). A daVinci S surgical system was used for these cases with residents as operative assistants.

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Conflicts of Interest: none

Renal hilar tumors were defined as tumors located in the region of the renal hilum in physical contact with the renal artery and/or renal vein on preoperative 3-dimensional computerized tomography. Selection for a robotic approach was based on the presence of a complex renal hilar tumor and patient preference. A summary of patient demographical data is presented in Table 1. All patients had a preoperative estimated glomerular filtration rate within normal limits (>85 ml/min/1.73m²). Three patients had hereditary kidney cancer. A representative CT scan of a posterior renal hilar tumor in our series is demonstrated in Figure 1 and a representative CT scan of an anterior hilar tumor is demonstrated in Figure 2.

SURGICAL TECHNIQUE

Flexible cystoscopy with ureteral catheter placement was performed for identification of collecting system entry by retrograde injection of methylene blue. Patients were positioned in flank position and pneumoperitoneum (15 mm Hg) was established. A medial camera position was used for the first seven cases, with port placement and docking of the robot performed as previously described.¹⁰ A lateral camera position was used for the remaining four cases, with ports placed as previously described.¹⁰ Both port strategies are demonstrated in Figure 3. The fourth robotic arm was used for the four cases done with the daVinci S surgical system, with the robotic port positioned approximately 3–4 finger breaths medial to the inferior robotic instrument port (Fig. 3b). The fourth robotic arm was utilized to provide kidney retraction, using the robotic Double fenestrated retractor to lift the kidney anteriorly and place the renal hilum on stretch.

Robotic instruments used included Bipolar Maryland forceps, monopolar cautery scissors, and needle drivers. A laparoscopic ultrasound probe was used to locate renal tumors, identify adjacent vasculature using color Doppler, and to delineate margins of resection. If the fat overlying the tumor had to be removed to optimize view of renal hilar structures to be preserved, this fat was sent separately to pathology for analysis. Warm ischemia was achieved using laparoscopic bulldog clamps placed by the assistant, to occlude the renal artery and renal vein individually. Mannitol (12.5 gm) was administered intravenously prior to hilar clamping. Renal tumors were resected using cold resection with the robotic monopolar scissors with fine dissection from the renal vessels. Closure of the collecting system and hemostasis of the resection bed was achieved using robotic needle drivers with a 3-0 Vicryl suture on an SH or RB-1 needle for a running closure of large defects or a figure of eight closure of small vessels with Lapra-tye absorbable suture clips (Ethicon, Inc.) to anchor the ends of the sutures. A hemostatic agent, such as Floseal®, was applied to the resection bed. The renal parenchyma was closed over Surgicel bolsters using interrupted 2-0 Vicryl sutures on an SH or CT-1 needle through the renal capsule and anchored with Lapra-tye clips.

RESULTS

A total of 11 patients (mean age 56.4 years, range 30–76 years) underwent successful robotic partial nephrectomy for renal hilar tumors. Table 1 lists patient demographics and perioperative outcomes. Mean warm ischemia time was 28.9 minutes (range 20–39 minutes). Mean operating time was 202 minutes (range 154–253 minutes). Mean estimated blood loss was 220 ml (range 50–750 ml). Mean tumor size was 3.8 cm (range 2.3–6.4 cm). Mean hospital stay was 3.0 days (range 2.0–4.0 days). No patients experienced a significant elevation in serum creatinine or estimated glomerular filtration rate postoperatively. One patient from each institution developed a postoperative urine leak that resolved after placement of a ureteral stent. Histopathology confirmed clear cell renal cell carcinoma (RCC)-8, papillary RCC-1, and chromophobe RCC-2. Surgical margins were negative for malignancy in all cases.

Both institutions achieved similar outcomes with no statistically significant difference in variables except for a younger mean age (50.1 vs. 67.3 years, $p=0.036$) and a longer mean hospital stay (3 days vs. 2 days, $p=0.04$) for patients from the first institution (NCI).

DISCUSSION

Kidney tumors are being increasingly detected at smaller sizes¹ and evidence is accumulating regarding the potential medical benefits of nephron sparing surgery,^{4, 5} supporting an increasing role of partial nephrectomy. LPN has demonstrated benefits compared to OPN in regards to blood loss and recovery with similar long-term renal functional and oncologic outcomes.^{4,5} LPN requires advanced skills in laparoscopy to accomplish tasks of tumor resection and renal reconstruction while minimizing warm ischemia times. Tumors located near renal hilar structures can add to the technical challenges of a LPN. Robotic assistance may facilitate the advanced maneuvers required to successfully perform partial nephrectomy for renal hilar tumors using a minimally invasive surgical approach. The magnified, 3-dimensional visualization and articulating robotic instruments can facilitate precise tumor resection and renal reconstruction for tumors near hilar structures. Our multi-institutional experience demonstrates the safety and efficacy of RPN in select patients with renal hilar tumors.

Although other reports have also demonstrated the safety and feasibility of RPN,⁷⁻¹¹ ours is the first to address RPN specifically for renal hilar tumors. LPN for renal hilar tumors is described by Gill et al.⁶ However, these advanced surgeries were performed by one senior surgeon with considerable laparoscopic experience. Our study had more junior surgeons, with one immediately out of fellowship. Comparing our robotic experience for renal hilar tumors with this laparoscopic partial nephrectomy series, our mean warm ischemia time was shorter (28.9 vs. 36 minutes) with a similar mean tumor size (3.8 vs. 3.7 cm). We recognize that recent developments for LPN, such as the early unclamping technique described by Gill et al.,¹² can significantly reduce warm ischemia times. Although this technique was not utilized in our series, as it had not yet been reported, we would anticipate similar benefits in warm ischemia time when applying this technique to RPN.

The risk of bleeding and arteriovenous fistula formation would theoretically be increased with hilar tumors. We feel that these potential complications can be avoided with precise sutured closure of the resection bed of the kidney, avoiding deep passes with large needles that could potentially increase the risk of an arteriovenous fistula or an excluded calyx. Robotic assistance facilitates suturing with a smaller RB-1 needle in these situations. We did not experience any episodes of major bleeding or other complications that required open conversion. However, if open conversion were to become necessary, the robot could be quickly undocked by removing the robotic instruments and clutching the robotic arms to pull attached robotic trocars from the abdomen. The robot could be pulled back several feet to allow room for the surgeon, who would be gowned and gloved by that time. We keep a gown and gloves available at all times for this reason. We also place a laparoscopic sponge in the abdomen prior to hilar dissection that can be used to pack bleeding vessels to help achieve hemostasis. We have performed a “dry run” exercise of undocking for open conversion in a porcine model in under 1 minute.

The two centers in this study used different camera positions and port strategies, each with relative advantages. The medial camera placement offers a global view of anatomical structures that simulates conventional laparoscopy. Lateral placement of the camera port placement may reduce arm collisions, provide more space for the assistant, and facilitate use of the fourth robotic arm to minimize dependence on the surgical assistant. The strategy of port placement and sutures used may vary based on surgeon preference.

Limitations of our study include its small sample size. However, we feel our experience illustrates the potential for robotic assistance to facilitate a minimally invasive approach for challenging renal hilar tumors. Potential disadvantages of RPN include the cost. We recognize that robotic assistance may not be practical for all partial nephrectomy cases. It was beyond the scope of this study to perform a detailed comparative cost analysis. If robotic assistance can facilitate a minimally-invasive and nephron-sparing approach in select patients with challenging renal hilar tumors that might otherwise require total nephrectomy or open surgery, then the benefits might justify the costs for this particular group of patients.

Our study is not designed to compare robotic assistance with the other approaches to partial nephrectomy. A comparison of OPN and LPN has already been described.⁴ Our study is intended to assess feasibility and short term outcomes of RPN for a select group of patients with renal hilar tumors. Further studies comparing RPN to other surgical approaches are warranted.

CONCLUSIONS

RPN is safe and feasible for select patients with renal hilar tumors. Robotic assistance may facilitate the technical challenges of a minimally invasive application for partial nephrectomy in the setting of renal hilar tumors, potentially offering select patients to receive a minimally invasive and nephron sparing surgery surgical option who might otherwise receive total nephrectomy or open surgery.

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Fig 1. Posterior renal hilar tumor. Coronal CT demonstrates a 2.6 cm solid tumor located near the left renal vessels and abutting the renal pelvis.

Fig 2a.
Large anterior renal hilar tumor. CT demonstrates a right 6.4 cm solid mid/upper pole renal mass.

Fig 2b.
Coronal view of same tumor (black arrow) demonstrating proximity to renal hilar vessels (white arrow).

Fig 3a.

Port configuration for robotic partial nephrectomy utilizing medial camera port. Ports include a periumbilical camera port, robotic instrument ports in a V configuration toward the kidney tumor, and an infraumbilical 12 mm assistant port.

Fig 3b.
Port configuration for robotic nephrectomy utilizing a lateral camera port, fourth robotic arm, and medial 12 mm assistant port.