ORIGINAL ARTICLE

Initial Clinical Experience With Surgical Technique of Robot-assisted Transperitoneal Laparoscopic Partial Nephrectomy

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Background: The incidental finding of small renal masses has increased due to widespread use of computed tomography as a diagnostic procedure. Some patients with either exophytic renal masses less than 4 cm and suboptimal renal function, a solitary kidney and bilateral renal tumors, or genetic predisposition to renal tumors are considered candidates for laparoscopic partial nephrectomy (LPN). A technical difficulty of LPN is performing laparoscopic intracorporeal suturing under the pressure of warm ischemia time. Because robotic systems have been shown to provide easier intracorporeal suturing, we hypothesized that robotic-assisted LPN might improve efficacy.

Methods: Eight patients with a mean age of 41 years and mean tumor size of 2.3 cm underwent robot-assisted LPN between September 2006 and December 2008. Tumor excision and intracorporeal suturing under warm ischemia by renal artery clamp were performed entirely using a robotic system. All perioperative data and pathologic results were reviewed retrospectively.

Results: The mean operation time was 160 minutes, and the mean estimated blood loss was 165 mL. The mean warm ischemia time was 33 minutes, and mean postoperative hospital stay was 4.3 days. Average preoperative hemoglobin was 13.0 mg/dL and postoperative hemoglobin was 11.8 mg/dL. Average preoperative creatinine was 1.1 ng/mL and postoperative creatinine was 1.28 ng/mL. There was 1 conversion to laparoscopic nephrectomy due to a positive margin on a frozen section after discussion with family about better oncologic control. The resected lesions included renal cell carcinoma in 5 patients, angiomyolipoma in 2, and a renin-secreting renal tumor in 1 patient.

Conclusion: Robot-assisted LPN is feasible and may be a viable alternative to open or LPN in selected patients with small exophytic renal tumors. Compared with standard LPN, the robotic assisted LPN approach with precise renal reconstruction under a safe warm ischemia time is feasible and can be easily adopted by those with experience in robot-assisted surgery. [*J Chin Med Assoc* 2009;72(12):634–637]

Key Words: laparoscopic partial nephrectomy, laparoscopy, partial nephrectomy, robot-assisted laparoscopic nephrectomy

Introduction

Incidental discovery of small renal asymptomatic masses amenable to partial nephrectomy has increased due to the widespread use of computed tomography as a diagnostic procedure. Nephron-sparing surgery is often performed because of its proven efficacy and long-term patient-related benefits and laparoscopic partial nephrectomy (LPN) is an acceptable approach to this surgery.[1–3] LPN is indicated for patients who have suboptimal renal function, a solitary kidney, bilateral tumors, or a genetic predisposition to renal tumors and is considered appropriate for selected patients with larger, more endophytic tumors.[4,5] Technical difficulties, including intracorporeal suturing under pressure of renal artery clamping ischemia time, are mainly associated with tumor excision, hemostasis, and reconstruction of the collecting system and renal parenchyma.[6] Therefore, LPN is still not widely used due to the technical difficulty and the pressure placed on the surgeon.

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ELSEVIER

The advantages of telerobotic surgical systems such as multi-jointed endowristed instruments, 3-dimensional stereoscopic optics, and computer elimination of tremor might decrease the technical difficulties of LPN. Compared with LPN, robot-assisted LPN may decrease operative time, blood loss, and ischemia time. We hypothesized that robot-assisted LPN was feasible and safe and report here our initial experience with the da Vinci Surgical System (Intuitive Surgical Inc., Sunnyvale, CA, USA).

Methods

From September 2006 to December 2008, 8 consecutive patients underwent robot-assisted LPN (RALPN) performed by the same team of 3 surgeons. All patients had been evaluated with computed tomography and angiography to define the mass and vascular structure clearly. All patients had a normal contralateral kidney, and were candidates for LPN, with indications similar to those previously described by Gill et al.[7] All procedures were performed transperitoneally following the principles of LPN. The mean tumor size on the preoperative imaging study was 2.3 cm (range, 1.0–3.0 cm). The pathologic assessment was performed using the 1997 TNM staging system.

Surgical details

The patients were placed in the flank position with a 60° lateral tilt. All operative procedures were performed with the da Vinci Surgical System (Intuitive Surgical Inc.) transperitoneally. An assistant 12-mm trocar port was placed initially with an open method at the umbilicus during the robotic procedure. A 12-mm camera port was introduced under vision and placed 50 mm below the subcostal margin at the anterior axillary line. Two 8-mm robotic instrument ports were placed 8 cm from the camera port and medially toward the umbilicus. An additional 5-mm assistant trocar port for suction and an irrigation system were placed and adjusted with the 3-arm da Vinci Surgical System ports and assistant ports. RALPN followed the steps of conventional LPN, as previously described.[7–9] A 30° lens was used to visualize the operation site. The initial dissection was performed with a hook electrode on the medial working robotic arm and a Maryland bipolar device on the lateral working robotic arm. The line of Toldt was incised, the large bowel was mobilized medially, and Gerota's fascia was incised. The renal hilum was dissected, and Gerota's fascia was dissected off the surface of the kidney, but the perirenal fat was left intact over the area of the tumor. A laparoscopic ultrasound probe was used to define the deep and lateral tumor margins, then to plan the resection margin 10 mm beyond the tumor margin. The renal artery and renal vein were clamped with laparoscopic bulldog clamps. Mannitol (12.5 mg, 250 mL) was administered intravenously prior to clamping the pedicle. Kidney surface cooling was not attempted. The console surgeon then excised the tumor with robotic endoscopic shears. The assistant surgeon used a suction/irrigator or conventional laparoscopic grasper for counter traction and to optimize visualization of the surgical field. In addition, the base of the defect was cauterized with an argon beam and packed with fibrin-soaked Gelfoam after continued suturing with 3-0 Vicryl to repair collecting system defects and for parenchymal bleeders. The assistant surgeon then injected the fibrin glue with thrombin via the 5-mm trocar port with a fibrin glue laparoscopic injection catheter. Polyglactin mattress sutures (2-0) on CT-1 needles with bolsters were used to approximate the renal capsule. The bulldog clamps were released and a careful inspection was performed to note any bleeding points. A 15-Fr Jackson-Pratt drain was placed via the 8-mm port after the excised renal tumor was placed into a retrieval bag. Frozen section evaluation was performed in all cases.

Results

Eight patients with an average age of 41 years (age range, 12–65 years) underwent unilateral transperitoneal RALPN. Six masses were located on right kidneys and 2 on left kidneys. The average tumor size was 2.3 cm (range, 1.0–3.0 cm). A total of 8 da Vinci-assisted transperitoneal LPN procedures were performed, with a mean operative time of 160 minutes (range, 120–210 minutes). The mean operative time included the time of pneumoperitoneum setup, robot installation, and surgeon console time. The average preoperative hemoglobin was 13.0 mg/dL, and postoperative hemoglobin was 11.8 mg/dL. The average preoperative creatinine was 1.1 ng/mL, and postoperative creatinine was 1.28 ng/mL. The mean estimated blood loss was 165 mL (range, 20–450 mL). All cases required clamping of the renal artery, and the mean warm ischemia time was 33 minutes (range, 26–40 minutes). The mean hospital stay was 4.3 days (range, 2–7 days). Tables 1 and 2 list all the demographic data, operative parameters and perioperative parameters. No surface cooling or intra-arterial catheter cooling was performed. Postoperative complications were observed in 1 patient who experienced a urinary leak. This complication was resolved by double-J

Table 1. Demographic data and operative parameters in 8 patients who underwent robot-assisted laparoscopic partial nephrectomy

Case	Age (yr)	Sex	Site	Tumor size (cm)	Warm ischemia time (min)	Operative time (min)	Pathology & stage	Estimated blood loss (mL)
1	56	F	Left low pole, anterior	2.5	35	150	Clear cell RCC, pT1aN0M0	220
2	65	M	Right low pole, anterior	1	40	155	Clear cell RCC, pT1aN0M0	110
3	12	F	Right upper pole	1.5	36	140	Renin-secreting tumor	50
4	38	M	Right middle pole, anterior	3	26	145	AML	150
5	53	F	Left low pole, posterior	3	29	120	Clear cell RCC, pT1aN0M0	20
6	49	F	Right middle pole, anterior	2.5	34	175	Clear cell RCC, pT1aN0M0	225
7	55	M	Right upper pole, anterior	2	26	180	Clear cell RCC, pT1aN0M0	450
8	49	F	Right upper pole, anterior	2.7	38	210	AML	100

RCC = renal cell carcinoma; AML = angiomyolipoma. All tumors were exophytic tumors.

Table 2. Preoperative and postoperative parameters

Case	Preop/postop hemoglobin (g/dL)	Preop/postop creatinine (mg/dL)	Body mass index
1	11.2/9.7	1.1/1.3	1.4
2	13.7/12.1	1.6/1.9	1.6
3	12.8/13.5	0.9/0.9	1.3
4	14.5/12.9	1.2/1.4	1.3
5	12.3/12.5	1.3/1.0	1.5
6	11.4/8.8	0.8/1.4	1.4
7	14.3/10.4	0.9/1.6	1.6
8	12.9/11.5	1.0/0.8	1.3

Preop = preoperative; postop = postoperative.

stent insertion. Pathologic examination revealed renal cell carcinoma in 5 patients, a renin-secreting tumor in 1, and angiomyolipoma in 2 patients. All resection margins were excised and submitted for frozen section analysis. Only 1 patient was found to be positive for residual malignancy. This patient underwent laparoscopic transperitoneal radical nephrectomy due to the residual malignancy; at a mean follow-up time of 18 months, no recurrence had been observed.

Discussion

Nephron-sparing surgery is indicated for patients with a small renal tumor and reserved for patients with a solitary kidney, bilateral tumors, or renal insufficiency.[10] Acceptable disease-free survival and oncologic outcomes of nephron-sparing surgery in selected patients are equivalent to those of radical nephrectomy.[11] Most recent clinical series have demonstrated disease-specific survival rates of greater than 90%, with recurrence rates of less than 5%.[12,13]

LPN was first described in 1993 by Winfield et al.[14] It remains a technically difficult procedure due to the need for intracorporeal suturing and the stress on urologists from possible subsequent renal dysfunction because of the prolonged ischemic time.[15] The assistance of the da Vinci robotic system has significantly decreased the time required to learn laparoscopic skills, especially intracorporeal suturing skills.

The advantage of the da Vinci surgical system is its ability to decrease the difficulty of laparoscopic techniques. The 6 degrees of freedom at the end of instruments, 3-dimensional stereoscopic vision, vision movement-decreased tremor allowing suturing, and intracorporeal suturing techniques are more similar to those of open surgery than standard laparoscopy. The Maryland bipolar device and endoscopic shears can be rotated with a greater degree of freedom, aiding tumor dissection.

The disadvantages of the da Vinci system are the costs, the training times, the dangers of equipment malfunction, and lack of tactile feedback. Another potential disadvantage of the da Vinci system in RALPN is kidney mobilization with tumor location and exposure during the whole procedure.

RALPN is a procedure that should be performed by 2 experienced surgeons. The primary surgeon operates the robotic console and the other surgeon, who remains scrubbed and at the operating table, provides critical procedures such as renal pedicle clamping, exchanging instruments, and aids in hemostasis.

Phillips et al reported on their experience of 12 robotic partial nephrectomy procedures in which the robotic system was only used during tumor excision and defect intracorporeal suturing although initial kidney mobilization and hilar dissection were performed laparoscopically.[16] In our series, we performed the whole procedure including initial dissection, tumor location and exposure, hilar dissection, and defect suturing using the robotic system. We did not perform surface cooling or intra-arterial catheter cooling during the entire procedure. Gettman et al reported on 8 robotic-assisted laparoscopic partial nephrectomies with a procedure using an intra-arterial catheter to cool the kidney.[17] In our series, the mean operative time was 160 minutes, the mean warm ischemia time was 33 minutes and the mean estimated blood loss was 165 mL. The mean hospital stay was 4.3 days. The da Vinci robotic system has been shown to be advantageous only for intracorporeal suturing procedures in partial nephrectomy; it is disadvantageous in renal hilar dissection, kidney mobilization, and tumor exposure.

Our small number of RALPNs also revealed that blood loss, hospital stay, ischemic time, operative time, and complications rates were similar to those of standard LPN.[18] A larger randomized study would be needed to determine whether there is any significant difference between these 2 techniques. We believe that the intuitive design, stereoscopic vision, and endowristed instrumentation of the da Vinci robotic system has made a significant impact on how accurately we suture both the pelvicalyceal system and renal parenchyma within safe warm ischemia time. Our limited experience suggests that robot-assisted LPN is feasible for selected small renal masses, but the cost and unpopularity of the da Vinci system remains a limitation. Therefore, we hypothesize that the da Vinci robotic system may make RALPN easier to learn than LPN, and it may provide a more tangible benefit for complex lesions requiring more extensive reconstruction within warm ischemia time.

In conclusion, our initial results did not reveal significantly decreased ischemic time, operative time, blood loss, or risk of conversion, despite the use of the da Vinci robotic surgical system for LPN. Therefore, this robotic system is not routinely used for LPN at our institution. But this robotic system does reduce the technical difficulty of intracorporeal suturing and permits urologists who are inexperienced with laparoscopic procedures to complete the procedures within safe warm ischemia time. In our initial limited clinical experience, da Vinci-assisted LPN was feasible and is an alternative to open or LPN in appropriately selected patients with small renal masses.

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